Platinum Level

- An educational grant in support of The Foundation of the ASNR Symposium 2011: Neuroradiology of Trauma
- Annual educational grant in support of the Maintenance of Certification (MOC) and Self Assessment Modules (SAM)* programming live and as an internet activity on the ASNR website
- Performance and Quality Improvement (PQI) Initiative

Gold Level

- An educational grant in support of The Foundation of the ASNR Symposium 2011: Neuroradiology of Trauma
- Annual educational grant in support of the Maintenance of Certification (MOC) and Self Assessment Modules (SAM)* programming live and as an internet activity on the ASNR website
- Performance and Quality Improvement (PQI) Initiative

Silver Level

- An educational grant in support of The Foundation of the ASNR Symposium 2011: Neuroradiology of Trauma
- Annual educational grant in support of the Maintenance of Certification (MOC) and Self Assessment Modules (SAM)* programming live and as an internet activity on the ASNR website
- Performance and Quality Improvement (PQI) Initiative

Contributor

- An educational grant in support of The Foundation of the ASNR Symposium 2011: Neuroradiology of Trauma
- Annual educational grant in support of the Maintenance of Certification (MOC) and Self Assessment Modules (SAM)* programming live and as an internet activity on the ASNR website
- Performance and Quality Improvement (PQI) Initiative

* Session Programming qualified by the American Board in meeting the criteria for self-assessment toward the purpose of fulfilling requirements in the ABR Maintenance of Certification Program. 4/11. To obtain current SAM credit information, visit www.asnr.org
Dear Colleagues,

Welcome to the 49th ASNR Annual Meeting and The Foundation of the ASNR Symposium 2011. Dr. David B. Hackney, President-Elect of the ASNR and this year’s Program Committee Chair, has worked tirelessly with members of his committee to present timely and substantive educational and scientific material for this year’s programming.

Continuing a highly popular special feature piloted at the 2010 meeting, on Saturday morning ASNR will offer an intriguing collection of lectures in collaboration with the International Society for Magnetic Resonance in Medicine (ISMRM). This year’s topic of “Advanced Imaging of Neurotrauma” will provide the basis for The Foundation of the ASNR Symposium on the “Neuroradiology of Trauma” to follow on Saturday afternoon and Sunday. The 2011 Symposium promises to be educationally beneficial for all attendees, both specialists and generalists.

The Annual Meeting features Self-Assessment Module (SAM) sessions in each of the subspecialty areas of neuroradiology, general content SAM sessions, Maintenance of Certification (MOC) sessions in vascular, head and neck, pediatric neuroradiology, and the post-operative spine. The “Synaptic Junction” will serve as a hub for programming on issues that affect your practice. Focus Sessions developed in collaboration with our subspecialty societies, the American Society of Functional Neuroradiology (ASFNR), American Society of Head and Neck Radiology (ASHNR), American Society of Pediatric Neuroradiology (ASPNR), American Society of Spine Radiology (ASSR), and the Society of NeuroInterventional Surgery (SNIS), as well as the Society for Neuro-Oncology (SNO), cover a wide range of topics of interest for both sub-specialist and general neuroradiologists. Once again, attendees may take the American Board of Radiology (ABR) neuroradiology MOC recertification examination on site at the meeting.

I wish to express my deepest appreciation to the following Co-Chairs for their efforts in organizing superb programming in the following subspecialty areas:

American Society of Functional Neuroradiology (ASFNR) ......................... Joseph A. Maldjian, MD
American Society of Head and Neck Radiology (ASHNR) ....................... Suresh K. Mukherji, MD, FACR
American Society of Pediatric Neuroradiology (ASPNR) ...................... Tina Young Poussaint, MD
American Society of Spine Radiology (ASSR) ............................. Gregory W. Petermann, MD
Society of NeuroInterventional Surgery (SNIS) ................................................. Joshua A. Hirsch, MD

The Annual Meeting provides a unique opportunity to gain a better understanding of how the ASNR functions to lead the field of neuroradiology forward during a time of rapid change. The meeting also provides a wonderful opportunity to greet new and old colleagues and friends, as well as exchange ideas with world-renowned clinicians, researchers, and educators.

Congratulations to David Hackney and the many colleagues who contributed to developing a truly outstanding program for the 2011 Annual Meeting. I welcome you to make the most of this exciting opportunity to learn, share, and lead. I look forward to seeing you there, and hope to have the opportunity to speak with you personally and thank you for your contribution to ASNR.

Sincerely,

Carolyn Cdis Meltzer, MD, FACR
ASNR President
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About Seattle

The ASNR 49th Annual Meeting and Foundation of the ASNR 2011 host venue is the Washington State Convention Center in Seattle, Washington. Seattle invites you to explore two cities in one. You’ll find a vibrant, sophisticated metropolis surrounded by pristine natural beauty and abundant recreation. Seattle is metronatural.

Downtown Seattle is easily walkable and waiting to be explored. Shopping, dining, arts and visitor attractions are within steps of hotels and inns. The city is surrounded by pristine waterways, two mountain ranges and three national parks. To the west lies the only temperate rain forest in the continental U.S. To the east, a world-class wine region. Whether metro or natural, you can pack a lot into your Seattle itinerary.

Walking Map of Seattle
General Information

Meeting Registration
Registration will take place in the 4th Floor South Lobby, Washington State Convention Center. The registration desk will be open during the following hours:

- Friday, June 3 ........................................... 5:00 pm - 8:00 pm
- Saturday, June 4 .................................... 6:30 am - 6:00 pm
- Sunday, June 5 ...................................... 6:30 am - 6:00 pm
- Monday, June 6 ..................................... 6:30 am - 6:00 pm
- Tuesday, June 7 ...................................... 6:30 am - 6:00 pm
- Wednesday, June 8 ............................... 6:30 am - 6:00 pm
- Thursday, June 9 .................................... 6:30 am - 6:00 pm

Speaker Ready Room Location & Hours
Washington State Convention Center - Room 605/610

- Friday, June 3 ........................................... 5:00 pm - 8:00 pm
- Saturday, June 4 through
- Thursday, June 9 .................................... 6:00 am - 6:00 pm

Name Badges
Please wear name badges at all times while you are attending the scientific sessions, social programs, and technical exhibits. Badge colors are identified as follows:
- ASNR Members, ASNR Members-In-Training & ASNR Subspecialty
- Societies (ASFNR, ASHNR, ASPNR, ASSR & SNIS) ................ Blue
- Non-Member ............................................. Green
- Other Professional ..................................... Yellow
- Guest ...................................................... Peach
- Exhibitor ................................................. Gold
- Staff ....................................................... Purple

Committee/Specialty/Regional Society Meetings
Please refer to the Daily Postings on the Meetings & Announcements Board located in the 4th Floor South Lobby of the convention center.

Meetings & Announcements Board
The Meetings & Announcements Board is located in the 4th Floor South Lobby of the convention center. Please refer to the Daily Postings on the Meetings & Announcements Board for information on committee meetings.

CME Pavilion/Message Center/Alternate SAM Response Area
Located in Room 615 of the Washington State Convention Center, the CME Pavilion computer terminals will be available to registered attendees that can be used to evaluate attended sessions and print CME certificates.

Washington State Convention Center - Room 615

- Saturday, June 4 ........................................... 7:00 am - 9:00 pm
- Sunday, June 5 through
- Thursday, June 9 .................................... 6:30 am - 9:00 pm

Washington State Convention Center
800 Convention Place
Seattle, WA 98101
(206) 694-5030

Coat Check
Washington State Convention Center - 4th Floor South Lobby

Hours of Operation:
- Saturday, June 4 ........................................... 6:30 am - 6:00 pm
- Sunday, June 5 ...................................... 6:00 am - 6:00 pm
- Monday, June 6 ....................................... 6:00 am - 8:00 pm
- Tuesday, June 7 through
- Thursday, June 9 .................................... 6:00 am - 7:00 pm

Concierge Desk
Washington State Convention Center - 4th Floor South Lobby

Saturday, June 4 through
- Thursday, June 9 .................................... 9:00 am - 5:00 pm

24-Hour Medical Clinic/Hospital
Swedish Medical Center - First Hill
747 Broadway
Seattle, WA 98104-1320
(206) 386-6000

On-site First-Aid/Emergency
The Nurses office is located in the 4th Floor South lobby.
In the event of an on-site emergency an alarm is activated, a loud klaxon-type horn will be heard in the affected areas. This will be followed immediately by an announcement stating that security officer has been dispatched to the area to investigate and requesting you to please stand by for further information. The horn will continue to be heard in the background, but at a lower sound level allowing event activity to proceed. Once the security officer has located and determined the cause for the alarm, another announcement will be made giving instructions or, as in most cases, stating that it was a false alarm. While in the alarm condition, any doors that are magnetically held open will close automatically. These doors are primarily located on the 6th floor. The elevators will recall to the bottom levels and remain inoperative until resets. The escalators will continue to operate.

Remote Access Features in 2011!
A link will be provided so that you can evaluate for CME credits from your personal devices (phone/laptop/PDA) at any time.
General Information (continued)

**Food Service**
ASNR Food Service will be served in Exhibit Hall 4B during technical exhibition hours. Continental Breakfasts, Morning and Afternoon Coffee Service and Box Lunches are provided complimentary throughout the annual meeting. Please refer to the schedule below.

**Continental Breakfast**
Monday, June 6 through
  Thursday, June 9 .................................................. Ballroom 6 B/C Foyer

**Morning Breaks**
Monday, June 6 .................................................. Ballroom 6 B/C Foyer
Tuesday, June 7 through
  Thursday, June 9 .................................................. Exhibition Hall 4B

**Box Lunches**
Monday, June 6 .................................................. Ballroom 6 B/C Foyer
Tuesday, June 7 through
  Thursday, June 9 .................................................. Exhibition Hall 4B

**Afternoon Breaks**
Monday, June 6 .................................................. Ballroom 6 B/C Foyer
Tuesday, June 7 through
  Thursday, June 9 .................................................. Exhibition Hall 4B

**AJNR - 4th Floor South Lobby**
All attendees are invited to stop by the booth any time to tour the AJNR Website and Blog and take advantage of the meeting discount on subscriptions.

**MEETING LOCATION:** Washington State Convention Center

**REGISTRATION**
4th Floor South Lobby

**CME Pavilion/Message Center/Alternate SAM Response Area**
Room 615

**How-To Sessions**
Ballroom 6 B/C

**Focus/Scientific Paper Sessions**
Ballroom 6 B/C, Ballroom 6A, Room 606-609, Rooms 611/612, Rooms 602/603/604

**Synaptic Junction Workshops**
Rooms 613/614

**Synaptic Junction Lectures**
Rooms 619/620

**EXHIBITS**
Printed Scientific Posters, Electronic Scientific Posters, Scientific Exhibits and Electronic Scientific Exhibits
Exhibit Hall 4A

**TECHNICAL EXHIBITS**
Exhibit Hall 4B

**MISCELLANEOUS**
American Board of Radiology (ABR) Information Desk
4th Floor South Lobby

**ABR Exam Room**
Rooms 613/614 (Thursday, June 9 only)

**American Journal of Neuroradiology (AJNR) Desk & ASNR Booth**
4th Floor South Lobby

**Coat Check**
4th Floor South Lobby

**Young Physicians (Fellows, Residents and Medical Students)**
Rooms 616/617

**Headquarters Office**
Room 601

**Meetings & Announcements Board and Job Postings Board**
4th Floor South Lobby

**Speaker Ready Room**
Room 605 - 610

**VIP/The Foundation of the ASNR Lounge**
Room 618
Important Information for Young Physicians

Young Physicians Lounge - Room 616/617
(Fellows, Residents, Medical Students and Neuroradiologist in their first three years in practice)

Visit the Fellows, Resident & Medical Students Lounge at the Washington State Convention Center (Room 616-617) open from 6:30am – 6:00pm daily from Saturday, June 4 – Thursday, June 9, 2011. This will provide a “home base” for fellows to network and share knowledge and experiences throughout the meeting.

Young Physicians Luncheon
Tuesday, June 7, 2011 • 12:30pm - 1:30pm
Rooms 616/617
Fellows, Residents and Medical Students – join ASNR Leaders for Lunch, at 12:30pm on Tuesday, June 7, 2011 in the Fellows, Residents & Medical Students Lounge, Room 616-617.

Young Physicians Sessions
Fellows, Residents and Medical students, the ASNR has designed specific program topics for learning during the ASNR Annual Meeting. You won’t want to miss the following session presentations:

### Wednesday, June 8, 2011

#### Entering And Thriving In Private Practice
1:15pm - 2:45pm • Room 611/612
- Welcome to the Real World
  - John E. Jordan, MD
- Making the Transition
  - Donald F. Schomer, MD
- The HMO Environment
  - Sung LoGerfo, MD
- The Corporate Environment
  - Stephen T. Sweriduk, MD
- Understanding the Food Chain
  - Robert M. Barr, MD
- Keeping Up and Giving Back
  - Sean P. Cullen, MD
- Discussion

#### Launching Your Academic Career
3:15pm - 4:45pm • Room 602/603/604
- Getting Hired
  - Carolyn C. Meltzer, MD, FACR
- Getting Published
  - A. James Barkovich, MD, MPH
- Getting Promoted
  - David B. Hackney, MD, FACR
- Panel Discussion
Social Program

“Seattle Welcome Reception”
Monday, June 6, 2011
6:30 pm - 7:30 pm
Washington State Convention Center
Exhibit Hall 4B

We look forward to welcoming attendees to the Technical Exhibition Hall for a pre-dinner reception of local Seattle culinary favorites. The reception, located in Exhibit Hall 4B, offers attendees the perfect opportunity to see this year’s Technical Exhibition, the ASNR’s annual showcase for the newest products and services for the field of Neuroradiology. Enjoy complimentary pre-dinner hors d’oeuvres and beverages while you learn about the newest technologies. Connect with old friends, make new ones and meet representatives from companies participating in this year’s technical exhibition.

This casual social setting also allows plenty of informal discussion with the company representatives, so bring your product and service challenges and come in search of solutions to the place where advanced technology and diagnostic and interventional neuroradiological excellence come together.

The Scientific Exhibition (posters, scientific and electronic exhibits) will also be available for viewing throughout the reception.

2011 Scientific Exhibits Tour
Monday, June 6 - 12:30pm - 1:30pm
Wednesday, June 8 - 11:45am - 12:30pm
Exhibit Hall 4A – Level 4

Review Scientific Exhibits, visual presentation/educational displays designed to further the understanding of Neuroradiology by featuring cutting-edge material or by offering an instructional review of a particular topic. The session will allow for review of visually-oriented educational displays that demonstrate novel and innovative applications for computers in Neuroradiology clinical practice, training and research. Share this educational opportunity with your colleagues and primary Exhibit presenters and exchange in a lively Questions & Answers Session.

Another unique feature not to be missed at the ASNR…See you on the tour!

NEW in 2011 – Poster Viewing Session
Tuesday, June 7 – 6:30pm - 8:00pm
Exhibit Hall 4A – Level 4

Do you want to receive CME credits for viewing presentations in the Scientific Exhibits Hall? Your opportunity has arrived! Review Posters (Printed or Electronic), electronic Scientific Exhibits (eSE) and Scientific Exhibits and exchange dialogue with presentation authors from 6:30pm – 8:00pm to receive CME credits. This is a great opportunity to support Young Physicians and those who have original investigative research, pictorial essays, educational displays that demonstrate novel and innovative applications for computers in Neuroradiology clinical practice, training and/or research.

Join the lively exchange and education, networking while you receive CME credits. See you during the Poster Viewing Session!
Past Annual Meetings

Organizational Meeting
May 19, 1962 - New York
Keene's English Chophouse

Second Business Meeting
October 5, 1962 - Washington, DC
Shoreham Hotel

First Annual Meeting
October 7, 1963 - Montreal
Queen Elizabeth Hotel

Second Annual Meeting
September 23, 1964 - New York
Waldorf Astoria

Third Annual Meeting
June 11, 1965 - Atlantic City

Fourth Annual Meeting
June 15-16, 1966 - Washington, DC
Sheraton-Park Hotel

Fifth Annual Meeting
May 15, 1967 - New York
Columbia University

Sixth Annual Meeting
September 27-28, 1968 - New Orleans
Jung Hotel

Seventh Annual Meeting
May 13-19, 1969 - Cleveland
Joint Meeting with American Association of Neurological Surgeons
Sheraton-Cleveland Hotel

Eighth Annual Meeting
February 12-13, 1970 - Washington, DC
Washington Hilton

Ninth Annual Meeting
May 27-29, 1971 - San Francisco
Fairmont Hotel

Tenth Annual Meeting
February 21-24, 1972 - Mexico City
Maria-Isabel Sheraton

Eleventh Annual Meeting
May 26-28, 1973 - Boston
Statler Hilton

Twelfth Annual Meeting
March 14, 1974 - Punta del Este, Uruguay
(In conjunction with X Symposium Neuroradiologicum)
Punta del Este, Uruguay

Thirteenth Annual Meeting
June 3-7, 1975 - Vancouver
Bayshore Inn

Fourteenth Annual Meeting
May 18-22, 1976 - Atlanta
Peachtree Plaza

Fifteenth Annual Meeting
March 27-31, 1977 - Bermuda
Hamilton Princess Hotel

Sixteenth Annual Meeting
February 26-March 2, 1978 - New Orleans
Hyatt Regency

Seventeenth Annual Meeting
May 20-24, 1979 - Toronto
Hotel Toronto

Eighteenth Annual Meeting
March 16-21, 1980 - Los Angeles
Century Plaza

Nineteenth Annual Meeting
May 5-9, 1981 - Chicago
Marriott Hotel

Twentieth Annual Meeting
October 10-16, 1982 - Washington, DC
(In conjunction with XII Symposium Neuroradiologicum)
Washington Hilton

Twenty-First Annual Meeting
June 5-9, 1983 - San Francisco
St. Francis Hotel

Twenty-Second Annual Meeting
June 2-7, 1984 - Boston
Westin Copley Place Hotel

Twenty-Third Annual Meeting
February 18-23, 1985 - New Orleans
Marriott Hotel

Twenty-Fourth Annual Meeting
January 19-23, 1986 - San Diego
Sheraton Harbor Island Hotel

Twenty-Fifth Annual Meeting
(Silver Anniversary)
New York Hilton

Twenty-Sixth Annual Meeting
May 15-20, 1988 - Chicago
Chicago Hilton & Towers

Twenty-Seventh Annual Meeting
March 19-24, 1989 - Orlando
The Peabody Orlando

Twenty-Eighth Annual Meeting
March 19-23, 1990 - Los Angeles
Century Plaza Hotel & Tower

Twenty-Ninth Annual Meeting
June 9-14, 1991 - Washington, DC
The Washington Hilton and Towers

Thirtieth Annual Meeting
May 31-June 5, 1992 - St. Louis
Adam's Mark

Thirty-First Annual Meeting
May 17-20, 1993 - Vancouver
Vancouver Trade and Convention Center

Thirty-Second Annual Meeting
May 3-7, 1994 - Nashville
Opryland Hotel and Conference Center

Thirty-Third Annual Meeting
May 23-27, 1995 - Chicago
Sheraton Chicago Hotel and Towers

Thirty-Fourth Annual Meeting
June 23-27, 1996 - Seattle
Washington State Convention and Trade Center

Thirty-Fifth Annual Meeting
May 18-22, 1997 - Toronto
Metro Toronto Convention Center

Thirty-Sixth Annual Meeting
May 17-20, 1998 - Vancouver
Vancouver Convention and Exhibition Centre

Thirty-Seventh Annual Meeting
May 16-20, 2000 - Atlanta
Hyatt Regency Atlanta

Thirty-Eighth Annual Meeting
April 4-8, 2000 - Atlanta
Marriott Wardman Park Hotel

Thirty-Ninth Annual Meeting
April 23-27, 2001 - Boston
Hynes Convention Center

Fortieth Annual Meeting
May 13-17, 2002 - Vancouver
Vancouver Convention & Exhibition Center

Forty-First Annual Meeting
March 19-24, 1989 - Orlando
The Peabody Orlando

Forty-Second Annual Meeting
June 7-11, 2004 - Seattle
Washington State Convention and Trade Center

Forty-Third Annual Meeting
May 21-27, 2005 - Toronto
Metro Toronto Convention Center

Forty-Fourth Annual Meeting
April 29-May 5, 2006 - San Diego
San Diego Convention Center

Forty-Fifth Annual Meeting
June 9-14, 2007 - Chicago
Hyatt Regency Chicago

Forty-Sixth Annual Meeting
May 30-June 5, 2008 - New Orleans
Ernest N. Morial Convention Center

Forty-Seventh Annual Meeting
May 16-21, 2009 - Vancouver
Vancouver Convention and Exhibition Centre

Forty-Eighth Annual Meeting
May 15-20, 2010 - Boston
Hynes Convention Center

Forty-Ninth Annual Meeting
May 16-20, 2011 - San Francisco
Moscone Center

Fiftieth Annual Meeting
May 13-17, 2012 - Philadelphia
(In conjunction with XVI Symposium Neuroradiologicum)
Pennsylvania Convention Center

Fifty-First Annual Meeting
May 23-28, 2013 - San Diego
San Diego Convention Center

Fifty-Second Annual Meeting
May 13-17, 2014 - Chicago
Hyatt Regency Chicago

Fifty-Third Annual Meeting
May 10-15, 2015 - New Orleans
Hotel Sheraton New Orleans

Fifty-Fourth Annual Meeting
May 13-17, 2016 - Toronto
Metro Toronto Convention Centre

Fifty-Fifth Annual Meeting
May 23-28, 2017 - San Diego
San Diego Convention Center

Fifty-Sixth Annual Meeting
May 13-17, 2018 - Atlanta
Hyatt Regency Atlanta

Fifty-Seventh Annual Meeting
May 13-17, 2019 - San Diego
San Diego Convention Center

Fifty-Eighth Annual Meeting
May 13-17, 2020 - Chicago
Hyatt Regency Chicago

Fifty-Ninth Annual Meeting
May 13-17, 2021 - New Orleans
Hyatt Regency New Orleans

Sixtieth Annual Meeting
May 9-13, 2022 - San Diego
San Diego Convention Center

Sixty-First Annual Meeting
April 8-12, 2023 - Atlanta
Hyatt Regency Atlanta

Sixty-Second Annual Meeting
April 23-27, 2024 - Boston
Hynes Convention Center

Sixty-Third Annual Meeting
May 13-17, 2025 - Vancouver
Vancouver Convention & Exhibition Centre

Sixty-Fourth Annual Meeting
May 13-17, 2026 - Toronto
Metro Toronto Convention Centre

Sixty-Fifth Annual Meeting
May 13-17, 2027 - San Diego
San Diego Convention Center

Sixty-Sixth Annual Meeting
May 13-17, 2028 - Chicago
Hyatt Regency Chicago

Sixty-Seventh Annual Meeting
May 13-17, 2029 - New Orleans
Hyatt Regency New Orleans

Sixty-Eighth Annual Meeting
May 13-17, 2030 - San Diego
San Diego Convention Center

Sixty-Ninth Annual Meeting
April 8-12, 2031 - Atlanta
Hyatt Regency Atlanta

Seventieth Annual Meeting
April 23-27, 2032 - Boston
Hynes Convention Center

Seventy-First Annual Meeting
May 13-17, 2033 - Vancouver
Vancouver Convention & Exhibition Centre

Seventy-Second Annual Meeting
May 13-17, 2034 - Toronto
Metro Toronto Convention Centre

Seventy-Third Annual Meeting
May 13-17, 2035 - San Diego
San Diego Convention Center

Seventy-Fourth Annual Meeting
May 13-17, 2036 - Chicago
Hyatt Regency Chicago

Seventy-Fifth Annual Meeting
May 13-17, 2037 - New Orleans
Hyatt Regency New Orleans

Seventy-Sixth Annual Meeting
May 13-17, 2038 - San Diego
San Diego Convention Center

Seventy-Seventh Annual Meeting
April 8-12, 2039 - Atlanta
Hyatt Regency Atlanta

Seventy-Eighth Annual Meeting
April 23-27, 2040 - Boston
Hynes Convention Center

Seventy-Ninth Annual Meeting
May 13-17, 2041 - Vancouver
Vancouver Convention & Exhibition Centre

Eightieth Annual Meeting
May 13-17, 2042 - Toronto
Metro Toronto Convention Centre

Eighty-First Annual Meeting
May 13-17, 2043 - San Diego
San Diego Convention Center

Eighty-Second Annual Meeting
May 13-17, 2044 - Chicago
Hyatt Regency Chicago
ASNR Past Presidents and Founders

1962-64 Juan M. Taveras, MD
1964-65 Mannie M. Schechter, MD*
1965-66 Donald L. McRae, MD*
1966-67 Ernest H. Wood, MD*
1967-68 Harold O. Peterson, MD*
1968-69 Colin B. Holman, MD*
1969-70 Giovanni Di Chiuro, MD*
1970-71 D. Gordon Potts, MD
1971-72 Norman E. Chase, MD*
1972-73 Fred J. Hodges, III, MD*
1973-74 T. Hans Newton, MD*
1974-75 Hillier L. Baker, Jr., MD*
1975-76 Irvin I. Kricheff, MD
1976-77 Norman E. Leeds, MD
1977-78 Sadek K. Hilal, MD*
1978-79 Stephen A. Kieffer, MD
1979-80 David O. Davis, MD
1980-81 George Wortzman, MD
1981-82 Gabriel H. Wilson, MD*
1982-83 Arthur E. Rosenbaum, MD
1983-84 O. Wayne Houser, MD
1984-85 Samuel M. Wolpert, MD
1985-86 R. Thomas Bergeron, MD
1986-87 Derek C. Harwood-Nash, MD*
1987-88 Michael S. Huckman, MD
1988-89 Anne G. Osborn, MD
1989-90 Joseph F. Sackett, MD
1990-91 Anton N. Hasso, MD, FACR
1991-92 R. Nick Bryan, MD, PhD, FACR
1992-93 David Norman, MD
1993-94 Glenn S. Forbes, MD
1994-95 Robert M. Quencer, MD
1995-96 Robert R. Lukin, MD
1996-97 Burton P. Drayer, MD
1997-98 Richard E. Latchaw, MD
1998-99 A. James Barkovich, MD
1999-00 Eric J. Russell, MD, FACR
2000-01 William S. Ball, Jr., MD
2001-02 William P. Dillon, MD
2002-03 Patrick A. Turski, MD
2003-04 Charles M. Strother, MD
2004-05 Victor M. Haughton, MD
2005-06 Patricia A. Hudgins, MD
2006-07 Robert I. Grossman, MD
2007-08 David M. Yousem, MD, MBA
2008-09 Robert D. Zimmerman, MD, FACR
2009-10 John R. Hesselink, MD, FACR

Founding Members

Norman E. Chase, MD*
Giovanni Di Chiuro, MD*
William N. Hanafee, MD
Fred J. Hodges, III, MD*
Colin B. Holman, MD*
Norman E. Leeds, MD
Eugene V. Leslie, MD*
Donald L. McRae, MD*
Thomas H. Newton, MD*
Harold O. Peterson, MD*
D. Gordon Potts, MD
Mannie M. Schechter, MD*
Juan M. Taveras, MD*
Ernest H. Wood, MD*

*deceased
In Memoriam

T. Hans Newton, MD
1925 – 2010

Thomas Hans Newton, MD was born May 9, 1925 in Berlin, Germany. His immediate family escaped prior to World War II, starting a new life initially in Portland, Oregon. Hans enrolled in grade school speaking no English at the age of 11. His undergraduate years at the University of California, Berkeley were interrupted by military service in the Navy, but he graduated with a Bachelor of Arts in 1949, matriculating to UCSF where he received his MD degree in 1952. After a year of internship at the University of Wisconsin and a year as a UCSF medicine resident, Hans completed his residency in radiology at the Peter Bent Brigham Hospital under Merrill Sosman. Dr. Newton then spent one and a half years as a fellow in Stockholm, Zurich, and London, where he trained in neuroradiology at the National Hospital for nervous diseases, Queens Square. In 1959, he joined UCSF, and remained on the faculty for 50 distinguished years.

Dr. Newton will be remembered for his academic accomplishments and awards, and for his contributions to our discipline. He was one of 13 founding members and is a past-president of the American Society of Neuroradiology and received its first gold medal. He was an honorary member of the European Society of Neuroradiology, past-president of the Western Neuroradiologic Society, and served on the editorial boards of most of the leading journals in radiology.

Dr. Newton is survived by his life-long companion and spouse, Pat Newton, his daughters, Judie, an attorney and Diane, a neuroradiologist, as well as five wonderful grandchildren.

Gabriel H. Wilson, MD
1929 – 2011

Gabriel Henry Wilson, MD was born in Caruthersville, Missouri on January 30, 1929 to the late Michael E. Wilson and Alma A. Wilson. He graduated from St. Joseph’s Home for Boys, St. Louis, Missouri, St. Mary’s High School, Phoenix, Arizona, earned his Bachelor of Arts at Loyola University, Chicago, Illinois, and his Doctor of Medicine at Creighton University, Omaha, Nebraska. Dr. Wilson completed his Internship and Residency at Harbor General Hospital, Torrance, California, and was a Fellow in Radiologic Pathology with the Armed Forces Institute of Pathology, Washington, D.C., and in Neuroradiology with the National Institutes of Health at the University of California, Los Angeles (UCLA). He became a Neurodiagnostic Radiologist and Professor of Radiology at UCLA, Chief of Staff of the Radiology Department and, for eleven years, was Chairman of the Department of Radiological Sciences. He retired as Professor Emeritus in 1987. Dr. Wilson was a member of the American Medical Association for 52 years, the National Board of Medical Examiners as Diplomate, the American College of Radiology, Board of Chancellors and Fellow, the Radiological Society of North America, the American Society of Neuroradiology, President, 1981, American Roentgen Ray Society, American Board of Radiology, Diplomat, California Radiological Society, President, 1980, Los Angeles County Medical Association, Distinguished Service Award, 1986-1988, Los Angeles Radiological Society, President, 1974, Distinguished Service Award, Society of Magnetic Resonance in Medicine, and the Western Neuroradiological Society (WNRS), President, 1968-1971. Dr. Wilson is survived by his wife, Sage C. Faber-Wilson, San Diego, California and his stepson, Brock L. Halvorsen, Los Angeles, California.

Gabe will be remembered for his interest and numerous activities in the radiologic community as well as his great interest in and knowledge of sailing.
Awards and Honors

2010 - 2011 ASNR Gold Medal Award

The Gold Medal fosters the highest standards of the American Society of Neuroradiology, based on exceptional quality, service, and excellence, and not necessarily on fame. It emphasizes both professional and personal attributes...individuals who are superb neuroradiologists, clinicians, or scientists, and truly outstanding. The recipients are individuals who have extended themselves beyond furthering their own careers through contributions at all levels of professional strata, with an accent on consistency and duration of these outstanding contributions.

2011 Gold Medal Recipient
Burton P. Drayer, MD, FACR, FAAN
The Mount Sinai Medical Center, New York, New York

Burton Paul Drayer, M.D. is currently the Dr. Charles M. and Marilyn Newman Professor and Chairman of the Department of Radiology (1995-present) Mount Sinai School of Medicine, and the Executive Vice President for Risk at The Mount Sinai Medical Center. Additionally, from 2003 to 2008, Dr. Drayer served as President of The Mount Sinai Hospital. He completed his internship and Neurology residency at the University of Vermont, and then a radiology residency and neuroradiology fellowship under the tutelage of Arthur Rosenbaum, Ralph Heinz, and Charles Kerber at the University of Pittsburgh Health Center. He is Board-certified in both Neurology and Radiology, and a fellow of both the American College of Radiology and the American Academy of Neurology.

Dr. Drayer served as Associate Professor and Professor of Radiology at Duke University from 1979 to 1986, where he was also Director of Neuroradiology. In 1986, he joined the Barrow Neurological Institute as Director of Magnetic Resonance Imaging and Research. Internationally known for his CT and MRI research on the aging brain and neurodegenerative disorders, brain infarction, multiple sclerosis, and physiological and functional brain imaging, Dr. Drayer has almost over 200 publications as well as multiple book chapters. He was the first to describe metrizamide encephalopathy, nonradioactive xenon enhanced CT for measuring rCBF (for which he won the ASNR’s Cornelius G. Dyke Award 1977), and the normal and abnormal distribution of brain iron using MRI. He also popularized carotid and intracranial MRA, and educated a generation of physicians in the efficient clinical use of brain and spine MRI. He has been on numerous editorial boards, and was the editor of Neuroimaging Clinics of North America from 1990 to 2005.

Dr. Drayer spent many years providing service to the ASNR, and was elected President in 1996. He was the inaugural Chairman and founding member of The Foundation of the ASNR (formerly the Neuroradiology Education and Research Foundation). In 2003, Dr. Drayer was elected to the Board of Directors of the RSNA as Liaison for the Annual Meeting and Technology and, in 2009, ascended to Chairman of the Board, 2010 President-elect, and is presently RSNA President. He also presently serves on the Board of Chancellors of the ACR, and the Board of Trustees of the RSNA Research and Education Foundation, is a past-President of the New York Roentgen Ray Society, and has served on numerous national advisory boards for multiple sclerosis, stroke, and Alzheimer's disease.

Awards and Honors

Past ASNR Gold Medal Award Recipients

1995
Juan M. Taveras, MD*
T. Hans Newton, MD

1996
Sadek K. Hilal, MD*
Giovanni Di Chiro, MD*

1997
Derek C. Harwood-Nash, MB, ChB, DSc, FRCP, FACR, RCRAD(SA)*

1998
Irvin I. Kricheff, MD
D. Gordon Potts, MD

1999
Grant B. Hieshima, MD
Michael S. Huckman, MD

2000
Hillier L. “Bud” Baker, Jr., MD*

2001
O. Wayne Houser, MD
J. Arliss Pollock, MD*

2002
R. Thomas Bergeron, MD
David O. Davis, MD

2003
Norman E. Leeds, MD, FACR
Anne G. Osborn, MD, FACR

2004
Ralph Heinz, MD, FACR
Stephen A. Kieffer, MD, FACR

2005
Samuel M. Wolpert, MD

2006
R. Nick Bryan, MD, PhD, FACR
Charles W. Kerber, MD

2007
Robert M. Quencer, MD

2008
Robert R. Lukin, MD

2009
Glenn S. Forbes, MD, FACR

2010
Anton N. Hasso, MD, FACR

*deceased
Awards and Honors

2011 ASNR Honorary Member

Mitchel S. Berger M.D.
University of California, San Francisco, California

Mitchel S. Berger M.D., F.A.C.S., F.A.A.N.S. is the Kathleen M. Plant Distinguished Professor and Chairman of the Department of Neurological Surgery at the University of California, San Francisco (UCSF), and is an expert in the fields of neurosurgery and neuro-oncology. He also serves as Director of UCSF’s Brain Tumor Research Center and Neurosurgical Research Centers.

After graduating from Harvard University in 1974, Dr. Berger earned his medical degree from the University of Miami School of Medicine. He completed a clinical fellowship in neuro-oncology at UCSF, a fellowship in pediatric neurosurgery at the Hospital for Sick Children of the University of Toronto, and his neurosurgical residency at UCSF. In 1986, he became Assistant Professor of Neurosurgery at the University of Washington School of Medicine, after which he was named Associate Professor (1990) and Professor (1996).

Dr. Berger has clinical expertise in treating adult and pediatric brain and spinal cord tumors. He is a pioneer of intraoperative brain mapping – a technique used to avoid functional areas of the brain during surgical resection of a tumor. His work has enabled surgeons to perform more extensive resection of tumor with less chance of producing sensorimotor or language deficit.

Dr. Berger is a leader of translational research, and is the Principal Investigator of UCSF’s Specialized Program of Research Excellence for brain tumors and of the Brain Tumor Research Center’s Program Project Grant in neuro-oncology, both funded by the National Institutes of Health. In 2009, he became Principal Investigator of the Pediatric Brain Tumor Foundation Institute at UCSF – a world-class research program dedicated to defining the poorly understood basic biology of several types of childhood brain tumors and improving therapies. Most recently, Dr. Berger was named the Principal Investigator of a Disease Team Research Award funded by the California Institute for Regenerative Medicine, which is aimed at developing a stem cell therapy for glioblastoma that can be rapidly moved into clinical trials.

His specific research interests lie in identifying molecular markers related to the progression and prognosis of glial tumors, as well as the development of small-molecule therapeutic agents that can be administered directly to the brain via convection-enhanced drug delivery. Dr. Berger is also a co-investigator at UCSF’s Comprehensive Cancer Center, where he works to develop immunoliposome-directed targeted therapy for treating gliomas that express epidermal growth factor receptors.

Dr. Berger is a member of the Board of Directors of the American Association of Neurological Surgeons and the American Board of Neurological Surgery. In 2009, he was awarded the prestigious Winn Prize by the Society for Neurological Surgery. He is currently the Vice President of the American Association of Neurological Surgeons and Secretary of the American Academy of Neurological Surgery. He also currently serves as a member of the National Football League Head, Neck and Spine Committee, focusing on retired players’ issues, and examining the consequences of repetitive head injury and concussion.

During his distinguished career, Dr. Berger has served as President of the Society of Neuro-Oncology, President of the North Pacific Society of Neurology, and Vice President of the Congress of Neurological Surgeons. He is an active member of numerous professional organizations, including the American Organization for Cancer Research, the American College of Surgeons, and the World Federation of Neurosurgical Societies.

A prolific author, Dr. Berger has contributed over 380 scientific articles to peer-reviewed journals, has edited 6 textbooks, and has written over 80 chapters on various neurosurgical topics. He is currently on the editorial boards of several leading journals including Neuro-Oncology, Neurosurgery, and American Journal of Translational Research.

Past ASNR Honorary Members

Torsten Almen, MD
James W. Bull, MD*
Graeme M. Bydder, MD, ChB
M. Paul Capp, MD
Sten Cronqvist, MD*
B. G. Ziedeses des Plantes, MD*
George du Boulay, MD*
Richard R. Ernst, MD
Torgny V. B. Greitz, MD
Godfrey N. Hounsfield, PhD*
Yun Peng Huang, MD
Ian Isherwood, MD
Pierre Lasjaunias, MD, PhD
Paul C. Lauterbur, PhD*
Dennis LeBihan, MD, PhD
Marco Leonardi, MD
Erik Lindgren, MD*
Claude H. Manelfe, MD
Professor Luc Picard
Michel Ter Pogossian, MD*
Joseph Ransohoff, MD*
Jesus Rodriguez-Carbajal, MD
Lee F. Rogers, MD
Prof. Lucy Balian Rorke
Michael Radford Sage, MD,
FRANZCR, FRCR, FRCPC
( Lon), FRCPC (Ed), FHKCR (Hon)
Georges Salamon, MD
George Schuyler
S. I. Seldinger, MD

*deceased

Fjodor Serbienko, MD
Mutsumasa Takahashi, MD
E. Turgut Tali, MD
Galdino E. Valvassori, MD
Marjo S. van der Knaap, MD
Prof. Jacqueline Vignaud
M. Gazi Yasargil, MD
Ian R. Young, BSc, PhD
Awards and Honors

The Foundation of the ASNR Education and Research Award for Outstanding Contributions in Research

This award, created in 2004 in recognition of consistent excellence and lifelong accomplishment in basic or clinical neuroscience research, is given to an ASNR senior member over the age of 50 recognized in the neuroradiology field for distinguished long term achievement in basic or clinical research.

2011 The Foundation of the ASNR Award for Outstanding Contributions in Research

Thomas P. Naidich, MD
Mount Sinai Medical Center, New York, New York

Dr. Thomas Naidich graduated from Cornell University in Ithaca, New York, Phi Beta Kappa, and from New York University School of Medicine in New York, Alpha Omega Alpha. He trained in Radiology under Dr. Harold G. Jacobson at the Montefiore Hospital in the Bronx, and in Neuroradiology at both Montefiore Hospital and New York University under Drs. Norman E. Leeds and Irvin I. Kricheff. Dr. Naidich then advanced through the ranks as Assistant and Associate Professor of Radiology at the Mallinckrodt Institute of Radiology, St. Louis; as Associate and Full Professor of Radiology at the Children’s Memorial Hospital of Northwestern University, Chicago; and then as Professor of Radiology at Baptist Medical Center and the University of Miami in Miami. Dr. Naidich currently serves as Director of Neuroradiology, Professor of Radiology and Neurosurgery, and the Irving and Dorothy Regenstreif Research Professor of Neuroscience (Neuroimaging) at Mt. Sinai Medical Center in New York.

Dr. Naidich’s research interests have centered on the imaging display of neuroanatomy and gross pathology. He has published more than 70 chapters, 200 manuscripts and 5 books (so far). For his work, Dr. Naidich has been awarded the Cornelius Dyke Award for outstanding research from the American Society of Neuroradiology (1975), the John Caffey Award for original research from the Society for Pediatric Radiology (1983), the annual James Bull Medal of the British Society of Neuroradiologists (2000), the Gold Medal of the Sociedad Ibero-latinoamericana de Neurorradiología (2001), and the Gold Medal of the American Society of Pediatric Neuroradiology (2005). For his teaching, Dr. Naidich has been awarded Honorary Professorship at the Institute of Neurology, Queen Square, London and Honorary Membership in the British Society of Neuroradiologists, the European Society of Neuroradiology and many Latin American Societies of Neuroradiology. He has trained more than 80 Fellows in Neuroradiology. Two of his trainees have won the Cornelius Dyke Award of the American Society of Neuroradiology. Three have become Presidents of the ASNR or ASPNR.

With his wife, Michele Levin, Dr. Naidich enjoys music and poetry, summering at the Tanglewood Music Festival in Lennox, Massachusetts.

Past Award Recipients:
2010 Victor M. Haughton, MD
2009 R. Gilberto González, MD, PhD
2008 A. James Barkovich, MD
2007 Clifford R. Jack, Jr., MD
2006 No Award Given
2005 Dixon M. Moody, MD, FACR
2004 Robert I. Grossman, MD

2011 ASNR Cornelius G. Dyke Memorial Award

This award was established to honor Cornelius G. Dyke, one of the pioneers in neuroradiology, and is given to a trainee or junior faculty member in neuroradiology for excellence as demonstrated in a paper, which represents original, unpublished research in some aspect of neuroradiology.

No Award in 2011
Awards and Honors

Past ASNR Cornelius G. Dyke Memorial Award Recipients

1972
George M. McCord, MD
“The Venous Drainage to The Inferior Sagittal Sinus”

1973
Barton Lane, MD
“Cerebrospinal Fluid Pulsations at Myelography: A Video-Densitometric Study”

1974
Jacques Theron, MD
“Anatomical-Radiological Correlates of the Anterior Choroidal Artery”

1975
Thomas P. Naidich, MD
“The Normal Anterior Inferior Cerebellar Artery”

1976 - No Award

1977
Burton P. Drayer, MD
“The Capacity for CT Diagnosis of Cerebral Infarction. An Experimental Study in the Non-Human Primate”

1978
Joseph A. Horton, MD
“The Grain in the Stone: A Computer Search for Hidden CT Patterns”

1979
Dieter R. Enzmann, MD
“Experimental Brain Abscess Evolution Studied with the CT Scan and Neuroradiopathological Correlation”

1980 - No Award

1981
A. Ronald Cowley, MD
“The Influence of Fiber Tracts on the CT Appearance of Cerebral Edema: An Anatomical Pathological Correlation”

1982
B. Ludwig, MD
“Postmortem CT and Autopsy in Perinatal Intracranial Hemorrhage”

1983 - No Award

1984
Val M. Runge, MD
“Contrast Enhanced Magnetic Resonance Evaluation of a Brain Abscess Model”

1985 - No Award

1986
Jeremy B. Rubin, MD
“Part 1 Imaging Spinal CSF Pulsation by 2DFT Magnetic Resonance: Significance During Clinical Imaging”
“Part 2 Harmonic Modulation of Proton MR Precessional Phase by Pulsatile Motion Origin of Spinal CSF Flow Phenomenon”

1987 - No Award

1988
Vincent P. Mathews, MD
“Gadolinium Enhanced MR Imaging of Experimental Bacterial Meningitis: Evaluation and Comparison of CT”

1989
Allen D. Elster, MD

1990
Marvin D. Nelson, Jr., MD
“The Search for Human Telencephalic Ventriculofungal Arteries”

1991
Udo P. Schmiedl, MD
“Quantitation of Pathological Blood-Brain Barrier Permeability in an Astrocytic Glioma Using Contrast Enhanced MR”

1992
R. Gilberto Gonzalez, MD
“Quantitative In Vivo Human Brain Lithium Magnetic Resonance Spectroscopy”

Frank J. Lexa, VII, MD
“Wallerian Degeneration in the Feline Visual System: Characterization by Magnetization Transfer Rate with Histopathologic Correlation”

1993
Marc Jouandet, MD
“Mapping the Human Cerebral Cortex with Brainprints”

1994
A. Gregory Sorensen, MD
“Functional Magnetic Resonance Imaging of Brain Activity and Perfusion in Patients with Chronic Cortical Stroke A”

1995
John L. Ulmer, MD
“Magnetization Transfer or Spin-Lock? An Investigation of Off-Resonance Saturation Pulse Imaging Using Varying Frequency Offsets”

1996
John C. Strainer, MD
“fMRI of Primary Auditory Cortex: An Analysis of Pure Tone Activation and Tone Discrimination”

1997
Stephen G. Imbesi, MD
“Why Do Ulcerated Atherosclerotic Carotid Artery Plaques Embolize? A Flow Dynamics Study”

1998 - No Award

1999
Aquilla S. Turk, DO
“Definition of Aneurysm Ostium (Neck) and Morphology Using Intravascular Ultrasound: An Experimental Study in Canines”

2000
William F. Marx, MD
“Endovascular Treatment of Experimental Aneurysms Using Biologically Modified Embolic Devices: Coil-Mediated Intra-Aneurysmal Delivery of Fibroblast Tissue Allografts”

2001 - No Award

2002
Mehmet Kocak, MD
“Functional MR Imaging of the Motor Homunculus: Towards Optimizing Paradigms for Clinical Scenarios”

2003 - No Award

2004
Eric D. Schwartz, MD
“Apparent Diffusion Coefficients Within Spinal Cord Transplants and Surrounding White Matter Correlate With Degree of Axonal Dieback Following Injury”

2005 - No Award

2006
Ashok Panigrah, MD
“Quantitative Short Echo Time 1H Magnetic Resonance Spectroscopy of Untreated Pediatric Brain Tumors: Pre-operative Diagnosis and Characterization”

2007
Yulin Ge, MD
“Quantitative Assessment of Iron Accumulations in the Deep Gray Matter of Multiple Sclerosis by Magnetic Field Correlation Imaging”

2008 - No Award

2009
Josser E Delgado Almadoz, MD
“Diagnostic Accuracy and Yield of Multi-Detector CT Angiography in the Evaluation of Spontaneous Intraparenchymal Cerebral Hemorrhage”

2010
Elyssa Widjaja, MD
“Alteration of Human Fetal Subplate Layer and Intermediate Zone During Normal Development on MR and Diffusion Tensor Imaging”

David F. Kallmes, MD
“Guglielmi Detachable Coil Embolization for Unruptured Aneurysms in Neurosurgical Candidates: A Cost Effectiveness Exploration”
Awards and Honors

ASNR 2010 Outstanding Presentation Awards

ASNR is pleased to announce the winners of the Outstanding Presentation Awards. The overall quality of the paper and poster presentations at the Vancouver meeting was excellent, and the winners should be commended for their outstanding work. A $1,000 award will be given to the primary author of each winning presentation.

Seven awards were presented in Six categories: in Adult Brain/General Neuroradiology (two awards, one awarded by the ASNR, and another awarded by Bayer Healthcare Pharmaceuticals), Functional Neuroradiology, Head and Neck, Interventional Neuroradiology, Pediatrics, and Spine. Both awards in Adult Brain/General Neuroradiology were selected by a panel of ASNR members under the direction of the Education Committee. The five subspecialty awards were judged by panels selected from each of the specialty societies, including ASFRN, ASHNR, ASPNR, ASSR, and SNIS. We would like to thank all of the judges for their tremendous effort in evaluating the presentations. Congratulations to the winners!

General Neuroradiology

PAPER 8: Dose Reduction of Brain CT Images Using 3D Nonlinear Postprocessing
Gomori, J.M.1 • Kanal, E.2 • Aiken, A.H. • Bradley, W.G. • Russell, E.J. • Yuh, W. • Zaaoro, M. • Bar-Meir, E. (1Hadassah Hebrew University Medical Center, Jerusalem, ISRAEL, 2University of Pittsburgh Medical Center, Pittsburgh, PA, 3Emory University School of Medicine, Atlanta, GA, 4University of California San Diego Medical Center, San Diego, CA, 5Feinberg School of Medicine, Northwestern University, Chicago, IL, 6Ohio State University Medical Center, Columbus, OH, 7Rambam Medical, The Technion Israel Institute of Technology, Haifa, ISRAEL, 8Bnai Zion Medical Center, Haifa, ISRAEL)

Bayer Best Paper Award in General Neuroradiology

POSTER 6: Location of Vessel Occlusion and Volume of Affected Brain Predicts Clinical Outcome at 3 Months in Acute Stroke Patients Evaluated Within 4 Hours of Ictus
Silvennoinen, H.M.1 • Hamberg, L.M.1 • Mustanoja, S.1 • Putaala, J.1 • Hunter, G.J.1 (1Helsinki University Central Hospital, Helsinki, FINLAND, 2Massachusetts General Hospital, Boston, MA)

Functional Neuroradiology

PAPER 165: Arrival Time Demonstrates Active Cerebral Autoregulation in Normal Subjects Using Lower Body Negative Pressure and Arterial Spin Labeling MR Imaging
Cain, J.R. • Parkes, L.M. • Jackson, A. (University of Manchester, Manchester, UNITED KINGDOM)

Head and Neck Radiology

Paper 209: Can MR Replace the Need for CT in Evaluating Semicircular Canal Dehiscence? A Comparison Study between FIESTA MR Imaging and High Resolution CT of the Temporal Bone
Browaeys, P.1 • Larson, T.L.3 • Wong, M.L. • Patel, U.3 (1University Hospital, Lausanne, SWITZERLAND, 2University of Washington, Seattle, WA, 3Seattle Radiologists, Seattle, WA, 4Washington Otology Neurotology Group, Seattle, WA)

Interventional Neuroradiology

(The Michael Brothers Memorial Award)

Paper 340: Hemodynamic Characteristics Associated to Cerebral Aneurysm Rupture
Cbral, J.R.1 • Putman, C.M.2 (1George Mason University, Fairfax, VA, 2Inova Fairfax Hospital, Falls Church, VA)

Pediatric Neuroradiology

(The Derek Harwood-Nash Award)

POSTER 169: Diffusion Tensor Imaging of Commissural and Projection White Matter in Tuberous Sclerosis Complex and Correlation with Tuber Load
Simao G.N.1,2 • Raybaud, C.A.1 • Chuang, S.1 • Go, C.1 • Snead, O.C.1 • Widjaja, E.1 (1Hospital for Sick Children, Toronto, ON, CANADA, 2Clinics Hospital of Ribeirao Preto Medical School, Ribeirao, Preto, BRAZIL)

Spine

PAPER 33: Diffusion Tensor Imaging and Tractography of Traumatic Brachial Plexus Palsies: Preliminary Experience
Gasparotti, R. • Lodoli, G. (University of Brescia, Brescia, ITALY)

2010/2011 Specialty/Regional Society Awards

The American Society of Neuroradiology is pleased to announce the recipients of the 2010/2011 Special/Regional Society Awards. These individuals were selected by the respective societies as having the best presentation at each society's most recent Annual Meeting.

American Society of Spine Radiology (ASSR)
(Mentor Award)
Stephen F. Kralkid, MD
University of California San Francisco

Eastern Neuroradiological Society (ENRS)
(The Norman E. Leeds Award)
“Photo Printing Derived Temporal Bones for Trainee Simulated Surgery”
Sean Symons, MD
University of Toronto, Sunnybrook HSC, Canada

Southeastern Neuroradiological Society (SENRS)
“Cerebral Amyloid Angiopathy”
Daniel F. Broderick, MD
Mayo Clinic Florida

Western Neuroradiological Society (WNRS)
(The Gabriel H. Wilson Award)
“Reducing Patient Radiation Exposure During CT-Guided Injections for Spinal Pain”
Timothy M. Shepherd, MD, PhD
University of California, San Francisco
Awards and Honors

2011-2012 The Foundation of the ASNR Basic Science Research Award

This award, first presented in 1986, was created by the ASNR with the support of Bayer Healthcare Pharmaceuticals, Inc. to stimulate the scientific development of promising young men and women, and to aid them in embarking on a career in academic radiology. It is specifically designed to provide educational opportunities for young radiologists who are not yet professionally established in the radiologic sciences to gain further insight into scientific investigation, and to develop competence in research. This award is supported by The Foundation of the ASNR of the American Society of Neuroradiology.

The recipient of the 2011-2012 award is:

Rivka R. Coen, MD
Brigham and Women’s Hospital

The Foundation of the ASNR in Basic Science Research Award Recipients

1986-87
Jeremy B. Rubin, MD
Stanford University Medical Center
“New Methods Using MRI to Assess Ventricular Shunt Function and Measure Intraventricular Pressure Non-invasively in Patients with Ventricular Shunt Catheters”

1987-88
No Award

1988-89
Apichai Jarewattananon, MD
University of Wisconsin Medical Center
“In-Vivo Sodium MRI (Na-MRI) in Canine Model of Status Epilepticus”

Warren A. Stringer, MD
Loma Linda University Medical Center
“Evaluation of the Relationships Between Cerebral Perfusion, Ventilation, and Intracranial Pressure by Xenon-enhanced Computed Tomography in Children with Cerebral Edema”

1989-90
Todd Lempert, MD
University of California at San Francisco
“Evaluation of the Healing Response to Thrombogenic Coil Occlusion of Experimental Aneurysms”

1990-91
Lori L. Baker, MD
Stanford University Medical Center
“Evaluation of MR Diffusion Imaging Versus Magnetic Susceptibility Enhanced Mapping of Perfusion Pool in Regional Cerebral Ischemia”

Lee H. Monsein, MD
The Johns Hopkins University School of Medicine
“Primate Model of Reversible Regional Cerebral Ischemia”

1991-92
Steven N. Breiter, MD
The Johns Hopkins Hospital
“Proton MRS in the Determination of Lactic Acid Concentration in Seizures, Both Human and Animal”

Frank J. Lexa, VII, MD
University of Pennsylvania
“MRI Demonstration of Axonal Transport in the Mammalian CNS”

1992-93
Michael A. Kraut, MD, PhD
The Johns Hopkins Hospital
“Lactate Production and Metabolism in Cerebral Activation”

Brian W. Chong, MD
University of California at San Diego
“A Search for Hidden MRI Flow Patterns in Human Cranial Vessels”

1993-94
Thomas E. Conturo, MD, PhD
The Johns Hopkins Hospital and Johns Hopkins University
“Mechanisms of the Phase Enhancement Effects of Bolus-Injected Paramagnetic Contrast Agents and Applications in Quantitative Cerebral Blood Volume and Flow Imaging”

John P. Karis, MD
Barrow Neurological Institute
“Epilepsy Localisation: Advanced High Resolution MRI-PET FDG Correlation”

1994-95
Jerry Burke, MD
Bowman Gray School of Medicine
“Serial Positron Emission Tomography and Functional MR Imaging of Stroke”

Robert Fulbright, MD
Yale University School of Medicine
“Functional MR Imaging of the Spine”

1995-96
Norman J. Beauchamp, MD
The Johns Hopkins Hospital
“The Natural History of ‘Areas of Risk of Infarction’ as Defined by Perfusion MRI and MR Spectroscopy”

Anthony Masaryk, MD
University of Wisconsin-Madison
“Analysis of Aneurysm Hemodynamics Using MRI/MRA Morphology and Flow Measurements Correlated with Hemodynamic Numerical Analysis and Simulation”

1996-97
Joseph T. Lurito, MD, PhD
The Johns Hopkins Hospital
“Functional MRI and Electrophysiologic Correlates of Sub-modality Specific Somatosensory Activation”

Jeffrey L. Sunshine, MD
University Hospitals of Cleveland
“Early Identification of Ischemic Penumbra by Diffusion and Perfusion MR in Acute Stroke”

1997-98
Huy M. Do, MD
University of Virginia Health Sciences Center
“The Neuroprotective Effect of Intraarterial Nerve Growth Factor (HGF) in a Rabbit Embolic Stroke Model”

1998-99
William F. Marx, MD
University of Virginia
“Endovascular Treatment of Experimental Aneurysms Using Biologically Modified Embolic Coils: Promotion of Permanent Occlusion via Intra-aneurysmal Fibroblast Delivery”
The Foundation of The ASNR Basic Science Research Award Recipients (continued)

1999-00
Kevin R. Moore, MD
University of Utah Center for Advanced Medical Technology
“Meg-Constrained High-Resolution Surface-Coil MR Imaging and MR Spectroscopy for Evaluating Medically Refractory Epilepsy”

John G. Short, MD
University of Virginia
“Induction of Spinal Interbody Fusion Using Gene Therapy Tissue Engineering Techniques”

2000-01
John Port, MD, PhD
The Johns Hopkins Medical Institution
“Imaging Selective Attention Mechanisms”

Eric Schwartz, MD,
Hospital of the University of Pennsylvania
“Diffusion-based MR Imaging in a Rat Spinal Cord Following Injury and Transplantation”

2001-02
Pratik Mukherjee, MD, PhD
Mallinckrodt Institute of Radiology, Washington University School of Medicine
“Comparison of Magnetic Resonance Imaging and Positron Emission Tomography in the Study of Cerebral Hemodynamics”

2002-03
John G. Dalle, DO
University of Utah School of Medicine
“Polymer-Chelate Conjugates for Diagnostic Cancer Imaging”

Christopher Lascola, MD, PhD
Duke University Medical Center
“Magnetic Resonance Imaging of Spreading Depression-Induced Reactive Gliosis in Mice”

2003-04
Dheeraj Gandhi, MD
University of Michigan Health System
“Can the Choline/Creatine Ratio Predict Early Treatment Response of Head and Neck Squamous Cell Carcinoma Treated with Radiation Therapy in an Animal Model: A Prospective Study”

Susan M. Kealey, MD
Duke University Medical Center
“Correlation of MR Permeability Measurements with Histologic Markers of Angiogenesis in Rodent High-Grade Brain Tumors Before and After Treatment with Antiangiogenesis Agent PTK 787”

2004-05
Tuong Huu Le, MD, PhD
University of California, San Francisco
“Structural and Functional Correlates of Axonal Shearing in Traumatic Brain Injury: A Combined DTI, fMRI and MSI Study”

Whitney B. Pope, MD, PhD
David Geffen School of Medicine at University of California, Los Angeles
“Identification of Unstable Atherosclerotic Plaque at the Carotid Bifurcation Using High-Resolution CT-PET Imaging: Correlation to Histopathology and Patient Symptoms”

2005-06
Srinivasan Mukundan, Jr., PhD, MD
Duke University Medical Center
“Toward the Development of a Nanoscale, Target-Specific Liposomal Platform Technology for Computed Tomography Based Molecular Imaging”

Max Wintermark, MD
University of California, San Francisco
“Morphometric and Functional Characterization of Atherosclerotic Carotid Disease by Multidetector-Row CT-Angiography: A Comparative Study with Ex Vivo Histology and Imaging”

2006-07
Michelle S. Bradbury, MD, PhD
Memorial Sloan Kettering Cancer Center
“In Vivo Monitoring of Human Embryonic Stem Cell-derived Grafts in the Central Nervous System of Living Animals Using Optical Imaging Technologies”

Edwin Wang, MD
New York University School of Medicine
“In Vivo Imaging of the Epidermal Growth Factor Receptor with a Bimodal MRI/Optical Contrast Agent”

2007-08
Myria Petrou, MA, MBChB
University of Michigan, Ann Arbor, MI
“In Vivo Monitoring of Human Embryonic Stem Cell-derived Grafts in the Central Nervous System of Living Animals Using Optical Imaging Technologies”

Elysa Widjaja, MD
Hospital for Sick Children, Toronto, Canada
“Determining theExtent of Diffusion Tensor Abnormalities in Focal Cortical Dysplasia”

2008-09
Bradley Foerster, MD
Johns Hopkins Hospital, Baltimore, Maryland
“MR Molecular Imaging of Glutamate Carboxypeptidase II (GCPII) Modulation in an Experimental Model of Stroke”

Noriko Salamon, MD
Oregon Health & Science University, Portland, Oregon
“Diffusion Tensor Imaging in the Identification of the Extra-Hippocampal Abnormality in the Patients with Mesial Temporal Lobe Epilepsy with Hippocampal Sclerosis”

2009-10
Christopher T. Whitlow, MD, PhD
Wake Forest University School of Medicine, Chapel Hill, NC

2010-11
Stephen E. Jones, MD, PhD
Cleveland Clinic
“Validation of Prostatectomy DTI Algorithms Using Direct Stimulation Data from Stereotactic EEG Electrodes in Humans”
Awards and Honors

2011 The Foundation of the ASNR Scholar Award in Neuroradiology Research

Since 1995, The Foundation of the ASNR has been in the process of raising funds to support neuroradiology research. This is one of the most important goals of the NER Foundation, and of the ASNR as the premier organization for neuroradiology. This award was created for young investigators in the early stages of their careers, to enhance their competency in areas important to the future of neuroradiology, including health services research, physiological imaging and interventional neuroradiology. It also affords the Foundation the opportunity to begin to develop leadership in these areas.

The recipient of the 2011 award is:

Michael J. Paldino, MD
Children's Hospital Boston

“Abnormal Structural and Functional Connectivity in Pediatric Patients with Focal Cortical Dysplasia”

The Foundation of the ASNR Past Scholar Award in Neuroradiology Research Recipients

1999
L. Santiago Medina, MD, MPH
Children’s Hospital Medical Center, Cincinnati, OH
“The Role and Cost-Effectiveness of Imaging in Newborns with Suspected Occult Spinal Dysraphism”

2000
Melanie F. Bukui, MD
University of Pittsburgh Medical Center, Pittsburgh, PA
“Carotid Stenosis Evaluation: Cost-Effectiveness of Computed Tomographic Angiography vs. Magnetic Resonance Angiography”

2001
Soomhee Cha, MD
New York University Medical Center, New York, NY
“Dynamic Contrast Enhanced T2*-weighted MRI and Histopathological Assessment of Experimental Glioma”

2002
James D. Eastwood, MD
Duke University Medical Center, Durham, NC
“CT Perfusion Imaging in Subarachnoid Hemorrhage Related Vasospasm”

2003
Steven G. Imbesi, MD
University of California, San Diego Medical Center, San Diego, CA
“Alteration of Intracranial Aneurysm Flow Dynamics: Development and Evaluation of Potential Neurointerventional Endovascular Treatment Regimens of Wide Necked Aneurysms”

2004
Pratik Mukherjee, MD, PhD
University of California San Francisco, San Francisco, CA
“Diffusion Tensor MR Imaging and Quantitative Tractography of Brain Development in Premature Newborns”

2005
Donna R. Roberts, MD
University of California, San Francisco, CA
“The Assessment of Image-guided Transcranial Magnetic Stimulation as an Adjunct to Extradural Cortical Stimulation for the Treatment of Chronic Facial Pain”

Steven G. Imbesi, MD
University of California Medical Center, San Diego, CA
“Alteration of Intracranial Aneurysm Flow Dynamics: Development and Evaluation of Potential Neurointerventional Endovascular Treatment Regimens for Wide Necked Aneurysms”

2006
Erin Simon Schwartz, MD
Children’s Hospital of Philadelphia
Philadelphia, PA
“A Comprehensive MR Assessment of Fetal Physiologic Well-Being”

2007
Pina C. Sanelli, MD
Weill Medical College of Cornell University, New York, NY
“Assessing the Value of CT Perfusion in Improving Clinical Outcomes in Aneurysmal Subarachnoid Hemorrhage Using a Decision Analytic Model”

2008
Tammie L. S. Benzinger, MD, PhD
Washington University School of Medicine, St. Louis, MO
“Childhood Leukodystrophy with Neuromuscular Disability: Translational Use of MRI Directional Diffusivity as a Tool for Prognosis and Response to Therapy”

Vivek Prabhakaran, MD, PhD
Johns Hopkins Hospital, Baltimore, MD
“Characterizing the Neural Substrates of Stroke Recovery Utilizing fMRI and Perfusion Imaging”

2009
Greg Zaharchuk, M.D., PhD
Stanford University Medical Center, Stanford, CA
“Optimizing Arterial Spin Label MRI for the Visualization of Collateral Flow in Moyamoya Disease”

2010
Steven W. Hetts, MD
University of California, San Francisco
“Endovascular Catheter for Magnetic Navigation under MRI Guidance: Evaluation of Healing In Vivo at 1.5T”

Danel Mandell, MD
Hospital for Sick Children
“Evolution of Individual White Matter Lesions in Leukaoraiosis: A Serial MRI Study”
Awards and Honors

2011 The Foundation of The ASNR Research Scientist Award

The Foundation of the ASNR and Partner Organizations have established the Research Scientist Award to provide research opportunities for PhD investigators to advance the science of Neuroradiology. Scientific research is the foundation upon which the clinical practice of Neuroradiology is built. Research scientists in partnership with radiologists have traditionally led the development of new imaging technologies and image-guided procedures. The directive of these awards is to assist young scientists in their transition to becoming independent investigators in neuroradiology research, as well as to help established investigators initiate new projects with relevance to neuroradiology.

The recipient of the 2011 award is:
Jaime F Mata, PhD
University of Virginia

“Non-Invasive Targeted Delivery and In-vivo Evaluation of Brain Therapy Using MR Guided Focused Ultrasound”

The Foundation of the ASNR Past Award in Cerebrovascular Disease Research Recipients

2003-04
Joshua Shimony, MD, PhD
Washington University School of Medicine, St. Louis, MO
“Improved MR Methods for Evaluation of Brain Perfusion in Patients with Carotid Stenosis”

2004-05
Timothy J. Kaufmann, MD
Mayo Clinic and Foundation, Rochester, MN
“A Prospective Clinical Trial of 3.0T MR Angiography in the Follow-up of Intracranial Aneurysms Treated with Endovascular Coils”

2005-06
Donna Hoghooghi, MD
University of California, San Francisco, CA
“Extent and Effectiveness of Embolization and Determination of Vascular Supply in Meningiomas Using a Combined Interventional X-ray/MR Fluoroscopy Suite”

2006-07
Albert Yoo, MD
Massachusetts General Hospital, Boston, MA
“Predicting Clinical Outcomes of Intra-arterial Thrombolysis in Acute Stroke Using Diffusion/Perfusion MRI”

2007-08
Todd Abruzzo, MD
University of Cincinnati Medical Center, Cincinnati, OH
“Modeling Modes of Intracranial Aneurysm Recurrence After Coil Embolization: Mechanisms of Coil Compaction and Aneurysm Re-Growth”

2008-09
Humberto Morales, MD
University of Cincinnati, Cincinnati, OH
“Safety of Iodinated Contrast Material in a Middle Cerebral Artery Occlusion/Reperfusion Model”
An enhancement of the Continuing Medical Education online evaluation system allows for attendees to print out their official CME certificate for the number of hours claimed during The Foundation of the ASNR Symposium 2011 and ASNR 49th Annual Meeting and take it with them when they leave. Go to any terminal in the CME Pavilion and follow the simple directions for printing out an official The Foundation of the ASNR Symposium 2011 and ASNR 49th Annual Meeting CME Certificate.

Following the meeting, the ASNR 2011 CME certificate site will be available online by mid-July for 90 days for attendees to print out their CME certificates.

Please Note: Due to the availability of CME certificates online, certificates will not be mailed to attendees.

Letter of Attendance
If you wish to obtain a Letter of Attendance, please request one at the Registration Desk located in the 4th Floor South Lobby of the Washington State Convention Center.
ASNR 49th Overall Annual Meeting
Educational Objectives

After attending the 49th Annual Meeting, you will be able to:

- Analyze the clinical spectrum and imaging findings associated with spine disorders in children
- Review in Maintenance of Certification (MOC) and Self-Assessment Module (SAM) Programming with sessions highlighting Head & Neck, Brain, Spine, Pediatrics, and Vascular and Interventional Neuroradiology
- Identify major health policy and socioeconomic factors likely to affect the future of Neuroradiology, including changes in payment systems, evolution of Health Care Reform, Comparative Effectiveness Research, and Informatics as drivers of healthcare decisions
- Describe the normal findings after spinal instrumentation and diagnose complications arising after surgery
- Analyze the indications for, imaging findings, and outcomes related to diagnosis and endovascular therapy of arteriovenous malformations
- Interpret imaging studies of the pediatric head and neck
- Recommend advanced imaging methods to aid in diagnosis of metabolic disorders of the pediatric central nervous system
- Apply advanced imaging methods to diagnosis and treatment planning for acute stroke
- Identify the indications for, and perform interventional procedures in the head and neck
- Define and analyze new developments in MR spectroscopy, diffusion imaging, brain perfusion imaging, and molecular imaging
- Analyze current best practices and strategies for imaging evaluation and intervention of spine pain, the facet joint, and vertebroplasty
- Evaluate leadership and management approaches to optimizing performance of radiology practice
The ASNR Synaptic Junction provides the opportunity for connecting your practice to the future through offerings focused on enhancing workflow, efficiency, standardization of interpretation and reporting, and improvements in revenue cycle, particularly those that involve software, hardware and informatics-based solutions.

**Lectures and Workshops are FREE**

### Monday, June 6

**10:45 am - 12:15 pm • Room 619/620**

**Lecture: How To Minimize Radiation Dose, and How To Document It**  
Kalpana Kanal, PhD DABR  
Max Wintermark, MD

**1:30 pm - 3:00 pm • Rooms 613/614**

**Workshop: Post Processing Hands-On Workshop and Vendor Q&A Session**  
John L. Go, MD

### Tuesday, June 7

**10:45 am - 11:45 am • Room 619/620**

**Lecture: Resolving Conflicts in the Workplace**  
Andrew Simon, PhD, PsyD,  
Melissa Brodrick

**1:30 pm - 3:00 pm • Room 619/620**

**Lecture: Freeware for Post-Processing**  
Daniel P. Barboriak, MD

### Wednesday, June 8

**3:15 pm - 4:45 pm • Room 613/614**

**Workshop: MIRC 2.0 and Shared Teaching Files**  
Adam Flanders, MD

*Please Note: Due to the direct financial support from companies to conduct these sessions, CME credit hours will not be granted for any Sponsored Synaptic Junction Workshops.*
In addition to the Technical Exhibition, the leadership of the ASNR is pleased to announce the fourteenth annual slate of instructional How-To forums. These sessions, presented in conjunction with major corporate contributors, deal with advances in imaging and procedures as well as principles in neuroradiology and image information management. How-To Sessions are scheduled throughout the week.

The How-To Sessions offer a unique opportunity for neuroradiologists to discuss techniques, procedures, and products with their colleagues as well as with technical specialists from the imaging industry. Comments and suggestions from meeting registrants were integrated into this year’s format. The sessions vary and include both didactic presentations and demonstrations, all with a strong practical emphasis. A significant portion of each session is devoted to questions and answers.

How-To Session Programming in Ballroom 6 B/C

Sunday, June 5 ........................................................................................................................................... 12:00 pm - 1:00 pm

PHILIPS

Monday, June 6 ......................................................................................................................................... 12:30 pm - 1:30 pm

TOSHIBA

Leading Innovation

Tuesday, June 7 ......................................................................................................................................... 12:30 pm - 1:30 pm

BRACCO

LIFE FROM INSIDE

Wednesday, June 8 .................................................................................................................................... 12:00 pm - 1:00 pm

SIEMENS

Please Note: Due to the direct financial support from companies to conduct these sessions, CME credit hours will not be granted for any How-To Sessions
Washington State Convention Center
### Scientific Exhibits

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## Scientific Posters - Exhibit Hall 4A

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### Scientific Posters (Printed)

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<tr>
<td>Anatomy</td>
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<tr>
<td>Head and Neck</td>
<td>90-100</td>
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<tr>
<td>Interventional</td>
<td>101-126</td>
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<td>Pediatrics</td>
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<tr>
<td>Socioeconomic</td>
<td>153</td>
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<tr>
<td>Spine</td>
<td>154-170</td>
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### Electronic Scientific Posters (ePosters)

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<td>Anatomy</td>
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<td>136-162</td>
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<td>Socioeconomic</td>
<td>163</td>
</tr>
<tr>
<td>Spine</td>
<td>164-178</td>
</tr>
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</table>
“Seattle Welcome Reception”
Monday, June 6, 2011 • 6:30 pm - 7:30 pm
Washington State Convention Center • Exhibit Hall 4B

We look forward to welcoming attendees to the Technical Exhibition Hall for a pre-dinner reception of local Seattle culinary favorites. The reception, located in Exhibit Hall 4B, offers attendees the perfect opportunity to see this year’s Technical Exhibition, the ASNR’s annual showcase for the newest products and services for the field of Neuroradiology. Enjoy complimentary pre-dinner hors d’oeuvres and beverages while you learn about the newest technologies. Connect with old friends, make new ones and meet representatives from companies participating in this year’s technical exhibition. This casual social setting also allows plenty of informal discussion with the company representatives, so bring your product and service challenges and come in search of solutions to the place where advanced technology and diagnostic and interventional neuroradiological excellence come together. The Scientific Exhibition (posters, scientific and electronic exhibits) will also be available for viewing throughout the reception.
## Technical Exhibits Roster (as of 04/18/11)

### Washington State Convention Center - Exhibit Hall 4B

<table>
<thead>
<tr>
<th>Tuesday, June 7</th>
<th>Wednesday, June 8</th>
<th>Thursday, June 9</th>
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<td>608</td>
<td>Booth # 608 2180 South 1300 East, Suite 570 Salt Lake City, UT 84106</td>
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<td>Bayer Healthcare Pharmaceuticals</td>
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<td>Bracco Diagnostics Inc</td>
<td>420</td>
<td>Booth # 420 107 College Road East Princeton, NJ 08540</td>
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<td>BrainLab, Inc</td>
<td>221</td>
<td>Booth # 221 3 Westbrook Corporate Center, Suite 400 Westchester, IL 60154</td>
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<tr>
<td>DFine, Inc</td>
<td>520</td>
<td>Booth # 520 3047 Orchard Parkway San Jose, CA 95134</td>
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<td>Elsevier Saunders and Mosby</td>
<td>521</td>
<td>Booth # 521 2710 59th Street SW Everett, WA 98203</td>
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<td>ev3</td>
<td>612</td>
<td>Booth 612 9775 Toledo Way Irvine, CA 92618</td>
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<td>GE Healthcare</td>
<td>404</td>
<td>Booth # 404 9900 W. Innovation Dr, RP-2177 Wauwatosa, WI 53226</td>
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<td>Hitachi Medical Systems America, Inc</td>
<td>204</td>
<td>Booth # 204 1959 Summit Commerce Park Twinsburg, OH 44087</td>
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<td>Lippincott Williams and Wilkins</td>
<td>610</td>
<td>Booth # 610 4816 139th Pl SE Snohomish, WA 98296</td>
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<td>Microvention</td>
<td>110</td>
<td>Booth # 110 1311 Valencia Avenue Tustin, CA 92780</td>
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<td>NordicNeuroLab</td>
<td>622</td>
<td>Booth # 622 234 West Florida Street, Suite 210 Milwaukee, WI 53204</td>
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<td>Olea Medical</td>
<td>321</td>
<td>Booth # 321 93 Avenues Des Serbiers, 21 Athelia 4 La Ciotat, France 13600</td>
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<td>Philips Healthcare</td>
<td>130</td>
<td>Booth # 130 22100 Bothell-Everett Highway Everett, WA 98021</td>
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<td>Siemens Medical Solutions USA, Inc</td>
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<td>Booth # 304 51 Valley Stream Parkway Malvern, PA 19355</td>
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<td>Springer</td>
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<td>Booth # 124 233 Spring Street New York, NY 10013</td>
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<td>Stryker</td>
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<td>Booth # 506 4100 E Milham Ave Kalamazoo, MI 49001</td>
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<td>Booth # 320 1302 Wrights Lane East West Chester, PA 19380</td>
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<td>Thieme Publishers</td>
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<td>Booth # 614 333 7th Avenue New York, NY 10001</td>
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<tr>
<td>Toshiba America Medical Systems, Inc</td>
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<td>Booth # 104 2441 Michelle Drive Tustin, CA 92780</td>
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<td>Vital Images</td>
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<td>Booth # 620 5850 Opus Parkway, Suite 300 Minnetonka, MN 55343</td>
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ASNR 49th Annual Meeting Invited Speakers (as of 04/18/11)

Jeffrey S. Anderson, MD, PhD
University of Utah

Yoshimi Anzai, MD, MPH
University of Washington

Ray M. Baker, MD
Washington Interventional Spine Associates

Daniel P. Barboriak, MD
Duke University Medical Center

A. James Barkovich, MD, MPH
University of California, San Francisco

Robert M. Barr, MD
Mecklenburg Radiology Associates, P.A.

Jacqueline A. Bello, MD, FACR
Montefiore Medical Center

Jeffrey I. Berman, PhD
The Children's Hospital of Philadelphia

Bharat Biswal, PhD
New Jersey Medical School
University of Medicine & Dentistry of New Jersey

Susan I. Blaser, MD, FRCPC
Hospital for Sick Children

Eileen W. Bradley, D.Sc
National Institutes of Health

William G. Bradley, Jr, MD, PhD, FCRP
University of California San Diego Healthcare

Brian W. Bresnahan, PhD
University of Washington

Gretchen A. Brodnicki, JD
Harvard Medical School

Melissa Brodrick
Harvard Medical School

R. Nick Bryan, MD, PhD
University of Pennsylvania

Timothy J. Carroll, PhD
Northwestern University

Paul A. Caruso, MD
Massachusetts General Hospital

Mauricio Castillo, MD, FACR
University of North Carolina

Jens R. Chapman, MD
Harborview Medical Center

William A. Copen, MD
Massachusetts General Hospital

Sean P. Cullen, MD
Kaiser Permanente Medical Group

Richard A. Deyo, MD, MPH
Oregon Health & Science University

William P. Dillon, MD
University of California, San Francisco Medical Center

Nancy J. Fischbein, MD
Stanford University

Adam E. Flanders, MD
Thomas Jefferson University Hospital

David R. Flum, MD, MPH, FACS
University of Washington

Lawrence E. Ginsberg, MD
MD Anderson Cancer Center

John L. Go, MD
Los Angeles County, University of Southern California Medical Center

R. Gilberto Gonzalez, MD, PhD
Massachusetts General Hospital

David B. Hackney, MD, FCRP
Beth Israel Deaconess Medical Center

Sihoun Hahn, MD, PhD
University of Washington School of Medicine Seattle Children's Hospital

Hoby P. Hetherington, PhD
Yale University School of Medicine

Leah Hole-Curry, JD
Washington State Health Care Authority

Daniel P. Hsu, MD
University Hospitals of Cleveland

Thierry A. G. M. Huisman, MD, EQNR, FICIS
Johns Hopkins Hospital

Jeffrey G. Jarvik, MD, MPH
University of Washington

Blake A. Johnson, MD, FCRP
Center for Diagnostic Imaging, Minnesota

John E. Jordan, MD
Advanced Imaging of South Bay, Inc.
Providence Little Company of Mary Medical Center

Emanuel Kanal, MD
University of Pittsburgh Medical Center

Calpana Kanal, PhD, DABR
University of Washington

Charles W. Kerber, MD
University of California San Diego School of Medicine

Larry Kessler, Sc.D.
University of Washington

Bernadette L. Koch, MD
Cincinnati Children's Hospital

Bruce Korf, MD, PhD
University of Alabama at Birmingham

Meng Law, MD
University of Southern California Medical Center

Frank J. Lexa VII, MD
Drexel University
Global Consulting Practicum

William A. Copen, MD
Massachusetts General Hospital

William J. Liu, MD
University of California, San Diego

Laurie A. Loevner, MD
University of Pennsylvania Medical Center

George Loewenstein, PhD
Carnegie Mellon University

Sung LoGerfo, MD
University of Washington School of Medicine

Joseph A. Maldejian, MD
Wake Forest University School of Medicine

Carolyn C. Meltzer, MD, FCRP
Emory University

Philip M. Meyers, MD, FAHA
Columbia University

Jay P. Mohr, MD, MS, PhD
Columbia University
ASNR 49th Annual Meeting Invited Speakers (cont’d)

Suresh K. Mukherji, MD, FACR
University of Michigan Health System

Ryan D. Murtagh, MD, MBA
Moffitt Cancer Center

Thomas P. Naidich, MD
The Mount Sinai Medical Center

Marvin D. Nelson, MD
Children’s Hospital of Los Angeles

Gary M. Nesbit, MD
Oregon Health & Science University

A. Orlando Ortiz, MD, MBA
Winthrop University Hospital

Ashok Panigrahy, MD
Children’s Hospital of Pittsburgh University

Hemant A. Parmar, MBBS, MD
University of Michigan

C. Douglas Phillips, MD, FACR
Weill Medical College of Cornell University

Jeffrey M. Pollock, MD
Oregon Health & Science University

Tina Young Poussaint, MD
Children’s Hospital Boston

Sujit S. Prabhu, MD, FRCS
University of Texas / MD Anderson Cancer Center

Ansaar T. Rai, MD
West Virginia University

Charles A. Raybaud, MD
Hospital for Sick Children

Deborah L. Reede, MD
The Long Island College Hospital

Kent B. Remley, MD
Center for Diagnostic Imaging

Timothy P. L. Roberts, PhD
The Children’s Hospital of Philadelphia

Caroline D. Robson, MB, ChB
Children’s Hospital Boston

Brian D. Ross, PhD
University of Michigan Medical School

Andrea Rossi, MD
G. Gaslini Children’s Hospital, Italy

Howard A. Rowley, MD
University of Wisconsin, Madison

Eric J. Russell, MD, FACR
Northwestern University

David S. Sabsevitz, PhD
Medical College of Wisconsin

Pina C. Sanelli, MD, MPH
New York Presbyterian Hospital / Weill Cornell Medical College

Russell P. Saneto, DO, PhD
Seattle Children’s Hospital

Donald F. Schomer, MD
Radiology Imaging Associates

Erin S. Schwartz, MD
Children’s Hospital of Philadelphia

David J. Seidenwurm, MD
Radiological Associates of Sacramento

Deborah R. Shatzkes, MD
St. Luke’s – Roosevelt Hospital Center

Manohar Shroff, MD
Hospital for Sick Children

University of Toronto, Canada

Andrew F. Simon, PhD, PsyD

James G. Smirniotopoulos, MD
Uniformed Services University

Wendy R. K. Smoker, MD, FACR, MDMS
University of Iowa Hospitals & Clinics

Sean D. Sullivan, PhD
University of Washington

Pia C. Maly Sundgren, MD, PhD
Lund University, Sweden

Stephen T. Sweriduk, MD
Shields Health Care Group

Jeffrey Thompson, MD, MPH
Washington State Medicaid

Majda M. Thurnher, MD
Medical University of Vienna, Austria

Frank C. Tong, MD
Emory University School of Medicine

Patrick A. Turski, MD, FACR
University of Wisconsin, Madison

John L. Ulmer, MD
Froedtert Memorial Lutheran Hospital

Johan W. Van Goethem, MD
University Hospital of Antwerp, Belgium

Gilbert Vezina, MD
Children’s National Medical Center

Yi Wang, PhD
Weill Cornell Medical College / Cornell University

Christopher T. Whitlow, MD, PhD
Wake Forest University School of Medicine

Alan L. Williams, MD, FACR, MBA
Medical College of Wisconsin

Max Wintermark, MD
University of Virginia

Albert J. Yoo, MD
Massachusetts General Hospital

William L. Young, MD
University of California San Francisco

Robert D. Zimmerman, MD, FACR
New York Presbyterian Hospital / Weill Cornell University
**ASNR 49th Annual Meeting**

**Scientific Program Overview (as of 04/18/11)**

Meals and Breaks: Breakfasts, Morning and Afternoon Coffee Service and Box Lunches will be provided throughout the week.

**PLEASE NOTE**: Annual Meeting food service locations vary throughout week based on Technical Exhibit hours and programming.

**NOTE**: Page numbers referenced throughout the program correspond to the page number within the Proceedings Book.

### Monday June 6, 2011

- **6:00am - 7:45am** Breakfast
- **6:45am - 7:40am** Parallel Scientific Paper Sessions
  - **(E001) Excerpta Extraordinaire: Spine**
    - 1:30pm - 3:00pm Arteriovenous Malformations
  - **(E002) Excerpta Extraordinaire: Adult Brain I**
    - 1:30pm - 3:00pm Vascular, Intracranial
- **7:40am - 7:45am** (1) Opening Remarks
- **7:45am - 8:45am** Maintenance Of Certification (MOC) - Review Session (AR) Spinal Instrumentation: Imaging / Clinical Correlations And Complications
- **8:45am - 10:15am** Plenary Session: Translational Research In Neuroradiology
- **10:15am - 10:45am** Morning Break
- **10:45am - 12:30pm** Parallel Scientific Paper Sessions
  - **Session 4a. Adult and Pediatric Trauma**
  - **Session 4b. Interventional: Aneurysms**
  - **Session 4c. Spine: Intervention & Neoplasms**
  - **Session 4d. Adult Brain: Vascular, Intracranial**
  - **Session 4e. Translational Reseach in Neuroradiology II, Functional Studies**
- **10:45am - 11:45am** Synaptic Junction Programming: Lecture: How To Minimize Radiation Dose, and How to Document It
- **12:30pm - 1:30pm** Lunch Break
- **12:30pm - 1:30pm** How-To Session Workshop - Toshiba America Medical Systems, Inc.
- **1:30pm - 3:00pm** ASSR Programming: Updates In Pediatric Spinal Imaging
- **1:30pm - 3:00pm** SNIS Programming: Arteriovenous Malformations
- **1:30pm - 3:00pm** Socioeconomic Programming: CMS Prospective Payment System: Outpatient (HOPPS) And Physician Incentives (PQI And PQRI) (SAM Session - #1) (AR)
- **1:30pm - 3:00pm** Translational Research In Neuroradiology, III, Advanced Technologies
- **3:00pm - 3:30pm** Afternoon Break
- **3:30pm - 5:00pm** Parallel Scientific Paper Sessions
  - **Session 11a. Interventional: New Devices**
  - **Session 11b. Demyelinating/White Matter Disease**
  - **Session 11c. Vascular, Extracranial & Intercranial**
  - **Session 11d. Spine: Advanced Imaging Techniques**
  - **Session 11e. Translational Research In Neuroradiology, IV, Functional and Diffusion Imaging**
- **5:00pm - 6:30pm** SNIS Programming: Perfusion Imaging For The Stroke Interventionalist (SAM Session - #2) (AR)
- **5:00pm - 6:30pm** ASSR Programming: Comprehensive Spine Review: Tumor, Infection And Traumatic Injury of The Spine
- **5:00pm - 6:30pm** Translational Research In Neuroradiology, V/Advanced Imaging Seminar: Microstructural Brain MRI

*AR = Audience Response Session

**Session Programming qualified by the American Board in meeting the criteria for self-assessment toward the purpose of fulfilling requirements in the ABR Maintenance of Certification Program. 4/11. To obtain current SAM credit information, visit www.asnr.org.**
## Scientific Program Overview (as of 04/18/11)

### Tuesday, June 7, 2011

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<td>Breakfast</td>
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<td>6:45am - 7:40am</td>
<td>Parallel Scientific Paper Sessions</td>
<td>(E003) Excerpta Extraordinaire: Interventional</td>
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<td>(E004) Excerpta Extraordinaire: Adult Brain II</td>
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<tr>
<td>7:45am - 8:45am</td>
<td>(15) Maintenance Of Certification (MOC) - Review Session (AR) Vascular</td>
<td>p. 115</td>
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<tr>
<td>8:45am - 10:15am</td>
<td>(16) Plenary Session: Socioeconomic Programming: Hot Topics</td>
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<td>10:15am - 10:45am</td>
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<td>10:45am - 12:30pm</td>
<td>(17) Parallel Scientific Paper Sessions</td>
<td>Session 17a: Cerebrovascular Occlusive Disease</td>
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<td>Session 17b: Spine: Trauma, Spinal Cord &amp; Degenerative</td>
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<td>Session 17c: Interventional: Thrombolysis/Stroke</td>
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<td>Session 17d: Brain: New Techniques/Post Processing</td>
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<td>Session 17e: Adult Brain: Neoplasms</td>
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<td>11:45am</td>
<td>(17f) Synaptic Junction Programming: Lecture: Resolving Conflicts in the Workplace</td>
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<td>12:30pm - 1:30pm</td>
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<td>How-To Session Workshop - Bracco</td>
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<td>12:30pm - 1:30pm</td>
<td>Young Physicians Luncheon</td>
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<td>1:30pm - 3:00pm</td>
<td>Session 23a: Adult Brain: Neoplasms II: Gliomas</td>
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<td>Session 23b: New Devices &amp; Arteriovenous Malformations/Fistulae</td>
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<td>Session 23d: Spine: Intervention &amp; Other</td>
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<td>1:30pm - 3:00pm</td>
<td>Session 23e: Socioeconomics &amp; Anatomy</td>
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<td>(18) ASSR Programming: Interventional Spine-facets, Disc and The Vertebral Body (SAM Session - #3) (AR)</td>
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<td>(20) ASFNR Programming: Resting State fMRI Connectivity</td>
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<td>(21) ASHNR Programming: Pediatric Head And Neck</td>
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<td>(21a) Synaptic Junction Programming: Workshop: Post-Processing</td>
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<td>(22) Synaptic Junction Programming Workshop: Freeware for Post-Processing</td>
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<td>(23) Parallel Scientific Paper Sessions</td>
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<tr>
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<td>3:30pm - 5:00pm</td>
<td>Session 23e: Socioeconomics &amp; Anatomy</td>
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<td>5:00pm - 6:30pm</td>
<td>(24) Comparative Effectiveness Research, Evaluation Of Common Neuroradiologic Studies</td>
<td>p. 205</td>
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<td>(25) Comparative Effectiveness Research, Evaluation Of Common Neuroradiologic Studies</td>
<td>p. 205</td>
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<td>5:00pm - 6:30pm</td>
<td>(26) ASPNR Programming: Metabolic Diseases Of Childhood</td>
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<td>5:00pm - 6:30pm</td>
<td>(27) Advanced Imaging Seminar: Imaging Brain Hemodynamics</td>
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</table>

*AR = Audience Response Session

**Session Programming qualified by the American Board in meeting the criteria for self-assessment toward the purpose of fulfilling requirements in the ABR Maintenance of Certification Program. 4/11. To obtain current SAM credit information, visit www.asnr.org.
### Scientific Program Overview (as of 04/18/11)

**Wednesday, June 8, 2011**

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<td>6:45am - 7:40am</td>
<td>Parallel Scientific Paper Sessions</td>
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<td>(E005) Excerpta Extraordinaire: Adult Brain III</td>
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<td>(E006) Excerpta Extraordinaire: Pediatrics</td>
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*AR = Audience Response Session

**Session Programming qualified by the American Board in meeting the criteria for self-assessment toward the purpose of fulfilling requirements in the ABR Maintenance of Certification Program. 4/11. To obtain current SAM credit information, visit [www.asnr.org](http://www.asnr.org).**
### Scientific Program Overview (as of 04/11/11)

#### Thursday, June 9, 2011

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*AR = Audience Response Session

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50th Annual Meeting
New York City

April 21-26, 2012
New York Hilton
New York, New York

1962-2012
ASNR
50th Anniversary
Annual Meeting

SAN DIEGO 2013

51st Annual Meeting | May 18 - 23
San Diego Convention Center
San Diego, California

MONTREAL 2014

52nd Annual Meeting | May 17 - 22
Palais des Congrès de Montreal
Montreal, Quebec, Canada
Presence of Fluid Spaces Inside Psoas Muscle Acting as a Reservoir in Vertebral Fracture with Avascular Necrosis

Teng, M. M. H. • Yuan, W.
Taipei Veterans General Hospital
Taipei, TAIWAN

PURPOSE
The most common fluid spaces inside psoas muscle with marginal enhancement on MR imaging (MRI) are abscesses. We report the presence of aseptic fluid spaces inside the right psoas muscle in a case of L2 vertebral fracture with avascular necrosis.

CASE REPORT
An 82-year-old female complained of severe low back pain more on right side. MR imaging showed an L2 vertebral body fracture with avascular necrosis, and fluid-containing spaces with marginal enhancement inside the right psoas muscle suspecting abscess formation initially. CT-guided fluid aspiration showed no bacterial growth. Pinkish fluid with no foul odor was aspirated from L2 vertebral body. The back pain relieved after percutaneous vertebroplasty, and she returned to her work 1 month after the procedure.

IMAGING FINDINGS
MR imaging showed T12 old fracture, L1 hemangioma, and L2 fracture with avascular necrosis. In addition, there are fluid spaces in right psoas muscle with marginal enhancement. Differential diagnosis for the lesion in psoas muscle includes abscess, hematoma and aseptic fluid related to the avascular necrosis inside L2 vertebral body. Contrast media was injected inside the L2 vertebral body before vertebroplasty. CT scan after vertebroplasty showed contrast media entered the fluid spaces in the right psoas muscle.

SUMMARY
This is a case of L2 vertebral body fracture with avascular necrosis, and psoas muscle spaces simulating abscesses. Fluid inside the psoas muscle spaces connected to the avascular necrosis and acting as a reservoir at changing of the body position. The psoas muscle originates from T12 to L4 vertebral bodies. We presume fracture of these vertebral bodies with avascular necrosis may cause similar aseptic fluid spaces in the psoas muscle acting as a reservoir during changing of body position.

KEY WORDS: Vertebral fracture, psoas muscle abscess, vertebroplasty
of our knowledge, only 11 known cases of pregnancy-related sacral fractures have been reported in the literature, including patients with symptom onset both pre and postpartum. Of these, only one has been diagnosed by imaging during pregnancy, and our case is the only one we are aware of which has been diagnosed before the third trimester. This is also the only case that featured a twin gestation, as well as assisted reproductive therapy.

SUMMARY
The exact etiology of pregnancy-associated sacral fractures is not known, although most authors suggest that they likely are related to osteoporosis. Pregnancy-associated osteoporosis is a rare condition during the last trimester of pregnancy or immediately postpartum. This reduction in bone mineral density is attributed primarily to prolactin-related osteopenia combined with body weight gain, on top of hyperlordosis, which changes the biomechanics of the sacral axial loading, possibly complicated by insufficient maternal calcium intake and relaxin-related loosening of pelvic ligaments. Because back pain is a common condition affecting so many pregnant patients, it is likely that sacral fractures are underdiagnosed in this population. Clinicians caring for pregnant patients should have a high index of suspicion, and MRI offers the opportunity for definitive diagnosis, without any known complications.

KEY WORDS: Sacrum, insufficiency, fracture

Case Report
A 66-year-old female presented with progressive lower extremity numbness, tingling, weakness, and gait instability for a month.

IMAGING FINDINGS
MRI of the thoracic spine was performed using conventional sequences including contrast material-enhanced imaging. An intramedullary ring-enhancing lesion was identified at T7-8 level with surrounding T2 hyperintensity extending from T5 to T10 vertebral level and mild cord expansion. Slight accentuation of thoracic kyposis was noted at T7-8. The remaining thoracic spine was essentially unremarkable. The likely etiologies for the ring-enhancing lesion included infection, metastasis, hemangioblastoma. The work-up for metastatic disease was however negative. It then was decided to perform operative procedure for relief of patient’s symptoms. T6 to T9 laminectomies were performed. The dura was opened longitudinally in the midline fromT6-T9 followed by the arachnoid and pia. Myelotomy then was performed and the tumor was identified in the midline with pearlescence consistency. The margins of the mass were well defined and it appeared adherent to the ventral pia. The mass was circumferentially decompressed, wound was irrigated and dura was closed. The specimen was sent for pathology. On pathologic examination, the specimen showed fragments of cartilage and nucleus pulposus with reactive changes. No tumor was seen. The final diagnosis was intramedullary herniated disk fragment.

SUMMARY
First report of intramedullary herniation of disk fragment in humans. The disk fragment appeared as ring-enhancing lesion at the level of T7-8 disk with surrounding edema mimicking neoplastic and infectious processes. Hitherto only reported instances have been in veterinary literature.

REFERENCES

KEY WORDS: Disk herniation, intramedullary, spinal cord

Paper 003 Starting at 6:55 AM, Ending at 7:00 AM
Intramedullary Sequestration of Disk Fragment
Flanders, A. E.1 • Sharma, P.1 • Lachman, T.2 • Teufack, S.1 • Prasad, S.1 • Kenyon, L.1 • Harrop, J.1
1Thomas Jefferson University Hospital, Philadelphia, PA, 2Thomas Jefferson University Hospital, Bala Cynwyd, PA

PURPOSE
To describe an unusual case of intramedullary space occupying lesion-herniated disk fragment.
Calcifying Pseudoneoplasm of the Neural Axis Arising within the Lumbar Spine: Implication of Unique Cross-Sectional Imaging Characteristics of a Rare Spinal Column Lesion

Naidu, P. K. • Patel, S. C.
Henry Ford Hospital
Detroit, MI

PURPOSE
To describe and further delineate the CT and MR imaging (MRI) characteristics of a calcifying pseudoneoplasm of the neural axis (CAPNON) found in the lumbar spine, the sixth to be described in the literature thus far and the first to be characterized comprehensively on these imaging modalities.

CASE REPORT
A 43-year-old male presented with unremitting low back pain radiating down the left leg. Physical examination was notable for low back tenderness, bilateral positive straight leg raising test, and an area of numbness along the anterior left thigh extending down the left lateral calf.

IMAGING FINDINGS
CT showed a 14 mm, densely calcified lesion with smooth margins within the left aspect of the spinal canal that was not continuous with the adjacent L4 vertebral body. This correlated to a 14 mm intradural, extramedullary, T1 isointense to muscle, T2 hypointense to cerebrospinal fluid (CSF) lesion within the left aspect of the spinal canal at L4 on MRI that was compressing portions of the left L4 and L5 nerve roots. On postcontrast T1-weighted images, the lesion demonstrated a background of diffuse enhancement, with superimposed curvilinear areas of more pronounced enhancement internally and along its margins. Histopathology of this calcified lesion showed lobular zones of mineralization with cascading epithelial cells at their margins. The tissue surrounding these nodules was composed of a richly vascular fibrous stroma. The final pathologic diagnosis was CAPNON.

SUMMARY
CAPNON are relatively recently established pathologic entities that have gained increasing attention as more cases are recognized and reported. Symptoms from CAPNON usually arise from compression of adjacent structures, and can resolve completely with appropriate surgical resection. Most cases have been intracranial, with fewer described involving the spinal column. We characterize the 6th case of CAPNON within the lumbar spine reported in the literature to date, elaborating upon its appearance on both CT and MRI. Notably, our case is the first of these lesions to be comprehensively characterized on both cross-sectional imaging modalities. While all CAPNON are densely calcified on CT, our case is slightly unusual relative to prior descriptions because of its diffuse enhancement on MRI, which may be explained by its rich fibrovascular stroma. Indeed, variability in histopathologic components has been described in CAPNON, implying some degree of unpredictability and inconsistency in imaging findings. Therefore, CAPNON may mimic other lesions, including the most common intradural, extramedullary lesion within the spinal canal, a meningioma. Given this variability in imaging findings, CAPNON should be included in the differential diagnosis for any intradural, extramedullary calcified lesion within the spinal column.

KEY WORDS: CAPNON, pseudoneoplasm, spine

Unexplained Extensive Craniocervical Pneumatization

Mansour, A. • Swaidan, M. • Al-Wiswasy, A. • Shurbaji, A.
1King Hussein Cancer Center, Amman, JORDAN, 2King Hussein Medical Center, Amman, JORDAN

PURPOSE
Pneumatization of the craniocervical junction is very rare and to the best of our knowledge only six cases without history of trauma have been reported. In five cases there was history of frequent Valsalva maneuver and one with history of habitual free diving. Atlanto-occipital assimilation has been suggested as a cause for the craniocervical pneumatization but in our case as well as in few other cases no such anomaly was noted. Other authors suggested the role of destructive effect of elevated middle ear pressure which in turn causes mastoid air cells to expand throughout the skull base and into the atlas crossing sutures and synovial joints. Our purpose is to report the radiologic findings of one patient who developed neurologic symptoms after a commercial air flight, suggesting barotrauma, and was found to have extreme craniocervical pneumatization associated with epidural air. We present for the first time the MR imaging (MRI) findings of this very rare condition.

CASE REPORT
A 50-year-old man presented with neck pain and upper limb numbness after commercial airplane travel. There is no prior history of trauma or habitual Valsalva maneuver.

IMAGING FINDINGS
A cervical spine MRI and a craniocervical junction CT scan were performed which showed extreme pneumatization of the temporal bone, craniocervical junction and upper three cervical vertebrae including both the anterior and posterior elements. Air tracked along the dorsal epidural space from C1 down to T2 compressing the thecal sac which is the likely cause of the patient's symptoms. Associated soft tissue emphysema with no assimilation between the atlas and skull base was noted. The patient was treated conservatively with complete recovery of his symptoms.
CONCLUSION
This unusual case demonstrates extreme craniocervical pneumatization without provocative trauma or habitual Valsalva maneuver which made him liable for barotrauma and self-limiting thecal sac compression.

KEY WORDS: Craniocervical pneumatization, barotrauma, cord compression

Paper 006 Starting at 7:10 AM, Ending at 7:15 AM
Management of Spinal Epidural Arteriovenous Fistulas

Ramanathan, D. • Levitt, M. • Hallam, D. • Sekhar, L. • Ghodke, B.
University of Washington
Seattle, WA

PURPOSE
Spinal epidural arteriovenous fistulae (SEDAVF) are rare clinical entities, which can sometimes be symptomatic. Clinical progression and management of SEDAVF is not well reported in the literature.

CASE REPORT
We report a series of five consecutive cases treated at our center to analyze their diagnostic characteristics, clinical history, progression and treatment strategies in their management. We report a successful technique of percutaneous embolization of fistulas in a patient with failed previous attempts.

IMAGING FINDINGS
All five patients were symptomatic; three patients presented with history of back pain, which progressed to myelopathic symptoms such as bilateral leg weakness or numbness, and two patients had symptoms of persistent back pain alone. Of the three patients who had myelopathic symptoms, two were treated successfully with transarterial embolizations with Onyx copolymer (ev3 Neurovascular, CA, USA). The third patient who had a prominent epidural venous pouch with numerous arterial feeders was embolized percutaneously with a flat detector CT-guided navigation (X per CT, Phillips Inc., The Netherlands) and real time fluoroscopic monitoring of the injected glue, after unsuccessful attempts with surgery and arterial embolizations. All three treated patients had complete angiographic remission of the fistulae and symptoms on follow up (mean 7.2 months). Of the two patients presenting with back pain alone, one patient was found to have a spontaneous thrombosis of the medullary vein before a scheduled percutaneous intervention and the other patient is being monitored closely.

SUMMARY
The diagnosis and treatment of SEDAVF can be challenging due to their rare occurrence and intricate pathomechanics. Patients with mild symptoms of pain should be monitored closely. Patients with severe pain or progression of symptoms or myelopathic symptoms need to be treated at the earliest opportunity. Successful percutaneous embolization of fistulae can be performed when a sizeable venous pouch is present in association with numerous arterial feeders.

KEY WORDS: Arteriovenous fistulae, percutaneous, intervention
Chordoma and Benign Intraosseous Notochordal Cell Tumor: Chicken or the Egg?

Shah, L. M. • Zollinger, L. • Ng, P.
University of Utah
Salt Lake City, UT

Purpose
Chordomas are rare malignant tumors that occur along the neural axis. Increasing evidence suggests that malignant chordomas may arise from benign intraosseous notochordal tissue (BNCT). We report a series of three large pathologically proved chordomas of the lumbar spine with features consistent with the presence of BNCT as well as classic malignant chordoma. The imaging characteristics and clinical course of all three cases will be discussed with a review of the literature.

Case Report
All three patients presented with chronic low back pain, which prompted MR imaging of the lumbar spine for evaluation. No neurologic deficits were reported. Given the extensive tumor involvement of the axial skeleton, the patients underwent percutaneous biopsy and open surgical debulking to decrease mass effect on the spinal nerve roots. Subsequently, the patients received radiation treatment.

Imaging Findings
The lesions in each case demonstrated heterogeneous T2 hyperintensity and minimal curvilinear enhancement centrally and peripherally. Each lesion was multilobulated and extended across multiple vertebral levels, grossly skipping the intervertebral disks. The lesions insinuated into the epidural and paravertebral regions. Posterior element involvement was noted in all cases, which is atypical for chordomas. The involved vertebral bodies demonstrated increased sclerosis rather than the lytic, destructive appearance described in chordomas.

Summary
Vertebral chordomas are rare tumors arising along the course of the notochord, and the thoracic and lumbar spine are rare sites of primary involvement. Our case series highlights the fact that while chordomas are typically avid-enhancing lesions with lytic destruction, these features may be absent. The best diagnostic clues that suggest the diagnosis of chordoma are the presence of a relatively preserved vertebral body that is sclerotic with mildly thickened trabeculae and a multilobulated T2 hyperintense extraosseous component. Literature review suggests the preferred terms when discussing notochordal lesions should be limited to EPV, BNCT and chordoma, all of which appear to be along a spectrum from benign remnant to low grade tumor.

Key Words: Spine, chordoma, benign intraosseous notochordal tissue

Pigmented Villonodular Synovitis of the Cervical Spine: Distinguishing Features and Pathologic Correlation

Chaitowitz, I. M. • Quencer, R. • Robinson, P. • Green, B.
University of Miami
Miami, FL

Purpose
Pigmented villonodular synovitis (PVNS) is a proliferative disorder affecting synovial joints nearly exclusively in the knees, hips, ankles, shoulders, and elbows. It is extremely rare in the spine and in the few previous reports of PVNS, the imaging features shown were nonspecific. We present a case of PVNS where the MR findings may allow prospective diagnosis. These MR findings are based on specific histopathologic features.

Case Report
A 71-year-old man was referred for evaluation of a cervical spine tumor, diagnosed by a percutaneous biopsy 6 years ago at an outside hospital as a “histiocytic (nonmalignant) tumor”. Worsening myelopathy, increasing neck pain, urinary incontinence, and difficulty walking persuaded him to seek surgery.

Imaging Findings
Preoperative CT imaging showed a destructive mass involving the right side of the C6 vertebral body with erosion of the lamina, pedicle, and facets with a few areas of punctate bony sclerosis. A low attenuation soft tissue extra-axial mass extended into the spinal canal and posterolaterally into the extraspinal muscular. The MR findings (Figure) were dramatic showing not only an inhomogeneously enhancing mass with cord compression but importantly demonstrated that this mass was markedly hypointense on T2-weighted images. Surgery revealed a large, solid, multinodular mass. Subtotal tumor removal was followed by spinal column stabilization with bone allograft, iliac bone autograft, and instrumentation. On microscopic examination, there was proliferation of synovial - like mononuclear cells with foamy macrophages, multinucleated giant cells, and histiocytes with intracellular hemosiderin. A pathologic diagnosis of PVNS was established.
Figure. Sagittal FSE T2-weighted imaging of the cervical spine shows a markedly hypointense mass. Associated characteristics are described above.

**SUMMARY**

In this case of PVNS, presumably arising from the synovial-lined right facet joint, the markedly hypointense MR signal of the tumor was thought to be secondary to the widespread hemosiderin deposits in the histiocytic component of the tumor. Recurrent hemorrhage in PVNS of large weight-bearing joints such as the knees and hips explains this finding; however, this has not been a recognized feature in the few previously reported PVNS cases of the spine. The differential diagnosis of a spinal lesion with the characteristics shown here is very limited and should suggest the possibility of PVNS. With consideration of such a benign tumor rather than a malignant mass, the clinical and surgical approach may be affected.

**KEY WORDS:** Cervical spine, pigmented villonodular synovitis, PVNS

**Paper 009 Starting at 7:25 AM, Ending at 7:30 AM**

**Melanotic Schwannoma: A Rare but Very Important Variant**

Adas, R. A. • Glikstein, R. • Woulfe, J.
The Ottawa Hospital/University
Ottawa, ON, CANADA

**PURPOSE**

To present a case of spinal psammomatous melanotic schwannoma without features of Carney’s complex.

**IMAGING FINDINGS**

Enhanced MRI of the whole spine was performed. It demonstrated a well-demarcated extramedullary soft tissue mass with both an intra and extradural component travelling along the course of the right T8 nerve root. The lesion had a high T1, low T2 signal and heterogeneous enhancement postcontrast administration with what seemed like central area of necrosis.

**SUMMARY**

Melanotic schwannomas are rare melanin producing nerve sheath tumors, which were first described in 1932. Since then, less than 100 cases have been reported in the literature. These tumors can appear intracranially (intra or extra axial) and less commonly in the spinal canal. They can arise from cranial, spinal or peripheral nerves. Few cases arising within the skin, muscles, lungs, pancreas, bones, stomach and tongue have been reported in the literature. It is thought that 10% of these tumors are malignant. The presence of psammomatous calcification also is rare in melanotic schwannomas and is often linked to the malignant potential of these tumors. It is reported that 40-50% of psammomatous melanotic schwannomas have Carney’s complex, an AD disorder characterized by skin pigmentation, cardiac myxoma, and endocrine over activity. It is essential for the radiologist to be familiarized with this tumor, which may have similar signal characteristic to lymphoma or melanoma on MR imaging.

**KEY WORDS:** Melanotic schwannoma, MR imaging, spine

**Paper 010 Starting at 7:30 AM, Ending at 7:35 AM**

**Intradural Cervical Neuromuscular Choristoma**

Nathoo, N. • Slone, H. W. • Gandhe, A. • Sarkar, A. • Chaudhury, A. R. • Bourekas, E. C.
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Columbus, OH

**PURPOSE**

Initially described in 1895 with involvement of the sciatic nerve, neuromuscular choristomas, also known as neuromuscular hamartomas, benign triton tumors or nerve rhabdomyomas, are extremely rare, pediatric tumors also that can occur in adults. Although they usually involve the brachial plexus or...
large peripheral nerve trunks, they also may involve cranial nerves and occur intracranially, especially in adults. They consist of striated muscle intimately associated with neural elements. Although resection is curative, biopsy or incomplete excision occasionally is accompanied by spontaneous regression. Treatment should, therefore, be conservative and focused on preservation of nerve function. We report the first case of an intradural cervical neuromuscular choristoma in an adult, involving the posterior nerve rootlets of C2 at the dorsal root entry zone, with histopathologic and neuroimaging findings.

**CASE REPORT**
A previously healthy 44-year-old left-handed female presented with spontaneous onset of right side pain in her neck and shoulder region. Magnetic resonance imaging (MRI) of the cervical spine revealed an enhancing linear lesion continuous with the posterior nerve rootlets at the C2 on the right posterior or spinal cord. The differential diagnosis considered included a schwannoma, or exophytic ependymoma. Following informed consent she underwent a C2-3 laminectomy with opening of the dura and complete excision of the focal lesion at the dorsal root entry zone which involved the posterior nerve rootlets of C2. Her postoperative course was uneventful except for nondisabling right-sided hemi-dysasthesia excluding the face. Microscopic examination revealed bundles of myelinated nerves intermingled with skeletal muscle fibers, fibroconnective tissue and ganglion cells. Immunostaining for S-100 protein - nerves; Desmin - muscle fibers and EMA - for fibroconnective tissue and ganglion cells. Final pathologic diagnosis of any focal lesion which has imaging characteristics of muscle and is located on the cord surface and is intimately associated with the spinal nerve rootlets.

**IMAGING FINDINGS**
On MRI the mass was noted along dorsal spinal nerve roots on the right adjacent to the spinal cord at the C2 level. As is classically seen, it had the same signal intensity as skeletal muscle on all pulse sequences, with signal isointense to the cord on T1-weighted images and low signal intensity relative to the cord on T2-weighted images. After contrast, the lesion was well defined and demonstrated moderate contrast enhancement.

**SUMMARY**
Neuromuscular choristomas are rare, benign tumors that have been described mostly in infants and generally are associated with large nerves such as the brachial plexus, peripheral nerve trunks or cranial nerves. This is the first case of an intradural cervical neuromuscular choristoma in an adult, involving the posterior nerve rootlets at the dorsal root entry zone. Neuromuscular choristoma should be added to the differential diagnosis of any focal lesion which has imaging characteristics of muscle and is located on the cord surface and is intimately associated with the spinal nerve rootlets.

**KEY WORDS:** Neuromuscular choristoma, spinal tumor

Paper 011 Starting at 7:35 AM, Ending at 7:40 AM


Chopko, B. W.1,2 • Georgy, B.3 • Barr, J.3
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**PURPOSE**
The SpineAlign VerteLift device is a controlled expansion, reconstrainable, percutaneously placed vertebral body implant designed to treat thoracolumbar compression fractures. The device is inserted bilaterally, typically via a transpedicular route, with the goals of height restoration, internal support, and cement capture. The author reports magnetic resonance (MR) imaging data on both in vivo and cadaveric constructs.

**CASE REPORT**
All imaging was obtained using 1.5 T commercially available scanners designed for general clinical use. The in vivo scan was additionally obtained with gadolinium contrast. The in vivo patient, an 85-year-old female, was enrolled in a United States Investigational Device Exemption Trial. She experienced excellent pain relief from the implant at L2, but 10 months later underwent MR investigation due to new pain referable to L4-L5. The cadaveric construct was an elderly (over 65 years) female and was implanted at L3.

**IMAGING FINDINGS**
Both studies yielded excellent anatomical resolution at the level of the implanted devices. Signal distortion was minimal and localized to the immediate vicinity of the implant, which had low signal on T1 and T2 sequences. No distortion or artifact was observed in the region of the pedicle, lateral recess, spinal canal or foramen. Enhancement was absent at the treated level. The patient reported no ill effects during or after the MR scan and remained free of complaints referable to this level at 4 months follow up.

**SUMMARY**
The VerteLift implant was associated with minimal MR signal distortion or artifact despite the metallic, bilateral nature of the construct. MR imaging in vivo was well tolerated. The lack of MR signal degradation is advantageous, as postimplant imaging yields highly detailed and useful data to guide subsequent clinical decision making.

**KEY WORDS:** Vertebroplasty, nitinol, MR imaging
Dynamic Cine Angiography as a Diagnostic Tool for Rotational Vertebral Artery Occlusion

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PURPOSE
We describe two cases of bow hunter syndrome also called rotational vertebral artery occlusion associated with osteophytes of cervical vertebral body.

CASE REPORT
Case one: a 48-year-old male with a known right VA occlusion was admitted for vertigo and visual obscuration that were induced by head rotation to the left. On admission date, he intentionally provoked the symptoms by prolonged head rotation which led to loss of consciousness. Case two: a 75-year-old female was seen in our clinic for intermittent episode of vertigo, diplopia and speech difficulty. MR imaging (MRI) and CT angiography revealed left VA occlusion. A functional stenosis of the right VA associated with osteophytes was suspected. The dynamic cine DSA performed in both patients revealed a severe rotational-induced stenosis of the VA at the level of osteophytes.

IMAGING FINDING
Catheter angiography of the affected VA was carried out in neutral head position followed by cine angiograms in various rotational position of the head to provoke the described symptoms (Figure). In both patients the stenosis was visible during dynamic maneuver and reproducible.

SUMMARY
Bow hunter syndrome or rotational vertebral artery stenosis is a rare diagnosis characterized by typical posterior circulation symptoms induced by extrinsic compression of the VA during head rotation. Multiple etiologies have been reported in the literature such as osteophytes, disk herniation, fibrous band and tumors. We present dynamic cine angiograms of two patients with this rare diagnosis.

KEY WORDS: Bow hunter syndrome, dynamic angiography, osteophyte

Monday Morning
6:45 AM - 7:40 AM
Ballroom 6A

(E002) - Excerpta Extraordinaire:
Adult Brain I
(Scientific Papers 013 - 023)

See also Parallel Session
(E001) Excerpta Extraordinaire: Spine

Moderators: Ann K. Jay, MD
Christopher P. Wood, MD
Dynamic contrast-enhanced MR imaging (DCE-MRI) with a multiple-echo 3D projection reconstruction sequence (ME-VIPR) is shown to characterize cerebral blood volume (CBV) and permeability over the entire brain efficiently. The required temporal resolution for simultaneously estimating the arterial input function (AIF) and modeling contrast kinetics often compromises spatial resolution to achieve whole brain coverage. T1 mapping also is required to convert the MR signal into contrast concentration.

**Case Report**

The ME-VIPR sequence was implemented to collect eight radial lines each traversing a different angle in each repetition (TR) on a 3 T scanner (GE Healthcare, Milwaukee, WI). Imaging parameters included receive bandwidth/FOV/TR/TE1/resolution=125kHz/24cm/3.7ms/0.27ms/2.5mm isotropic. Thirty-five 10s acquisitions (total acquisition <6 minutes) were performed continuously. The delivery of intravenous administration of gadolinium contrast (Omniscan, 0.2ml/kg, 5 ml/s) was at the 11th volume. The flip angles (α) changed evenly from 2.5° to 15° in the first six acquisitions to map T1 for conversion of MR signal into contrast concentration. Since $TR << T1$ and $α << 1$ (radian), the T1-weighted MR signal $S = M_0 \rho \sin(1-\exp(-TR/T1))/(1-\exp(-TR/T1)\cos(\alpha))$ was simplified as $S = M_0 \rho (1+T1\alpha^2/2TR)$, where $M_0$ is the apparent spin density. Baseline $T1$ ($T1\rho$) then was obtained by linearly fitting $S_\rho = S(T1\rho)^2TS_\rho + M_0$. MR signal intensity is related to contrast concentration $C$ by: $rC = 1/T1\rho - \alpha/S(2TR(M0\rho - S))$, where $r$ is the contrast relaxivity. The impact of $B1$ inhomogeneity $k$ becomes apparent when replacing $\alpha$ with $ka$: $T1_{act} = T1m/k^2$ and $M0_{act} = M0m/k$ with $T1_{act}$, $M0_{act}$, $T1m$ and $M0m$ being the actual and measured $T1$ and apparent spin densities, respectively. $B1$ correction is straightforward when flip-angle imaging is used for $B1$ mapping. The effective frame rate was increased to 2.5s/frame by using a moving window during reconstruction. Contrast concentration was calculated and fitted to the Tofts model to estimate CBV and permeability.

**Imaging Findings**

Representative T1, CBV and permeability maps from a patient are shown in the figure. The T1 values in the white matter and gray matter are ~800ms and ~1000ms, respectively, and ~3000 ms in the CSF, consistent with literature values. This tumor shows increased CBV and permeability, indicating persistent tumor following radiation and chemotherapy.
IMAGING FINDINGS
Initial pre and postcontrast-enhanced CT scan of the brain demonstrated diffuse enhancement of the basimeninges as well as a homogeneously enhancing solid lesion with cystic component in the right temporal lobe. Subsequent contrast-enhanced T1-weighted MRI of the brain demonstrated extensive diffuse nodular enhancement of the basimeninges associated with solid and cystic mass in the right temporal lobe as well as the preoptic cistern. On T2-weighted imaging, the cystic components of these lesions demonstrated extremely high signal intensity which suppressed on FLAIR imaging while T1-weighted imaging demonstrated hypointense signal. MR imaging of the spinal axis demonstrated diffuse nodular meningeal enhancement extending from cervical to lumbar spine. Avid FDG uptake was noted on FDG PET imaging.

SUMMARY
Diffuse astrocytoma account for about 5% of primary central nervous system (CNS) tumors with protoplasmic astrocytoma being the rarest variant. Radiologically, these tumors can mimic neurosarcoidosis, tuberculosis, and fungal infections among other rare entities. Our patient’s presentation and clinical course demonstrate the importance of repeat biopsy in cases of diffuse leptomeningeal enhancement of the craniospinal axis associated with intracranial lesions on MR imaging when a diagnosis is unknown and there is no clinical history to support other differential diagnoses. Radiologists need to be aware of diffuse protoplasmic astrocytomas, as both radiologic and clinical presentation can make this a complex and challenging diagnosis.

KEY WORDS: Protoplasmic astrocytoma, MR imaging, craniospinal axis

IMAGING FINDINGS
Primary gliosarcoma (PG) is a rare malignant brain tumor presenting both glial and mesenchymal components. Prognosis is at least as poor as glioblastoma’s. Imaging appearance with conventional MR imaging (MRI) is variable and can be indistinguishable from glioblastoma. Recent literature reported two different types of PG with different prognosis: one mimicking the appearance of a meningioma, and one resembling glioblastoma. Primary gliosarcomas features have not been reported with combined multimodal including perfusion and spectroscopy. The purpose of this presentation is: 1. to present the MRI aspects of pathologically confirmed PG with conventional MRI, spectroscopy and perfusion. 2. Determine whether perfusion and spectroscopy can help distinguish PG from glioblastomas.

CASE REPORT
We retrospectively reviewed the MRI findings, clinical information and pathology reports of four patients presenting with PG between 2005 and 2010 in our institution. All patients had a multimodal MRI protocol including at least T2-weighted images, FLAIR images, T1-weighted images with and without gadolinium injection, diffusion images, MR perfusion and spectroscopy (TE: 35ms 144ms). Eleven patients with glioblastoma studied during the same period with the same MRI protocol were used as a control population. The Perfscape software (Olea Medical, La Ciotat, France) was used to determine maximal rCBV (relative cerebral blood volume), KTrans and rCBF.

IMAGING FINDINGS
Patients were three male and one female. Average age at diagnosis was 59 years, ranging from 48 to 75 year. Three lesions were supratentorial (one frontal and two temporal) and one lesion was cerebellar. Lesion sizes ranged from 26mm to 64mm (average 44mm). Two patients presented with a predominantly tissular mass, while the other two patients presented with a mostly necrotic tumor resembling glioblastoma with adjacent dural thickening. Macroscopic peripheral vessels were observed in two patients on conventional sequences. Findings on diffusion imaging were unremarkable. Spectroscopy sequences showed a profile of high-grade tumor, with elevated choline, decreased NAA and presence of a large resonance of lipids and lactate. In perfusion sequences, maximal rCBV values were higher than those observed in gliosarcomas. The mean maximal rCBV value was 10.2 in PG patients, as compared to 2.96 in glioblastoma patients (p < 0.001).
SUMMARY
We present the first reported results of multimodal MRI in primary gliosarcomas in four patients. We confirm the two different subtypes of this tumor: predominantly solid or heterogeneous necrotic masses with dural invasion. Spectroscopy results were similar to those of glioblastomas. Gliosarcomas always appeared hypervascular with higher perfusion values than glioblastomas.

KEY WORDS: Gliosarcomas, perfusion, spectroscopy

Paper 016 Starting at 7:00 AM, Ending at 7:05 AM
An Unusual Cause of Multiple Intracranial and Spinal Extradural Masses
Hingwala, D. R. • Thomas, B. • Chandrasekharan, K. • Radhakrishnan, V. V.
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Thiruvananthapuram, INDIA

PURPOSE
To study the imaging findings in an unusual case of germinoma.

CASE REPORT
A 24-year-old male patient presented with intermittent, moderate, holocranial headache of 1 year duration, weakness and numbness of left half of body and whole face(left > right) since 2 months and difficulty in chewing food. He also complained of visual diminution for 1 month(left > right) with repeated bumping into objects. On examination, patient was conscious and co-operative. Visual acuity was reduced to 4 feet in right eye and 2 feet in left eye. Bitemporal field cuts were present. Corneal reflex was impaired bilaterally with numbness on both sides of face(CN V involvement). Remainder of cranial nerves were normal. Power on left side was 3/5 and on right side was 5/5. There were no neurocutaneous markers.

IMAGING FINDINGS
MR imaging(MRI) showed multiple mass lesions located in the sellar-suprasellar, pineal, and parasellar regions. Parasellar masses extended up to the Meckels cave. Suprasellar mass was separate from the optic chiasm and displaced it superiority. All these masses were of similar signal intensity (isointense to gray matter on T1-weighted images, mildly hyperintense on T2-weighted images with intense, homogenous enhancement on administration of contrast). There was mild restriction of diffusion. There were no susceptibility artifacts in the masses or rest of the brain. Similar intensity extradural lesions also were present in left C2 - C3 foramen causing cord compression and adjacent to the right pedicle of fifth dorsal vertebra.

SUMMARY
Primary germ cell tumors of the central nervous system(CNS) typically develop as midline mass lesions. In our case, neuroradiologic recognition of germinoma was difficult; as apart from the suprasellar and pineal masses, MRI showed parasellar and spinal epidural masses, raising the suspicion of neurofibromatosis II. The histopathologic diagnosis was made after surgery of the spinal and suprasellar mass and supported by Periodic Acid Schiff and Placental Alkaline Phosphatase staining. While germinomas are known to have subarachnoid and intramedullary metastases, epidural metastases are rare. Ascending metastases also have been described. However, after cerebrospinal fluid (CSF) dissemination, malignant cells could be trapped in the spinal nerve sheath and thus metastasize to the epidural space. In our case, it is unclear which tumor is primary or whether all the tumors are synchronous. This case is an unusually disseminated case of germinoma involving pineal, suprasellar, parasellar and extradural spinal regions. Radiologic diagnosis of germinoma is important as these tumors are sensitive to craniospinal irradiation.

KEY WORDS: Germinoma, parasellar, extradural

Paper 017 Starting at 7:05 AM, Ending at 7:10 AM
Diffuse Intracranial and Spinal Leptomeningeal Gliomatosis: Diagnostic Challenges
Potter, G. M. • Shewchuk, J. R. • Redekop, G. A. • Maguire, J. A. C. • Heran, M. K. S.
University of British Columbia
Vancouver, BC, CANADA

PURPOSE
To demonstrate the diagnostic challenges which may be encountered in patients with diffuse leptomeningeal gliomatosis.

CASE REPORT
A 27-year-old male presented with progressive nausea and vomiting, weight loss, left lower extremity weakness and decreased level of consciousness. CT head showed hydrocephalus, for which VP shunts were placed. There was no history of fever, sweats or chills. Past medical history included Dengue fever and an 8-year history of nausea and vomit-
ing. Physical examination showed only mild left lower extremity weakness with no meningismus. Initial dural biopsy was nondiagnostic. Infectious and inflammatory markers were negative. Brain MR imaging (MRI) showed diffuse leptomeningeal enhancement, a mass at the pontomedullary junction and multiple areas of cortical T1 hyperintensity, suggestive of histologic laminar necrosis. Whole spine MRI showed diffuse leptomeningeal enhancement, patchy high T2 cord signal, prominent vessels on the dorsal and ventral surface of cord, and patchy cord enhancement. Spinal angiogram showed extensive hypervascular blush on cord surface, with no evidence of a dural arteriovenous fistula. Arachnoid/dorsal nerve root biopsies were performed via lumbar laminectomy. Pathologic features were indeterminate, with no consensus amongst members of the neuropathology service. Definitive biopsy of the left pontomedullary junction mass was performed by neurosurgery. Pathology was definitively confirmed as leptomeningeal gliomatosis.

**IMAGING FINDINGS**

MR imaging of brain showed multiple areas of T1 hyperintensity suggestive of cortical laminar necrosis due to subacute infarction, and diffuse leptomeningeal enhancement with further enhancement in the basal ganglia regions and in a perivascular distribution. A mass also was identified at the anterior pontomedullary junction, although it was unclear whether this was intraaxial or extraxial in location. Spine MRI showed prominent vessels along the surface of the entire spinal cord and patchy T2 cord hyperintensity (left, Figure), diffuse leptomeningeal enhancement and patchy cord enhancement (right, Figure). Formal spinal angiography showed an enlarged artery of Adamkiewicz, retrograde filling of the contralateral-recruited hypertrophied pial arterial circulation, opacification of the posterior spinal artery, and marked venous engorgement, but no arteriovenous shunting. Venous engorgement was postulated to be due to a combination of increased blood flow as well as impaired venous drainage, particularly in the spinal subarachnoid space.

**SUMMARY**

This case demonstrates a case of diffuse leptomeningeal gliomatosis, a rare but important condition, in a young patient with minimal neurologic deficit, in whom MRI showed marked leptomeningeal enhancement throughout the neuraxis, most likely originating from a primary brainstem site, and features mimicking a spinal dural arteriovenous fistula.

**KEY WORDS:** Leptomeningeal, gliomatosis

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**Neurocytoma of the Hippocampal Allocortex: A Rare Cause of Chronic Partial Complex Seizures**

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University of Iowa Hospitals & Clinics
Iowa City, IA

**PURPOSE**

To review a case of atypical extraventricular neurocytoma of the hippocampus causing chronic epilepsy and to revisit the concept of limbic tumors.

**CASE REPORT**

A 36-year-old man presented with 20-year history of partial complex seizures with aura followed by brief aphasia. MR imaging in 1997 (not available) was interpreted as left hippocampal sclerosis. He unsuccessfully received multiple antiepileptic drugs. MR imaging on 9/5/2008 showed a mass within the left hippocampus. Video EEG displayed left temporal seizure onset. The patient did not comply with follow-up. On 06/21/2010 he sought medical care for seizures and language difficulties. CT and MR imaging revealed frank enlargement of the mass. On 6/23/10 the patient underwent left anterior temporal lobectomy. Microscopic analysis showed densely packed tumor cells with round to oval nuclei and perinuclear halos. Up to nine mitoses per high power field were identified with areas of nuclear pleomorphism. Large ganglion-like cells but no Rosenthal fibers or eosinophilic granular bodies were found. Immunohistochemistry was strikingly positive for synaptophysin and NeuN. MIB1 showed 10% positive nuclei. GFAP and S-100 were positive only in reactive astrocytes. Cytogenetics did not show 1p 19q deletions. Final diagnosis was atypical extraventricular neurocytoma (WHO grade III). Radiation therapy was completed on 9/21/10 with a total dose of 61.2 Gy in 34 fractions. Four months after surgery the patient’s speech was clear. He had right temporal visual field deficit. Cranial nerves were otherwise intact. Muscle strength was normal. He denied headaches, numbness, seizures, or problems with balance or coordination.

**IMAGING FINDINGS**

An MR image on 9/5/2008 showed a mass lesion strictly circumscribed within the left hippocampal formation with homogeneous low T1, high T2 signal and no contrast enhancement (Figure). A diagnosis of lograde tumor was entertained. Follow-up MRI 21 months later displayed contrast enhancement, edema and mass effect consistent with dedifferentiation into grade III neurocytoma.
SUMMARY
The case presented is remarkable in that an originally low-grade neuronal neoplasm of the left hippocampus was the likely cause of the patient’s 20-year history of seizures. MR imaging displayed a tumor strictly circumscribed to the allocortex of the left hippocampus. The limbic system is composed of an inner allocortex (including the hippocampus) and a periallocortical belt. Limbic tumors tend to spread within the confines of the allocortex. Limbic tumors associated with epilepsy involve younger subjects, exhibit stable behavior for years and benefit from excellent seizure control when completely resected.

KEY WORDS: Allocortex, epilepsy, neurocytoma

Paper 019 Starting at 7:15 AM, Ending at 7:20 AM
Metastatic Adenocarcinoma to an Intracranial Meningioma: Case Report
Gostenik, K. • Patel, S. • Wang, A. • Donev, K.
William Beaumont Hospital
Royal Oak, MI

PURPOSE
To review the relatively uncommon phenomenon of metastatic disease to an intracranial meningioma and to discuss the associated imaging features.

CASE REPORT
A 77-year-old female with a history of lung cancer initially presented with mental status change and seizures. MR imaging of the brain was obtained and revealed a large extra-axial mass with somewhat unusual imaging features in the left frontal lobe.

IMAGING FINDINGS
MR imaging showed a 4 cm extra-axial mass within the left frontal lobe, which was relatively isointense on T1 images, hyperintense on T2 images and demonstrated enhancement following administration of gadolinium. There was associated surrounding vasogenic edema. The mass was presumed to be a meningioma. However, within the meningioma there was a well circumscribed 1.6 cm area, which was hypointense on T1 images, hyperintense on T2 images and demonstrated delayed enhancement on postcontrast images.

SUMMARY
Tumor to tumor metastasis is a rare phenomenon with the majority of reported cases involving intracranial meningiomas. There have been several case reports of intracranial collision tumors; however, the imaging characteristics of this phenomenon have been described infrequently. We present a case of a 77-year-old female with a history of lung cancer who presented with mental status change and seizures and
was found to have a meningioma with atypical imaging features. The mass subsequently was resected and pathology revealed metastatic adenocarcinoma to a WHO grade I meningioma. A review of the literature with attention to the imaging characteristics of metastatic disease to intracranial meningiomas will be discussed.

**Key Words:** Metastasis to meningioma, collision tumor

**Paper 020 Starting at 7:20 AM, Ending at 7:25 AM**

**Rare Anaplastic Hemangiopericytoma of the Cerebellopontine Angle Arising from the Facial Nerve**

Bernhard, M. R. • Reardon, M. A. • Mohila, C. A. • Kesser, B. W. • Mukherjee, S. • Wintermark, M. • Raghavan, P. • Bernhard, M. R. • Reardon, M. A. • Mohila, C. A. • Kesser, B. W. • Mukherjee, S. • Wintermark, M. • Raghavan, P.

University of Virginia Medical Center
Charlottesville, VA

**Purpose**

To describe the first case in the literature of an anaplastic hemangiopericytoma of the cerebellopontine (CP) angle arising from the facial nerve and to review the radiologic and histopathologic features. Primary intracranial hemangiopericytomas are rare, aggressive sarcomas arising from Zimmermann pericytes. Hemangiopericytomas are difficult to distinguish from meningiomas, solitary fibrous tumors, or nerve sheath tumors based on presentation and imaging findings. Isolated hemangiopericytomas of the CP angle rarely have been reported; however, no previous reports have described a hemangiopericytoma involving the facial nerve.

**Case Report**

A 61-year-old, African-American woman presented with a left facial droop, unresponsive to steroid and acyclovir treatment for presumed Bell’s palsy. Intervally, the patient had developed acute left-sided hearing loss, followed by nausea, vomiting, and hypesthesia on the left half of her face.

**Imaging Findings**

Noncontrasted CT demonstrated a 2.7 x 2.8 x 2.2 cm hemorrhagic, extra-axial left CP angle mass which exerted mass effect on the pons, cerebellar peduncle, and left cerebellar hemisphere with surrounding edema and effacement of the fourth ventricle. The mass extended into and widened the internal auditory canal (IAC), destroying the roof of the IAC. The mass extended along the facial nerve, destroying the labyrinthine, tympanic, and mastoid portion of the canal. There was expansion of the geniculate fossa with lateral displacement of the ossicles and erosion of the tegmen tympani, apical turn of the cochlea and the vestibule. There was destruction of the roof of the petrous segment of the temporal bone, as well as smooth enlargement of the left stylomastoid foramen. Denervation atrophy of the left risorius muscle also was identified. On MRI, a hemorrhagic mass was seen within the left CP angle, extending into and widening the internal auditory canal. The mass was again seen to follow the course of the facial nerve, expanding the labyrinthine, tympanic, and mastoid segments of the canal. T1 postcontrast images demonstrated contrast enhancing soft tissue in the middle ear cavity, displacing the ossicles and eroding the tegmen tympani, cochlea, vestibule, and semicircular canals. Histologic examination demonstrated a hypercellular neoplasm composed of irregular, pleomorphic, spindled cells embedded within a collagenous matrix. The immunohistochemical profile was consistent with an anaplastic hemangiopericytoma.

**Summary**

Hemangiopericytomas are rare, aggressive mesenchymal tumors predominantly arising in the skin and musculoskeletal system, but also have been documented in the pleural cavity, extrapleural space, thyroid, and nasal cavity. Hemangiopericytoma of the CP angle have been described previously in the neurosurgical and radiologic literature, and only one other case report has identified a hemangiopericytoma arising from a cranial nerve. To our knowledge, this case represents the first description in the literature of a hemangiopericytoma arising from the facial nerve.

**Key Words:** Hemangiopericytoma, facial nerve, cerebellopontine angle

**Paper 021 Starting at 7:25 AM, Ending at 7:30 AM**

**Lymphomatosis Cerebri: A Rare Imaging Presentation of Central Nervous System Lymphoma**

Ismail, A. F. • Bruch, L. A. • Moritani, T. • Capizzano, A. A.

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Iowa City, IA

**Purpose**

To review the imaging findings of lymphomatosis cerebri (LC), a rare imaging presentation of primary central nervous system lymphoma (PCNSL); and to propose that LC also may be seen in secondary central nervous system (CNS) lymphoma.

**Case Report**

We present two cases of LC. Case 1: Fifty-five-year-old female presented with memory problems, gait disturbance and left hemiparesis that had progressed over a year. Contrast-enhanced brain MR imaging showed extensive white matter lesions with minimal enhancement, few foci of restricted diffusion and predominantly facilitated diffusion. Differential diagnoses included progressive multifocal leukoencephalopathy (PML), gliomatosis cerebri or encephalitis. Work-up for malignancy and HIV was negative. Cerebrospinal fluid (CSF) analysis was negative for multiple sclerosis, viral or cryptococcal markers. Right frontal lobe biopsy showed infiltrating large B-cell lymphoma. Case 2: Sixty-four-year-old man with tonsillar diffuse large B cell lymphoma presented with increased ataxia, low-grade fever and leukocytosis starting after initiation of chemotherapy. Contrast-enhanced brain MRI showed diffuse white matter lesions without enhancement or restricted diffusion. Differential diagnoses were postchemotherapy leukoencephalopathy versus lymphomatous infiltration of the brain. Cerebrospinal fluid cytology showed no tumor cells. Right frontal lobe biopsy showed infiltrating large B-cell lymphoma.
IMAGING FINDINGS
MR imaging in both patients showed extensive high T2/FLAIR signal in the subcortical and periventricular white matter, external and internal capsules, corpus callosum, basal ganglia, cerebral peduncles, cerebellar peduncles and bilateral cerebellar hemispheres. There was minimal patchy enhancement and few areas of restricted diffusion in one patient, with predominantly facilitated diffusion of the lesions.

SUMMARY
The most common presentation of PCNSL in immunocompetent patients is focal or multifocal masses involving the basal ganglia, periventricular white matter and corpus callosum. These masses are usually homogenously hypointense or isointense to the cortex on both T1- and T2-weighted images, and demonstrate avid enhancement and restricted diffusion. Secondary CNS lymphoma most frequently presents with leptomeningeal infiltration (two thirds of cases) with parenchymal infiltration seen in one third of cases. Diffusely infiltrating PCNSL, known as LC in imaging literature, involves the white matter with varying mass effect, predominantly facilitated diffusion and minor or no enhancement. However, to our knowledge, LC has not been described in secondary CNS lymphoma. Differential diagnoses of LC include leukoencephalopathies such as PML, gliomatosis cerebri or demyelinating disease, resulting in delayed proper treatment of these patients. Therefore, LC should be considered in the differential diagnosis of extensive nonenhancing white matter lesions to optimize treatment for these patients in timely fashion.

KEY WORDS: Lymphoma, MR imaging, DWI

Advanced MR Brain Imaging, Diffusion Tensor Imaging and Susceptibility-Weighted Imaging, Demonstrating Marantic Emboli and Intracranial Metastases of Cardiac Myxoma
Nguyen, V. N. • Quigley, E. P. • Evans, C. J.
University of Utah
Salt Lake City, UT

PURPOSE
To demonstrate the role of advance imaging techniques in the diagnosis of neoplastic thromboembolic disease.

CASE REPORT
A 38-year-old, previously healthy, female who presented to an outside hospital with acute onset of right-sided weakness. According to outside emergency department, patient was dysarthric, had right facial droop, and was complaining of occipital headache. Nonenhanced and contrasted-enhanced CT brain was performed, demonstrating focus of hemorrhage, hyperdensity, and adjacent edema within right occipital lobe. Upon transfer, stroke service evaluation yielded GCS of 15 with full resolution of prior symptoms. Upon further patient interrogation, the patient’s spouse reported a 1-year history of slow neurologic decline with episodic right-sided paresthesia and personality changes. A stroke work up to include CTA of the neck and brain was performed. There were no findings for arterial occlusive disease. However, abnormal vessels were present adjacent to the area of hemorrhage. MR imaging evaluation showed findings concerning for an enhancing mass with multiple additional areas of multiterritorial diffusion restriction abnormalities concerning for a central embolic source. This was followed by transthoracic echocardiography demonstrating left atrial mass concerning for a myxoma. After neurosurgical consultation, patient underwent intracranial tumor resection. Histologic evaluation of the lesion was consistent with metastatic cardiac myxoma. The patient subsequently underwent cardiac tumor resection with pathology positive for atrial myxoma.

IMAGING FINDINGS
Nonenhanced CT of brain demonstrates right occipital hyperdense mass with adjacent low density. MR imaging of brain shows right occipital heterogenous enhancing mass with associated vasogenic edema. However, Diffusion tensor imaging (DTI) displays multiple bilateral supratentorial foci of acute diffusion restriction. On susceptibility imaging, there is associated hypointensity, suggesting hemorrhage, blood products, or hemorrhagic metastases. These small lesions exhibited associated FLAIR signal but did not demonstrate enhancement.
SUMMARY
The advanced imaging sequences of diffusion tensor and susceptibility-weighted imaging critically modifies the differential diagnosis in a young patient with a solitary brain mass. Given the random distribution, mural or embolic etiologies were considered. In the setting of solitary brain mass with additional embolic disease, differential diagnosis includes embolic stroke, mural or tumor emboli, or hypercoagulability associated with neoplasm.

KEY WORDS: Metastasis, susceptibility, diffusion tensor

Paper 023 Starting at 7:35 AM, Ending at 7:40 AM

Third Ventricular Craniopharyngioma with Unusual MR Perfusion Characteristics

Jones, J. G. A. • Mogensen, M. A. • Shiroishi, M. S. • Go, J. L. • Kim, P. E. • Chen, B. T. • Boyko, O. B. • Kang, J. S. • Law, M.

1University of Southern California, Los Angeles, CA, 2City of Hope, Duarte, CA, 3California State University Los Angeles, Los Angeles, CA

PURPOSE
To describe previously unreported imaging characteristics, including MR perfusion and permeability, of an intraventricular papillary craniopharyngioma.

CASE REPORT
A 45-year-old male with intermittent headache, nausea, and dizziness over the course of a year was found to harbor a third ventricular mass on MR imaging (MRI). Pathology of the operatively managed lesion was consistent with a papillary craniopharyngioma.

IMAGING FINDINGS
MR imaging of the brain (Figure 3) revealed a well circumscribed 2.3 x 2.5 x 2 cm heterogenously enhancing mass adjacent to the hypothalamus within the third ventricle. The lesion appeared hypervascular, and on MR perfusion demonstrated increased blood volume, with an rCBV of 1.94 (Figure 1). Permeability also was elevated.

SUMMARY
Papillary craniopharyngiomas are rare intraxial brain tumors with a predilection for older patients and intraventricular extension. As opposed to the adamantinomatous form, fibrovascular microarchitecture (Figure 2) of papillary craniopharyngiomas may underlie increased blood volume, which mimics findings of high-grade glioma.

KEY WORDS: Craniopharyngioma, perfusion, ventricle
Monday Morning
7:40 AM - 7:45 AM
Ballroom 6 B/C

(1) Opening Remarks
— Carolyn Cidis Meltzer, MD, F ACR, ASNR President

Opening Remarks
Carolyn Cidis Meltzer, MD, F ACR, ASNR President

PRESENTATION SUMMARY
Welcome participants to the 49th annual ASNR meeting. Brief overview of meeting contents and highlights.

Monday Morning
7:45 AM - 8:45 AM
Ballroom 6 B/C

(2) Maintenance of Certification (MOC) - Review Session (AR) Spinal Instrumentation: Imaging/Clinical Correlations and Complications

(025) Lumbar Spine Instrumentation
— Jens R. Chapman, MD
(026) Imaging of the Lumbar Spine Fusion
— Alan L. Williams, MD, F ACR, MBA
(027) Complications of the Lumbar Spine Procedures
— Ryan D. Murtagh, MD, MBA

Moderator: Robert M. Quencer, MD

An Educational grant was received by Bayer Healthcare Pharmaceuticals Inc. in support of the Audience Response (AR) technology in the Maintenance of Certification (MOC) Review Sessions.

Lumbar Spine Instrumentation
Jens R. Chapman, MD

Imaging of the Lumbar Spine Fusion
Alan L. Williams, MD, F ACR, MBA

PRESENTATION SUMMARY
Operative techniques for immobilizing a painful lumbar vertebral motion segment or segments, or an unstable portion of the lumbar spine have been in use for many years. This presentation will describe the various types of lumbar fusions in current clinical practice, including an alphabet soup of ALIF (anterior interbody fusion), TLIF (transforaminal interbody fusion), DLIF (direct lateral interbody fusion), XLIF (extreme lateral interbody fusion), AxiaLIF (transsacral fusion), and various posterior fusions and associated instrumentation. Common interbody fusion devices will be reviewed. Osteoinductive bone graft substitutes such as bone morphogenetic protein (BMP) will be discussed. The radiographic appearance of these fusion procedures, with emphasis upon computed tomography (CT), will be presented. Examples of complications related to these procedures will be demonstrated.

REFERENCES

Complications of the Lumbar Spine Procedures
Ryan Murtagh, MD, MBA

PRESENTATION SUMMARY
Operative techniques for immobilizing a painful lumbar vertebral motion segment or segments, or an unstable portion of the lumbar spine have been in use for many years. This presentation will describe the various types of lumbar fusions in current clinical practice, including an alphabet soup of ALIF (anterior interbody fusion), TLIF (transforaminal interbody fusion), DLIF (direct lateral interbody fusion), XLIF (extreme lateral interbody fusion), AxiaLIF (transsacral fusion), and various posterior fusions and associated instrumentation. Common interbody fusion devices will be reviewed. Osteoinductive bone graft substitutes such as bone morphogenetic protein (BMP) will be discussed. The radiographic appearance of these fusion procedures, with
emphasis upon computed tomography (CT), will be presented. Examples of complications related to these procedures will be demonstrated.

REFERENCES

Monday Morning

8:45 AM - 10:15 AM
Ballroom 6 B/C

(3) Plenary Session: Translational Research in Neuroradiology

(028) Introduction
   — David B. Hackney, MD, FACP
(029) From Bench to Bedside Diffusion and Perfusion Imaging, and What’s Next
   — Timothy P. L. Roberts, PhD
(030) Coding and Reimbursement Considerations in Adopting New Imaging Methods
   — Robert M. Barr, MD
(031) New Techniques into Clinical Practice: The Academic Viewpoint
   — William P. Dillon, MD
(032) Panel Discussion
Moderator: David B. Hackney, MD, FACP

Introduction
David B. Hackney, MD, FACP

From Bench to Bedside Diffusion and Perfusion Imaging and What’s Next
Timothy P. L. Roberts, PhD

Coding and Reimbursement Considerations in Adopting New Imaging Methods
Robert M. Barr, MD

Presentation Summary
What determines how a new imaging procedure or technique becomes a reimbursable code? The basic steps will be discussed with a focus on the Current Procedural Terminology (CPT) Editorial Panel and the Relative Value Scale Update Committee (RUC), and the role the ASNR Clinical Practice Committee plays in advocating for the development and reimbursement of codes through this process. The presentation will include important points to consider when developing new CPT Category I or Category III (investigational) CPT codes for neuroradiology procedures. Next, the RUC process for valuing new codes will be reviewed, as well as the various methods by which existing codes can be reevaluated by the RUC for potential changes in reimbursement. Following establishment of a Category I CPT code and a recommended valuation by the RUC, it is up to the Center for Medicare and Medicaid Services (CMS) to establish the final code value and to determine coverage policy. We will discuss how this process has affected recent neuroradiology codes and what role ASNR members can play in that process.

New Techniques into Clinical Practice: The Academic Viewpoint
William P. Dillon, MD

Presentation Summary
Academic medical centers are challenged with developing and testing new imaging techniques and processing algorithms years prior to reimbursement. Yet clinicians come to depend on such techniques and demand their use, presenting formidable economic and legal issues to academic neuroradiologists. In this presentation, I will highlight some of these issues, and how UCSF has dealt (or not dealt) with these challenges. We will highlight the development of MR spectroscopy and perfusion imaging for brain tumors, DTI, and perfusion imaging for stroke as examples of the integration of "bleeding edge" technology and how this can encourage referrals, as well as prevent "leakage" of imaging outside of a medical center.
Selective Age-Dependent Microstructural Central Nervous System Injury in Nonaccidental Trauma: A Diffusion Tensor Study

Panigrahy, A.1,2 • Wisnowski, J.2,3 • Tokar, E.2 • Ceschin, R.1 • Hamilton, A.2 • Tavare, C. J.2 • Nelson, M. D.2 • Bluml, S.2,4 • Imagawa, K. K.2
1Children's Hospital of Pittsburgh of UPMC, Pittsburgh, PA, 2Children's Hospital Los Angeles, Los Angeles, CA, 3University of Southern California, Los Angeles, CA, 4Rudi Schulte Research Institute, Santa Barbara, CA

PURPOSE
While diffusion-weighted imaging has been shown to provide additional information about cytotoxic edema patterns in nonaccidental trauma (NAT), the utility of diffusion tensor imaging (DTI) in the evaluation of NAT patients is not understood. We hypothesized that DTI could delineate potential age-dependent patterns of microstructural injury which may be better at predicting outcome compared to other variables.

MATERIALS & METHODS
High-resolution DTI data were obtained in 35 infants with confirmed NAT and a comparison cohort of 46 age-matched control-term infants. Quantitative analysis was performed with: (1) manual region of interest (ROI) analysis of 11 standardized regions and (2) voxel-based analysis of cerebral white matter tracts using Tract-Based Spatial Statistics (TBSS), FSL (Oxford). Brain metric measurements and initial presentation clinical variables were recorded. Outcome data were determined by using a Pediatric Cerebral Performance Category Score in review of the charts of NAT patients who returned for follow-up evaluation.

RESULTS
In patients less than 3 months of age, the splenium of the corpus callosum demonstrated reduced anisotropy (Figure 1 - right) (p<0.001). In contrast, in patients greater than 3 months of age, the genu of the corpus callosum demonstrates reduced anisotropy (Figure 1 - left) (P<0.006). The reduced fractional anisotropy in the genu and frontal lobe volume in the NAT patients greater than 3 months of age did correlate with poor outcome (p< 0.0001) compared to conventional imaging and initial clinical variables including GSC score. There was no statistical difference in average diffusivity metrics between the NAT and controls. However, the standard deviation of the diffusivity measurements was increased statistically in the NAT group (p<0.001) which likely reflect a combination of acute and chronic injury.

CONCLUSION
Diffusion tensor imaging demonstrates selective age-dependent microstructural injury in cerebral white matter structures in NAT patients. Reduction in fractional anisotropy in the genu of the corpus callosum and decreased frontal lobe volume can predict poor outcome in NAT patients.

KEY WORDS: Nonaccidental trauma, brain imaging

Diffusion Tensor MR Imaging in Blast-Induced Brain Injury after Combat-Related Exposures

Kim, J. • Jorge, R.
University of Iowa
Iowa City, IA

PURPOSE
Traumatic brain injury (TBI) has been described as the "signature wound" of Operation Iraqi Freedom (OIF) and Operation Enduring Freedom (OEF). The purpose of the present study is to investigate the neurobiologic evidence of the neurobehavioral changes observed after combat-related blast injury. We assessed structural brain alterations in a group of veterans who had a blast TBI during active military duty using diffusion tensor imaging (DTI) technique.
**Materials & Methods**

We studied 44 male veterans (aged 22-55; mean±SD 29.6±9.31) who have sustained a blast TBI during deployment to OIF/OEF and 48 control veterans with similar demographic characteristics and deployment experiences who have not experienced TBI (aged 22-55; mean±SD 31.8±8.41). Only right-handed veterans without evidence of macroscopic brain injuries participated in this study. All participants underwent extensive neuropsychiatric and neuropsychological assessments. Traumatic brain injury participants sustained injuries between 5 and 60 months prior to data collection. Severity of TBI was assessed using the Mayo Clinic classification system. Brain MRI examinations were performed on a 3 T scanner including a single-shot diffusion-weighted echo-planar sequence and structural T1- and T2-weighted 3D imaging sequences. Integrity of major white matter (WM) fiber tracts was indirectly inferred by means of mean diffusivity (MD), radial diffusivity (RD), fractional anisotropy (FA) and volume ratio (VR) metrics. Images were spatially transformed into a standard template using a non-linear spatial normalization method. Group DTI images were analyzed statistically using the tract-based spatial statistics (TBSS) method. General linear model analyses were performed to evaluate local differences of DTI metric values across the whole WM skeleton between the groups. Statistical significance inference was made using permutation-based nonparametric testing with threshold-free cluster enhancement (TFCE) and family-wise error correction.

**Results**

Traumatic brain injury subjects had lower FA and higher VR values than controls (uncorrected P < 0.01, or corrected P < 0.4) in the following WM areas: corpus callosum (CC), right corona radiata, right posterior limb of internal capsule, right superior longitudinal fasciculus, right sagittal stratum and right cerebral peduncle. The splenium of the CC showed the greatest FA reduction in TBI group (corrected Pmax = 0.27). Higher RD values were observed in the TBI group compared to the controls in the right parahippocampal WM, left subthalamic area, right central pons, and bilateral superior cerebellar peduncles (uncorrected P < 0.05). Mean diffusivity map showed nonsignificant difference between TBI and control groups when we applied the same statistical threshold criteria as in the FA comparison. The results from voxel-wise analyses were verified using a secondary region-of-interest approach.

**Conclusion**

This study found evidence for WM injury in subjects with combat-related TBI. Fractional anisotropy and VR differences were found predominantly in the projection and callosal WM tracts on the right side. Our results are somewhat different from previous mild TBI studies in civilian populations, which may be due to the different pathophysiologic mechanism associated with blast injuries. In addition to a meticulous validation, further studies should investigate the effect of recurrent mild TBI, the structural WM changes associated with substance abuse, and the relationship of DTI alterations with the neuropsychiatric and neuropsychological variables.

**Key Words:** Neurotrauma, blast injury, diffusion tensor imaging

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**Paper 035 Starting at 11:01 AM, Ending at 11:09 AM**

**CT Patterns of Traumatic Subarachnoid Hemorrhage and Neurologic Outcome**

Wong, G. K. C. • Yeung, J. • Poon, W. • Rainer, T.

The Chinese University of Hong Kong

**Purpose**

Traumatic subarachnoid hemorrhage is a poor prognostic factor for traumatic brain injury. We aimed to further investigate neurologic outcome among head injury patients by examining the prognostic values of computed tomography (CT) patterns (thickness and distribution) of traumatic subarachnoid hemorrhage.

**Materials & Methods**

The study was conducted in a regional trauma center in Hong Kong. We collected prospective data on consecutive trauma patients from January 2006 to December 2008. We recruited patients with significant head injury [as defined by a head Abbreviated Injury Scale (AIS) score of 2 or more] with traumatic subarachnoid hemorrhage according to admission CT.

**Results**

Over the 36-month period, 661 patients with significant head injury were admitted to the Prince of Wales Hospital in Hong Kong. Two hundred fourteen (32%) patients had traumatic subarachnoid hemorrhage (tSAH) on the admission CT. The mortality and 6-month unfavorable outcome were significantly greater for patients with tSAH. Multivariable analysis showed that favorable outcome was independently associated with a younger age, a lower ISS, a lower RTS, thinner subdural hematoma, thicker extradural hematoma, and thinner tSAH, but not with location of tSAH. Multivariable analysis also revealed that survival was associated independently with a younger age, a lower ISS, a lower AIS head and neck, open cisterns, and thinner tSAH, but not with the location of tSAH.

**Conclusion**

Maximum thickness of tSAH was an independent prognostic factor for mortality and clinical outcome. Anatomical distribution per se did not affect the clinical outcome.

**Key Words:** Traumatic brain injury, subarachnoid hemorrhage, neurologic outcome
Initial Prefrontal Axial Diffusivity Predicts Long-Term Executive Function after Mild Traumatic Brain Injury

Gulko, E.1 · Lipton, M. L.1,2 · Zimmerman, M. E.2 · Gardin, T.1 · Branch, C. A.1,2 · Lipton, R. B.1,2
1Montefiore Medical Center, Bronx, NY, 2Albert Einstein College of Medicine, Bronx, NY

PURPOSE
Only a minority of mild traumatic brain injury (mTBI) patients will suffer serious long-term sequelae of their injury, for which early diagnosis is an important prelude to preventive intervention. Yet detection, at the time of mTBI, of those patients at risk for adverse long-term outcome remains elusive. Using diffusion tensor imaging (DTI), we have shown previously that injury to the dorsolateral prefrontal cortex (DLPFC) in acute mTBI, evidenced by low fractional anisotropy (FA), is implicated in executive dysfunction at the time of injury. The purpose of this study was to elucidate whether axial (L1) and radial (LR) diffusivity will differentially predict executive function at follow up.

MATERIALS & METHODS
The study had IRB approval and written consent. Diffusion tensor imaging was performed on 22 mTBI patients within 2 weeks of injury and 20 matched controls. L1 and LR (3.0T; 32 directions; b=1000) were measured in the DLPFC. Executive function was measured in mTBI patients using computerized versions of the Austin Maze Task and Switching of Attention task 3-6 months following injury. Student’s t-test was used to identify DTI parameters that differed between mTBI patients and controls. Spearman’s rank correlation analyses evaluated associations between initial diffusion measures and follow-up executive function in mTBI patients. Stepwise backward multiple regression analyses were performed to assess L1 and LR as predictors of follow-up executive function in mTBI patients.

RESULTS
In comparison to controls, patients demonstrated significantly lower L1 (p=0.011) and higher LR (p=0.022) in the DLPFC 2 weeks after injury. Both L1 and LR demonstrated significant associations with follow-up executive function (p<0.05). However, multiple regression analyses showed that only L1 was a significant predictor of follow-up executive function (p<0.05).

CONCLUSION
Baseline L1 predicts follow-up executive function in mTBI patients 3-6 months following injury, suggesting that L1 might be a useful predictor of cognitive outcome. As lower L1 has been associated with intra-axonal structural derangement in animal models of ischemia and trauma, our findings in humans suggest that L1 may be a useful biomarker for significant initial axonal injury, which could lead to persistent impairment. The fact that abnormal LR did not predict executive function at follow up suggests that alterations in LR may represent a benign transient phenomenon, such as expansion of the extracellular and/or intracellular space due to microscopic edema.
Hypoactivations due to mild TBI were observed in temporal gyri, premotor regions and anterior cingulate in all conditions, suggesting that mild TBI patients’ attention was affected more significantly than WM. Lower activations in VLPFC and temporal gyri in conditions with higher memory loads may suggest affected verbal memory in response to the language-related stimuli in the WM task. The decreased activation in the left orbitofrontal gyrus in mTBI patients for the 2-back > 0-back contrast suggests poor self-monitoring processes in patients. In general, patients may have worse attentional support, verbal memory and self-monitoring than controls in response to high WM loads.

**REFERENCES**

**KEY WORDS:** Traumatic brain injury, memory, fMRI

**Paper 038 Starting at 11:25 AM, Ending at 11:33 AM**

**Comparison Study between Plain Film (Skeletal Survey) and Three-Dimensional Reconstruction CT for the Evaluation of Skull Fractures In Nonaccidental Injury**

Boddu, S. R. • Dineen, R. • Jaspan, T.
Nottingham University Hospitals NHS Trust
Nottingham, UNITED KINGDOM

**PURPOSE**
The aim of this study is to identify the best imaging modality between conventional plain films and newly developed 3D CT reconstruction for demonstration of the skull fracture and associated findings in nonaccidental injury (NAI).

**MATERIALS & METHODS**
Retrospective study. All suspected NAI evaluations at Nottingham University Hospitals NHS Trust during July 2006 - July 2010 (4 years) were reviewed retrospectively. A total of 169 studies from 166 patients were reviewed. Patients having both plain films of skull as a part of skeletal survey and 3D reconstructions following skull CT with NAI protocol is the main inclusion criteria of study. Based on the inclusion and exclusion criteria, 99 studies from 97 patients were included in the study of which 17 patients demonstrated fractures on individual studies. The anonymyed 17 studies were evaluated by the four consultants (2 pediatric and 2 neuroradiologists). A stratification scale from 1 to 5 has been used to score the clarity of fracture, soft tissues and sutures on plain film and 3D CT. The same stratification scale was used to score the overall preference of the assessors between plain film and 3D CT. The scores of both groups were analyzed using paired t-test.

**RESULTS**
Three-dimensional CT demonstration of fracture (p<0.0001), soft tissue (p=0.0037) and sutures (p<0.0001) is superior to plain film with significant statistical difference. Similarly 3D CT is the preferred assessor’s choice for imaging for skull fracture in NAI compared to plain film with statistical difference.

**Conclusion**
Three-dimensional CT skull is superior to plain films in the evaluation of NAI and is the preferred choice.

**Key Words:** Nonaccidental injury, 3-dimensional reconstruction, pediatric

**Paper 039 Starting at 11:33 AM, Ending at 11:41 AM**

**Tectorial Membrane Injury: Frequently Overlooked in Pediatric Traumatic Head Injury**

Meoded, A. • Singhi, S. • Poretti, A. • Eran, A. • Tekes, A. • Huisman, T. A. G.
The John Hopkins Medical School
Baltimore, MD

**PURPOSE**
Retroclival epidural hematomas (REH) and tectorial membrane injuries are rare complications of traumatic head and neck injuries in children. The goals of our study were: 1) to describe the neuroimaging in children with confirmed traumatic REH, 2) to summarize the mechanism of injury in these patients and, 3) to correlate the imaging findings with the clinical presentation.

**MATERIALS & METHODS**
The acute neuroimaging studies (CT and/or MRI) of ten children with a confirmed traumatic REH were evaluated retrospectively. Depending on the anterior-posterior diameter, REHs were classified as small (<2mm), medium (2-4mm) or large (>4mm). The other craniovertebral ligaments were evaluated systematically. The presence or absence of 1) focal spinal cord or lower brainstem lesions, 2) CCJ dislocations, 3) osseous lesions, 4) pre-/paravertebral hematomas, and 5) vessel injuries also were evaluated. The brain was evaluated for post-traumatic lesions. The imaging findings were compared for those patients who had no symptoms suggestive of CCJ injury versus patients with clinical CCJ symptoms. Finally, the medical records also were reviewed for performed treatment and global outcome.

**RESULTS**
Ten patients (mean age 7.1 years, range 21 months-15 years) were included in the study. The majority of patients had suffered from motor-vehicle accidents (n = 5), followed by falls (n = 3). Tectorial membrane injury was shown by CT in 30% and by MRI in 62.5% of patients. Retroclival epidural hematomas were seen by CT in nine (9/10, 90%) and by MRI in eight children (8/8, 100%). Twenty percent of REHs were classified as small, 50% as medium, and 30% as large. In none of the patients a focal spinal cord or brainstem injury, CCJ dislocation or vertebral fracture was detected. MR imaging showed bone marrow edema involving the upper cervical vertebral bodies in four patients. Paravertebral soft tissue edema and hematomas were seen by CT in four (4/10) and by MRI in seven (7/8) of patients. MR imaging showed intracranial lesions in five (5/8), CT in four (4/10) patients. Tectorial membrane disruption was diagnosed in (2/2, 100%) of patients with clinical symptoms suggestive of CCJ injury and in (5/8, 62.5%) of patients without CCJ symptoms. The majority of patients were treated conservatively with a neck collar.
CONCLUSION
Tectorial membrane lesions and REH typically are seen in young children who sustained a high-speed head and neck injury. The higher mobility of the pediatric CCJ compared to adult patients is believed to facilitate CCJ injuries. The radiologist should be aware of these kinds of injuries in children. Computed tomography and MRI studies always should include this region when the mechanism of trauma is suggestive of CCJ injury. Sagittal soft tissue and bone algorithm reconstructions are helpful to identify these lesions. MR imaging appears to be more sensitive than CT and allows studying the CCJ ligaments in better detail. Clinical symptoms may be minimal or misleading.

KEY WORDS: Retroclival epidural hematoma, tectorial membrane, trauma

Paper 040 Starting at 11:41 AM, Ending at 11:49 AM
Correlation between CT Characteristics of Chronic Subdural Hematoma and Its Recurrence
Shi, D.1 • Xu, L.1 • Ru, X.2 • Ma, J.1
1Capital Medical University Affiliated Tian Tan Hospital, Beijing, CHINA, 2Capital Medical University Affiliated Neurosurgical Institute, Beijing, CHINA

PURPOSE
To analyze the relationship between CT characteristics of chronic subdural hematoma (CSDH) and its recurrence and also the related pathology.

MATERIALS & METHODS
A total of 178 cases (213 lesions) of CSDH who underwent surgery for CSDH were collected retrospectively. Thirty-eight patients (40 lesions) underwent a repeated operation because the CSDH recurred. Univariate and multivariate logistic analyses were performed to assess the relationships among various variables and CSDH recurrence.

RESULTS
The width of hematoma, midline shift, types of hematoma were found to be related with the recurrence of CSDH in the univariate analysis, the OR and 95% CI value of hematoma of which width >30mm, midlineshift >10mm and the separated type are 18.40 (2.024-167.301), 4.643 (1.815-11.877) and 14.385 (3.601-57.467). The midline shift, types of hematoma were found to be related with the recurrence of CSDH in the multivariate analysis, the OR and 95% CI value of hematoma that width >30mm was 14.838 (1.353-162.698).

CONCLUSION
Types of hematoma, midline shift were found to be associated independently with the recurrence of CSDH, the width of hematoma also is related with its recurrence.

KEY WORDS: Chronic subdural hematoma, CT, recurrence

Paper 041 Starting at 11:49 AM, Ending at 11:57 AM
Cerebral Fat Embolism: Imaging Characteristics of an Enigmatic Entity
Chin, B. M.1 • Osborn, A. G.1 • Glastonbury, C. M.2 • Shah, L. M.1 • Salzman, K. L.1
1University of Utah, Salt Lake City, UT, 2University of California San Francisco, San Francisco, CA

PURPOSE
Cerebral fat embolism (CFE) is a potential neurologic complication after lower extremity or pelvic fractures and subsequent fixation surgery. Mortality rates of up to 15% have been reported. The diagnosis often is delayed hours to days after the initial traumatic event. MR imaging is the most sensitive tool for diagnosis, with diffusion-weighted imaging and susceptibility-weighted sequences improving detection and characterization. The purpose of this study was to characterize the incidence, clinical presentation, and radiologic spectrum of CFE in a large tertiary care center.

MATERIALS & METHODS
A retrospective search of imaging databases using keyword “fat emboli” was performed from 2004 to 2010. Patient data collected included clinical findings suggestive of fat emboli syndrome (FES), specifically hypoxia, petechial rash, and neurologic changes, in the setting of trauma and surgery. Patients without concurrent MR imaging were excluded. Imaging features were characterized.

RESULTS
Ten patients with clinical findings of FES were identified. Seven patients had concurrent brain imaging, including nonenhanced head CT, CT angiogram and brain MR imaging. The average age at presentation was 55 years. All patients underwent surgery for lower extremity fractures. Six of seven patients (86%) had hypoxia, aphasia, altered mental status, lethargy, and/or paresis immediately or within hours of orthopedic surgery. One patient presented with neurologic symptoms 24 hours following orthopedic surgery. The pathologic hallmark of CFE is intravascular fat emboli that occlude arterioles and cause perivascular microhemorrhages. These microhemorrhages are best identified on susceptibility-weighted imaging. MR imaging of the brain in CFE showed small, scattered foci of restrictive diffusivity in the subcortical and deep white matter, corpus callosum, basal ganglia, pons, and cerebellum, with corresponding T2 and FLAIR hyperintensity. In two patients, susceptibility-weighted imaging showed diffuse areas of low signal throughout the white matter, basal ganglia, and cerebellum. Both patients had no abnormalities on conventional T2-weighted imaging. Patients with short-term serial imaging showed progressive diffusion abnormalities. Six of seven patients (86%) with CFE survived. Four of six patients (67%) required rehabilitation for CFE complications.
CONCLUSION
Cerebral fat embolism is an important consideration in post-traumatic or operative patients with unexplained deterioration. Cerebral fat embolism is a clinical diagnosis but commonly does not present with the classically described signs and symptoms. Susceptibility-weighted sequences are important, particularly in the setting of multifocal emboli when suspecting CFE given the associated petechial hemorrhages in the white matter. Knowledge of CFE presentation and its imaging appearance is imperative for optimal patient outcomes.

KEY WORDS: Fat emboli, trauma, stroke

Monday Morning  
10:45 AM - 12:30 PM  
Ballroom 6A

(4b) Interventional: Aneurysms  
(Scientific Papers 042 - 054)

See also Parallel Sessions  
(4a) Adult & Pediatric Trauma  
(4c) Spine: Intervention & Neoplasms  
(4d) Adult Brain: Vascular, Intracranial  
(4e) Translational Research in Neuroradiology II, Functional Studies

Moderators: Alessandra Biondi, MD  
Albert J. Yoo, MD

Paper 042 Starting at 10:45 AM, Ending at 10:53 AM

Intra-Aneurysmal Thrombosis as a Possible Cause of Delayed Aneurysm Rupture after Flow-Diversion Treatment

Kulcsar, Z. • Houdart, E. • Bonafe, A. • Parker, G. • Millar, J. • Goddard, A. • Renowden, S. • Gal, G. • Turowski, B. • Mitchell, K. • Gray, F. • Rodriguez, M. • van den Berg, R. • Gruber, A. • Desal, H. • Wanke, I. • Rüfenacht, D. A.

1 Hirslanden Clinic Zurich, Zurich, SWITZERLAND, 2 Hopital Lariboisiere, Paris, FRANCE, 3 University Hospital Center, Gui de Chauliac Hospital, Montpellier, FRANCE, 4 Royal Prince Alfred Hospital, Sydney, AUSTRALIA, 5 Wessex Neurological Centre, Sothampton, UNITED KINGDOM, 6 Leeds General Infirmary, Leeds, UNITED KINGDOM, 7 Frenchay Hospital Bristol, Bristol, UNITED KINGDOM, 8 Odense University Hospital, Odense, DENMARK, 9 University of Dusseldorf, Dusseldorf, GERMANY, 10 Royal Brisbane and Women’s Hospital, Brisbane, AUSTRALIA, 11 APHP Lariboisière Hospital -University Paris, Paris, FRANCE, 12 Sydney Southwest Area Health Service, Sydney, AUSTRALIA, 13 AMC, Amsterdam, NETHERLANDS, 14 Medical University Vienna, Vienna General Hospital, Vienna, AUSTRIA, 15 University Hospital Laennec Hospital, CHU de Nantes, Nantes, FRANCE

PURPOSE
Flow-diversion (FD) technology enables reconstructive repair of otherwise difficult-to-treat intracranial aneurysms. These stent-like devices may induce progressive aneurysm thrombosis without additional implants and may initiate complete reverse vessel remodeling. The associated vascular biologic processes are as yet only partially understood.

MATERIALS & METHODS
From 12 different centers, 13 cases of delayed postprocedural aneurysm rupture were recorded and analyzed. Symptom, aneurysm location and morphology, and the time elapsed from treatment until rupture were analyzed.

RESULTS
There were 10 internal carotid and 3 basilar artery aneurysms. Mean aneurysm diameter was 22.8; 6 mm. Eleven patients were symptomatic before treatment. A single FD was used for all saccular aneurysms, while fusiform lesions were treated by using multiple devices. A supplementary loose coiling of the aneurysm was performed in one patient only. Ten patients developed early aneurysm rupture after FD treatment (mean, 16 days; range, 2-48 days); in three patients, rupture occurred 3-5 months after treatment. In all cases, most of the aneurysm cavity was thrombosed before rupture. The biologic mechanisms predisposing to rupture under these conditions are reviewed and discussed.
**Conclusion**
Flow diversions alone may modify hemodynamics in ways that induce extensive aneurysm thrombosis. Under specific conditions, however, instead of reverse remodeling and cicatrization, aggressive thrombus-associated autolysis of the aneurysm wall may result in delayed rupture.

**Key Words:** Aneurysm, flow diversion, thrombosis

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**Paper 043 Starting at 10:53 AM, Ending at 11:01 AM**

**Endovascular Treatment of Middle Cerebral Artery Aneurysms: A Safe Alternative to Surgical Treatment in Ruptured and Unruptured Cases. The Bristol Experience**

Williams, F. • O’Leary, S. M. • Bradley, M. • Nelson, R. • Renowden, S. A.
Frenchay Hospital
Bristol, UNITED KINGDOM

**Purpose**
The International Subarachnoid Aneurysm Trial (ISAT) has changed the management of intracranial aneurysms, with endovascular treatment becoming mainstream and the treatment of choice in most neurosciences centers. However, middle cerebral artery (MCA) aneurysm treatment has not been studied exclusively. Due to the anatomical location of MCA aneurysms it has been thought that they would be better treated by surgical clipping. This has been supported by several reports in the literature suggesting poor results with endovascular treatment. We will give the results of the MCA aneurysms treated in our neurosciences center, where coiling is the treatment of choice.

**Materials & Methods**
All patients admitted to our neurosciences unit for the treatment of MCA aneurysms, between January 1995 and October 2010, were included. Patient data, clinical presentation, and aneurysm characteristics were recorded. These included side, site, size and neck morphology. The WFNS grade of the subarachnoid hemorrhage at presentation also was included. Patient outcome was recorded using the Glasgow outcome score. Standard follow-up protocols of an MRA at 6 months and 2 years following the procedure were followed and the results were collated.

**Results**
Two hundred fifty-seven patients with MCA aneurysms were treated. Sixty-eight percent of cases in our series were ruptured aneurysms treated as emergencies. The WFNS grades were, 16% grade 1, 24% grade 2, 32% grade 3 and 26% grade 4. The majority were morphologically small, 72% compared to medium/large 24.5% and giant 3.5%. The technical failure rate was 1.5%, with four patients needing surgical clipping of the aneurysm. Nine patients (3.5%) suffered thromboembolic or hemorrhagic complications in the immediate aftermath of the procedure, which resulted in death. One was unruptured, seven were grade 4 and one was grade 5 WFNS. The retreatment rate overall is 7%. Eighty-five percent had a Glasgow outcome score of 0-1. It is interesting to notice that since January 2006 we have treated 138 MCA aneurysms endovascularly with a reduced retreatment rate of 4.2%. As we know the equipment used in endovascular treatment has improved over the years and we feel this may be contributing to improved outcomes.

**Conclusion**
Our experience demonstrates that endovascular treatment of MCA aneurysms is a safe treatment with low rates of technical failure, complications (in line with those of other intracranial aneurysms) and retreatment. Therefore coiling is acceptable as the primary treatment for MCA aneurysms.

**Key Words:** MCA aneurysm, endovascular
MATERIALS & METHODS
A total of 56 aneurysms in 49 patients was treated (mean age 55 years, range 30-79). Seventeen aneurysms were smaller than 5 mm (n=13 neck<4mm; n=3 neck >4mm; n=1 fusiform), 20 were 5-10mm in diameter (n=8 neck<4mm; n=9 neck >4mm; n=3 fusiform), 10 were 10-20mm in diameter (n=2 neck<4mm; n=6 neck >4mm; n=2 fusiform), and nine were larger than 20mm (n=4 neck >4mm; n=5 fusiform). The aneurysms originated in 82% of the cases from the cavernous ICA (25%), carotid-opthalmic segment (23%), the posterior communicating artery (13%), the supraclinoid/paraclinoid ICA (8%), the middle cerebral artery (8%), and the posterior ICA wall (5%). To achieve the calculated flow disruption between the parent artery and aneurysm and required for an occlusion, single devices, tailored to local boundary conditions, were placed endovascularly in parent arteries and covering the aneurysm. Implanted devices measured 2.9-5.3mm in diameter with a length of 10-80mm. Immediate control angiography demonstrated various degree of flow reduction within aneurysm up to a complete flow stagnation. Up to six-month follow-up angiography available in nine patients showed a complete/near-complete occlusion of eight aneurysms and size reduction in one aneurysm. In two patients tortuosity of ICA prevented a successful device deployment with the first generation of delivery system. All perforating arteries covered by the implant remained patent during the follow-up period of up to 15 months and included anterior choroidal artery, ophthalmic artery, PComA, anterior cerebral artery and lenticulostriates.

RESULTS
Procedure-related thromboembolic complications were seen in two patients and resolved in one patient while the other patient continues to have a hemianopia. Another patient experienced a wire perforation during device deployment that led to an ICH necessitating a surgical intervention. At 90-day follow up the patient presented with an improving upper extremity hemiparesis and dysphasia. Another patient with a preexisting aneurysm-associated partial CN III palsy developed a complete ptosis. None of the patients ruptured their aneurysm. One patient with a fusiform basilar trunk aneurysm died during follow-up period due to sepsis caused by pseudomonas pneumonia resistant to antibiotics.

CONCLUSION
Preliminary data demonstrate in treatment of complex aneurysms the safety and effectiveness of a new generation of FD device without the need for coiling.

KEY WORDS: Aneurysm, interventional, flow diverter

Paper 045 Starting at 11:09 AM, Ending at 11:17 AM
“Y” and “X” Stent-Assisted Coiling of Wide-Necked Intracranial Bifurcation Aneurysms

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PURPOSE
Stent-assisted endovascular treatment of intracranial aneurysms currently is performed in many endovascular centers. Unfortunately, some parent vessel bifurcation aneurysms are not treatable with single stent-assisted coiling. Recently, small series presented a novel treatment using double stents in “Y” and “X” configuration. We present our experience with “Y” and “X” stent-assisted coiling of wide-necked intracranial aneurysms, with emphasis on clinical and angiographic outcomes.

MATERIALS & METHODS
Clinical and angiographic outcomes of 44 patients harboring 50 intracranial aneurysms, treated with “Y” and “X” stent-assisted coiling in 47 procedures from June 2006 to October 2010, were analyzed retrospectively.

RESULTS
We treated 44 patients (11 men and 33 women, ages ranging from 35 to 78 years, average: 54 years), harboring 50 aneurysms (sac sizes from 2.1 mm to 22.0 mm, mean: 8.0 mm; neck sizes from 1.8 mm to 10.7 mm, mean: 5.6 mm), 52.0% (26/50) localized at the middle cerebral artery bifurcation, 26.0% (13/50) on the anterior communicating artery and 22.0% (11/50) at the apex of the basilar artery, in 47 procedures. Clinical presentations were: incidental discovery 68.0% (34/50), recanalizations of previously coiled aneurysms 24.0% (12/50), subarachnoid hemorrhages 8.0% (4/50). All but one procedure (in cases of acutely ruptured aneurysm) were carried out under full heparinization and dual antiplatelet medication (clopidogrel and aspirin). In one case of acutely ruptured aneurysm abciximab was administrated intra-arterially and intravenously during the procedure, aspirin and clopidogrel being started after the treatment. We performed 47 procedures, 89.4% (42/47) with “Y” stenting, 6.4% (3/47) with “X” stenting, while 4.2% (2/47) attempted stenting failed. Out of 45 successful procedures, we delivered the stents before coiling in 89.9% (40/45), after in 8.9% (4/45), without coils in 2.2% (1/45). Complications associated with transitory or reversible neurologic deficit (<7 days) were encountered in 10.6% (5/47) of the procedures, while permanent neurologic deficits were noted in 10.6% (5/47) of the procedures. The 10 procedure-related complications were the following: two stent occlusions, four thromboembolisms, three intraprocedural ruptures and one intraparenchymal hematoma. There were no cases of procedure-related mortality. The immediate angiographic controls showed a complete occlusion in 60.0% (30/50) of the aneurysms, a partial (neck or sac remnant) occlusion in 40.0% (20/50). On clinical follow up, the modified Rankin Scale score was 0 in 88.6% (39/44) of the patients, 1 in 4.5% (2/44), 3 in 4.5% (2/44) and 4 in 6.8% (3/44). To date, 52.0% (26/50) of the aneurysms had been followed up (average: 18
months) with angiography, disclosing a recanalization in 15.4% (4/26) and an improvement in 34.6% (9/26). No aneurysm rebled during the follow-up period.

**CONCLUSION**

“Y” and “X” stent-assisted coiling of wide-necked bifurcation intracranial aneurysms is a feasible and effective technique for endovascular treatment of wide-necked bifurcation aneurysms. However, we encountered a high rate of complications with permanent neurologic deficits. These clinical results should be balanced with those of surgical series. Improvement of stent design and technology may improve the procedural safety in the future.

**KEY WORDS:** Stent, aneurysm, wide-necked

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**Paper 046 Starting at 11:17 AM, Ending at 11:25 AM**

**Multicenter Prospective Study on the Safety and Efficacy of the Neuroform3TM Stent for Aneurysm Treatment (SENAT Study): 1 Year Follow-Up Results**

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**PURPOSE**

Neuroform3TM (Boston Scientific, Neurovascular, Fremont, CA) is a self-expandable nitinol stent, specifically designed for treating intracranial aneurysms. The first goal of SENAT study is to evaluate the morbi-mortality of Neuroform3TM stent-assisted procedure in the endovascular treatment of intracranial aneurysms.

**MATERIALS & METHODS**

SENAT study is a prospective, multicenter, consecutive registry carried out in France from July 2008 to July 2009. Ten French centers have participated in this study. One hundred eighteen patients, in whom a stent-assisted coiling procedure was planned for the treatment of an intracranial aneurysm, were included in the study. There were 79 women and 39 men ranging in age from 23 to 77 years (mean age: 52.4 years). Most of the aneurysms were unruptured (n = 109, 92.4%). Inclusions and results were controlled by an independent clinical monitoring lab. Clinical evaluation, assessed by modified Rankin Scale (mRS) or WFNS, was performed before and after embolization and then at hospital discharge. Clinical follow up was assessed at 1 month, 6 months and 1 year after the procedure. The occlusion rate of the aneurysm after the procedure was determined by angiographic analysis. Angiographic follow up was scheduled at 1 year. Intermediate follow ups were optional. Technical and clinical complications were recorded systematically. Adverse clinical events, even if unrelated to the aneurysmal pathology and treatment, also were recorded.

**RESULTS**

Successful deployment of the stent was achieved in 95.7% of procedures. After the stent-assisted procedure, complete occlusion of the aneurysm was observed in 62.7% of cases, a residual neck in 23.7% and a residual sac in 13.6% of cases. Technical complications, with or without clinical consequences, were encountered in 9.8% of patients. At 1 month follow up, 93% of patients were unchanged in relation to their preoperative neurologic status, 6% improved and 1% worsened. According to mRS, 90.2% of patients had a score of 0 or 1; 4.4% a score of 2, 1% a score of 3; and 4.4% a score of 4. One-year follow-up results are under analysis.

**CONCLUSION**

Analysis of the preliminary clinical results observed in the patients enrolled in this multicenter, prospective, consecutive and controlled study shows that the use of Neuroform3TM stent in the treatment of intracranial aneurysms is relatively safe. The use of Neuroform3TM stent does not seem to increase the percentage of complications and the incidence of morbi-mortality in relation to coiling procedures performed without stenting. Partial analysis at 1-year follow up seems to confirm the safety of the device and a good long-term tolerance to the stent.

**KEY WORDS:** Aneurysm, stent, interventional

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**Paper 047 Starting at 11:25 AM, Ending at 11:33 AM**

**Flow Diverter Stents for the Endovascular Treatment of Intracranial Aneurysms at and beyond the circle of Willis**

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**PURPOSE**

To report our 2-year experience with flow diverters (FD) in the treatment of cerebral aneurysms at and beyond the circle of Willis.

**MATERIALS & METHODS**

From September 2008 to November 2010, 110 aneurysms (99/110 anterior circulation, 11/110 posterior circulation) were treated at our institution with FD (Silk and Pipeline). Among them, 29 were located at and beyond the circle of Willis. Modes of presentation were fortuitous (17/29), angiographic recurrence of previously treated aneurysms (10/29), SAH (2/29). Aneurysms were treated with FD alone in 79.3% (23/29) and with FD and coils in 20.7% (6/29).

**RESULTS**

Twenty-nine aneurysms (27/29, 93.1% saccular; 2/29, 6.9% fusiform; sizes 1.2 to 19.6, mean 7.0 mm) were treated in 25 patients (16 women, 9 men, age ranging from 10 to 77, mean: 48 years) in 26 procedures. Aneurysms were located at the anterior communicating arterial complex in 17/29 (58.6%), at the middle cerebral artery bifurcation in 8/29 (27.6%), at the pericallosal artery in 3/29 (10.3%), and at the posterior cerebral artery in 1/29 (3.5%). Access site complication (hematoma) was noted in 3.8% (1/26, 1 requiring blood transfusion). Transient or reversible neurologic complications (2 ischemic) were noted in 7.3% (2/26). Permanent neurologic complication was delayed in 3.8% (1/26). Thirty days postprocedural mortality was 0.0%. No aneurysms bled or rebled after treatment. Aneurysms treated with FD alone were similar to those treated with FD and coils (mean size: 6.6 and 8.4 mm respectively; P=0.3148, Unpaired t test with Welch correction). Immediate angio-
graphic occlusion was achieved in 39.1% (9/23) with FD alone, in 33.3% (2/6) with FD and coils. Twenty (69.0%) aneurysms had been followed (mean 8 months). At follow up, 81.2% (13/16) of aneurysms treated with FD, while 100% (4/4) of aneurysms treated with FD and coils were occluded (Fisher’s Exact Test, P=1.00). There was no angiographic recurrence of initially totally occluded aneurysms.

CONCLUSION
Aneurysms at and beyond the circle of Willis are amenable to selective treatment with FD.

KEY WORDS: Aneurysm, stent, flow diverter

Paper 048 Starting at 11:33 AM, Ending at 11:41 AM
Results of Pipeline Flow Diversion Device in Australian Multicenter Registry for the Treatment of Aneurysms: Mid-Term Results

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PURPOSE
To investigate the efficacy and sequelae of the pipeline embolization device in the treatment of aneurysms mid-term results.

MATERIALS & METHODS
Prospective multicenter registry in established neurointerventional sites in Perth, Sydney and the Gold Coast established a protocol for the collection of data regarding aneurysm characteristics, previous endovascular therapy, antiplatelet regimen, mass effect, procedural and delayed complications, aneurysm closure rate at 1 and 6 months and restenosis rates were gathered in 63 aneurysms between August 09 and September 2010.

RESULTS
Fifty-two elective and 11 aneurysms in the setting of acute subarachnoid hemorrhage (SAH) were treated. Sixteen patients had previous therapy (9 coiled, 5 stents, 1 clip, 1 coronary stent and onyx). All patients were pretreated with clopidogrel and aspirin. In the elective cases there was 0 % mortality and stroke, one acute and three delayed TIs. In the latter group, two were still smoking and all three were noncompliant with plavix. Three cases had transient increased mass effect. In the SAH group there were two fatalities. Closure of aneurysm was >85% (final figure pending) at 6 months in the cases with no prior treatment and 10/16 (final figure pending) in the previously treated group. Five patients each had a 70%, 60%, 50%, 25% and 15% asymptomatic narrowing respectively at 6 months. The patient with 50% narrowing demonstrated marked improvement in the length and degree (now 25%) of narrowing at 10-month follow up.

CONCLUSION
Pipeline embolization device is an effective and safe agent in the treatment of difficult wide-necked aneurysms with low morbidity in elective cases. It should be used with caution in the setting of acute SAH.

KEY WORDS: Aneurysm, stent, pipeline

Paper 049 Starting at 11:41 AM, Ending at 11:49 AM
Fundamental Principles of Stenting and Flow Diversion Studied with Experimental Canine Aneurysms

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PURPOSE
Flow diverters (FD) are a new generation of intracranial stents designed to occlude aneurysms while preserving flow to jailed arterial branches. We aimed to test this fundamental principle in a new aneurysm model, using stents, double stents or FDs, as well as to prove that flow patterns are responsible for the differential effects on aneurysms and branches.

MATERIALS & METHODS
Canine lateral wall vein pouch aneurysm constructs featuring a branch located immediately opposite the aneurysm ostium were created in 14 animals, to study the effects of the same device on aneurysm or branch ostia in each animal. Single conventional stents (n = 4), two overlapping conventional stents (n = 4), or a single flow diverting stent (n = 4) were used to treat aneurysms 4 weeks later. To test whether this result was due to flow patterns, two additional animals, in which the construct was modified to create a venous pouch aneurysm with an efferent branch originating from the fundus also were treated with FDs. Angiographic results following deployment, at 2 weeks and 3 months, were scored along an ordinal scale (from 0 to 3), and sacrifice at 3 months was followed by macroscopic photography of the free segment of stent (FSS) over the aneurysm and branch, with attention to the amount and quality of neointima formation.

RESULTS
Flow diverter stents occluded aneurysms in 3/4 cases, compared to 0/4 for single conventional stents, and 2/4 for double overlapping stents. All stented arterial branches remained patent. Animals with branches originating from the aneurysm fundus did not have aneurysm occlusion after FD treatment. The degree of neointima formation correlated with the decreased porosity and increased pore density of the devices.

CONCLUSION
Aneurysms are more likely to occlude following FD than equivalent branches. Occlusion is related to neointima formation on the FSS. The decreased porosity and increased pore density of a device correlates with increasing device efficacy. The presence of an arterial outflow pattern from the stented aneurysm or branch correlates with continued patency and partial neointimal coverage.
**Paper 050 Starting at 11:49 AM, Ending at 11:57 AM**

**Pipeline Flow Diverter Stent in the Treatment of Cervico-Cranial Aneurysms: Our Initial Results**

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**PURPOSE**

Using high-density mesh intracranial stents with flow diverter property is a recent management strategy in the endovascular treatment of wide neck, fusiform, and large aneurysm with mass effect located proximal to circle of Willis. We summarized our initial results.

**MATERIALS & METHODS**

Between January and October 2010, during 11 months period, we retrospectively analyzed 22 patients having cervico-cranial 29 aneurysms (15 male, 7 female) with age range of 8-70 years (mean, 45 years) treated with a new flow diverter intracranial stent - Pipeline (EV3).

**RESULTS**

Nine patients presented with symptoms attributable to mass effect. There was SAH in six patients (2 acute, 4 chronic phase), and ischemia in one, while six patients were asymptomatic. Of 29 aneurysms, 24 were located in distal ICA, one in cervical ICA, one in petrous ICA, one in vertebral artery V4 segment, one in bazilar tip, and the last one in basilary artery trunk. The aneurysm diameter was between 2-50 mm (mean, 17 mm). Total 32 Pipeline stents were implanted in 29 aneurysms of 22 patients. Multiple stent implantations were done in five aneurysms, while two aneurysms were treated with only one stent in three patients. There was one clinical (TIA) and one technical complication without clinical consequence (tip wire fracture of stent delivery system and dislodgement in the A1 segment of anterior cerebral artery) during the procedure. The patients were followed up 1-11 months (mean, 4 months). Six-month radiologic control was available in only eight patients with seven aneurysm occlusion and one residual filling. There was neither restenosis in the controlled patients, nor late clinical complication in any patient.

**CONCLUSION**

Pipeline intracranial stent (EV3), as a flow diverter, appears to be feasible treatment alternative with high technical success rate and good early clinical and radiologic follow-up results in selected aneurysm located proximal to circle of Willis; but, larger series with longer follow up are needed.

**KEY WORDS:** Aneurysm, stent

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**Paper 051 Starting at 11:57 AM, Ending at 12:05 PM**

**Numerical Simulation of the Deployed Configuration of Braided Flow Diverters**

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**PURPOSE**

Initial clinical experience has demonstrated that flow diverters can be applied successfully to treat cerebral aneurysms. The accurate delivery and deployment of these devices is critical to achieving adequate parent artery reconstruction. Due to the braided composition of the devices, their configuration adapts to the local vessel geometry and a considerable degree of foreshortening occurs during deployment, making device sizing and positioning challenging. An a priori knowledge of the vessel length that will be spanned by a given device after deployment is critical for accurate device positioning. The purpose of this study was to create and test a mathematical algorithm designed to accurately simulate the deployed length of a braided flow diverter within any defined vascular segment.

**MATERIALS & METHODS**

The calculations are based on three known device parameters - diameter, length and braiding angle (i.e., the angle that the wires make with the device axis) in air. The 3D geometry of the vessel (centerline, lumen surface) is obtained from imaging. Further, the distal vessel position at which deployment begins is known. Beginning at this location and moving proximally, a helix is constructed with the curved vessel centerline as its axis and with a varying pitch defined by the local vessel circumference. The total number of turns of a braided device remains conserved. With the calculated pitch, the total length of vessel segment covered by the device thus can be calculated. A flow diverter of known diameter and braiding angle in air was cut to two different lengths (2.5 cm and 4 cm) and deployed in three arbitrarily curved tubes. Vessel and device geometry were obtained by rotational angiography acquired with an Artis Zeego (Siemens, Germany). The in-air device parameters were used to numerically simulate device deployment in the vessel geometry beginning at the same distal location as in the experiments.

**RESULTS**

Figure shows the rotational angiography reconstruction from one of the three trials and the simulated device configuration in the luminal geometry (only centerlines of every other wire pair are shown). The absolute error between experimentally measured and numerically simulated deployed lengths was 1.1 +/-0.1mm (n=3); the percent error was 3.4 +/-1.3%.

**KEY WORDS:** Braided flow diverters, 3D simulation.
CONCLUSION
Preliminary results suggest that the deployed length of a flow diverter in any vessel segment can be calculated easily prior to deployment. This information would be helpful to neurointerventionists in determining device choice and vessel position at which device deployment should be initiated.

Acknowledgement: Supported by NIH R01 NS045753.

KEY WORDS: Deployment length, braiding angle

Enhanced Procedural Guidance in Stent-Assisted Coiling of Intracranial Aneurysms Using C-Arm CT Imaging

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PURPOSE
Stent-assisted coiling and flow diversion of wide-neck aneurysms is being adopted as a viable alternative to surgical clipping. Unfortunately, self-expanding stents and to a lesser extent, flow diverters are poorly visible on real-time fluoroscopy and road-map images. We propose a technique to enhance the visibility of these devices by superimposing high-resolution images of these devices obtained from C-arm CT on the real-time fluoroscopy or road-map images.

MATERIALS & METHODS
We obtain a C-arm CT study (DynaCT, Axiom Artis zee, Siemens) after the deployment of the stent in the desired location across the neck of the aneurysm. A high-resolution 3D image of the stent then is reconstructed from the same dataset. The reconstructed high-resolution image of the stent then is overlaid on the real-time 2D fluoroscopy or roadmap image inside the procedure room (syngo iPilot, Siemens). The algorithmic and procedural detail of projecting the 3D image onto the 2D images already has been described.

RESULTS
The proposed stent overlay on 2D fluoroscopic images was used in a total of seven clinical cases for aneurysm coiling (Figure 1). The superimposition of the stent from C-arm CT on real-time fluoroscopy, adds significant advantage in the visualization of the device. Specifically, the relationship of the deployed stent to the aneurysm and to the parent artery is extremely useful for the safe conduct of the procedure. Moreover, the overlay can be controlled from the procedure room and can be adjusted dynamically with various C-arm angulations. In one of the cases, the merged C-arm CT/fluoroscopy image showed a clear deformity of the stent struts due to the sharp curvature of the parent artery.

CONCLUSION
The overlay feature provides a platform to fuse the information from C-arm CT with real-time fluoroscopy or road-map images for enhanced visualization of the deployed stents or flow diverters in endovascular coiling procedures. The overlaid stent on 2D fluoroscopy or roadmap images serves as a reference frame to coil the aneurysm with a better assessment of the apposition of the stent to the parent artery wall.

KEY WORDS: Stent-assisted coil embolization, C-arm CT imaging, real-time fluoroscopic overlay
Endovascular Treatment of Intracranial Microaneurysms

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**PURPOSE**
Recently, sparse series focused on the endovascular treatment (EVT) of small aneurysms ≤ 3 mm. Our goal is to report our experience in the EVT of microaneurysms ≤ 2.5 mm, 1.5 mm being the present inferior limit of coil size available on the market, and to expose the different strategies in the endovascular management of such tiny lesions.

**MATERIALS & METHODS**
This is a single center retrospective study based on a prospectively gathered database. From 2002 to 2010, 1687 aneurysms were treated selectively by EVT. Aneurysm sizes were measured on 3D reformatted images acquired after rotational angiographies (Philips Allura). Among them, 60 (3.5%) were microaneurysms ≤ 2.5 mm in 57 patients (16 men and 41 women, ages ranging from 29 to 76 years, mean: 51 years). Aneurysm sizes ranged from 1.2 to 2.5 mm, mean: 2.1 mm. Neck sizes ranged from 0.6 to 4.0 mm, mean: 1.8 mm. Out of the 60 aneurysms, 22 were acutely ruptured. Out of the 38 unruptured aneurysms, 14 were discovered in the setting of a subarachnoid hemorrhage (SAH) caused by the rupture of another aneurysm, three other aneurysms were treated in the setting of familial history of aneurysmal rupture (including polycystic kidney disease in one patient), the remaining 21 aneurysms were associated with other unruptured aneurysms treated endovascularly.

**RESULTS**
Out of the 60 aneurysms, 15 (25.0%) were qualified as “blistert-like” lesions (dome/neck ratio ≤1). Fifty-two aneurysms were treated with coils, eight were treated with flow diverters (FD) alone in 58 procedures. Out of the 52 aneurysms treated with coils, 11 were treated with stent-assisted coiling (six coiling through stent mesh, three with the stent-jack technique, one with the jailed-catheter technique, one balloon-stenting). Out of the 11 stented aneurysms, four were in the setting of SAH. Out of the eight aneurysms treated with FD, two were treated in the acute setting of SAH. There were four (6.9%) procedure-related complications, all hemorrhagic (three aneurysm perforations, one vessel perforation). The 30 days postprocedural mortality rate was 5.3% (three of 57 patients, one as a consequence of initial SAH, one due to dome perforation in a previously ruptured aneurysm, one secondary to vessel perforation in an asymptomatic patient). Immediate angiographic occlusion was achieved in 53.3% (32/60). Angiographic follow up was available in 63.3% (38/60), ranging from 1 to 55 months (mean: 20 months), showing total occlusion in 76.3% (29/38). One ruptured aneurysm rebled 18 days after EVT despite initial total aneurysm occlusion. Among the 27 followed aneurysms that were treated without stent or FD, eight (29.6%) were not totally excluded at follow up. Among the 11 followed aneurysms that were treated with stents or FD, one (9.1%) was not totally excluded at follow up.

**CONCLUSION**
Selective EVT of microaneurysms ≤ 2.5 mm is feasible. The use of stents and FD allows the treatment of “blistet-like” lesions that were otherwise not amenable to selective EVT. Stenting was already known to favor the long-term occlusion of aneurysms. Stents are also beneficial to the long-term occlusion of microaneurysms.

**KEY WORDS:** Small aneurysms, aneurysm sizes, stent

Midterm Follow Up in a Consecutive Series of Patients with Intracranial Aneurysms Treated by Flow Diverter Stents

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**PURPOSE**
To evaluate midterm follow-up clinical and angiographic results in a consecutive series of patients with intracranial aneurysms treated using a flow diverter stent.

**MATERIALS & METHODS**
Twenty-one patients (ranging in age from 38 to 75 years) with 27 unruptured or recanalized intracranial aneurysms treated by a flow diverter stent were included in the study. Sixteen out of 21 patients were symptomatic. Nine aneurysms were intradural and 18 extradural; 77% of lesions were large or giant. At total, 30 stents were deployed (from 1 to 3/patient). Four patients with adjacent aneurysms (from 1 to 3) were treated by only one stent. Flow diverter stents were silk stent (Balt company) in 13 aneurysms and pipeline stent (ev3 company) in 14. In four cases, coils also were positioned within the aneurysm sac immediately before the deployment of the stent. After the procedure and at 1 year follow up, angiographic results were evaluated using the Kamran score (Grade 0 - no change in endosaccular flow; Grade 1 - residual contrast filling, greater than 50%; Grade 2 - residual sac filling, less than 50% of pretreatment aneurysm volume; Grade 3 - residual filling confined to the neck region, and not extending beyond the width of neck; Grade 4 - no residual filling, (i.e., complete obliteration of the aneurysm). Technical and clinical complications were recorded systematically.

**RESULTS**
Immediate complications included one regressive hemiparesis in a patient with a severe groin hematoma. Transient worsening of mass effect syndrome in eight patients with one case of persistent ophthalmoparesis. At 1 month, one patient died because of cataclysmic hemorrhage during surgical treatment of a tumor. Due to worsened clinical conditions, the patient underwent surgery only 10 days after the discontinuation of the antiplatelet treatment. At 6 months-1-year follow up, improvement or cure of the compressive syndrome was observed in 80% of patients. Fourteen aneurysms were occluded completely (grade 4); five aneurysms (grade
CONCLUSION
Our results confirm that the use of flow diverter stents is a very promising technique in some configurations of intracranial aneurysms, especially in large or giant lesions. However, more experience and long-term follow up is needed in order to define the indications of these new stents.

KEY WORDS: Aneurysms, flow diverter stent, interventional

Materials & Methods
We retrospectively reviewed 80 SNRBs performed by four interventionalists (20 consecutive each). Data collected included mA, CTF time, and level injected. Patient body habitus was evaluated by measuring the AP and transverse diameter at the level of injection on scout images. Image quality was evaluated objectively and subjectively. Noise [standard deviation (sd) of attenuation] was measured in the psoas muscle and subcutaneous fat on CTF images. Subjective image quality was graded by two readers as ability to identify the nerve root on a scale of 1-4 (1=nonvisualization, 4=clear identification). Both the planning CT (performed with normal diagnostic scanning parameters) and the CTF images were evaluated.

RESULTS
The mean mA for CTF was 59 mA (sd 20) and was categorized into low (20-40, n=27), medium (50-70, n=36), and high (>80, n=17) mA. The mean CTF time was 14 seconds (sd 7). Based on the scout images, the mean transverse body size was 37 cm (sd 5), and the mean AP body size was 27 cm (sd 5). Interventionalist A had both the lowest mean mA selection (42 mA) and the shortest CTF time (9.8 sec). Interventionalist D had both the highest mean mA selection (80 mA) and the longest CTF time (18.3 sec). There was a statistically significant difference in the interventionalist's choice of tube current (p<0.0001) and CTF time (p = 0.001). Yet there was no statistically significant difference between the transverse diameter (p = 0.95) or AP diameter (p=0.27) of patients between interventionalists. There was a relationship between body size and image noise when controlled for mA (p<0.0001). On subjective assessment of image quality, 15 cases were excluded because readers could not visualize the nerve root on the planning CT. Of 65 remaining cases, there was no significant difference between subjective image quality on CTF in the three mA groups (p= 0.30-0.34). Reader A found Grade 1 quality (nerve root not seen) in five cases: 2, 1 and 2 in the low, medium and high mA groups, respectively; and Reader B found Grade 1 quality in eight cases: 4, 2 and 2 in the low, medium and high mA groups, respectively.

CONCLUSION
There is variation in mA selection and CTF time between interventionalists for CT-guided lumbar SNRB resulting in wide variation in radiation dose to the patient. The nerve can be visualized with low mA settings in the majority of patients. Future research will be directed at developing a method of determining dose settings for CTF based on body habitus.

KEY WORDS: Nerve root block, radiation dose, CT fluoroscopy
Accuracy of CT-Guidance for Lumbar Facet Blocks

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PURPOSE
Lumbar facet joint blocks (FJB) are performed for diagnostic and/or therapeutic purposes, and generally are carried out under fluoroscopy-guidance. Precise intra-articular injection is desirable for diagnostic specificity, and therapeutic efficacy. Our purpose was to assess the rate of procedural success profile of FJB under CT-guidance and to estimate patient periprocedural radiation doses.

MATERIALS & METHODS
We retrospectively reviewed a series of clinically indicated FJB procedures in 37 consecutive patients (13 men, 24 women; mean age 60 ± 12 years; age range 37-82 years) for a total of 47 procedures, and a total of 84 targeted facet joints. All procedures were performed under local anesthesia using a 22G beveled spinal needle, either 3.5" or 5", depending on patients’ body habitus. A posterior paravertebral access was used with patients in prone decubitus position, under CT-guidance on a 64 MDCT scanner. A precocedure localizing scan to determine local anatomy and optimal skin entry point was followed by intermittent low dose (120 kV/30 mAs) guidance scans (3 slices, 2.5/1.25 mm slice thickness/overlap; anatomical coverage of 3.75 mm). Presence of posterior facet osteophytes overlying a direct joint access, type of needle direction for joint access (oblique ipsilateral, straight isplilateral, oblique contralateral), and number of CT-guidance scans needed for final placement of the needle were recorded, together with the corresponding Dose Length Product (DLP). Intra-articular needle placement was confirmed by contrast opacification of the joint space.

RESULTS
Lumbar facet joint blocks were technically successful in 79/84 cases (94%). Access side and direction were as follows: 73/84 ipsilateral (53 straight, 20 oblique), 11/84 contralateral oblique (13%). 46 FJB (54%) were at L4/L5, 29 (35%) at L5/S1, 5 (6%) at L3/L4, and 4 (5%) at L2/L3. Forty of 84 facet joints presented posterior osteophytes. Average number of guiding scans needed to obtain final needle position was 4 ± 2 with a range between 2 and 11 scans (11 x 2 scans, 24 x 3 scans, 21 x 4 scans, 15 x 5 scans, 2 x 6 scans, 8 x 7 scans, 2 x 8 scans, 1 x 11 scans). Average DLP per FJB was estimated at 16 mGy-cm, corresponding to an effective dose of 0.2 mSv. No major periprocedural complication was reported.

CONCLUSION
Facet joints targeted by FJB often present challenging anatomy, due to presence of osteophytes. Optimal needle access often requires nonconventional ipsilateral straight or contralateral oblique approach, extremely difficult to obtain with fluoroscopic guidance. Our results indicate that FJB using CT-guidance is safe and rapid, ensures reliable needle guidance, individual to each facet joint’s anatomy, and allows precise intra-articular injection, with extremely high procedural accuracy. The patient effective dose (0.2 mSv) is comparable to that associated with 1 minute of fluoroscopy guidance.

KEY WORDS: Lumbar facet joint block, CT-guidance

Evaluation of CT-Guided Transoral FNAC, Biopsy, and Therapeutic Interventions for C2 Lesions

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PURPOSE
Upper cervical spine traditionally poses difficulties in diagnostic and therapeutic interventions because of the proximity to vital vascular and neural structures. Unlike thoracic and lumbar spine, transpedicular approach often is not possible due to small pedicle size. Transoral approach to C2 lesions has been used commonly by surgeons and is well known to interventional radiologists. This is underutilized by interventional radiologists and there are only occasional small series and case reports of this approach. Largest reported series consists of only five cases with four biopsies and one vertebroplasty with diagnostic yield of 50%. We present our experience with ten consecutive transoral diagnostic and therapeutic procedures from October 2008 to November 2010. To the best of our knowledge, this is the largest FNAC/Biopsy series, first series directly comparing diagnostic yield of FNAC and biopsy, and first report of combining tumor ablation with vertebroplasty using CT-guidance transoral approach for C2 lesions.

MATERIALS & METHODS
This retrospective case series examines total eight consecutive patients with C2 lesions who underwent total ten CT-guided transoral interventional procedures from October 2008 to November 2010. All eight patients underwent both FNAC (22 gauge needle) and core biopsy (16 gauge needle) procedure and in addition, two of them also underwent combined tumor ablation/vertebroplasty using CT-guidance transoral approach for C2 lesions.

RESULTS
Total eight FNAC, eight Biopsy (both FNAC and Biopsy on each patient), and two combined ablation/vertebroplasty procedures were performed in eight patients. Patient’s age ranges from 39 to 83 years with five males and three females. All the FNAC, Biopsy, and therapeutic procedures in our series were technically successful with no procedural or postprocedural complications. Diagnostic yield of FNAC was only 62.5% compared to 100% yield of core biopsy. Both patients that underwent ablation and vertebroplasty procedure had significant pain relief following the procedure.
**CONCLUSION**
CT-guided transoral approach is safe and effective in performing both diagnostic and therapeutic interventions for C2 lesions. Diagnostic yield can be significantly improved by making effort to obtain core biopsy along with FNAC. Although visibly challenging, transoral approach is technically straightforward when performed with proper technique and appropriate precautions.

**KEY WORDS:** Transoral, biopsy, ablation

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**Paper 058**

**Posterior Vertebral Arch Cement Augmentation (Laminoplasty) to Prevent Fracture of Spinous Processes after Interspinous Spacer Implant**

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**PURPOSE**
To assess the safety, feasibility, and effectiveness of posterior vertebral arch cement augmentation in preventing delayed spinous processes’ fracture after interspinous spacer device implant, for the treatment of intermittent neurogenic claudication, in patients with risk factors for fragility fractures.

**MATERIALS & METHODS**
From June 2007 to March 2010, we implanted interspinous spacers in 35 eligible patients with risk factors for fragility fractures. In 19 of them, treated after April 2009, after assessment of the theoretical biomechanical effects of cement augmentation of the laminae by finite elements analysis, a percutaneous cement augmentation of the posterior vertebral arch (laminoplasty) also was performed. Clinical and radiologic followup ranged between 3 and 14 months after the intervention.

**RESULTS**
No intraprocedural spinous processes nor laminar fractures were observed in either group, and no patient in the 24-hour postoperative period suffered from any symptom possibly related to the procedure. A symptomatic delayed spinous process fracture was diagnosed in four out of 16 patients who did not undergo laminoplasty (25.0%), while no fractures were diagnosed in the 19 treated patients (p = 0.035).

**CONCLUSION**
Intralaminar cement injection is feasible and safe. It has a biomechanical rationale, as demonstrated by a finite elements analysis. In our preliminary experience, it seems effective in preventing delayed fractures of the posterior arch postinterspinous spacer placement, in patients at risk for fragility fractures. These patient have a significant risk of developing a symptomatic delayed spinous processes’ fracture if not treated with posterior arch cement augmentation.

**KEY WORDS:** Interspinous spacers, cement augmentation, insufficiency fractures

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**Paper 059**

**Cryoablation/Vertebroplasty versus Radiofrequency/Vertebroplasty in Neoplastic Vertebral Localization**

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**PURPOSE**
The aim of our study was to emphasize the state of the art in vertebral neoplastic percutaneous palliative treatment by comparing the Visuale Analogue Scale (VAS) scores in cryoablation plus vertebroplasty versus radiofrequency (RF) plus vertebroplasty, and their feasibility, reliability and efficacy in short-term series.

**MATERIALS & METHODS**
Combined procedure of radiofrequency thermal ablation plus vertebroplasty or cryoablation plus vertebroplasty were performed in osteolytic neoplastic localizations in 45 consecutive patients suffering for pain refractory to conservative therapies. We evaluated pain with a VAS, performed in the preoperative period and at 4 hours, 24 hours, 1 week, 1 month, 3 months and 6 months from the procedure.

**RESULTS**
There were no statistically significant differences in the VAS score between patients treated with cryoablation and vertebroplasty and those treated with RF ablation and vertebroplasty at 1 week (p = 0.34), 1 month (p = 1), 3 months (p = 0.68) and 6 months (p = 0.65). Patients treated with cryoablation and vertebroplasty have less pain at 4 hours (p<0.001) and at 24 hours (p<0.001) than patients treated with RF ablation and vertebroplasty.

**CONCLUSION**
Both RF ablation and cryoablation are optimal techniques in the treatment of painful vertebral neoplastic lesions. Cryoablation achieves reduced treatment-related pain in the early follow-up time and a better volume control by real-time depiction of ablation margins.

**KEY WORDS:** Vertebroplasty, radiofrequency, cryoablation
Early Experience Using a New Bone Augmentation Material for Treating Vertebral Compression Fractures

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PURPOSE
A new synthetic, nonresorbable, bioactive composite material, Cortoss™ (Orthovita, Inc., Malvern, PA), received FDA clearance in mid-2009 as a strengthening agent for injection into vertebral bodies with compression fractures or weakened bone stock. It is composed of cross-linked resins and a glass ceramic component that in animal testing promoted deposition of calcium phosphate on the implant surface. Our early clinical experience and results using this material are reported.

MATERIALS & METHODS
Eighteen vertebral augmentation cases were performed using Cortoss Bone Augmentation Material from October, 2009 to August, 2010 in 16 patients. Material handling characteristics, ease of use and material distribution patterns in the treated vertebral bodies were evaluated. All leaks were recorded; pre and 4 weeks posttreatment VAS pain data were recorded.

RESULTS
There were eight women and eight men; average age 66 years old (range 28-90 years). Diagnoses included 34 compression fractures and one hemangioma. Thirty-five levels were treated (T4-L5); six single-level, seven 2-level and five 3-level cases. The fractures included 18 thoracic and 17 lumbar levels, and were clustered around the thoracolumbar junction. There was one vertebra plana. Sixteen fractures were classified as Genant’s Grade 1 (mild deformity), 8 as grade 2 (moderate), and 9 as grade 3 (severe). A unipedicu lar approach was used in 21 levels. Post-treatment CT scans demonstrated leaks in 24/35 levels (68.6%). In 22/35 levels treated a trabecular fill pattern was noted. There was basivertebral venous plexus extension at 10 levels in seven patients. None of these leaks resulted in compression of the spinal cord. On average, pain improved from 7.4 preprocedure to 3.2 postprocedure.

CONCLUSION
Cortoss was used to augment vertebral fractures in a heterogeneous population. The material is supplied ready to use in a dual chambered cartridge that permits material to be supplied on demand requiring no extra preparation. Initially, a unipedicu lar approach was used that evolved to bipedicu lar in order to achieve optimal vertebral fill. Leaks were evident fluoroscopically and most of the time the procedure could be halted until the material polymerized and then restarted until desired fill was achieved. All leaks were asymptomatic. Patients presented with severe and/or chronic pain that was relieved with treatment.

KEY WORDS: Vertebroplasty, kyphoplasty, Cortoss
CONCLUSION
Age of fracture has minimal impact on outcome following single-level vertebroplasty, with good outcomes noted among acute, subacute, and chronic fractures.

KEY WORDS: Vertebroplasty, pain duration, fracture age

MATERIALS & METHODS
All consecutive procedures performed at one institution from July 2010 through December 2010 were reviewed. All patients had neck and/or upper extremity pain. Procedures were performed on 16-slice CT scanners equipped with tableside foot switch and hand controls. Intermittent CT fluoroscopy technique was used. Injections were performed using a posterior oblique approach, with injection of contrast to confirm epidural location prior to administration of steroid. Four attending neuroradiologists performed a total of 41 injections on 39 patients. Demographic data, levels of injection, total fluoroscopic time and mA settings were recorded. Additionally, the contrast distribution pattern was examined to evaluate spread of injectate within the epidural space. Procedural details were reviewed for complications, including inadvertent puncture of the thecal sac.

RESULTS
No minor or major complications were observed, and no evidence of thecal sac penetration was observed following contrast injection. Average fluoroscopic time was 23.8 seconds (range 6-87); all but five procedures required less than 30 seconds of fluoroscopic time. Average mA was 73 (range 30-150), and only two patients required greater than 100 mA for acceptable image quality. The superior-most level injected was C2-C3, and the inferior-most level injected was C7-T1. The most commonly injected level was C5-C6. Contrast was observed to spread bilaterally in the epidural space in 83% of injections (Figure), to the margin of the ipsilateral neural foramen in 93%, and into the ipsilateral neural foramen in 41%.

CONCLUSION
Our preliminary results confirm that cervical interlaminar epidural injections can be performed using CT-fluoroscopic guidance. Furthermore, our initial experience suggests that this technique allows injections to be performed safely at levels cranial to those typically performed with conventional fluoroscopy.

KEY WORDS: CT fluoroscopy, cervical epidural, spine injection
Paper 063 Starting at 11:49 AM, Ending at 11:57 AM

CT Myelographic and Cerebrospinal Fluid Opening Pressure Findings in Patients Treated with CT-Guided Targeted Epidural Blood Patching for Spontaneous Intracranial Hypotension

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Purpose
To describe the dynamic CT myelographic findings and opening cerebrospinal fluid (CSF) pressures in spontaneous intracranial hypotension (SIH) patients who were treated with our institutional protocol for CT-guided targeted epidural autologous blood patching.

Materials & Methods
Eleven patients with SIH who were treated with CT-guided targeted epidural autologous blood patching were chosen retrospectively based on pretreatment MR imaging (MRI) brain findings classic for SIH. All 11 patients followed our institutional treatment protocol of a dynamic CT myelogram which consists of a CT-guided lumbar puncture for intrathecal iodinated contrast administration, subsequently followed by a total spine CT scan, which was used to plan for blood-patching locations. All blood patches, including the initial LP site, utilized CT fluoroscopy to accurately target the epidural blood patch (1-3 mL) at each presumed site of potential CSF leakage. Eight of the 11 patients had opening CSF pressures recorded prior to intrathecal contrast administration.

Results
Eleven patients (3 men and 8 women, mean age 48.4 ± 10.0 years) were considered to have positive pretreatment MRIs. Ten of the 11 brain MRIs were contrasted studies and demonstrated both thick smooth pachymeningeal enhancement plus a venous distension sign (VDS). One patient did not receive gadolinium contrast, but had other classic findings of SIH including VDS, bilateral subdural collections, and low lying cerebellar tonsils, and thus was considered positive. The opening CSF pressure was recorded in eight patients which showed an average pressure of 7.7 ± 6.2 cm H2O (range 0-19). On the CT myelogram, nine of the 11 patients (81%) had frank epidural collections all involving the thoracic spine. The average number of blood-patch locations (not including the LP site), which were performed via a transfornaminal or interlaminar approach, was 4.2 ± 6.5 (range 2-14). All 11 patients experienced symptomatic relief after the initial treatment, although six patients returned for additional targeted blood patches. Of the six patients that returned for further treatment, none of the patients demonstrated frank epidural collections on the follow-up myelogram.

Conclusion
CT myelogram is diagnostic and/or confirmatory for SIH, if epidural collections consistent with CSF leak are present. In our experience, the majority of patients with positive MRI brain findings will have epidural collections which involve the thoracic spine. Our institution’s dynamic CT myelogram/blood-patching protocol allows for a diagnostic and therapeutic same day intervention, with opening pressure and myelographic findings which can help direct future treatment if needed.

Key Words: Intracranial hypotension, blood patching

Paper 064 Starting at 11:57 AM, Ending at 12:05 PM

Cyclic Cerebrospinal Fluid Flow (II): The Role of Cerebrospinal Fluid Pressure in the Pathogenesis of Syringomyelia

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Purpose
Phase contrast MR imaging in patients with the Chiari I malformation demonstrates abnormal cerebrospinal fluid (CSF) flow in the foramen magnum and upper cervical spinal canal, related to abnormal pressure gradients. The purpose of this study was to analyze the role of CSF pressure in the pathogenesis of syringomyelia, with computational models.

Materials & Methods
The spinal cord was modeled as a cylindrical poro-elastic structure with homogenous and isotropic permeability. The permeability then was made heterogeneous and anisotropic to represent the different properties of the central canal, gray and white matter. Fluid with a defined pressure, varying both in time and space, was prescribed in the subarachnoid space (SAS). Simulations were performed to quantify deformations and fluid movement within the cord.

Results
In the simulations with uniform permeability fluid moved into the cord in regions of higher pressure and out of the cord in regions of lower pressure. With permeability differences simulating gray and white matter the pattern was more complex, but similar. Adding the central spinal canal, fluid moved into the cord as in the previous case. However, preferential flow along the central canal and diminished flow back into the SAS was observed.

Conclusion
Pressure gradients in the SAS produce movement of fluid in the spinal cord. Assuming different relative permeability in gray matter, white matter and the central spinal canal, abnormal CSF gradients lead to accumulation of fluid within and adjacent to the central canal.

Key Words: Syringomyelia, computer simulations, Chiari I malformation
Role of MR Imaging of the Sciatic Nerves and Sciatic Nerve Blocks in the Diagnosis of Patients with Clinically Suspected Extraspinal Sciatica

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PURPOSE
Patients with leg pain resembling lumbosacral radicular sciatica sometimes have a normal lumbar MR imaging (MRI). The term “piriformis syndrome” or extraspinal sciatica has been used in such cases, but evidence of sciatic nerve entrapment is controversial and difficult to diagnose. MR imaging of the sciatic nerves has emerged as a powerful tool. Sciatic nerve blocks have not been described previously as a potential diagnostic tool for evaluating extraspinal sciatica. The purpose of this study was to evaluate MRI of the sciatic nerves and sciatic nerve blocks in the diagnosis of patients with clinically suspected extraspinal sciatica.

MATERIALS & METHODS
Retrospective review of patients from August 2004 to September 2010 diagnosed with extraspinal sciatica referred for CT-guided sciatic nerve block(GE VCT Lightspeed 64 Scanner). Twenty-two-gauge spinal needles were advanced to the sciatic nerve at the sciatic notch and injected with 1.6 cc of anesthetic/steroid mixture. Assessment postinjection and in follow up with referring physicians was correlated with MRI of the sciatic nerves, EMGs and intraoperative findings. MRI: Coronal and axial inversion recovery sequences of the sciatic nerves(1.5 T magnet TR 2530 TE 20 TI 160 3/3.5 mm FOV 34 NEX 3). Cross-sectional measurements of the sciatic nerves at the sciatic notch and signal intensity ratios of the sciatic nerve relative to muscle on the symptomatic nerve and contralateral asymptomatic nerve were performed using the measurement tool on the Agfa PACS. Wilcoxon signed rank and paired t tests were performed for statistical analysis.

RESULTS
Nineteen patients - 5M, 14F; aged 30-87 years(mean 51 years) underwent 32 injections; typical symptoms included buttock pain radiating to the leg sometimes reproducible by sciatic notch palpation. Twenty-five of 32 injections contained 0.75% Bupivacaine and Celestone 6 mg/ml; 5/32 injections contained 0.75% Bupivacaine and Kenalog-40; 2/32 injections were 0.75% Bupivacaine without steroid. Fourteen of 19 had immediate relief; duration of relief 1-10 days. No complications. Seventeen of 19 had sciatic nerve MRls(12/17 abnormal). Signal intensity of the symptomatic sciatic nerve, mean 510 +/- 1042, was significantly higher relative to the asymptomatic side 432 +/- 920, P=.020. Size of nerve at the sciatic notch(symmetric: mean .56 cm +/- .11; asymptomatic mean .58 cm, +/- .12) is highly correlative with symptoms(p=.002). Ten of 19 had electrodiagnostic studies, only two were abnormal. Five of 14 underwent surgical decompression(4/5 pain free 1 month postoperative). Intraoperative findings included flattening of the sciatic nerve, entrapment by a fibrous band and enlarged piriformis muscle. The one patient who did not benefit from surgical decompression also did not respond to the sciatic nerve injection with immediate pain relief.

CONCLUSION
Extraspinal sciatica is difficult to diagnose with equivocal radiographic, clinical and electrodiagnostic findings. MR neurograms and sciatic nerve blocks may be helpful in evaluating patients with potential sciatic nerve entrapment. Those patients who demonstrate relatively smaller sciatic nerves at the sciatic notch, perhaps related to compression, with relative increased T2 signal and who respond with immediate relief following sciatic nerve blocks may benefit from surgical decompression. Sciatic nerve blocks are a safe diagnostic tool.

KEY WORDS: Sciatica, MR neurography, sciatic nerve block

Primary Peripheral Neuroectodermal Tumors of the Spine: Two Distinct Imaging Patterns

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PURPOSE
Spinal primary primitive neuroectodermal tumors (pPNET) are extremely rare with only a few reported cases in the literature. pPNET are sub-classified as central or peripheral types. Central PNET (cPNET) are morphologically indistinguishable neoplasms from medulloblastomas but located in the central nervous system outside the posterior fossa. Peripheral PNET (pPNET) are related closely to the Ewing’s family of tumors. The histologic appearance of cPNET and pPNET are similar; however, they display different cytogenetics and immunoreactivity. Nowadays, demonstration of MIC2 glycoprotein expression by immunocytochemical stain (CD99) aids in differentiation of both types. The purpose of this study was to retrospectively review the MRI features in all cases of primary spinal PNET in two institutions from 2003 to 2010. Literature review of primary spinal pPNET also was performed for comparison.

MATERIALS & METHODS
Six patients (2 males, 4 females; mean age, 10 y/o) with primary spinal PNET were recruited. Clinically, one patient presented protruding back mass and the other four patients presented compressive myelopathy and/or radiculopathy. All underwent MR imaging (MRI) of the spine at their initial presentation. Four received surgery (subtotal in three and grossly total removal in one) and one underwent CT-guided biopsy followed by adjuvant chemoradiotherapy.

RESULTS
One did not undergo MIC2 staining, and the other five cases were subclassified as pPNETs as identified by positive immunohistochemical MIC2/CD99 staining. All patients of pPNET had a solitary but contiguous spinal lesion involving multilevels (Table 1). Thoracic spine was involved most commonly. Anatomically, four pPNETs were located epidurally in the central spinal canal with transforaminal and
paraspinal extension (dumbbell appearance), and one was located intradurally in the cauda equina with nerve roots thickening. Various degrees of vertebral body involvement were seen in four. Lesions were seen as isointense on T1-weighted image in four and isointense on T2-weighted image in three. All had various degrees of enhancement. During the follow-up period, one patient died of disease, one was lost to follow up and the other three patients were still alive for 4, 17 and 24 months since the initial presentation.

Table 1: Summary of five cases with spinal primary pPNET

<table>
<thead>
<tr>
<th>Patient No</th>
<th>Age (yr)</th>
<th>Sex</th>
<th>Level</th>
<th>Location</th>
<th>Trans-neuroforamen</th>
<th>Vertebral involve ment</th>
<th>T1W</th>
<th>T2W</th>
<th>Enhancement after Gd⁻</th>
<th>Survival (months)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>8</td>
<td>F</td>
<td>T2-6</td>
<td>Epidural</td>
<td>+</td>
<td>+</td>
<td>hypo</td>
<td>hypo</td>
<td>Hetero</td>
<td>Alive at 17</td>
</tr>
<tr>
<td>2</td>
<td>9</td>
<td>F</td>
<td>C4-T1</td>
<td>Epidural</td>
<td>+</td>
<td>+</td>
<td>iso</td>
<td>iso</td>
<td>Strong</td>
<td>Alive at 4</td>
</tr>
<tr>
<td>3</td>
<td>9</td>
<td>M</td>
<td>S1-2</td>
<td>Intradural</td>
<td>+</td>
<td>+</td>
<td>iso</td>
<td>iso</td>
<td>Strong</td>
<td>Alive at 24</td>
</tr>
<tr>
<td>4</td>
<td>11</td>
<td>M</td>
<td>T3-5</td>
<td>Epidural</td>
<td>-</td>
<td>+</td>
<td>iso</td>
<td>iso</td>
<td>Strong</td>
<td>Lost F/U2</td>
</tr>
<tr>
<td>5</td>
<td>24</td>
<td>F</td>
<td>T10</td>
<td>Epidual</td>
<td>+</td>
<td>+</td>
<td>iso</td>
<td>hyper</td>
<td>Hetero</td>
<td>12</td>
</tr>
</tbody>
</table>

CE= cauda equina

CONCLUSION
In contrast to most cases of secondary spinal PNET, which are metastases dropping from intracranial tumors, primary spinal pPNET tends to appear as a solitary infiltrative mass with intraspinal multilevel extension and the radiographic features of primary spinal pPNET can be divided in two distinct patterns according to the lesional level: (1) epidural-transforaminal dumbbell appearance above cauda equina, (2) intradural with nerve root enlargement or encasement in the cauda equina.

KEY WORDS: PNET, peripheral primitive neuroectodermal tumor, spine

Paper 067 Starting at 12:21 PM, Ending at 12:29 PM

Diffusion-Weighted Imaging of the Spine Improves Sensitivity of Lesion Detection in Multiple Myeloma

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PURPOSE
Traditional spine surveys for multiple myeloma employ T1, T2, STIR and sometimes, contrast-enhanced sequences. Despite multimodal assessment, disease is often difficult to detect and characterize particularly in elderly patients with heterogeneous marrow and in locations like the pedicles, facets and endplates. Myeloma presents a unique challenge as traditional imaging techniques often are lacking in sensitivity. Recently, interest in diffusion-weighted imaging (DWI) of the spine for metastatic disease has increased. From a microscopic perspective, multiple myeloma is composed of densely packed cells that impede water diffusivity in surrounding bone matrix. This would be expected to manifest on diffusion-weighted imaging sequences as restriction compared to background tissues. We therefore attempted to assess the added value of diffusion imaging in lesion detection and its contribution to confidence in diagnosis.

MATERIALS & METHODS
We retrospectively reviewed spinal surveys performed at our institution from June 2009 to December 2010. All patients were known to have multiple myeloma at the time of imaging by prior pathologic confirmation. All surveys employed sagittal T1, STIR and T2-weighted sequences. Contrast-enhanced sequences were obtained if requested. A DWI was obtained (3-6 directions, B value 500) in the sagittal plane. Studies were consensus reviewed twice by two experienced radiologists and each lesion was graded separately. In the first review, only the T1, STIR and (if available) contrast-enhanced sequences were reviewed, and each lesion was graded on a scale of 1-4 (1 = missed lesion that was visible only in retrospect on second review; 2 = equivocal lesion; 3 = probable lesion; 4 = definite lesion). Subsequently, the DWI sequence was reviewed in conjunction with conventional sequences. Lesions were graded again from 1-4 based on their diffusion characteristics. Conspicuity differences also were evaluated.

RESULTS
Diffusion-weighted imaging added significant information often outperforming traditional sequences in terms of conspicuity on diffusion-weighted imaging compared to conventional imaging.

CONCLUSION
Diffusion-weighted imaging is a rapid sequence that may practically be added to routine spine MRI in patients with suspected multiple myeloma. It can improve lesion detection sensitivity and characterization, especially in problematic locations. While previous studies showed mixed results with spine DWI, newer machines with stronger and faster gradients and new coils can improve image signal to noise while using intermediate b values of 500-800. Our study has shown that DWI can improve conspicuity of spinal multiple myeloma lesions and assist in diagnosing smaller lesions that otherwise would have been missed.

KEY WORDS: Spine, Diffusion-weighted imaging, myeloma
Comparison of CT Perfusion and Digital Subtraction Angiography in the Evaluation of Delayed Cerebral Ischemia

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New York, NY

PURPOSE
To compare CT perfusion (CTP) and digital subtraction angiography (DSA) for determining delayed cerebral ischemia (DCI) in aneurysmal subarachnoid hemorrhage (A-SAH).

MATERIALS & METHODS
A retrospective study of A-SAH patients admitted between December 2004 and December 2008 was performed. CT perfusion and DSA were obtained at days 6-8 following aneurysm rupture. Both qualitative and quantitative analyses of CT perfusion deficits were performed. Digital subtraction angiography was categorized as presence or absence of vasospasm. The reference standard for determining DCI was based on clinical deterioration or infarction on CT or MRI. The test characteristics of CTP and DSA were calculated and their graphs of conditional probabilities (GCP) were constructed using Bayesian analysis.

RESULTS
Fifty-seven patients were included; 79% (45/57) had DCI. Seventy percent (40/57) had CTP perfusion deficits; 80% (36/45) of the DCI and 33% (4/12) of no DCI patients. Sixty-three percent (36/57) had DSA demonstrating vasospasm; 73% (33/45) of the DCI and 25% (3/12) of no DCI patients. Quantitative analysis of the CTP data revealed a significant difference in CBF values for the DCI (29.4 mL/100gm/min) and no DCI groups (40.5 mL/100gm/min, p=0.0213). The sensitivity, specificity, positive and negative predictive values for CTP were 0.80 (95% CI 0.68-0.92), 0.67 (95% CI 0.40-0.93), 0.90 (95% CI 0.82-0.96), 0.47 (95% CI 0.27-0.62) and for DSA were 0.73 (95% CI 0.60-0.86), 0.75 (95% CI 0.50-0.99), 0.92 (95% CI 0.82-0.98) and 0.43 (95% CI 0.26-0.53), respectively. Graphs of conditional probabilities for CTP (Figure 1A) and DSA (Figure 1B) for determining DCI reveal no clinically significant difference. To illustrate this result, patients with high Hunt Hess grades have a 40% pretest probability (solid line) for developing DCI. In these patients, if the CTP is positive for a perfusion deficit, then the post-test probability increases to 62%. However, if the CTP exam is negative then the post-test probability decreases to 17% (Figure 1A). In comparison, for this same patient a positive DSA increases the post-test probability to 66% whereas a negative DSA decreases the post-test probability to 19% (Figure 1B). For example, if the treatment threshold is set at a 60% and above probability level for DCI, then CTP and DSA provide comparable usefulness in determining treatment decisions for A-SAH patients with high Hunt Hess grades.

CONCLUSION
CT perfusion and DSA have similar test characteristics and Bayesian analysis for determining DCI in A-SAH patients.

KEY WORDS: Vasospasm, CT perfusion imaging, digital subtraction angiography

Hemodynamics Are Altered in Patients with Aneurysm-Related Vasospasm: Serial Evaluation with Whole-Brain CT Perfusion

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PURPOSE
Diagnosis and monitoring of vasospasm remains a challenge with limitations using TCD, cerebral angiography and CT angiography (CTA). In most settings decreased cerebral perfusion is inferred from changes in arterial diameter rather than by simultaneous measurement. Recent generation of 320-slice CT scanners now give whole brain CT perfusion
Utility of Qualitative CT Perfusion in Determining Vasospasm and/or Delayed Cerebral Ischemia in Patients with Aneurysmal Subarachnoid Hemorrhage

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Purpose
To evaluate the clinical usefulness of qualitative CT perfusion (CTP) for determining vasospasm and/or delayed cerebral ischemia (DCI) in patients with aneurysmal subarachnoid hemorrhage (aSAH).

Materials & Methods
Retrospective study was performed on aSAH patients admitted from December 2004 to December 2008. IRB approval and HIPAA compliance were obtained. CT perfusion typically was performed between days 6-8 following aneurysm rupture in asymptomatic patients or on the same day symptoms occurred in patients with clinical deterioration. Qualitative analysis of CTP was performed to identify perfusion deficits, defined as focal regions of reduced cerebral blood flow and/or prolonged mean transit time. The reference standard consisted of both imaging and clinical criteria for determination of vasospasm and/or DCI. In this study, the purpose of CTP was considered as an imaging test that would prompt further testing and/or treatment in patients with a high likelihood of either vasospasm or DCI. The test characteristics of CTP were calculated and graphs of conditional probabilities (GCP) were constructed using Bayesian analysis.

Results
Ninety-seven patients were included; 41% (40/97) patients had vasospasm/DCI. Qualitative CTP perfusion deficits were seen in 95% (38/40) patients with vasospasm/DCI and 18% (10/57) patients without vasospasm/DCI. The sensitivity, specificity, positive and negative predictive values for CTP were 0.95 (95% CI 0.88-1.0), 0.83 (95% CI 0.73-0.92), 0.79 (95% CI 0.68-0.91) and 0.96 (95% CI 0.90-1.0), respectively. The likelihood ratios of positive and negative CTP were 5.4 (95% CI 3.1-9.6) and 0.6 (95% CI 0.02-0.24), respectively. Bayes’ theorem calculated the post-test probability of vasospasm/DCI for any given pretest probability and the GCP (Figure 1). To illustrate the application of probability theory in clinical practice, an example treatment threshold was set at 60% probability for vasospasm/DCI. Using this as a reference, then a positive CTP would increase the post-test probability of vasospasm/DCI above the treatment threshold when the pretest probability is ≥21% (Figure 1a). In contrast, a negative CTP would maintain the posttest probability of vasospasm/DCI below the treatment threshold when the pretest probability is ≤96% (Figure 1b).

Materials & Methods
Patients with aSAH who had whole-brain baseline CTA/CTP were included. Follow-up CTA/CTP was performed if patients clinically deteriorated, had TCD evidence of vasospasm (vasospasm group) or at days 7-14 if asymptomatic (without vasospasm). All individuals with TCD evidence of vasospasm were treated with hemodynamic augmentation and intra-arterial milrinone (per institutional protocol). A total of 31 automated regions of interest (ROIs)/hemisphere placed at six standard levels covering the entire brain measured serial perfusion parameters: CBF, CBV, MTT, TTP. Individual ROIs then were grouped to evaluate perfusion in the MCA, ACA, PCA territories. Arterial diameters were measured in the terminal ICA, MCA (M1, M2) and PCA (P1, P2). A Pearson-correlation coefficient was used to evaluate the relationship between artery diameter and perfusion. To evaluate the effect of treatment, a t-test was used to compare perfusion pre and postvasospasm therapy. Because of the exploratory nature of the analysis, no correction was performed for multiple comparisons.

Results
There were 10 patients without (total 20 CTP/CTA) and six patients with vasospasm (total 17 CTP/CTA) who had perfusion studies for comparison. Changes in arterial diameter were significantly correlated with changes in MTT (r=−0.58, p=0.02) and TTP (r=−0.54, p=0.01) i.e., patients who developed angiographic vasospasm had prolongation of MTT and TTP. Patients who developed vasospasm had decreased CBF from baseline in MCA and ACA territories (p<0.05). For vasospasm patients treated with milrinone, there was a significant improvement in MTT (p=0.02) and trends towards improved CBF (0.07) and TTP (p=0.07).

Conclusion
Changes in perfusion are seen with change in arterial diameter from vasospasm. Patients who develop vasospasm had significant changes from baseline CBF in the MCA and ACA territories. There was improvement in perfusion seen with intra-arterial treatment.

Key Words: Vasospasm, CT perfusion, aneurysm
CONCLUSION
Qualitative CTP has high sensitivity for determining vasospasm/DCI to identify A-SAH patients for immediate treatment and/or further testing. The application of Bayesian analysis provides further understanding for the appropriate utilization of CTP in clinical practice. Based on our example, CTP is most useful when the pretest probability is between 21-96%. In other words, if the pretest probability of vasospasm/DCI is very low (<21%) or very high (>96%), then CTP does not contribute to guiding patient care.

KEY WORDS: CT perfusion, vasospasm, Bayesian analysis
CONCLUSION
CT angiography is a valuable adjunct in the evaluation of patients with nonperimesencephalic SAH who have a negative initial catheter angiogram, demonstrating a causative cerebral aneurysm in 9.3% of patients.

KEY WORDS: Subarachnoid hemorrhage, CT angiography, catheter angiography

Diagnostic Yield of Repeat Catheter Angiography in Patients with Catheter and CT Angiography Negative Subarachnoid Hemorrhage

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PURPOSE
To determine the yield of repeat catheter angiography for the detection of causative vascular abnormalities in patients with subarachnoid hemorrhage (SAH) who have negative initial catheter and CT angiograms.

MATERIALS & METHODS
From January 1st, 2005 until July 31st, 2010, we instituted an IRB-approved prospective protocol in which patients who presented with SAH documented by noncontrast CT (NCCT) or cerebrospinal fluid (CSF) xanthochromia and had negative initial catheter and CT angiograms also were evaluated with repeat catheter angiography at 7 days and 3 months after presentation to assess for causative vascular abnormalities. Two neuroradiologists evaluated the NCCTs to determine the pattern of SAH (perimesencephalic or not) with differences in interpretation resolved by consensus. Catheter angiograms were reviewed by experienced interventional neuroradiologists at the time of clinical care.

RESULTS
Seventy-one patients were included in our study, with a mean age of 53.6 years (median 54 years, range 19-88 years). Forty-five patients were female (63.4%) and 26 male (36.6%). Sixty-eight patients had SAH by NCCT (95.8%) and three patients had CSF xanthochromia (4.2%). Among the former, 29 patients had perimesencephalic SAH (42.6%) and 39 had nonperimesencephalic SAH (57.4%, kappa 0.91, 95% CI 0.89-0.93). Repeat catheter angiograms 7 days after presentation were performed in all patients and 3 months after presentation were performed in 42 patients (59.2%). Mean time interval between presentation and the first repeat catheter angiogram was 6.4 days (median 6 days, range 3-12 days), and the second repeat catheter angiogram was 92 days (median 90.5 days, range 35-164 days). The first repeat catheter angiogram demonstrated a causative vascular abnormality in four patients (yield of 5.6%), three of which had nonperimesencephalic SAH (yield of 7.7%) and one had perimesencephalic SAH (yield of 3.4%). The vascular abnormalities were three aneurysms and a 2 mm arteriovenous malformation at the skull base supplied by the right vertebral artery. Aneurysm locations were one right suprachiasmatic internal carotid artery (blister-like), one right superior hypophyseal artery and one distal left superior cerebellar artery. Mean aneurysm size was 1.67 mm (median 1.5 mm, range 1.5-2 mm). Three patients underwent endovascular treatment of the vascular abnormality and one patient elected not to undergo any treatment. The second repeat catheter angiograms did not demonstrate any causative vascular abnormalities. No causative abnormalities were found in patients with CSF xanthochromia.

CONCLUSION
Repeat catheter angiography performed 7 days after presentation is a valuable adjunct in the evaluation of patients with SAH who have negative initial catheter and CT angiograms, demonstrating a causative vascular abnormality in 5.6% of patients.

KEY WORDS: Subarachnoid hemorrhage, CT angiography, catheter angiography
Contrast Dose, Temporal Footprint, and Spatial Resolution Tradeoffs in Dynamic Contrast-Enhanced MR Angiography Performed in a Swine Model of an Intracranial Aneurysm

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PURPOSE
A swine model of an intracranial aneurysm was used to evaluate the choice of contrast dose and the tradeoff between temporal and spatial resolution in dynamic contrast-enhanced MR angiography (MRA).

MATERIALS & METHODS
Bilateral carotid artery aneurysms were created surgically in this IACUC-approved study, mimicking an intracranial aneurysm, using a pouch derived from a segment of the left external jugular vein. Dynamic contrast-enhanced MRA (TWIST) was performed at 3 T (Verio, Siemens Medical Systems, Erlangen, Germany) employing gadobutrol (Gadovist, Bayer Healthcare, Berlin, Germany). Sequences were performed optimized for temporal (high-temp) resolution, achieving intermediate spatial and temporal (mid-temp) resolution and optimized for spatial (low-temp) resolution (2.2 sec scan acquisition with 1.2 x 1.2 x 1.2 mm³ voxel size, 1.1 sec with 1.3×1.1×2.5 mm³ and 0.5 sec with 1.4 x 1.1 x 3.0 mm³). High-temp CE-MRA was performed twice, using a very low dose of 1 ml and a low dose of 2 ml of 1 M gadobutrol5 (equivalent to approximately 0.02 and 0.04 mmol/kg respectively). Signal to noise ratio (SNR) was assessed by region of interest (ROI) analysis. A blinded read, using only the coronal time-resolved MIPs, evaluating dose, dynamic information and image quality also was performed.

RESULTS
A total of 16 aneurysms were evaluated in eight swine subjects (mean weight 45 ± 5 kg). Dynamic SNR measurements showed a temporal difference in the filling of the aortic arch, carotid artery and aneurysm only on the high-temp scans. Delayed filling of the larger aneurysms was visualized on all sequences. The rank of scan sequences in terms of SNR, from highest to lowest was: high-temp low dose, low-temp, mid-temp and high-temp very low dose (56.7, 48.1, 47.5 and 39.9 respectively). Statistically significant differences were noted for contrast dose and for the high-temp low dose scan relative to the other sequences (with contrast dose held constant). The blinded read showed consistently the superiority of the full dose (“low dose”) of gadobutrol, depiction of temporal information only on the high-temp scans and no difference in image quality amongst the three full dose scans(Figure).

CONCLUSION
Low-dose high-temporal resolution dynamic contrast-enhanced MRA can be performed without significant in-plane image quality degradation. However, the additional information gained is limited when compared to the value of an isotropic acquisition (low temp). Contrast dose dependence was demonstrated, with limitations due to SNR and image quality at very low doses.

KEY WORDS: Brain, aneurysm, dynamic contrast-enhanced MR angiography

Volumetric Analysis of the CT Angiography Spot Sign Enables Calculation of the Rate of On-Going Hemorrhage in Patients with Primary Intracerebral Hemorrhage

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PURPOSE
To determine whether volumetric analysis of the CT angiography (CTA) spot sign, a potent predictor of hematoma expansion and poor outcome in patients with primary intracerebral hemorrhage (ICH), can be used to calculate the rate of on-going hemorrhage.
**Materials & Methods**

We retrospectively identified all primary ICH patients with spot signs who underwent both first-pass and delayed CTA acquisitions at our institution over a 10-year period. We then recorded the time interval between the 2 CTA acquisitions (T, in minutes) and utilized computer-assisted volumetric analysis to determine the volume of extravasated contrast material within the hematoma in each acquisition (Vspot1 for first-pass and Vspot2 for delayed, in mL). The rate of on-going hemorrhage was calculated as follows: (Vspot2-Vspot1)/T (in mL/min). If Vspot1>Vspot2, the rate of on-going hemorrhage was designated as 0 mL/min. Medical records were reviewed for baseline clinical characteristics, in-hospital mortality and poor outcome among survivors (defined as a modified Rankin scale ≥4 at 3-month follow up). Baseline and follow-up ICH volumes were calculated with computer-assisted volumetric analysis.

**Results**

Sixty-nine patients were included in our study, with a mean age of 71.9 years (median 76 years, range 26-92 years). Forty-two patients were male (60.9%) and 27 female (39.1%). Mean initial ICH volume was 56.3mL (median 52.5mL, range 2-169.9mL). Mean delay time between first-pass and delayed CTA acquisitions was 2.24 minutes (median 1.87 minutes, range 0.13-9.58 minutes). Thirty-seven patients had a follow-up noncontrast CT examination performed (53.6%, mean time to follow-up 9.1 h, median 7.5 h, range 2.5-42.8 h). Mean volume of extravasated contrast material in the first-pass CTA was 0.16mL (median 0.04mL, range 0-2.32mL), and mean volume of extravasated contrast material in the delayed CTA was 1.15mL (median 0.35mL, range 0-11.6mL). The mean calculated rate of on-going hemorrhage was 0.48mL/min (median 0.13mL/min, range 0-3.53mL/min). Table 1 summarizes the risk of hematoma expansion, in-hospital mortality and poor outcome among survivors for different rates of on-going hemorrhage. In multivariate logistic regression analysis, the rate of on-going hemorrhage was an independent predictor of hematoma expansion (OR 19.9, 95% CI 2.4-169.2, p-value 0.006) and in-hospital mortality (OR 3.6, 95%CI 1.1-12.2, p-value 0.036).

**Table 1. Risk of Hematoma Expansion, Mortality and Poor Outcome by Rate of On-Going Hemorrhage**

<table>
<thead>
<tr>
<th>Rate of Hemorrhage (mL/min)</th>
<th>Risk of Expansion</th>
<th>Poor Outcome</th>
<th>Mortality</th>
<th>Poor Outcome and Mortality</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00-0.025 (n=23)</td>
<td>50.0</td>
<td>43.5</td>
<td>34.5</td>
<td>3.5</td>
</tr>
<tr>
<td>0.025-0.325 (n=23)</td>
<td>86.7</td>
<td>80.0</td>
<td>77.1</td>
<td>3.1</td>
</tr>
<tr>
<td>0.325-0.65 (n=23)</td>
<td>100.0</td>
<td>73.9</td>
<td>66.7</td>
<td>3.1</td>
</tr>
<tr>
<td>AUC (0.5% C2)</td>
<td>0.61 (0.04-0.94)</td>
<td>0.81 (0.24-0.97)</td>
<td>0.81 (0.42-0.93)</td>
<td>n.a.</td>
</tr>
<tr>
<td>P-value</td>
<td>&lt;0.0001</td>
<td>0.031</td>
<td>0.022</td>
<td>0.05</td>
</tr>
</tbody>
</table>

*Hematoma expansion defined as an increase of >6mL or >30% from the baseline ICH volume in the 37 patients with a follow-up noncontrast CT. Defined as mRS ≥4 at 3-month follow up among the 26 survivors. ICH: intracerebral hemorrhage; mRS: modified Rankin Scale; n: number of patients within each rate of hemorrhage group; AUC: area under the curve after receiver operating characteristic analysis; CI: confidence interval; n/a: not applicable.

**Conclusion**

Volumetric analysis of the CTA spot sign in primary ICH enables calculation of the rate of on-going hemorrhage, which, in turn, predicts the risk of hematoma expansion, in-hospital mortality and poor outcome among survivors.

**Key Words:** Spot sign, intracerebral hemorrhage, outcome

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**Paper 075 Starting at 11:41 AM, Ending at 11:49 AM**

**Early Rate of Contrast Extravasation in Intracerebral Hemorrhage: A CT Perfusion Study**

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**Purpose**

CT perfusion (CTP)-derived permeability surface area product (PS) is a novel method of measuring the rate of contrast extravasation from the intra to extravascular compartment. Knowing the rate of contrast extravasation may provide insight into the pathophysiology of hematoma expansion by identifying the target abnormality most likely to contribute to hematoma growth. This study assessed whether CTP-PS measures can distinguish between different rates of contrast extravasation for patients with and without CT angiography (CTA) spot sign or postcontrast CT contrast leakage (PCL). We hypothesize that the rate of contrast extravasation will be higher in CTA spot sign regions compared to PCL and hematoma regions in patients without extravasation.

**Materials & Methods**

We report CTP-derived blood-brain barrier (BBB) permeability findings of 16 consecutively screened ICH patients with and without confirmed contrast extravasation within 3 hours of symptom onset. CTPerfusion-derived parametric maps of PS were analyzed using custom software (IDL v6.1, RSI Inc, Boulder, Colo. USA). Four regions of interest were placed on perfusion-weighted average images: 1) Extravasation positive regions [CT angiographic spot sign and postcontrast leakage (PCL)], 2) mirrored contralateral hematoma volumes, 3) background hematoma excluding extravasation and 4) region within hematoma volume for patients without extravasation. Baseline and follow-up hematoma volumes were measured.

**Results**

Mean PS was 3.8 ± 2.9 ml · min⁻¹ · 100g⁻¹ · 0.12 ± 0.39 ml · min⁻¹ · 100g⁻¹ · 0.10± 0.26 ml · min⁻¹ · 100g⁻¹ and 0.38 ± 0.26 ml · min⁻¹ · 100g⁻¹ in the extravasation positive, hematoma excluding extravasation, contralateral mirror regions, and extravasation negative patients, respectively. Extravasation positive group was significantly different (p < 0.05). Within the extravasation group, spot sign and PCL regions had a mean PS of 6.5 ± 1.6 ml · min⁻¹ · 100g⁻¹ and 0.95 ± 0.39 ml · min⁻¹ · 100g⁻¹ respectively. These values were significantly different from each other and all other regions of interest (p < 0.05). Average absolute or percent hematoma volume increased from 34.1 ± 41.0 ml to 40.2 ±
46.1 ml or 27.8% in contrast extravasation positive patients. In extravasation negative patients absolute and percent volume decreased from 19.8 ± 31.8 ml to 17.4 ± 27.3 ml, or -1.5% (p < 0.05).

CONCLUSION
A clinical technique that quantifies the rate of extravasation provides objective assessment of hematoma expansion risk rather than the qualitative approach currently used. Such information may become increasingly important as novel ICH treatments are developed that will target specific lesions. We report a gradation of PS values in CTA and post-contrast CT detected lesions and patients without extravasation.

KEY WORDS: Blood-brain barrier, CT perfusion, intracerebral hemorrhage

Paper 076 Starting at 11:49 AM, Ending at 11:57 AM
Diagnosis of Intracranial Hemorrhagic Lesions: Can 3D SWAN Replace Standard 2D T2*Weighted?
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PURPOSE
3D SWAN (T2 star-weighted angiography) is a T2*-based multi-echo acquisition combined with a special reconstruction technique designed to optimize imaging of brain vasculature, and this 3D sequence is capable of producing high-resolution images with an excellent susceptibility-weighted contrast at a relatively short acquisition time. Our purpose is to determine the sensitivity of 3D SWAN for depicting various hemorrhagic lesions of the brain in comparison with 2D T2*-weighted gradient-echo images (2D T2*WI), and to assess the basic susceptibility characteristics of both sequences by using a phantom.

MATERIALS & METHODS
Our 3D SWAN sequence was optimized for suppressing the imaging of brain vasculature and achieved T2* weighted contrast. An acquisition time was almost equal between the 3D SWAN and 2D T2*WI (3 min.2 sec. vs 3 min.16 sec.). First, by using the agar phantom doped with five different concentrations of superparamagnetic iron oxide (SPIO), the contrast-to-noise ratios (CNRs) of 3D SWAN and 2D T2*WI were measured. In the prospective clinical study, 75 patients suspected of having brain lesions on the basis of clinical history or neurologic findings underwent MR imaging at 3 T with 3D SWAN and 2D T2*WI. Two neuroradiologists compared the detectability and conspicuity of the hemorrhagic lesions between both sequences.

RESULTS
For the CNR of the agar phantom at any concentrations of SPIO, the 3D SWAN was greater than 2D T2*WI. For the clinical study, 278 hemorrhagic lesions were identified in 50 patients: 229 microbleeds, 18 intracerebral hemorrhages, 3 subarachnoid hemorrhages, 2 subdural hematomas, 3 brain contusions, 8 axonal injuries, 13 superficial siderosis, a cavernous hemangioma, and a dural arteriovenous fistula. 3D SWAN detected significantly more lesions than 2D T2*WI (P<0.01); 3D SWAN was particularly useful for the detection of microbleeds and small traumatic lesions near the skull base (Figure). 3D SWAN also showed better lesion conspicuity for superficial siderosis and subarachnoid hemorrhage than 2D T2*WI.

Figure: A 62-year-old woman with microbleeds. The microbleed (arrow) in the pons is clearly visible on 3D SWAN, whereas the 2D T2*WI does not depict this lesion due to the partial volume effect and susceptibility artifacts (arrow).

CONCLUSION
3D SWAN is superior to standard 2D T2*WI in the conspicuity and detection of the various hemorrhagic lesions. 3D SWAN at a reasonable acquisition time may replace 2D T2*WI in most patients.

KEY WORDS: Microbleed, siderosis, SWAN

Paper 077 Starting at 11:57 AM, Ending at 12:05 PM
Spot Sign is More Common in the Absence of Multiple Prior Microbleeds
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PURPOSE
Mural thickening and permeability changes in amyloid angiopathy (CAA) and chronic hypertensive (CH) patients are implicated in the pathophysiology of multiple, chronic subclinical microbleeds. The spot sign, contrast extravasation on CT angiography, predicts hematoma expansion and is presumed to represent acute vessel damage. We hypothesize that the spot sign is more common in patients without multiple prior chronic microbleeds.

MATERIALS & METHODS
A retrospective study of 59 patients presenting within 6 hours of primary ICH onset undergoing CT angiography (CTA) and MRI. CT angiography spot sign presence was documented blinded to MR imaging. Hematoma expansion was defined as >6mL or 30% enlargement. The Boston criteria were applied to microbleed interpretation dichotomizing subjects into probable and negative CAA. Basal ganglia, thalamic, and brainstem microbleed location were interpreted as chronic hypertensive pattern. Univariate logistic
regression and ordinal logistic regression analysis identified significant predictive factors between spot positive and negative patients, or microbleed pattern.

**RESULTS**

The incidence of spot positivity was 42%, 22% and 0% for CAA negative, CH and CAA positive patients respectively (p = 0.01). CAA negative patients had higher baseline NIHSS (p = 0.039), larger follow-up hematoma volume (p = 0.02) and poorer Rankin score (p = 0.049) than CH or CAA positive patients. After age adjustment, spot positive (p = 0.023), age-related white matter change (p = 0.041), number of microbleeds (p < 0.0001) and modified Rankin score (p = 0.027) remained significantly different between groups.

**CONCLUSION**

Boston criteria-defined CAA negative status demonstrates the highest risk of spot positivity compared to probable CAA and CH patients.

**KEY WORDS:** CTA spot sign, contrast extravasation, computed tomography angiography

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**Paper 078 Starting at 12:05 PM, Ending at 12:13 PM**

**Calculation of Wall Shear Stress in Arteriovenous Malformations Using High-Resolution 3D-Radial PC-MR Angiography**

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University of Wisconsin School of Medicine and Public Health

Madison, WI

**PURPOSE**

Arteriovenous malformations (AVM) are congenital abnormalities in blood vessels that progress after birth. Some studies suggest that high wall shear stress (WSS) from increased flow leads to increased growth factor expression, endothelial proliferation, and AVM progression. Others suggest arterial feeders to AVMs have similar WSS compared to normal contralateral arteries despite having larger diameters and velocities, suggesting increased WSS stimulates vessel dilation, normalizing WSS. We compared WSS values in arteries feeding AVMs to unaffected contralateral vessels to determine whether AVMs are stable, or if dilation and flow will continue to increase over time.

**MATERIALS & METHODS**

We imaged 24 patients with AVMs, eight were clinically stable, and 16 presented with symptoms (15 female, 9 male, age 27-73 years, median 47.5 years), using whole-brain 3D-radial PC-MRA (PC-VIPR) at a spatial resolution of 0.67x0.67x0.67 mm3 (imaging time 5 min). We selected points around arteries feeding AVMs in a custom MATLAB environment, and calculated WSS using Green’s theorem and B-spline interpolation. Patients were considered stable (n=8) if asymptomatic with the AVM discovered as an incidental finding, or if they had a known untreated AVM and their symptoms were mild (headaches, or clinically stable seizures controlled with antiepileptic medication) and stable for 2 years. Patients were considered symptomatic and received treatment after imaging (n=16) if they presented with new onset of symptoms with increasing severity or frequency, or presented with hemorrhage, mental status changes or neurologic deficits.

**RESULTS**

In eight stable patients, calculated WSS from feeding vessels was 0.966 ± 0.10 N/m2; WSS from normal contralateral vessels was WSS 0.951 ± 0.13 N/m2. A two-sample T-test was performed finding a p-value of 0.273, showing no statistical difference between WSS in AVM feeders and normal vessels. In 16 symptomatic patients, calculated WSS from feeding vessels was 0.831 ± 0.07 N/m2; the calculated WSS from normal contralateral vessels was 0.695 ± 0.09 N/m2. A two-sample T-test was performed finding a p-value of 0.014, showing a statistical difference between WSS in AVM feeders and normal vessels.

**CONCLUSION**

Estimates of WSS may improve the characterization and staging of AVMs by demonstrating altered hemodynamics. In this study, variation in WSS between feeders and normal vessels appeared to correlate with the clinical course of the patient. Stable patients tended to have similar WSS in feeders when compared to normal contralateral vessels, whereas patients presenting with acute symptoms had higher WSS in the arteries supplying the AVM when compared to normal contralateral vessels.

**KEY WORDS:** Arteriovenous malformations, radial PC-MR angiography, whole brain
Performance of Contrast-Enhanced MR Venography, 3D Gradient-Echo Postcontrast T1-Weighted, and Spin-Echo T1-Weighted Sequences for Detection of Venous Sinus Thrombosis and Stenosis

Mitchell, B. C. • Saindane, A. M. • Dehkharghani, S. • Desai, N. K.
Emory University School of Medicine
Atlanta, GA

PURPOSE
Evaluation of the dural venous sinuses with MR imaging (MRI) often is performed for suspected venous sinus thrombosis or for venous sinus stenosis as a sign of chronically elevated intracranial pressure in the setting of idiopathic intracranial hypertension (IIH). There is considerable variability in MR protocols, including use of conventional postcontrast spin-echo T1-weighted (SE-T1) versus 3D gradient-echo postcontrast T1-weighted (3D-GRE-T1) sequences, and in use of contrast-enhanced MR venography (CE-MRV). The purpose of this study was to evaluate the performance of these three techniques at evaluation of dural venous sinus thrombosis and stenosis.

MATERIALS & METHODS
Seventy-three patients were enrolled retrospectively in this IRB-approved study. Each patient underwent MRI and MRV evaluation at the same imaging session using precontrast axial SE-T1, postcontrast axial SE-T1, postcontrast sagittal 3D-GRE-T1, and pre and postcontrast gradient-echo based MRV with generation of MIP images from the subtracted dataset. The SE-T1, 3D-GRE-T1, and CE-MRV datasets were separated, anonymized, and randomized. Three neuroradiologists evaluated each of the 219 datasets for presence or absence of dural venous sinus thrombosis of each internal jugular vein, sigmoid, transverse, superior sagittal, straight, and cavernous sinuses, resulting in 10 segments. SE-T1 datasets also were evaluated for presence or absence of intrinsically T1-hyperintense thrombus. Venous sinus stenosis at both transverse-sigmoid sinus junctions were evaluated in each patient. Sensitivity, specificity, and degree of concordance between the techniques were evaluated per segment and per patient.

RESULTS
There were a total of 13 patients (37 total segments) with suspected venous sinus thrombosis by at least one reader on at least one technique, and nine patients (24 segments) considered as having definite thrombosis on CE-MRV. Complete concordance rates (3/3 readers in agreement) for thrombosis in segments where at least one reader suspected thrombosis were 88% (21/24) on CE-MRV, 38% (6/16) on 3D-GRE-T1, and 12% (3/25) on SE-T1. In comparison to CE-MRV per segment over all 73 patients, the sensitivity/specificity/false positive rate of detection of thrombus was 54%/100%/0% for 3D-GRE-T1 and 30%/97%/24% for postcontrast SE-T1. On a per patient basis for detection of any venous sinus thrombosis, the sensitivity/specificity/false positive rate was 67%/100%/0% for 3D-GRE-T1, and 33%/99%/25% for both postcontrast SE-T1, and for T1 hyperintensity on precontrast SE-T1. There were 58 transverse-sigmoid sinus junction stenoses in 30 patients suspected by at least one reader on one technique. Fifty stenoses in 25 patients were determined to be definite on CE-MRV. Complete concordance rates for stenosis in segments where at least one reader suspected stenosis were 94% (47/50) on CE-MRV, 25% (14/56) on 3D-GRE-T1, and 0% (0/16) on SE-T1. On a per patient basis for detection of any venous sinus stenosis, in comparison to CE-MRV the sensitivity/specificity/false positive rate was 68%/97%/17% for 3D-GRE-T1, and 8%/99%/3% for postcontrast SE-T1.

CONCLUSION
Postcontrast 3D-GRE-T1 sequences offer improved detection of venous sinus thrombosis and stenosis over postcontrast SE-T1 imaging; however, CE-MRV with subtraction and MIPs demonstrates superior sensitivity, specificity, and interrater concordance for both indications. Intrinsic T1-hyperintensity in a venous sinus on SE-T1 imaging is neither sensitive nor specific for dural venous sinus thrombosis.

KEY WORDS: Venous sinus thrombosis, MR venography, idiopathic intracranial hypertension

Cerebral Small Resistance Artery Structure and Cerebral Blood Flow in Normotensive Subjects and Hypertensive Patients Investigated with Perfusion MR Imaging

Gasparotti, R.1 • De Ciuceis, C.2 • Cornali, C.1 • Mardighian, D.1 • Agabiti Rosei, E.1 • Rizzoni, D.2
1 ‘Spedali Civili di Brescia, University of Brescia, Brescia, ITALY. 2 Clinica Medica, University of Brescia, Brescia, ITALY

PURPOSE
It has been demonstrated previously that, in essential hypertensive patients, subcutaneous small resistance artery structural alterations, as indicated by an increased media to lumen ratio (M/L), may predict coronary and forearm flow reserve. In essential hypertension also human cerebral small arteries present a clear increase in M/L. The purpose of the study is to investigate the relationship between cerebral blood flow (CBF) and cerebral small resistance artery structure.

MATERIALS & METHODS
Ten subjects were included in the present study, five hypertensive patients and five normotensive control subjects. All subjects underwent a neurosurgical intervention. A small portion of morphologically normal cerebral tissue was excised and rapidly put in chilled physiologic saline solution. Cerebral small resistance arteries were dissected and mounted on an isometric myograph, and the M/L was measured. Before neurosurgical intervention patients underwent dynamic susceptibility-weighted contrast (DSC)-enhanced MR imaging (MRI) with a single-shot gradient-echo EPI sequence (TR/TE 1.4 sec/30 msec, slice thickness, 5 mm; field of view, 230 mm; acquisition matrix, 128x128) and bolus injection of Gd-DTPA at a rate of 4 ml/sec. Maps of regional cerebral blood flow (CBF), regional cerebral blood volume (CBV) and of the mean transit time (MTT) were calculated with the commercial software NordicICE (version 2.3.9, NordicImagingLab AS, Bergen, Norway). Cerebral
blood volume and CBF maps were corrected for contrast agent leakage. Round-shaped ROIs were manually placed in the lenticular nucleus, thalami, fronto-temporo-occipital gray matter, frontal and temporal white matter and the mean values of CBF (ml/100g/min) and CBV (ml/100g) were determined in both intact and affected hemispheres.

RESULTS
Cerebral blood flow values were reduced in different areas of the brain in hypertensive patients compared with normotensive subjects. However, these differences reached statistical significance only in the thalamus. No difference between groups was observed for CBV (Table 1). A statistically significant inverse correlation was observed between M/L of cerebral arteries and CBF in the cortical gray matter (r=-0.65, p<0.05), lenticular nucleus (r=-0.74, p<0.01), thalamus (r=-0.71, p<0.01 and subcortical white matter (r=-0.60, p<0.05), while correlation with CBV in the different areas were not statistically significant. Microvessel density in the brain was not significantly correlated with CBF or CBV in any area.

Table 1. Regional CBF and CBV as evaluated by MRI in the study population.

<table>
<thead>
<tr>
<th></th>
<th>Normotensive subjects (n=5)</th>
<th>Hypertensive patients (n=5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CBF cortical gray matter (ml/100g/min)</td>
<td>72.9±5.19</td>
<td>66.4±6.74</td>
</tr>
<tr>
<td>CBF lenticular nucleus (ml/100g/min)</td>
<td>72.8±5.58</td>
<td>64.8±7.95</td>
</tr>
<tr>
<td>CBF thalamus (ml/100g/min)</td>
<td>73.1±6.33</td>
<td>59.2±9.55*</td>
</tr>
<tr>
<td>CBF subcortical white matter (ml/100g/min)</td>
<td>22.9±3.29</td>
<td>21.9±4.1</td>
</tr>
<tr>
<td>CBV cortical gray matter (ml/100g)</td>
<td>5.4±0.42</td>
<td>5.93±0.87</td>
</tr>
<tr>
<td>CBV lenticular nucleus (ml/100g)</td>
<td>5.12±0.82</td>
<td>5.53±0.87</td>
</tr>
<tr>
<td>CBV thalamus (ml/100g)</td>
<td>4.99±0.79</td>
<td>5.53±0.3</td>
</tr>
<tr>
<td>CBV subcortical white matter (ml/100g)</td>
<td>1.69±0.21</td>
<td>1.81±0.11</td>
</tr>
</tbody>
</table>

*p<0.05 vs normotensive subjects

CONCLUSION
The present study has shown a direct relationship between cerebral blood flow and cerebral small resistance artery structure. Our results indicate that microvascular structure might play a major role in controlling CBF, and this might help to explain the relevant role of structural alterations of small resistance arteries in predicting cerebrovascular events.

KEY WORDS: Cerebral blood flow, perfusion, hypertension

Monday Morning
10:45 AM - 12:30 PM
Room 602/603/604

(4e) Translational Research in Neuroradiology II, Functional Studies (Scientific Papers 081 - 093)

See also Parallel Sessions
(4a) Adult & Pediatric Trauma
(4b) Interventional: Aneurysms
(4c) Spine: Intervention & Neoplasms
(4d) Adult Brain: Vascular Intracranial

Moderators: Peter Barker, D.Phil
Vittoria Spampinato, MD

Paper 081 Starting at 10:45 AM, Ending at 10:53 AM
Imaging of Excitatory and Inhibitory Neurotransmitters in Fibromyalgia

Foerster, B. R. ¹ • Petrou, M. ² • Edden, R. A. E. ² • Hoefling, N. L. ³ • Sundgren, P. C. ³ • Lowe, S. E. ³ • Clauw, D. J. ³ • Harris, R. E. ³
¹University of Michigan, Ann Arbor, MI, ²Johns Hopkins University, Baltimore, MD

PURPOSE
Widespread pain sensitivity in fibromyalgia (FM) subjects suggests a central nervous system (CNS) processing problem. Several neuroimaging studies have reported increased in ‘Glx’ (combined measure of glutamate and glutamine) in pain processing regions in the brain suggesting an elevation in excitatory neurotransmitters. However, there is a paucity of data evaluating the neuroinhibitory pathway in chronic pain. The purpose of this study was to assess for decreases in of γ-aminobutyric acid (GABA), the major inhibitory neurotransmitter in the central nervous system (CNS), (as measured by magnetic resonance spectroscopy imaging) in a number of brain regions implicated in pain processing in fibromyalgia subjects compared to healthy controls.

MATERIALS & METHODS
The subjects in this study were15 female subjects (aged 22-60 years, mean age 36.5 years) who met the 1990 American College of Rheumatology (ACR) criteria for fibromyalgia as well as nine female healthy controls (aged 22-52 years, mean age 31.4 years). MR imaging (MRI) examinations were performed on a Philips Achieva 3 T MRI (Best, Netherlands). Subjects underwent conventional MR point-resolved spectroscopy (PRESS); the MR spectral editing technique,
MEGA-PRESS, was used to measure GABA relative to NAA. Voxels were placed in brain regions which have been implicated in pain processing in other neuroimaging studies including the anterior insula, posterior insula and the anterior cingulate cortex. LCMModel was used to calculate creatine, choline, N-acetylaspartate (NAA), myo-inositol and Glx concentrations. Determination of GABA/NAA ratio as well as GABA concentrations were carried out in Matlab (The Mathworks, Natick, MA) using in-house software. γ-aminobutyric acid concentrations were quantified in institutional units (i.u.) as the ratio between the GABA integral and the NAA integral multiplied by the NAA concentration calculated in LCMModel. Differences in GABA measurements between the different brain regions were analyzed using unpaired t-tests (p<0.05).

RESULTS
There was a significantly lower GABA/NAA ratio in the posterior insula in fibromyalgia subjects (0.220 ± 0.014) compared to healthy controls (0.244 ± 0.032; p = 0.02). There was a significantly lower GABA concentration in the posterior insula in fibromyalgia subjects (1.449 i.u. ± 0.161) compared to healthy controls (1.645 i.u. ± 0.262; p = 0.03). There was also a significant higher Glx/GABA ratio in the posterior insula in fibromyalgia subjects (4.804 ± 0.684) compared to healthy controls (4.173 ± 0.660; p = 0.04). There were no significant differences in the GABA/NAA ratios, GABA concentration or Glx/GABA ratios in the anterior insula or the anterior cingulate cortex.

CONCLUSION
Diminished inhibitory neurotransmission resulting from lower concentrations of GABA as well as an increased ratio of Glx (neuroexcitatory transmitter) to GABA (neuroinhibitory transmitter) within the posterior insula may play a role in the pathophysiology of FM and other central pain augmentation syndromes.

KEY WORDS: Chronic pain, MR spectroscopy

Materials & Methods
Fifty (27 female, 23 male, 75% right-handed) clinical fMRI language cases were retrospectively and independently reviewed by three blinded, board-certified neuroradiologists. One or more of the following fMRI tasks had been employed in each case: visual semantic decision task, visual sentence comprehension task, and silent word generation from letters. These scans were performed on patients with a variety of pathologies including brain tumors (20) and epilepsy without neoplasia (30). Functional MRI time-series were uniformly processed with an MRix Nivana Workstation by Thulborn Associates using a single-sided t-test. All data sets were reviewed across the four statistical threshold options most commonly employed at our institution and activation maps were superimposed on T1 SPGR and T2 SE-EPI images. Readers assigned laterality and Cartesian coordinates for the center of Broca’s and Wernicke’s areas. Dispersion was quantified as the perimeter length in mm of the triangle defined by each reader’s assigned 3D coordinates. In the event of an initial laterality disagreement among the readers, the discordant reader was required to select coordinates in the contralateral hemisphere prior to calculation of dispersion. Dispersion values and initial agreement on laterality then were compared across the readers and fMRI tasks.

RESULTS
The study design allowed for up to 300 measurements of dispersion in the 50 subjects (3 tasks by 2 brain regions), but only 228 measurements were obtained because one or more of the tasks had not been performed on a given patient (50), or language centers were not identifiable by the readers (22). Laterality disagreements were observed in 9% (21/228) of the initial readings. The highest percentage occurred with the sentence comprehension task (15%, 15/99), followed by the silent word generation task (8%, 4/53) and the semantic decision task (3%, 2/76) (P=0.028). The percentage of laterality errors did not significantly differ between Broca’s and Wernicke’s areas. Using ANOVA, the overall differences in dispersion values by brain region and by fMRI task were not statistically significant (p=0.126). The estimated dispersion values ranged from a low of 16mm for Wernicke’s area on the silent word task to a high of 33mm for Wernicke’s area on the sentence comprehension task.

CONCLUSION
No statistically significant difference in the dispersion of the location of Broca’s and Wernicke’s areas was found between the three language tasks. An average intrahemispheric dispersion coefficient of approximately 30 mm for all three language tasks suggests that readers were within about 1 cm of each other, indicating good interobserver repeatability in localization. However, there were statistically significant differences among language tasks in the number of initial lateralization disagreements, suggesting that choice of language task impacts the accuracy of fMRI lateralization.

KEY WORDS: Functional MR imaging, Broca’s, Wernicke’s

PAPER 082 Starting at 10:53 AM, Ending at 11:01 AM
Retrospective Analysis of Interobserver Spatial Variability in the Localization of Broca’s and Wernicke’s Areas Using Three Different Functional MR Imaging Language Paradigms

Black, D. F. • DeLone, D. R. • Kaufmann, T. J. • FitzGibbon, P. D. J. • Carter, R. E. • Machulda, M. M. • Welker, K. M.

Mayo Clinic
Rochester, MN

Purpose
Language functional MR imaging (fMRI) is used increasingly in presurgical evaluation to determine laterality of language function and its proximity to the intended cerebral surgical bed. Variability exists both between the capacity of different fMRI language tasks to activate critical language areas and between different radiologists’ interpretations. Understanding such variability is paramount to accurately localize language centers and to inform surgical planning and adjust outcome expectations.
**Mapping Perfusion of the Human Orbitofrontal Cortex: A Reference for Functional Imaging Studies**

Kamran, M. • Schweder, P. • Byrne, J. V.

University of Oxford
Oxford, UNITED KINGDOM

**Purpos**
The human orbitofrontal cortex is a prefrontal cortical region located above the orbital roof. It is involved in higher cognitive and emotional functions, and commonly is studied with functional MR imaging (fMRI). Functional imaging measures the hemodynamic response and thus is dependent on local perfusion patterns of the region of interest studied. We analyzed the perfusion patterns in 15 nonischemic orbitofrontal cortices and constructed a perfusion map using MR and C-arm CT perfusion modalities.

**Materials & Methods**
C-arm CT perfusion data were acquired using a biplane angiography system (Axiom Artis dBA; Siemens Healthcare, Germany). The imaging protocol included two 8-seconds rotational acquisitions: mask and contrast-enhanced runs, each comprised of 400 projection images at 0.50 steps. Cerebral blood volume (CBV) maps were constructed after registration of the two volumes, voxel-by-voxel subtraction, and normalization with an automatically estimated input function. Perfusion, diffusion, T1-, and T2-weighted imaging data was acquired on a 1.5 T Philips Achieva Magnet. Perfusion-weighted imaging (PWI) was performed using following parameters: T2*-weighted gradient echo, TR 2018 ms, TE 44 ms, FOV 248×248 mm, reconstruction matrix 256×256, bandwidth 806 Hz/pixel, SENSE factor 2.1, 15 slices with 4 mm thickness at 50 time points. The data were acquired following administration of 0.2 mmol/kg gadolinium at 5 ml/s in the antecubital vein using a power injector. Time-of-flight MR angiograms were obtained to exclude significant abnormalities of arterial patency. Initial processing of MR-PWI data was performed using a deconvolution-based software package (NordicNeuroLab, Bergen, Norway). C-arm CT-based CBV maps as well as MR-based CBV and cerebral blood flow (CBF) maps were aligned onto a stereotactic brain using affine registration. Mean perfusion was calculated across each modality.

**Results**
Perfusion patterns were visualized on a stereotactic brain template and thresholded at 2-98% maximum cortical perfusion (Figure 1). Cerebral blood flow analysis demonstrated highest perfusion in gyrus rectus, anterior and lateral orbitofrontal cortices. Medial and posterior orbitofrontal gyri demonstrated lower relative CBV (p<0.05). Cerebral blood flow analysis demonstrated a similar perfusion pattern. C-arm CBV measurements were highest in gyrus rectus and medial orbitofrontal gyrus (p<0.05).

**Conclusion**
Perfusion of the human orbitofrontal cortex demonstrates a topographic pattern which varies according to the modality of analysis. The reference perfusion patterns may aid in our understanding of the complex neurophysiology of this cortical region, aid in interpretation of clinical diagnostic perfusion imaging, as well as the analysis of blood-oxygen level-dependent fMRI signal.

**Key Words:** Orbitofrontal cortex, C-arm CT, MR-PWI

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**Calibration of PaCO2 and Lactate during Hyperventilation Challenge at 3 T**

Friedman, S. D. • Shaw, D. W. W. • Dager, S. R.

1Seattle Children's Hospital, Seattle, WA, 2University of Washington, Seattle, WA

**Purpose**
Brain lactate measurements can be made using proton MR spectroscopy (1H MRS). Lactate is elevated in a range of diseases (e.g., mitochondrial disease, stroke), but also in response to task performance (e.g., activation), and with physiologic loading (e.g., pH manipulation, respiratory fluctuations). The calibration of PaCO2 to lactate has not been well quantified, a critical variable to understand disease versus physiologic variance. This investigation used the enhanced signal-to-noise at 3 T combined with a hyperventilation challenge to derive a calibration equation between end-tidal CO2 and lactate. This relationship may be utilized to aid in study interpretation where small PaCO2 differences could drive statistical lactate results.

**Materials & Methods**
A cohort of 13 healthy control subjects were evaluated using MR spectroscopy (left insula localization, TE = 80 ms, TR = 2s, 2048 points, bandwidth = 2000, 4 averages, 375 total spectra) and capnometry during a 50-minute hyperventilation challenge (10 minutes baseline, two 10-minute hyperventilation periods to a target of 20 mmHg PaCO2, and two 10-minute recovery periods). IRB approval was obtained for all studies.
**Results**

Findings demonstrate close concordance between end-tidal CO₂ variation and lactate/N-acetylaspartate ratio. A calibration derived during the most stable hyperventilation interval (second 10 minutes) yielded a within-subject estimate of 1.6 mmHg end-tidal CO₂ per .01 Lac/N-acetylaspartate change. Cramer-rao lower bound estimates for lactate were < 20 (LCModel %SD), a highly reproducible estimate.

**Conclusion**

The data presented shows that small increases in PaCO₂ result in substantial Lac/NAA changes (on the order of group differences described in the literature). These findings support that PaCO₂ fluctuation must be considered as an important experimental factor in studies employing this metric.

**Key Words:** Brain, spectroscopy, lactate

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**RESULTS**

Mean FA in NPSLEs was significantly different from SLEs (p = 0.022) and controls (p = 0.014). Color-maps from TBSS showed frontal lobe, thalamus, and corpus callosum(CC) to be mainly involved. Selected region of interest(ROI) analysis confirmed regional FA decreases. No difference was found in MD between patients’ groups. Controls’ MD, radial diffusivity and axial diffusivity was significantly lower than patients (all p<0.05). Metabolite ratios were measured in CSI maps using corresponding ROIs in FA maps. N-acetylaspartate/Cr showed significant decrease in NPSLEs compared with other groups (p<0.05). Compared to controls, Cho/Cr showed significant increases in both patient groups (p<0.05). Table 1 quotes ROI in CC as example. In NPSLEs, we found positive correlation between NAA/Cr and FA in CC (r=0.625), and negative correlation between Cho/Cr and FA in CC(r=-0.599) and frontal lobe(r=-0.605). In SLEs, statistical correlations between metabolic ratios and FA were not found.

**TABLE 1**

<table>
<thead>
<tr>
<th></th>
<th>NPSLE</th>
<th>SLE</th>
<th>CONTROL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean FA</td>
<td>0.239±0.02</td>
<td>0.254±0.17</td>
<td>0.252±0.11</td>
</tr>
<tr>
<td>MD</td>
<td>0.00106±0.00012</td>
<td>0.00102±0.0009</td>
<td>0.00095±0.00069</td>
</tr>
<tr>
<td>Radial diffusivity</td>
<td>0.00095±0.00012</td>
<td>0.00090±0.00009</td>
<td>0.00084±0.00007</td>
</tr>
<tr>
<td>Axial diffusivity</td>
<td>0.00128±0.00012</td>
<td>0.00125±0.00001</td>
<td>0.00118±0.00007</td>
</tr>
<tr>
<td>NAA/Cr in CC</td>
<td>1.185±0.33</td>
<td>1.548±0.52</td>
<td>1.714±0.84</td>
</tr>
<tr>
<td>Cho/Cr in CC</td>
<td>0.949±0.26</td>
<td>0.982±0.33</td>
<td>0.711±0.23</td>
</tr>
</tbody>
</table>

**Conclusion**

In NPSLEs, co-existing FA and NAA/Cr decline and their positive correlation indicate a possible causal relationship between severe demyelination and neuron loss, which is not evident in SLEs. High Cho/Cr in both patient groups indicates membrane breakdown possibly due to vasculitis. Our findings suggest a complex interplay between demyelination and vasculitis in NPSLEs.

**Key Words:** Neuropsychiatric systemic lupus erythematosus, diffusion tensor imaging, MR spectroscopy
Phosphorus MR Spectroscopy in Malformations of Cortical Development

Andrade, C. S. 1 • Otaduy, M. C. G. 1 • Valente, K. D. R. 1 • Maia, D. F. 1 • Park, E. J. 1 • Valério, R. M. F. 1 • Tsunemi, M. H. 2 • Leite, C. C. 1

1Faculdade de Medicina da Universidade de Sao Paulo, Sao Paulo, BRAZIL, 2Universidade Estadual Paulista Julio de Mesquita Filho, Sao Paulo, BRAZIL

PURPOSE

The novel goal of this study is to evaluate phospholipids metabolism in vivo in patients with epilepsy caused by malformations of cortical development (MCD).

MATERIALS & METHODS

Three-dimensional phosphorus magnetic resonance spectroscopy (31P-MRS) at 3.0 T was performed in 37 patients with MCD and in 31 control subjects. Selected voxels were predominantly composed of gray matter tissue and were chosen in the lesions and compared with voxels in frontoparietal cortex of controls (effective volumes of 12.5 cm³). Robust methods of quantification were applied and the following metabolite peaks were identified: phosphoethanolamine (PE), phosphocholine (PC), inorganic phosphate (Pi), glicerophosphoethanolamine (GPE), glicerophosphocholine (GPC), phosphocreatine (PCr), alpha, beta, and gamma-adenosine triphosphate (ATP, Figure 1). We also estimated the total ATP (ATP=sum of alpha+beta+gamma-ATP), phosphodiesters (PDE=GPC+GPE) and phosphomonoesters (PME=PE+PC), as well as the ratios of PME/PDE, PCr/ATP and PCr/Pi. Magnesium (Mg²⁺) and pH were calculated with the chemical shifts of PCr, Pi and beta-ATP.

RESULTS

In comparison to controls and assuming a p value < 0.05 for statistically significant differences, patients presented lower levels of pH and higher contents of Mg²⁺. It was found a reduction of GPE and PDE, with increased PME/PDE ratio. The ratio PCr/ATP was significantly higher in patients. The results are summarized in Table 1.

Table 1 - Comparisons of 31P-MRS data between MCD and control subjects

<table>
<thead>
<tr>
<th>Metabolites and ratios</th>
<th>Patients</th>
<th>Controls</th>
<th>p-value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>6.891 ± 0.041</td>
<td>6.977 ± 0.048</td>
<td>p &lt; 0.001***</td>
</tr>
<tr>
<td>Mg²⁺</td>
<td>0.145 ± 0.035</td>
<td>0.126 ± 0.029</td>
<td>p = 0.018</td>
</tr>
<tr>
<td>Pi</td>
<td>0.090 ± 0.015</td>
<td>0.085 ± 0.013</td>
<td>p = 0.181</td>
</tr>
<tr>
<td>ATP</td>
<td>0.297 ± 0.032</td>
<td>0.200 ± 0.027</td>
<td>p = 0.014</td>
</tr>
<tr>
<td>PC</td>
<td>0.133 ± 0.024</td>
<td>0.090 ± 0.020</td>
<td>p = 0.225</td>
</tr>
<tr>
<td>GPE</td>
<td>0.080 ± 0.016</td>
<td>0.070 ± 0.015</td>
<td>p = 0.062</td>
</tr>
<tr>
<td>GPC</td>
<td>0.121 ± 0.016</td>
<td>0.145 ± 0.010</td>
<td>p = 0.003</td>
</tr>
<tr>
<td>PME</td>
<td>0.179 ± 0.024</td>
<td>0.176 ± 0.022</td>
<td>p = 0.036</td>
</tr>
<tr>
<td>PDE</td>
<td>0.201 ± 0.027</td>
<td>0.220 ± 0.023</td>
<td>p = 0.003</td>
</tr>
<tr>
<td>PME/PDE</td>
<td>0.907 ± 0.184</td>
<td>0.815 ± 0.171</td>
<td>p = 0.036</td>
</tr>
</tbody>
</table>

Note: *p-value obtained with Student's t test, **SD = standard deviation, ***Mann-Whitney test for 2 group-sample. p-values < 0.05 are printed in bold type.

CONCLUSION

Mg²⁺, pH and high-energy phosphates are very important in the regulation and modulation of brain bioenergetics and are involved in many pathways of electrical activity in neurons and glia. Our data support the idea that neurometabolic impairments occur along with seizure onset and propagation. The results also demonstrate deficient regulation of membrane turnover in MCD. In addition, this study raises a potential useful neuroimaging tool in differentiating focal cortical dysplasias and low-grade gliomas, because of the differences in pH values reported in our study and in the literature between these two disorders.

KEY WORDS: Phosphorus spectroscopy, neurometabolism, epilepsy

Resting Brain for Neurosurgical Planning

Stufflebeam, S. M. 1 • Liu, H. 1 • Buckner, R. 1 • Tanaka, N. 1 • Grant, P. 2

1Massachusetts General Hospital Martinos Center, Charlestown, MA, 2Children's Hospital Boston, Charlestown, MA

PURPOSE

We propose a method to determine the dominant hemisphere for language function (lateralization) using a resting-state fMRI (rs-fMRI) paradigm that does not require active subject participation. We previously proposed a method to determine the overall lateralization of cortical networks and localize eloquent cortex. Here we apply a similar method to rs-fMRI specific for quantifying language lateralization, based on the functional connectivity (fcMRI).

MATERIALS & METHODS

Subjects: We studied retrospectively 40 healthy subjects and nine patients with epilepsy who also had an intracarotid amobarbital procedure (IAP) for language and memory lateralization (with LI scores estimated). Structural MRI scans acquired
with a T1 MPRAGE on a 3 T Tim-Trio scanner with a 32-channel head coil provided by the manufacturer (Siemens, Erlangen, Germany). Functional MRI: Standard MGH BOLD fMRI sequences were used for the resting state and task fMRI scans. Subjects performed visual semantic decision tasks in the MRI. Imaging parameters were acquired identically for both the task-based and resting-state fMRI (3 mm isotropic voxels). Resting-state functional connectivity analysis: We retrospectively analyzed the fcMRI in the healthy subjects, and also compared a laterality index (fcMRI-LI) to the IAP laterality index (LI-IAP) for the patients. The right and left frontal language ROIs comprising the dorsal lateral prefrontal cortex, including the pars triangularis and pars opercularis, was identified. The mean time course in this seed region was extracted and the correlation coefficient calculated between two pairs of points defined as: LI-fcMRI = [(LL - RL) - (RR - LR)]/[LL + LR + RR + RL], where LL is the number of voxels above 0.25 in the entire left hemisphere with seeding the left pars triangularis and opercularis, LR is the number of voxels above the threshold in the right hemisphere ROIs with seeding the left pars triangularis and opercularis; RL & RR was similarly calculated.

RESULTS
There was a remarkable similarity in the fcMRI maps in the task-based fMRI and the fcMRI language maps (Figure). In healthy subjects, we found a linear relationship between the task-based fMRI using a language paradigm. In the healthy subjects, we found a linear relationship between the IAP-LI (r = 0.75; p < 0.05) and the fcMRI-LI (r = 0.8; p < 0.1).

CONCLUSION
Using a single 10 minute rs-fMRI acquisition, it might be possible to determine the language laterality using a fcMRI analysis.

KEY WORDS: Functional MR imaging, intrinsic, connectivity

Paper 088 Starting at 11:41 AM, Ending at 11:49 AM
Impact of Varying Arterial Input Functions in CT Perfusion Studies of the Brain in Pathologic Ischemic Studies
Smoller, B. • Cherney, A. • Mangla, S. • Dubey, A. • Bluestone, A. • Zhabin, S.
State University of New York Downstate Health Science Center
Brooklyn, NY

PURPOSE
CT perfusion (CTP) is used clinically to distinguish infarcted tissue from the penumbra. It requires the operator to choose an arterial input function (AIF) that best represents the entry of contrast to the system; however, there have been limited studies that explore this selection. The purpose of this study is to evaluate the impact of varying arterial input function (AIF) in seven pathologic ischemic patients undergoing CTP.

MATERIALS & METHODS
We performed a retrospective study at the State University of New York (SUNY) Downstate for CTP studies performed from 5/23/06 to 7/12/2009. One hundred and fifty-seven patients were found; seven pathologic patients were selected for initial evaluation. Five were diagnosed with embolic stroke; two were diagnosed with high-grade stenosis. All CTP studies were performed using a standard protocol. The six major branches of the circle of Willis were used as varying AIFs. The CTP maps were coregistered to noncontrast CT images, and 19 regions of interest (ROIs) were selected for analysis. The ROIs then were divided into "ischemic" and "nonischemic", based on the location of the occlusion for each patient (everything "downstream" from an occlusion was defined as "ischemic"). A 3-way ANOVA was performed using SPSS (SPSS 14.0, SPSS Inc, USA) using CBV, CBF, and MTT as the dependent variables, and ROI, AIF, and Ischemic Status as the independent variables.

RESULTS
Our data demonstrated that assessing an ROI for ischemia vs normal with regards to MTT, CBF, CBV was independent of the AIF selected (Table 1, Ischemic*ROI), suggesting that a relative measure of ischemia was independent of AIF selection. However, the absolute values of these parameters were highly variable depending on the AIF selected, both within the ischemic and nonischemic territories (Figure 1, CBF and CBV). Although this is a limited pilot study on a small preliminary patient population, our results suggest that the precision and accuracy of the absolute values may be highly dependent on AIF.
CONCLUSION
Using a single 10 minute rs-fMRI acquisition, it might be possible to determine the language laterality using a fcMRI analysis.

KEY WORDS: Stroke, perfusion imaging, interventional therapy

Paper 089 Starting at 11:49 AM, Ending at 11:57 AM
Impact of Vascular Lesions on Morbidity and Mortality: A Retrospective Functional MR Imaging Study
Baniulis, D. • Kornder, N. • Gallagher, T. • Wood, J. • Kundu, B. • Utter, A. • Voss, J. • Nair, V. • Field, A. • Moritz, C. • Meyerand, M. • Prabhakaran, V.
University of Wisconsin
Madison, WI

PURPOSE
Motor and language deficits are particularly debilitating functional deficits and thus a major neurosurgical concern in the preoperative or postoperative setting of vascular lesion patients. The distance from vascular lesion to functioning cortex is a critical parameter for predicting deficits. This study examined the role of functional MR imaging (fMRI) as a noninvasive method of preoperative planning for patients about to undergo resection of vascular brain lesions encroaching on areas of primary motor and language function. We tested the hypothesis that as the distance between areas of primary motor or language fMRI activation and vascular lesion edge decreases, patient morbidity will increase.

MATERIALS & METHODS
Patients were selected from a growing database exceeding 400 patients (accumulated between 1999 and 2009) who underwent preoperative fMRI for various brain vascular lesions. Preoperative fMRI language and motor maps of 84 and 72 subjects respectively were reviewed retrospectively. Functional paradigms were tailored to vascular lesion location to elicit either primary motor or language activations. Distances from vascular lesion edge to edge and distances from vascular lesion edge to center of maximum primary motor or language fMRI activation (<1 cm, 1 - 2 cm, and >2 cm) were measured and correlated with pre or postoperative morbidity information obtained from the electronic medical record. For enhancing vascular lesions, vascular lesion edge was considered the margin of enhancement. For non-enhancing vascular lesions, vascular lesion edge was estimated as the margin of its T2 or T2 FLAIR weighted signal abnormality. Morbidity information in terms of weakness and aphasia as well as mortality was examined. Statistical analysis was performed using chi-square test and multivariate ANOVA.

RESULTS
Preliminary data focused on a subset of patients n = 72 (vascular lesions near motor area) and n = 84 (vascular lesions near language areas). A significant trend was found between distance from vascular lesion to motor activation and the existence of weakness/paresis (p = 0.06). A significant association was found between distance of the lesion from Wernicke’s area alone and the presence of the deficit (p = 0.03).

CONCLUSION
Distance between vascular lesion edge and areas of primary motor and language function may serve as predictors of motor and language deficits respectively.

KEY WORDS: Functional MR imaging, vascular lesions

Paper 090 Starting at 11:57 AM, Ending at 12:05 PM
Distinguishing Vegetative State from “Locked-in Syndrome” through Functional Mapping of Higher Cognitive Function
Thulborn, K. R. • Calderon-Arnulphi, M. • Atkinson, I. C.
University of Illinois at Chicago
Chicago, IL

PURPOSE
To distinguish “locked-in” syndrome from “vegetative” state in a male patient who had been in a comatose state for over 12 months after a massive hemorrhagic stroke of the right cerebral hemisphere and extensive chronic ischemic changes to the brainstem and cerebellum.

MATERIALS & METHODS
Functional MR imaging (fMRI) using blood oxygenation level dependent (BOLD) contrast was performed on a 3.0 T clinical scanner using gradient-echo echo-planar imaging (TR = 2500ms, TE = 30 ms, matrix size = 64 x 64, FOV = 20 cm) and superimposed over high-resolution anatomical images (T1-weighted IRFSGR). The patient was intubated on an MR-compatible respirator during imaging. Two separate two-condition, block-design auditory paradigms were used. The auditory files recorded reading from the children’s story of “Green Eggs and Ham”. These paradigms used an auditory input as the auditory-evoked responses had been demonstrated to be intact. Paradigm I consisted of seven cycles of contrasting condition A of 30 seconds of no sound to condition B of 30 seconds of listening to “Green Eggs and Ham” being read by the patient’s spouse. Paradigm II consisted of seven cycles of contrasting condition A of 30 seconds of listening to “Green Eggs and Ham” to condition B in which the same sound file was played in reverse. In reverse, there is no comprehensible language but the frequency and volume content are identical to condition A and, therefore, should cancel all activation except for language comprehen-
sion. Activation maps were calculated by a student t-test comparing conditions A and B and superimposed over high-resolution anatomical images. Thresholds were adjusted so that only activation in auditory and Wernicke’s areas was present, indicating that this activation was the most significant BOLD effect present.

RESULTS
The activation map from paradigm I demonstrated selective activation in the left auditory cortex along Herschel’s gyrus and in the posterior aspect of the left superior temporal sulcus in Wernicke’s area. The activation map from paradigm II demonstrated selective activation only in the posterior aspect of the left superior temporal sulcus in Wernicke’s area. No activation was present in the right temporal lobe as this region had been destroyed by the previous hemorrhagic stroke. The brainstem also involved stroke as would be expected for a patient with locked-in syndrome or in a vegetative state.

CONCLUSION
The activation in Wernicke’s area of a patient in a comatose state suggests that higher cognitive function is still present. Although the patient is unresponsive, this finding may suggest that this is “locked-in” syndrome rather than a true vegetative state.

KEY WORDS: functional MR imaging, locked-in syndrome, vegetative state

Summary
One of the significantly reduced FC is localized to the PCC, which is the most highly interconnected regions of the cerebral cortex and constitute the hub of the default mode network. The additional finding of strongly decreased FC of a bilateral insula/parisylvian network in AgCC may help explain the diminished pain sensitivity and altered emotional processing commonly found in these patients. These initial observations demonstrate the great potential of resting-state fMRI to reveal abnormal function in the malformed brain and thereby also help elucidate the function of the normal human brain.

KEY WORDS: Callosal dysgenesis, functional connectivity, resting-state functional MR imaging
Keyhole PRES Functional MR Imaging: Improved Temporal Resolution with Reduced Distortions

Thomasson, D. • Biassou, N.
National Institutes of Health
Bethesda, MD

Purpose
Principle of echo shifting (PRES) was optimized for functional MR imaging (fMRI) applications. The PRES technique is based on simple gradient recalled-echo technique where the TE is greater than the TR by using additional gradients. Principle of echo shifting was optimized for higher temporal resolution by the addition of an echointrain, and described by principle of echo shifting with train of observations (PRESTO). The susceptibility distortions from dissimilar tissue interfaces are minimized by using an echo-shift technique with increased bandwidth and we observe reduced blurring and shape distortions typically found in echo-train techniques. While this technique can show activations with reduced distortions, the dynamic scan times were too great. In order to increase the temporal resolution; decrease the scan time per volume; we implemented a keyhole strategy.

Materials & Methods
Studies were performed at 3.0 T with PRES optimizations for TE, excitation flip angle and bandwidth. A multielement array head coil with SENSE-based parallel acquisition was necessary to obtain the adequate temporal resolution for the PRES-based functional MR imaging technique. Phantoms were used for contrast to noise optimization and to quantify sources of susceptibility distortions. Optimal T2* weightings were validated by comparison to standard gradient-echo EPI protocol. Functional neuroactivation was validated with healthy human subjects using a standard GRE-EPI in a simple motor task activations paradigm, and then used for both the PRES and keyhole PRES applications.

Results
Figure 1 shows the distortions inherent in both GRE-EPI; PRESTO and PRES. The standard EPI imaging has both edge blurring as well as shape distortions, while the PRESTO has less edge blurring but still significant shape distortions. In addition we found that the PRES technique can maintain the T2* contrast necessary for demonstrating activations but has reduced distortions when compared to the GRE-EPI technique. By increasing the temporal resolution we achieved greater activation volumes with the keyhole PRES technique. We also found reduced blurring for the PRES technique that otherwise exists from T2* decay in echo-train strategies. In addition there is both a reduced SAR and dB/dt using PRES.

Summary
One of the significantly reduced FC is localized to the PCC, which is the most highly interconnected regions of the cerebral cortex and constitute the hub of the default mode network. The additional finding of strongly decreased FC of a bilateral insula/perisylvian network in AgCC may help explain the diminished pain sensitivity and altered emotional processing commonly found in these patients. These initial observations demonstrate the great potential of resting-state fMRI to reveal abnormal function in the malformed brain and thereby also help elucidate the function of the normal human brain.

Key Words: Callosal dysgenesis, functional connectivity, resting-state functional MR imaging

Feasibility and Acceptance of a Management for Incidental Findings in Anonymous Volunteers in Neuroimaging Research

Ulmer, S.1,2 • Hartwigsen, G.2 • Reiter-Theil, S.1 • Ahlhelm, F. J.1 • Ponseti, J.2

1University Hospital Basel, Basel, SWITZERLAND, 2University of Schleswig Holstein, Kiel, GERMANY

Purpose
The prevalence of incidental findings (IF) in neuroimaging studies has been reported previously to range between 2 and 18% with up to 9% having potential clinical relevance. As subjects expect to be informed about IF, a responsible management needs to be in place. However, management of IF varies widely across institutions and there are no established guidelines to date. Since insurance issues differ among countries, coverage of costs following the detection of IF are not regulated for the most part. Recently, a possible management has been introduced, which however does not cover subjects, who want to remain anonymous. The aim of this study was to prove the acceptance and feasibility of this approach in volunteers who want to remain anonymous while providing a responsible management in the event of detecting IF.

Materials & Methods
Fifty-six male subjects were included in this study after written informed consent was obtained. The study was approved by the local IRB. All volunteers participated in a functional MRI (fMRI) study examining cortical representation of visual stimuli with sexual content and were sexually attracted to either adult women, adult men, prepubescent boys, or prepubescent girls. Subjects were recruited either by self-referral, advertisement on the campus and website of the institute or collected from a self-support group or psychotherapeutic treatment groups of pedophilic men. To guarantee anonymity, only the PI was aware of the volunteer’s sexual preference. In addition to the fMRI study, a standard MPRAGE in sagittal orientation and a FLAIR sequence was performed on a 3 T scanner (Philips, Best, The Netherlands) using a 8-channel Sense head coil. MR images were read by two board-certified neuroradiologists blinded to the clinical data. Subjects were told to call the PI within 1 week whether IF were detected.
RESULTS
None of the volunteers refused to participate in the study due to the above described regulations and all subjects showed a high reliability in calling the PI. The study population included 21 heterosexual men, 14 homosexual men, 10 heteropedophilic men and 11 homopedophilic men. Mean age was 32 years (range 18-64 years). In 16 cases (29% of all subjects), we found potentially clinically relevant findings including pituitary abnormalities and white matter lesions being highly suggestive for multiple sclerosis (according to the Barkhof criteria). These volunteers were instructed to see their primary care physician.

CONCLUSION
As previously reported, IF were very frequent in our sample. These results further stress the need for a responsible management of IF. One potential limitation of our study is that we cannot guarantee that all volunteers followed the instructions to see their primary care physician. However, we assume that participants managed to have further work up done for two reasons: First, we observed a high reliability in calling the PI. Secondly, data were collected from an ongoing study with further participants joining in based on a word-of-mouth propaganda. Together, this suggests that subjects were highly motivated and reliable. We conclude that our setup covers all needs and has proved feasible in this special study collective.

KEY WORDS: Incidental findings, anonymity, brain

Monday Afternoon
1:30 PM - 3:00 PM
Ballroom 6A

(6) ASSR Programming: Updates in Pediatric Spinal Imaging
   — Erin S. Schwartz, MD
(94) Pediatric Spine Tumors
   — Andrea Rossi, MD
(95) Dysraphism of Spine
   — Pia C. Maly Sundgren, MD, PhD
Moderators: Gregory W. Petermann, MD
           Veronica Rooks, MD

Pediatric Spine Tumors
Erin S. Schwartz, MD

PRESENTATION SUMMARY
Spine tumors in the pediatric population generally share imaging features with their adult correlates. Several tumors are unique to children, including the atypical teratoid/rhabdoid tumor and the sacrococcygeal teratoma. Spinal manifestations of types 1 and 2 neurofibromatosis have characteristic findings, with extramedullary and intramedullary manifestations.

Dysraphism of Spine
Andrea Rossi, MD

PRESENTATION SUMMARY
Spinal cord development occurs through three consecutive periods: (i) gastrulation (2nd gestational week): the embryonic disk is converted from a bilaminar into a trilaminar arrangement, with formation of the intervening mesoderm; the notochord is laid down along the midline, identifying the craniocaudal embryonic axis; (ii) primary neurulation (18th-27th day): under the induction of the notochord, the midline ectoderm specializes in neural ectoderm. The neural plate progressively bends and folds until it fuses in the midline to form the neural tube. The primary neural tube produces the uppermost 9/10 of spinal cord; (iii) secondary neurulation (28th-48th day): a secondary neural tube is laid down caudal to the termination of the primary neural tube resulting in the tip of the conus medullaris and filum terminale. Defects in one of these three embryologic steps produce spinal dysraphisms which may be categorized clinically in two subsets: open and closed spinal dysraphisms. In open spinal dysraphisms (OSD) the neural placode is exposed to the envi-
environment through a cutaneous defect along the child’s back. Open spinal dysraphisms include myelomeningocele, myelocele, hemimyelomeningocele and hemimyelocele, and are associated with a Chiari II malformation. Myelomeningocele is by far the most common of these forms; the placode protrudes through a posterior defect and is elevated above the skin surface due to concurrent dilatation of the subarachnoid spaces. Closed spinal dysraphisms (CSD) are covered by intact skin, although cutaneous stigmata usually indicate their presence. Closed spinal dysraphisms are associated with a subcutaneous mass comprised of lipomyeloschisis, lipomyelomeningocele, meningocele, and myelocystocele. Other CSD (without a subcutaneous mass) are categorized into simple (isolated spinal cord or filum terminale anomaly, including tight filum terminale, filar and intradural lipomas, and persisting terminal ventricle) and complex (associate spine and spinal cord anomaly), including diastematomyelia, caudal regression, and segmental spinal dysgenesis. Diastematomyelia (literally, split cord) is caused by failure of midline notochordal integration, resulting in two heminochords that induce two separate hemineural plates. Caudal agenesis and segmental spinal dysgenesis are related to defective notochordal formation, characterized by absence or hypoplasia of a segment of the notochord, in turn resulting in absence or hypoplasia of a corresponding segment of the spinal cord.

**Pediatric Spinal Trauma**

*Pia C. Maly Sundgren, MD, PhD*

**LEARNING OBJECTIVES**

Upon completion of this presentation, participants will be able to:

1) Increase the awareness of the typical and atypical spinal injuries in children.
2) Increase awareness of the possible complexity of trauma to the spine and its contents in various types of injuries.
3) Learn the neuroradiologic algorithms in the management of spinal trauma in the pediatric population with respect to the different combinations of imaging modalities available.

**PRESENTATION SUMMARY**

Spinal injuries are generally less common in children compared to adults. Of all spine injuries cervical spine injuries are the most frequent spine injury accounting for 40-60% of all pediatric spine injuries. The etiology varies depending on the age of the child with motor vehicle accidents being the most common cause of pediatric cervical spine injury, but obstetric complication, fall, child abuse, sports, and diving accidents account for many injuries as well. The specific biomechanics of the pediatric cervical spine leads to a different distribution of injuries and distinct radiologic features and represent a distinct clinical entity compared to those seen in adults. Young children more commonly have upper cervical injuries seldom below C3 whereas older children are prone to lower cervical injuries. The spinal cervical injuries in children less than 8 years of age demonstrate a high incidence of subluxation without fractures. Children are also more prone to spinal cord injury with normal radiographs compared to adults. Early radiologic evaluation is essential with correct description of fractures, ligament injuries, dislocations, and evaluation of stability. The methods of choice for imaging suspected spinal injuries in children are the same as for adults; multislice CT with reformatted images, and, if indi-
Cerebrovascular Imaging without a Catheter: Pushing the Limits

William A. Copen, MD

Presentation Summary

Invasive catheter-based angiography was one of the earliest neuroimaging techniques, and was once the only available means for studying the cerebral vasculature in the clinical setting. Although catheter angiography remains the usual gold standard for cerebrovascular imaging, in recent years its use has been eclipsed to some extent by techniques that are based on CT, MR imaging, and ultrasound, rather than conventional x-ray fluoroscopy. Some of these techniques allow for cerebrovascular imaging without exposure to ionizing radiation, and/or without requiring an exogenous contrast agent that could cause nephrotoxicity, allergic reaction, or other adverse effects. All of these techniques avoid the extra time, expense, and possibility of complications that are associated with arterial catheterization. Ongoing developments in CT- and MR-based angiography continue to improve the effectiveness of these techniques, and to expand the clinical roles that they can fill. For example, in addition to providing images with spatial resolution that was previously achievable only with catheter angiography, noninvasive cerebral angiographic techniques now can offer time-resolved images, in which arterial and venous phases can be distinguished, and can provide selective visualization of vessels supplied by a single supplying cervical artery. Until recently, time-resolved imaging and selective arterial visualization were available only with catheter angiography. This presentation will review the latest developments in CT- and MR-based cerebral angiography, including both investigational techniques, and those that currently are available for clinical use.

Challenging the Notion of Treatment! The ARUBA Trial

J. P. Mohr, MD, MS

Dr. Mohr is from Lynchburg, Virginia, graduated from Haverford College in 1958, and from the University of Virginia in Charlottesville in 1963 with an M.D. and M.S. in Pharmacology (as a USPHS 5-year Plan Fellow). He was an Intern and Medical Resident at the Mary Imogene Bassett Hospital in Cooperstown, NY from 1962-1965. He had one year of residency training in Neurology at the New York Neurological Institute at Columbia-Presbyterian Medical Center in New York City, and finished in 1969 at the Massachusetts General Hospital in Boston, where he also trained in Neuropathology and Stroke under C.M. Fisher, M.D. After 3 years Army service during the Vietnam war at Walter Reed Army Institute of Research he returned to Boston in 1971 as an Assistant Professor of Neurology at Harvard Medical School to direct the Behavior Laboratory and newly organized Stroke Service, later also co-director and founder of the Neuro Intensive Care Unit at the Massachusetts General Hospital. During those years he was also Director of the Neurology Unit at the then new Massachusetts Rehabilitation Hospital (now named Josiah P Spaulding Rehabilitation Institute). In 1978 he became founding chairman of the Department of Neurology, University of South Alabama in Mobile. In 1983 he returned to New York to become the Daniel S. Scarra Professor of Clinical Neurology and Director of Stroke research, which developed into the Doris & Stanley Tannanbaum Stroke Center, Horace W. Goldsmith Neurovascular Laboratory and James M. Nederlander Teaching Unit at the Neurological Institute. He is associate editor of the journal Cerebrovascular Diseases, serves on national and international committees and consulting boards, has edited 3 books, and has several hundred refereed and invited publications.

Presentation Summary

ARUBA (A Randomized trial of Unruptured Brain Arteriovenous malformations, NINDS U01 U01 NS051483/NS51566 www.arubastudy.org) continues to accrue patients. As of January 2011, 143 patients have been randomized for the planned 400. At an NINDS-sponsored Data and Safety Monitoring Board meeting 12 Jan 2011 the committee expressed satisfaction at its progress, and recommended continuation of recruitment of patients as well as new centers. The trial’s executive committee is making application to NINDS for continuation of the project for 5 years, allowing extended follow up of participants. The first enrollee will have a minimum 5 years follow up in 2012; should application for continued funding prove successful, patients will have follow up of up to 10 years by 2017. The literature to date does not answer the research questions posed by ARUBA and continues to justify its continuation. The trial is open only for those unruptured brain arteriovenous malformations (AVMs) deemed suitable for attempted eradication, based on the expertise and ethical equipoise of each local center. To date the patients randomized by the 33 active centers (65 in contract, >1,000 patients screened) show a satisfactory distribution of Spetzler-Martin grades (I=26%, II=28%, III=34%, IV=19%, V=0). The target number of randomized cases should suffice to test the endpoints of death and stroke for the published maximum rates of adverse events from intervention against the published minimum rates of initial hemorrhage. The planned follow up of clini-
Tuesday Afternoon
1:30 PM - 3:00 PM
Ballroom 6 B/C

(8) Socioeconomic Programming: CMS Prospective Payment System: Outpatient (HOPPS) and Physician Incentives (PQI and PQRI) (SAM* Session - #1) (AR)

(102) Rationale and Development of Performance Measures
   — David J. Seidenwurm, MD

(103) Implementing Performance Measures in Practice
   — Pina C. Sanelli, MD, MPH

(104) MOC: Implications for Present and Future Practice
   — Robert D. Zimmerman, MD, FACR

(105) Discussion

Moderators: David J. Seidenwurm, MD
            Pina C. Sanelli, MD, MPH

*Qualified by the American Board of Radiology in meeting the criteria for self-assessment toward the purpose of fulfilling requirements in the ABR Maintenance of Certification Program Date: 4/11.

Rationale and Development of Performance Measures
David J. Seidenwurm, MD

Presentation Summary
Payment for services in medicine traditionally have been organized under a fee for service model in which physicians and others are paid for each unit of service without regard to the quality of the service provided, or sometimes even without regard to its necessity. Recent trends in physician payment link payment to performance of specific actions that are thought to improve the quality of patient outcomes.

Other systems of payment link outcomes to payments directly. New statutes and regulations in the Medicare program increase the pace of payment reforms linking quality with payment. Programs affect payment at the individual or group level and are based upon clinical and administrative data (refs 1-5). Measure sets that affect radiology practice include those related to imaging in general, stroke and stroke rehabilitation, as well as those related to clinical patient care that may be relevant to interventional practice. Measures may apply to structures, processes or outcomes of care. Measures may be based upon clinical data such as radiologic findings, reporting methodologies or report contents themselves. Some measures are based purely on administrative data such as those used for billing, while others may require the collection of additional data or even the development of new coding methods in order to report compliance with the measure. Recent legislation will reward quality of care to a significantly greater extent. One way is the bonus that will be awarded for participation in certification process.

Implementing Performance Measures in Practice
Pina C. Sanelli, MD, MPH

Presentation Summary
Practice quality improvement (PQI) is defined as a self-evaluation of practice performance linked to a process of continuing quality improvement. The overall goal is to narrow the gap between health care as it is practiced and health care as it should be for our patients. The importance of PQI is to improve the quality of care delivered, reduce errors in medical practice and improve the safety of patients. National efforts have been organized to incorporate performance measures in practice. The American Board of Medical Specialties (ABMS) has initiated the Maintenance of Certification (MOC) program in 2007 to improve the quality of health care through diplomate initiated learning and quality improvement, and document that each certified physician maintains the necessary competencies to provide quality patient care. The American Board of Radiology (ABR) has incorporated evaluation of practice performance as part IV of the MOC program [1]. Every diplomate must select a project that potentially can improve the quality of their practice. The following five categories of PQI projects are promoted by the ABR: (1) patient safety, (2) accuracy of interpretation, (3) reporting timeliness and critical value reporting, (4) practice guidelines and technical standards, and (5) referring physician surveys. The Centers for Medicare and Medicaid Services (CMS) has initiated a prospective payment plan to encourage physicians to participate in quality improvement efforts [2]. The physician quality reporting initiative (PQRI) is a reporting program that provides an incentive payment to physicians who satisfactorily report data on quality measures for covered Physician Fee Schedule services furnished to Medicare Part B Fee for Service (FFS) beneficiaries. This program was modified under the 2008 Medicare Improvements for Patients and Providers Act (MIPPA) that established the PQRI program as an incentive payment of 2% of total allowed charges for Physician Fee Schedule covered professional services. In order to qualify for the incentive payment, each physician must report a minimum of three measures that are applicable to their practice and obtain 80% compliance or above. There are at least three measures that are applicable to...
Neuroradiology practice, including (1) measure #10 Stroke and Stroke Rehabilitation: Computed Tomography (CT) or Magnetic Resonance Imaging (MRI) Reports, (2) measure #195: Stenosis Measurement in Carotid Imaging Reports, and (3) measure #145 Radiology: Exposure Time Reported for Procedures Using Fluoroscopy.

MOC: Implications for Present and Future Practice
Robert D. Zimmerman, MD, FACR

PRESENTATION SUMMARY
1) Current requirements for Maintenance of Certification: A) Professionalism, B) CME, C) SAMs, D) PQI projects, E) Cognitive exams. 2) Future directions: A) Increase in number of SAMs, B) Documentation that CME fulfills specific individual "practice gaps", C) Institutional PQI projects?, D) Establishment of national directories to chart outcomes. 3) Drivers of change: A) Internal - Those groups trying to maintain our ability to determine standards for physician practice and self-certify and self-accredit; i) ABR and American Board of Medical Specialties (ABMS); ii) ACGME and ACCME, B) External - Those groups that may wish take over all or part of the process of accreditation and certification; i) Federal Government; ii) Federation of State Boards of Medical Licensure; iii) Patient safety advocacy groups; iv) Non-ABMS; medical boards [e.g., American Board of Physician Specialties (ABPS)]; v) National Board of Medical Examiners (NBMS).

Monday Afternoon
1:30 PM - 3:00 PM
Room 611/612

(9) Translational Research in Neuroradiology, III, Advanced Techniques
(Scientific Papers 106 - 116)

Moderators: Aaron S. Field, MD, PhD
Joseph A. Maldjian, MD

Paper 106 Starting at 1:30 PM, Ending at 1:38 PM

Tissue Sodium Concentration Bioscales from Sodium MR Imaging: Application to Aging and Alzheimer Disease at 3.0 and 9.4 T

Thulborn, K. R.1 • Atkinson, I. C.1 • Lu, A.1 • Ganin, H.1 • Shah, R.2 • Bennett, D. A.2 • Fleischman, D. A.2

1University of Illinois at Chicago, Chicago, Chicago, IL, 2Rush University Medical Center, Chicago, IL

PURPOSE
To pilot the use of quantitative sodium MR imaging as a method to measure tissue cell density in the hippocampus and motor cortex of older persons with normal cognition, mild cognitive impairment (MCI), or mild Alzheimer disease (AD).

MATERIALS & METHODS
Six participants 64 years or older with normal cognition (n = 3), MCI (n = 1), and mild AD (n = 2) provided written informed consent for a single imaging session. The Mini Mental State Examination (MMSE) was used to evaluate cognitive performance. Quantitative sodium MR imaging used a 3.0 T clinical scanner or a 9.4 T scanner designed for human neuroimaging. Tissue sodium concentration (TSC, mM units) bioscales were acquired using flexible twisted projection imaging and a birdcage transmit/receive radiofrequency volume coil. The TSC values in hippocampal and motor regions were measured in customized COMPASS software (Figure) avoiding partial volume effects from adjacent cerebrospinal fluid to quantify tissue cell density.

Figure 1: COMPASS software cross-registers T1-weighted (left) and T2-weighted (center) proton images to the coronal TSC bioscale (right) to guide voxel selection in the right hippocampus region of the bioscale.

RESULTS
Participant diagnosis, MMSE score and TSC values for hippocampal and motor regions are provided in Table 1. The TSC values in hippocampus but not in motor cortex demonstrate an inverse correlation (R2 = 0.91) with cognitive performance.

<table>
<thead>
<tr>
<th>Subject</th>
<th>Diagnosis</th>
<th>MMSE Score</th>
<th>Hippocampal TSC (mM)</th>
<th>Motor TSC (mM)</th>
<th>TSC Ratio</th>
<th>Field (T)</th>
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<tbody>
<tr>
<td>A</td>
<td>pAD</td>
<td>20</td>
<td>57.5</td>
<td>34.9</td>
<td>1.65</td>
<td>3</td>
</tr>
<tr>
<td>B</td>
<td>pAD</td>
<td>24</td>
<td>42.3</td>
<td>34.0</td>
<td>1.24</td>
<td>3</td>
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<tr>
<td>C</td>
<td>MCI</td>
<td>28</td>
<td>38.6</td>
<td>33.3</td>
<td>1.16</td>
<td>3</td>
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<td>Normal</td>
<td>30</td>
<td>36.2</td>
<td>30.7</td>
<td>1.18</td>
<td>3</td>
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<tr>
<td>E</td>
<td>Normal</td>
<td>30</td>
<td>36.2</td>
<td>33.9</td>
<td>1.07</td>
<td>3</td>
</tr>
<tr>
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<td>Normal</td>
<td>30</td>
<td>34.8</td>
<td>35.2</td>
<td>0.99</td>
<td>9.4</td>
</tr>
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</table>
CONCLUSION
Tissue sodium concentration can be measured safely at 3.0 and 9.4 T in older persons representing the cognitive spectrum from normal cognition to mild AD and correlates with cognitive performance. Further studies are needed to determine if TSC bioscales could identify older persons at greater risk for clinically significant cognitive decline. As the higher resolution and signal to noise ratio of 9.4 T improves detection of TSC differences, such studies should be performed optimally at 9.4 T.

KEY WORDS: Sodium MR imaging, Alzheimer disease, aging

Paper 107 Starting at 1:38 PM, Ending at 1:46 PM
Cyclic Cerebrospinal Fluid Flow (I): Towards the Understanding of Cerebrospinal Fluid Flow Dynamics in Chiari I Malformation
Linge, S. O.1,2 • Haughton, V.1,3,4 • Levgren, A. E.1 • Mardal, K. A.1 • Helgeland, A.1 • Langtangen, H. P.1 • Støverud, K.1
1Simula Research Laboratory, Oslo, NORWAY, 2Telemark University College, Porsgrunn, NORWAY, 3University of Wisconsin Hospitals and Clinics, Wisconsin, WI

PURPOSE
Chiari I malformation leads to abnormal cerebrospinal fluid (CSF) flow dynamics and often is accompanied by syrinx formation. Phase contrast MR investigations reveal that peak flow velocities increase, whereas the altered pressure gradients are much more difficult to assess noninvasively. In this study, we use computer simulations to investigate how tonsil herniation changes pressure dynamics and flow in the cervical subarachnoid space.

MATERIALS & METHODS
A 3D mathematical model of the cervical subarachnoid space, with and without herniated tonsils, was used to simulate CSF flow dynamics over several cycles of sinusoidal flow. Simulation results for the case with herniated tonsils were compared with corresponding results for normally positioned tonsils, while keeping all other parameters the same.

RESULTS
Tonsil herniation caused pressure gradients to increase both in the superior-inferior direction and in axial planes of the model. The change in pressure dynamics caused a more complex flow velocity pattern with higher peak velocities, pronounced synchronous bi-directional flow, and larger velocity components within axial planes.

CONCLUSION
Chiari I malformation increases pressure gradients and flow complexity in the cervical subarachnoid space. This implies, e.g., that the spinal cord - CSF interaction dynamics changes following tonsil herniation, something which might have a role to play in syrinx formation.

KEY WORDS: Chiari I malformation, syrinx, computer simulation

Paper 108 Starting at 1:46 PM, Ending at 1:54 PM
Analysis of CT Perfusion Parameters to Determine Thresholds for Infarct Core, Ischemic Penumbra, and Benign Oligemia in Patients Undergoing Endovascular Revascularization Therapy
Mangla, S. • Li, Z. • Smoller, B. • Cherney, A.
State University of New York Downstate Health Science Center
Brooklyn, NY

PURPOSE
CT brain perfusion (CTP) is emerging as a powerful tool in guiding stroke therapy. Limited studies have shown CTP parameter (MTT, CBF, CBV) thresholds that differentiate ischemic penumbra from infarct core. The purpose of this study is to determine CTP parameter thresholds (MTT, CBF, CBV) that differentiate infarct core, penumbra, and benign oligemia in patients undergoing endovascular revascularization therapy (ERT).

MATERIALS & METHODS
Retrospective review of prospective clinical database for patients receiving ERT was performed from 05/01/07-09/30/10. Ten patients with complete datasets who underwent CTP, and delayed noncontrast CT (NCT) or MR imaging (MRI), >24 hours after stroke were divided into either the persistently occluded group (n=4) or the revascularized group (n=6), based on catheter angiography postintervention for initial review. CT brain perfusion source images were processed by Philips Extended Brilliance Workshop 3.5.0.2254. MATLAB was used to coregister perfusion maps with delayed final infarct NCT or MRI. For both groups, the final infarct was outlined as region of interest (ROI) on the NCT or MRI. For the occluded group, the region that survived (nROI=32) was defined as benign oligemia (BO) while the region that infarcted (nROI=35) represented the original penumbra (P) and infarct core (IC). In contrast, for the revascularized group, the region that survived (nROI=35) encompassed the original BO and P while the final infarct (nROI=22) was defined as the IC. Individual single pixel perfusion data were assessed and are represented in absolute count histograms to show distribution of survival and infarcted pixels for two groups under various CBV and CBF (Figure 1).
RESULTS
In the occluded group, the number of pixels of infarcted tissue peak at CBF of 10 while the peak for survived tissue is CBF of 17. For the revascularized group, histograms of infarcted tissue peaks at CBF of 2 and CBV of 0.4 while the peaks for survived tissue is at CBF of 8 and CBV of 2.5, suggesting that threshold of CBF and CBV are likely to be between two and eight, and between 0.4 and 2.5 respectively. Significant tissue survival was observed below CBV of 2.5 (Figure 1).

CONCLUSION
Our histograms suggest that potentially salvageable tissue may be found below CBV values of 2.5, and as low as 0.4. Further prospective study of these parameters in patients experiencing successful revascularization will be required to further refine these thresholds. Thresholds for basal ganglia, gray matter, and white matter may need to be investigated independently.

KEY WORDS: Perfusion imaging, interventional therapy, stroke

Paper 109 Starting at 1:54 PM, Ending at 2:02 PM
Reducing Radiation Dose while Maintaining Diagnostic Accuracy of Cerebral 3D Digital Subtraction Angiography: In vivo Study in Swine
Pearl, M. S. 1 • Radvany, M. G. 1,2 • Messina, S. A. 1 • Rao, S. 3 • Ehtiati, T. 1 • Gailloud, P. 1 1The Johns Hopkins Hospital, Baltimore, MD, 2Uniformed Services University of the Health Sciences, Bethesda, MD, 3Siemens Corporation, Baltimore, MD

PURPOSE
Three-dimensional (3D) DSA is the gold standard imaging technique for the diagnosis and characterization of intracranial aneurysms. This study evaluates the impact of various dose reduction strategies on 3D DSA image quality.

MATERIALS & METHODS
The standard manufacturer 5s 0.36µGy/frame setting was modified to create lower dose 3D DSA protocols by varying the acquisition time (5s or 3s) and/or dose per frame (0.10 µGy/frame). All protocols were performed in three swine. For each protocol, multiplanar (2D) and 3D reconstructions were created with fixed rotation, window width, and contrast level. Four neuroradiologists measured a specified vessel’s diameter on the 2D reconstructions. Bland-Altman analysis was performed (Figure 1B). 0.5 mm was defined as a clinically acceptable difference. Three-dimensional image quality was scored by the same group and based on the visibility of nuanced vessel architecture.

RESULTS
Dose: Delivered system doses ranged from 43.8 mGy to 6.5 mGy. 5s 0.10 µGy/frame protocols generated 65%-68% less delivered dose compared with the 5s 0.36 µGy/frame setting. Measurement Accuracy: The mean difference in measured vessel diameters between the standard and the lowest dose 5s protocol (5s 0.10 µGy/frame) was < 0.2 mm for all swine. All 95% confidence intervals were less than 0.5 mm (Figure 1A). Vessel diameters from the 5s 0.10 µGy/frame protocols were within the estimated 95% limits of agreement for all swine. Morphologic Assessment: Three-dimensional image quality of the 5s was scored superior to the 3s protocols. Incidentally noted was poor image quality on the 3s 2D reconstructions.

Paper 110 Starting at 2:02 PM, Ending at 2:10 PM
Diffusion Tensor Imaging in Determining Axonal Integrity in the Transcollosal Pathway in Relation to Multiple Sclerosis and Memory
Modic, M. E. • Koenig, K. A. • Lin, J. • Mathew, B. • Beall, E. • Stone, L. • Bermel, R. • Rao, S. • Jones, S. • Phillips, M. • Lowe, M. Cleveland Clinic Cleveland, OH

PURPOSE
Multiple sclerosis (MS) leads to degeneration of axonal pathways. Diffusion tensor imaging (DTI) has been used to evaluate pathways demonstrating that transverse diffusivity (TD) and longitudinal diffusivity (LD) are correlated with demyelination and axonal damage, respectively. Previous studies showed that DTI measures are correlated with functional connectivity in the transcollosal motor pathway in MS, confirming the relationship between function and axonal integrity. The present study extends these findings by using DTI to examine axonal integrity posterior cingulate cortex and the entorhinal cortex (PCC-EC) pathway. This pathway is involved in spatial and memory processing and is
shown to be abnormal in Alzheimer disease and may provide a method to evaluate cognitive changes in MS. We hypothesize that subjects will demonstrate increased TD and LD in the PCC-EC track as compared to controls.

**Materials & Methods**

Eighteen MS subjects and 18 age-/sex-matched controls (MS: mean age 44.00(10.08), 6 males, mean EDSS; Control: mean age 43.78(9.56), 6 males) were scanned at 3 T. Scans included an anatomical whole-brain T1-weighted volumetric imaging, motor finger tapping fMRI and high angular resolution diffusion imaging (HARDI) scans with 51 2 mm thick axial slices acquired with 71 noncollinear diffusion weighting gradients. The PCC-EC pathway was defined by an ROI in the entorhinal cortex drawn on the T1 anatomical image and by a 6 mm sphere placed in the PCC. The transcallosal pathway connecting bilateral primary motor areas, defined by activation-based ROIs using t-maps created from the bilateral tapping task. Probabilistic tracking is performed between pairs to determine white matter pathways. Fractional anisotropy (FA), TD, LD, and mean diffusivity (MD) images are masked to the white matter mask. Averaged values were created for each pathway, per subject. This is done by dividing the sum of track-density weighted diffusivity values by the sum of track density for the pathway.

**Results**

The PCC-EC was reliably identified using probabilistic tracking in all subjects. Importantly, tracking was achieved even in subjects with lesions identified within the pathway. Multiple sclerosis subjects have higher MD, LD, and TD in bilateral PCC-EC pathways and transcallosal motor pathway Table 1.

<table>
<thead>
<tr>
<th></th>
<th>TD</th>
<th>LD</th>
<th>MD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transcallosal Motor Pathway</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MS</td>
<td>635.59 (156.37)*</td>
<td>1311.8 (282.26)*</td>
<td>861.00 (134.14)*</td>
</tr>
<tr>
<td>Control</td>
<td>537.86 (124.34)</td>
<td>1122.7 (242.03)</td>
<td>732.81 (96.95)</td>
</tr>
<tr>
<td>PCC-EC, Left</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MS</td>
<td>710.82 (161.66)*</td>
<td>1305.7 (248.46)*</td>
<td>909.11 (143.13)*</td>
</tr>
<tr>
<td>Control</td>
<td>590.50 (139.64)</td>
<td>1119.7 (208.35)</td>
<td>766.89 (111.09)</td>
</tr>
<tr>
<td>PCC-EC, Right</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MS</td>
<td>718.27 (166.34)*</td>
<td>1310.9 (252.55)*</td>
<td>915.80 (146.78)*</td>
</tr>
<tr>
<td>Control</td>
<td>597.78 (141.77)</td>
<td>1114.3 (207.64)</td>
<td>769.96 (111.85)</td>
</tr>
</tbody>
</table>

*Measure are significantly higher in MS, p<0.02.

**Conclusion**

Findings within the PCC-EC pathway are similar to results in the transcallosal pathway suggesting pathway specific injury in MS. Findings suggest that probabilistic DTI fiber tracking can be used to accurately characterize specific functional pathways even in the presence of MS lesions. Further, this methodology may be used in future to assess for specific injury in the PCC-EC pathway in MS subjects with spatial and memory deficits.

**Key Words:** Diffusion tensor imaging, multiple sclerosis, transcallosal pathway

**Differentiating Amnestic Mild Cognitive Impairment from Alzheimer Disease with MR Spectroscopy: Is It Possible?**

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1 Rambam Health Care Campus, Haifa, ISRAEL, 2 Technion - Israel Institute of Technology, Haifa, ISRAEL, 3 Haifa University, Haifa, ISRAEL

**Purpose**

Mild cognitive Impairment (MCI) is a transitional state between normal aging and clinically probable Alzheimer disease (AD). Pathologic studies show that the earliest regions that are affected in both MCI and AD are posterior cingulate gyrus and the temporal lobes including the hippocampus. Our purposes: 1. to assess metabolic profiles for AD and MCI using proton MRS in cerebral regions prone to pathologic changes. 2. to define a possible marker that might predict the transition from aMCI to AD.

**Materials & Methods**

Twenty-eight individuals aged 55-80 years old were included in this study: eight patients with aMCI, 11 patients with mild to moderate AD (MMSE >16) and nine normal controls. The neuropsychological assessment included a verbal memory test (CVLTII) and a visual-associative memory test (Paired associated learning- PAL). The Process Dissociation Procedure (PDP), as well as Receiver's Operating Characteristics (ROC) were used to estimate the contribution of familiarity and recollection to recognition memory. Single voxel proton MRS was performed in all patients with voxels located in the posterior and in the anterior cingulate gyri and hippocampus. Peak areas of water, N-acetylaspartate (NAA), choline (Cho), creatine/phosphocreatine (Cr), myo inositol (mI) were assessed and metabolite ratios of NAA/Cr, Cho/Cr and mI/Cr calculated. Nonparametric Man-Whitney-U test was used for statistical comparison.

**Results**

Significant statistical decrease of NAA/Cr ratio was noted in the Posterior Cingulate cortex in AD patients as compared to patients with aMCI. No significant changes between AD and aMCI patients were noted in other regions studied.

**Conclusion**

N-acetylaspartate/Cr ratio in the Posterior Cingulate Cortex was found as the most significant difference between aMCI and AD patients, suggesting that this ratio may serve as a marker for transition between aMCI patients and Alzheimer disease.

**Key Words:** Alzheimer disease, amnestic minimal cognitive disorder, MR spectroscopy
MR Imaging Study of Focal Brain Injury in Cats Part II: Correlation between MR Imaging and Pathologic Manifestation on the Penumbra

Zhang, Y. 1 • Ma, J. 2 • Xu, X. 2 • Shi, D. 2
1 Beijing Shi Jing Shan Hospital, Beijing, CHINA, 2 Capital Medical University, Beijing, CHINA

PURPOSE
To investigate the magnetic resonance mismatch and histologic manifestation of peri-contusion zone after focal traumatic brain injury.

MATERIALS & METHODS
Nine cats were divided randomly into two groups: experimental group (n=5) and control group (n=4). Modified Feeney's model was adopted to set up focal traumatic brain injury (TBI) cat model in experimental group. For control group only a bone window was opened on the skull without brain impact given. MR imaging study was performed at 6 hours and 24 hours after head injury, and a FLAIR/PWI mismatch was observed. Histologic examination was performed after the last MR imaging (MRI) study, and the emphasis was on the pericontusion area.

RESULTS
The cats in control group did not show abnormal signal intensity on any of the MR sequences. A mismatch between PWI and FLAIR exists (paired t-test, p<0.05) in the traumatic group. Ultrastructural observation revealed that neurons and astrocytes in the pericontusion area were swollen massively, and no apoptosis or necrosis cells were seen. For the neurons, mitochondria were swollen and nuclear chromatin was aggregated. For the astrocytes, the astrocytic processes around the capillary are swollen. The structure of cells and cell organs in the control group were generally normal.

CONCLUSION
Based on histologic study, cells in the pericontusion area just showed degeneration change, but might subject to many other protecting or injuring factors. The FLAIR/PWI mismatch and the pericontusion zone might indicate the presence of traumatic penumbra on different aspect of view.

KEY WORDS: Traumatic brain injury, penumbra, electron microscope

High-Resolution 3 T MR Neurography of Suprascapular Neuropathy

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The Johns Hopkins Hospital
Baltimore, MD

PURPOSE
The purpose of this study was to illustrate the imaging findings on high-resolution 3 T MR neurography (MRN) in patients with suprascapular nerve (SSN) neuropathy.

MATERIALS & METHODS
From 3 T MRN examinations performed for brachial plexus evaluation in 51 patients over a 3-year period, 15 patients with final diagnosis of suprascapular neuropathy were recruited. The diagnosis was confirmed by electrodiagnostic studies (EDS), clinical and/or surgical follow-up examinations. Studies performed for the evaluation of tumor, neurofibromatosis or known diffuse polyneuropathy were excluded.

RESULTS
Two cases were excluded due to suboptimal imaging related to motion degradation and poor signal-to-noise ratio on the images. MR neurography depicted asymmetric enlargement and/or abnormal T2 hyperintensity of C5 nerve root (10/13 cases), C6 nerve root (10/13 cases), both C5 and C6 nerve roots (7/13 cases), upper trunk (11/13 cases) and SSN (11/13 cases), and other brachial plexus segments involvement (4/13 cases). MR findings of denervation changes in the ipsilateral supraspinatus and infraspinatus muscles were detected in 12/13 cases. In all seven cases, where contrast-enhanced images were available, MRN demonstrated enhancement of the denervated muscles but did not provide any additional information regarding the nerve abnormality. None of the MRN studies revealed a mass lesion along the course of the SSN.

CONCLUSION
3 T MRN is a valuable diagnostic tool in clinically suspected cases of suprascapular neuropathy, as it can directly demonstrate the nerve abnormality, as well as secondary
Paper 114 Starting at 2:34 PM, Ending at 2:42 PM

MR Imaging Study of Focal Brain Injury in Cats Part I: Is There a Mismatch between FLAIR and Perfusion-Weighted Imaging?

Zhang, Y.1 • Shi, D.2 • Xu, X.2 • Ma, J.1
1Beijing Shi Jing Shan Hospital, Beijing, CHINA, 2Capital Medical University, Beijing, CHINA

PURPOSE
To investigate the possibility to identify the mismatch in fluid attenuated inversion recovery (FLAIR) and perfusion-weighted imaging (PWI) around focal brain injury on cats.

MATERIALS & METHODS
Nine cats were divided randomly into traumatic group (n=5) and control group (n=4). Modified Feeney's model was adopted to set up focal TBI on cat in traumatic group. For control group only a bone window was opened without brain impact. Magnetic resonance sequences of T1-weighted, T2-weighted, FLAIR, GRE, PWI and enhanced T1-weighted were performed in a 3 T MR imaging machine 6 and 24 hours after the animal model established. The extent of the brain lesion on T1-weighted, FLAIR and PWI (CBF and CBV) was delineated and calculated. The data were analyzed by one-way analysis of variance (ANOVA), least significant difference (LSD) and paired t-test for multiple comparisons.

RESULTS
In the traumatic group, the area of the abnormal signal intensity is larger on PWI (CBF and CBV) than on structural MR images (T1-weighted and FLAIR) at 6-hour group (P<0.05) and at 24-hour group (P<0.05). And the area of the abnormal signal intensity on T1-weighted and FLAIR is expanding from 6 hours to 24 hours after traumatic injury (paired t-test, P<0.05). There was no significant abnormal signal in control group on any of the MR sequences.

CONCLUSION
For focal TBI, a mismatch was present between structural MR images and PWI which may indicate the traumatic penumbra.

KEY WORDS: Traumatic brain injury, penumbra, perfusion-weighted image

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Paper 115 Starting at 2:42 PM, Ending at 2:50 PM

Comparison of Radiation Dose Estimates and Scan Performance Time in Pediatric Head and Neck Imaging Using Volumetric 320 Row Detector Mean Diffusivity CT and Helical 64 Detector Row Mean Diffusivity CT

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1Cincinnati Childrens Hospital Medical Center, Cincinnati, OH, 2Duke Medical Center, Durham, NC, 3Toshiba Medical, Tustin, CA

PURPOSE
Determine and compare effective radiation dose (ED) estimates and scan time for clinical pediatric temporal bone, orbit, and sinus examinations using volume acquisition mode on a 320 row mean diffusivity CT (MDCT) scanner and helical acquisition mode on a 64 row MDCT scanner.

MATERIALS & METHODS
Using a 5-year-old pediatric anthropomorphic phantom, organ doses were measured using 20 metal oxide semiconductor field effect transistors (MOSFET) dosimeters for axial volumetric temporal bone, orbit, and sinus studies on a 320 MDCT scanner (Aquilion One, Toshiba) and compared to helically acquired studies on a 64 row MDCT scanner (Aquilion 64, Toshiba) using clinical pediatric acquisition parameters. Three scans for each protocol were averaged to calculate a mean ED using a weighted average of measured absorbed organ doses (ICRP 103). CTDI and DLP values and scan times were recorded for each study. Although image quality was not evaluated directly on the current study, the protocols are used clinically at the same hospital and image quality was considered diagnostic by a consistent group of pediatric neuroradiologists.

RESULTS
Effective radiation dose for volumetric studies (320 row) MDCT compared to helical studies (64 row) MDCT are: temporal bone - 0.17mSv (320) vs 0.44mSv (64); orbit - 0.41mSv vs 2.24mSv; sinus - 0.20mSv vs 1.09mSv. Use of volume acquisition on a 320 row MDCT resulted in a decrease in ED of 60.8%, 81.8%, and 80.6% (average 74.4%) respectively for temporal bone, orbit, and sinus studies compared to 64 row MDCT. Recorded CTDI and DLP values were consistently lower on the 320 row scanner. Scan times for all volumetric studies was 0.5 sec vs 3.33 sec for helical MDCT.

CONCLUSION
The combination of MOSFET and anthropomorphic phantoms provides an opportunity to study dose changes with new CT technology in the pediatric age group. Using clinical pediatric acquisition parameters, volumetric temporal bone, orbit, and sinus studies on a 320 row MDCT scanner resulted in a substantial decrease in effective dose (2.6 - 5.5 fold) compared to helically acquired studies on a 64 row MDCT scanner. Reduced scan time with volumetric studies may reduce the need for sedation and decrease motion artifact.

KEY WORDS: Radiation dose, pediatric head and neck
MR-Guided Focused Ultrasound Brain Surgery: In vivo Tissue Changes at Different Energy Levels and Multiple Sonications

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1University of Virginia, Charlottesville, VA, 2University of Lisbon, Lisbon, PORTUGAL

PURPOSE
Magnetic resonance-guided focused ultrasound (MRgFUS) is a promising noninvasive modality with possible applications to brain. Magnetic resonance-guided focused ultrasound uses MR images to guide the delivery of high amounts of nonionizing energy, in a focal location deep inside tissue. Delivery of energy ablates the targeted tissue in seconds and can be monitored using MR thermometry (Figure A). The purpose of this work was to characterize in vivo brain changes, with different MR imaging (MRI) techniques, which occur during high-energy FUS at different energy levels and at multiple sonications.

MATERIALS & METHODS
Sprague-Dawley rats underwent MRgFUS using a small animal focused ultrasound system (FUS, Canada). This system is composed of a single 1.06MHz transducer that can be moved under computer control with submillimeter accuracy. Each animal received two sonic ablations (duration=60 sec. each) in the same region of the right hemisphere (Figure A). Three groups received both ablations at one of the following sonic powers: 6, 12 and 24 watts. MR imaging using T2-weighted, T1-weighted, and susceptibility-weighted imaging (SWI) protocols was done at baseline, post-1st sonication and post-2nd sonication. In-plane resolutions varied between 0.2x0.2mm2-0.3x0.3mm2; slice thickness: 1.0-3.0mm.

RESULTS
Susceptibility-weighted and T1-weighted images showed insignificant changes between both sonications, and between baseline and post-2nd sonication. T2-weighted images proved to be the most sensitive of the three contrasts, and respective difference maps (Figure B) correlated well with histologic changes (Figure C) and thermal maps (Figure A). Figure D shows the mean difference per single ablation for each group. The 12-watt group only had one animal, which died after the second ablation. This may have caused a much lower than expected change in the difference between 2nd sonication and 1st sonication (Figure D, light blue bar for 12-watt group). Figure E shows the mean difference from baseline to final time-point.

CONCLUSION
The second sonication showed greater changes than those for the first sonication. We only can hypothesize that the first ablation may have suppressed the primary mechanisms responsible for the thermal-protection of the brain tissue, including changes in the regional hemodynamics. Consequently, these changes may have opened the door for bigger subsequent changes during second ablations. The total changes presented in Figure E showed the expected increase of the mean differences for the 24-watt group compared to the others. The value for the 12-watt group may reflect smaller changes than expected, due to the death of the only animal.

KEY WORDS: MR, focused ultrasound, MRgFUS

Machine Learning

R. Nick Bryan, MD, PhD
University of Pennsylvania Health System
Philadelphia, PA
**Purpose**

Retinoblastoma often presents with advanced intraocular disease, and despite conventional treatment with intravenous chemotherapy and external beam radiation may still require enucleation. Objective: To determine whether intra-arterial chemotherapy is safe and effective in advanced intraocular retinoblastoma.

**Materials & Methods**

Single arm, prospective registry from May 30, 2006 to May 30, 2010. Ninety-five eyes of 78 patients with unilateral or bilateral retinoblastoma were treated. Seventy-three eyes had large tumors with vitreous seeds (Reese-Ellsworth Group Vb) and 52 eyes had recurrent/refractory disease despite conventional treatment with intravenous chemotherapy and/or external beam radiation. We performed selective catheterization of the ophthalmic artery and injection of chemotherapy, usually melphalan with or without topotecan. Drug was dosed according to age and angioanatomy.

**Results**

Catheterization succeeded in 98.5%. There were 289 chemotherapy injections (median three per eye). The Kaplan-Meier estimates of ocular event-free survival at 2 years were 70% (95% confidence interval 57.9%-82.2%) for all eyes, 81.7% (95% confidence interval 66.8%-96.6%) for eyes that received IA chemotherapy as primary treatment, and 58.4% (95% confidence interval 39.5%-77.2%) for eyes that had failed previous treatment with intravenous chemotherapy and/or external beam radiation. There were no permanent extraocular complications.

**Conclusion**

Our experience suggests that intra-arterial chemotherapy is safe and effective in the treatment of advanced intraocular retinoblastoma.

**Key Words:** Intra-arterial chemotherapy, retinoblastoma, cancer
Comprehensive Noninvasive Assessment of Vasospasm following Aneurysmal Subarachnoid Hemorrhage Using Dyna-CT Cerebral Blood Volume Measurements in the Neurointerventional Suite: A Feasible Method for the Neurointensive Treatment Unit Patient

Kamran, M.¹ · Schweder, P.² · Deuerling-Zheng, Y.² · Mueller-Alissat, B.² · Byrne, J. V.¹

¹University of Oxford, Oxford, UNITED KINGDOM, ²Siemens AG, Forchheim, GERMANY

PURPOSE
Digital subtraction angiography (DSA) is the current gold standard for detecting cerebral vasospasm - a major cause of morbidity following aneurysmal subarachnoid hemorrhage (SAH). However, DSA can only reliably identify the major vessel spasm and is unable to estimate its hemodynamic significance. To overcome these issues and to enable comprehensive noninvasive assessment of vasospasm inside the interventional suite, a novel protocol involving measurement of cerebral blood volume (CBV) using C-arm angiographic systems was implemented.

MATERIALS & METHODS
Seventeen patients from the neuro-intensive treatment unit (ITU) with suspected vasospasm following aneurysmal subarachnoid hemorrhage (SAH) were scanned using a biplane angiography system (Axiom Artis dBA; Siemens Healthcare, Germany). The imaging protocol included two 8-seconds rotational acquisitions, each comprising approximately 400 projection images at 0.50 steps. Cerebral blood volume maps were constructed using a dedicated prototype software (Siemens AG, Healthcare). Contemporaneous MR scan including a perfusion-weighted sequence (MR-PWI) was obtained for comparison. For robust quantitative analysis, an automated approach with standardized regions of interest (ROIs) created for numerous white matter (WM) and gray matter (GM) structures was used. Statistical agreement between the two modalities was explored with the Pearson correlation and Bland-Altman tests. Correct identification or exclusion of hemodynamically significant vasospasm was used as diagnostic endpoint to evaluate the overall utility of C-arm CT (DynaCT) CBV in the management of vasospasm.

RESULTS
Seventeen patients (7 male, 10 female; mean age 54 years) underwent MR-PWI and Dyna-CT examinations performed within 12 hours of each other. Fisher CT grades were: 4 in 9, 3 in 6, and 2 in two patients; and WFNS scores were: 5 in 3, 4 in 7, 3 in 5, and 2 in two patients; and WFNS scores were: 5 in 3, 4 in 7, 3 in 5, and 2 in two patients; and WFNS scores were: 5 in 3, 4 in 7, 3 in 5, and 2 in tqq patients. Angiographic vasospasm was present in 12 patients, of whom nine had hemodynamic abnormalities detectable on MR-PWI examination (criterion standard). Dyna-CT MIP reconstructions showed spastic vessels in 11 patients (sensitivity 91.6%). Hemodynamic abnormalities were identified in all nine patients with Dyna-CT CBV maps. The two techniques correlated well in estimating the volume of tissue with relative CBV <0.5 (r=0.93). Quantitative analysis of the relative CBV (rCBV) values measured for the GM and WM ROIs showed good correlation (GM r=0.81, WM r=0.90). For rCBV, the two modalities were in good statistical agreement as shown by the Bland-Altman analysis (95% limits of agreement range for GM ROIs, -0.17 to 0.22; WM ROIs, -0.12 to 0.15; and combined GM and WM ROIs, -0.15 to 0.19). Bias in measurements was minimal (GM ROIs, 0.04; WM ROIs, -0.02; combined GM and WM ROIs, 0.01) and the limits of agreement included clinically significant rCBV discrepancies.

CONCLUSION
Our results demonstrate the feasibility and accuracy of Dyna-CT CBV measurements for neuro-ITU patients with vasospasm following aneurysmal SAH. A comprehensive, single scan, noninvasive assessment of the vasospasm and its hemodynamic significance in an optimized interventional environment, improves the workflow by avoiding patient transfer between the diagnostic and the interventional setups. Implications exist for the management of acute ischemic stroke, with the triage of patients in interventional environment, potentially reducing time delays between the diagnosis and treatment.

KEY WORDS: Vasospasm, cerebral blood volume, Dyna-CT
CONCLUSION
In this small series, endovascular stent placement in the TS was a highly effective treatment for patients with intracranial hypertension due to TS stenosis. It is a less invasive alternative to cerebrospinal fluid (CSF) diversion by shunts.

KEY WORDS: Pseudotumor cerebri, stent, dural sinus

Paper 120 Starting at 3:54 PM, Ending at 4:02 PM

Time-Resolved Three-Dimensional Volume (Four-Dimensional Angiography) and OMNI-Plane Roadmap Imaging Using A Flat Detector C-Arm Angiographic System

Davis, B. J. • Oberstar, E. • Royalty, K. • Mistretta, C. A. • Strother, C. M.
University of Wisconsin Madison
Madison, WI

PURPOSE
To extend the capabilities of x-ray digital subtraction angiography (DSA) to allow reconstruction of high frame rate temporal sequences of 3D volumes (4D-DSA) and to permit viewing of roadmaps at any angle without requiring a change in gantry position (OMNI-Plane Roadmap).

MATERIALS & METHODS
Following a single intra-arterial or intravenous injection of contrast medium, multiple rotations of a Siemens Zeego C-arm were used to collect 2D projections containing information about vascular filling. Using projections from a rotation providing consistent vascular opacification, a time-independent rotational 3D DSA volume is reconstructed. Four-dimensional DSA time frames then can be generated by combining information from this volume and the appropriate time-dependent information, i.e., contrast wash in and wash out, contained in the individual projections acquired during earlier or later rotations (typically only two projections are used). Due to the sparsity of the angiographic data time-dependent information can be embedded into the 3D volume with minimal shadowing. The result is a high-resolution, high SNR 4D DSA volume that can be viewed from any chosen view. To achieve OMNI-Plane roadmaps, fluoroscopic information is embedded into a standard 3D volume acquired at the same patient position as the fluoroscopy. These bi-plane roadmaps then can be viewed from any desired view without a need for gantry movement.

RESULTS
Present results have been reconstructed in a nonreal time MATLAB environment. Limitations in memory and processing times require use of a 2563 reconstruction. Figure 1B shows two views of a time-independent 3D DSA volume. Also shown are several selected time frames from a time-resolved 4D DSA volume showing the dynamics of vascular filling. OMNI-Plane road maps have been implemented for aneurysm coiling and catheter/guidewire movement. These will be discussed and illustrated.

CONCLUSION
Four-dimensional DSA and OMNI-plane roadmaps 4D add new dimensions to the capability of DSA. 4D-DSA not only removes the limitations of 2D IV-DSA caused by vascular superimpositions, but also allows viewing of vascular structures from multiple projections using only a single x-ray acquisition. OMNI-Plane roadmaps ensure that working projections will not be limited by mechanical C-arm constraints; both applications also result in potential significant savings in x-ray and contrast medium dose.

KEY WORDS: Advanced imaging, DSA, road map

Paper 121 Starting at 4:02 PM, Ending at 4:10 PM

Angiographic Evaluation and Endovascular Management of Acute Gun Shot Injuries to Arteries Supplying the Head and Neck and the Brain in Civilian Patients

Benndorf, G. • Yevich, S. • Shaltoni, H. • Mawad, M.
Baylor College of Medicine
Houston, TX

PURPOSE
Acute gun shot wounds (GSWs) inflicted by penetrating bullets may be associated with minor or major injuries to the external carotid, internal carotid (ECA, ICA) and vertebral arteries (VA) with potentially serious clinical consequences. The purpose of this study is the retrospective evaluation of angiographic findings indicating arterial injuries in patients suffering from gun shot injuries (GSIs), and to report their acute endovascular management.

MATERIALS & METHODS
Fifty-one patients, admitted to a level 1 trauma center with suspected GSIs of the extracranial or intracranial circulation (age range: 17-54 years, gender distribution: 30 males/10 females), were referred for four vessel angiograms. Angiographic evaluation of supra-aortic and cerebrovascular arteries was performed within 24 hours after admission.
either based on the clinical conditions or on computed tomographic findings to confirm potential injuries to the ECA, ICA or VA, and if necessary with the intent to treat by endovascular techniques.

**RESULTS**
In 8 patients, no direct vessel injury was documented and angiograms showed vasospasm or segmental dilatations. In 20 patients, minor vessel injuries were found indicated by minimal wall irregularities, caliber changes or small intimal flaps without distal embolization. Clinical management consisted in low-dose anticoagulation and angiographic follow up. In 13 patients, major vessel injuries were observed. In two cases, intracranial vessel occlusions and extravasations were documented; no treatment was initiated due to elevated intracranial pressure and restricted cerebral perfusion. In one case, internal carotid dissection causing thromboembolic events and neurologic deficit was treated by stent placement. Two patients presenting with ruptured cervical VAs without angiographically visible active extravasation were treated by endovascular coil occlusions. In six patients with life-threatening blood loss, significant active extravasations were documented arising from the internal maxillary (4), occipital (1) or superficial temporal (1) arteries. In all cases, immediate transarterial occlusions were performed using NBCA (5) or Onyx (1). In two patients, arteriovenous fistulas between the common carotid artery and internal jugular vein, and the subclavian artery and vein respectively, were found. Both lesions were surgically corrected. All but two patients recovered partially or completely from their injuries.

**CONCLUSION**
Gun shot injuries to the arteries supplying the head and neck and the brain are overall rare in civilian patients, but can be seen more frequently in large trauma centers. Minor damages to the vessel wall often are manageable with conservative management and low dose anticoagulation. Major vessel injuries leading to severe extracranial dissection or angiographic occlusion, may require stent placement or complete endovascular vessel blockage. In cases with significant active extravasations and critical blood loss, immediate transarterial embolization can become a life-saving measure. The use of adhesive liquids such as acrylic glue appears more efficient compared to coils to achieve rapid vessel occlusion.

**KEY WORDS:** Trauma, gun shot injuries, endovascular management

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**Paper 122 Starting at 4:10 PM, Ending at 4:18 PM**

**Safety of Spinal Digital Subtraction Angiography: Complication Rate Analysis in 302 Consecutive Diagnostic Angiograms**

Chen, J. X.\(^1\) • Gailloud, P.\(^2\)

\(^1\)Johns Hopkins School of Medicine, Baltimore, MD, \(^2\)The Johns Hopkins Hospital, Baltimore, MD

**PURPOSE**
Diseases involving the spinal cord vasculature are a rare, but often under or misdiagnosed group of illnesses that can lead to progressive symptoms and myelopathy if untreated. Digital subtraction angiography (DSA) remains the gold standard modality for diagnostic evaluation and treatment planning for these conditions. Despite concurrence on the importance of spinal DSA as the definitive means of spinal vascular imaging, there remains reluctance among practitioners to refer patients for this study more frequently. Much of this hesitance is fueled by historical misconceptions of spinal angiography as a dangerous, technically difficult, and unreliable procedure. Although improvements in devices, techniques, and contrast agents have made modern spinal DSA far safer than when it was first developed, there is a paucity of reports on modern complication rates. The purpose of this study was to analyze the rate of complications occurring in spinal angiography procedures performed at a single institution over the last 10 years.

**RESULTS**
The study population included 112 women and 173 men ranging from 3 months to 89 years of age (mean +/- SD, 50 +/- 18 years). All angiograms were technically successful. No intraprocedural complications were seen - specifically no iatrogenic vessel injury or neurologic deficits related to thromboembolic events were recorded. There were no cases of permanent postprocedural neurologic complications or mortalities. One systemic postprocedural complication was recorded for a patient who developed pulmonary edema from fluid overload (0.3%, 95% CI: 0.0% to 1.8%). Minor postprocedural complications included three cases of groin hematoma (0.6%, 95% CI: 0.2% to 2.9%) and one case of back spasm (0.3%, 95% CI: 0.0% to 1.8%). The contrast volume per study ranged from 16 - 245 mL (mean +/- SD, 110 +/- 40 mL) and the fluoroscopy time ranged from 10 - 55 minutes (mean +/- SD, 25 +/- 8 min).

**CONCLUSION**
No intraprocedural or postprocedural neurologic complications occurred in this series and the rates of systemic and minor complications were very low. These results confirm that modern spinal DSA can be performed safely in a broad range of patients with suspected spinal vascular disorders. The risks of this procedure should still be well discussed with patients and the study should always be conducted by experienced spinal angiographers. Concern for potential complications, however, should not deter prompt referral of patients with potential spinal vascular diseases for this diagnostically crucial study.

**KEY WORDS:** Spinal angiography, safety, complications
Cervical Spine Biopsy Facilitated by a Saline "Window" Technique

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University of Miami
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Purpose
Percutaneous cervical spine biopsies are often among the most dangerous and technically challenging biopsies to perform. We describe a technique that facilitates the safer passage of relatively large bore coaxial needle biopsy systems while biopsying these cervical spine lesions.

Materials & Methods
Seven cervical biopsies have been performed, all involving challenging cervical lesions for bone biopsy sampling. These biopsies involve the passage of large coaxial bone biopsy needles through soft tissue planes that are traversed by vital neurovascular structures. Tolerances are often so small, that biopsies are deemed to be technically not safe. CT, using prebiopsy contrast enhancement for vascular mapping, is used for guidance. A twenty-five gauge needle then is used to inject up to 10 cc of sterile saline into the perivascular soft tissues planes thus displacing them and vasculature, thus creating a wider "safe" path through which to guide the biopsy needle system.

Results
This technique has proved effective in all seven cases, making the biopsies less risky and in fact allowing the biopsies to be done at all via a percutaneous approach. The following diagnoses were made on vertebral body lesions: Case 1: C1 biopsy - florid degenerative change, no malignancy. Case 2: C3 biopsy- renal cell metastasis. Case 3: C3 biopsy - osteomyelitis. Case 4: C4 biopsy- HIV with candidal osteomyelitis. Case 5: C5 biopsy - lymphoma. Case 6: C6 biopsy - osteomyelitis. Case 7: C5 biopsy - lymphoma.

Conclusion
This technique has proved valuable in challenging cervical spine biopsies, making it easier and safer to obtain specimens for pathologic evaluation.

Key Words: Biopsy, cervical, technique
Impact of Radiation Savings Measures in Pediatric and Adult Neurointerventional Procedures

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Winston-Salem, NC

**Purpose**
To identify those components of radiation use during neuroangiographic and neurointerventional procedures most amenable to modification towards dose reduction without compromise of quality of patient care.

**Materials & Methods**
Radiation exposure data were collected prospectively over a 13-month period from a variety of neurovascular procedures in a Siemens Artis Zee biplane suite. Low-dose fluoroscopy and digital subtraction angiography protocols were programmed into the unit at settings below the manufacturer default, and their use was incorporated into the “Time Out” checklist observed before each case to assure compliance. These data were evaluated retrospectively for identification of factors contributing most to estimated patient exposure. The data also were compared with historical data spanning 15 years of radiation exposure in similar procedures on a variety of older biplane units recorded by the same operator.

**Results**
The pattern of use of fluoroscopy as measured by duration per case did not change significantly over a 15-year period for procedures of similar complexity. Low dose settings, 2 - 3 p/s fluoroscopy at 18nGy/p and 7.5 p/s for roadmap, provided thoroughly adequate visualization, even for complex intracranial procedures, in children. In adults, roadmap settings sometimes had to be adjusted higher to 10 or 15 p/s at 23 - 28 nGy/p, for visualization of some difficult procedures.

In pediatric diagnostic procedures, the contribution of such low dose settings to the overall dose was low, 5 - 10% of total dose. For all cases, digital subtraction angiography (DSA) settings, magnification, and duration of runs determined the major proportion of exposure. Use of adult DSA protocol in a child can increase exposure by up to 213%, under otherwise identical conditions. Similarly, use of higher magnification settings increases the estimated exposure by up to 64%. In complex adult and pediatric neurointerventional cases, total radiation dose depended on duration of fluoroscopy use and fluoroscopy settings, number of DSA runs, duration of DSA runs, and magnification factors during roadmapping and during DSA.

**Conclusion**
Avoiding the “fluoroscopy flat foot” phenomenon with pedal use during neurointerventional procedures may not be the solution to radiation savings for adult and pediatric patients. Experience was not a major factor either. Fluoroscopy duration for equivalent cases was steady over a 15-year period. The dominant factor determining patient exposure was the “technologist thumb”, i.e. number and duration of DSA runs. Adjustment of fluoroscopy settings had only a minor dose-impact on diagnostic procedures. Even when fluoroscopy played a bigger role during interventional cases (20%+ of total dose), fluoroscopy at low-dose settings was still a lesser factor, subordinate to the impact of DSA. The main determinant of radiation exposure during neurovascular procedures was the cumulative number of DSA images acquired during a case, and the associated settings and magnification. Modern biplane rooms provide the operator with the ability to modify several variables, previously beyond operator control on older machines. Trimming a physician’s long-established habits thus may substantially reduce radiation use. Engineer-adjusted settings below factory default have encouraging potential for even further minimization of dose.

**Key Words:** Interventional, radiation

Vertebral Artery Ostial Stenosis: Prevalence by Digital Subtraction Angiography, MR Angiography, and CT Angiography

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Worcester, MA

**Purpose**
(1) To determine the prevalence of vertebral arterial ostial stenosis (VOS) as determined by the "gold standard" of digital subtraction angiography (DSA). (2) To utilize retrospective imaging data to identify risk factors for vertebral ostial stenosis. (3) To determine the ability of contrast enhanced magnetic resonance angiography (CEMRA) and computed tomography angiography (CTA) to reflect the true prevalence of vertebral ostial stenosis as determined by DSA.

**Materials & Methods**
Three hundred twenty-nine patients who underwent DSA had recorded evaluation of 443 vertebral artery origins. Digital subtraction angiography patients were categorized into groups based on previous imaging findings and indications for the study. Cases also were profiled according to patient age. Studies of 244 patients who underwent CEMRA of the cervical vasculature were reviewed, with analysis of 465 vertebral artery origins. Studies of 249 patients who underwent CTA of the cervical vasculature were reviewed with analysis of 494 VA origins. Prevalence of VOS was analyzed, together with assessment of frequency of CEMRA studies nondiagnostic for evaluation of V0 disease.

**Results**
The prevalence of VOS in the DSA study population was 5.4%. Higher risk patients demonstrated higher prevalence of VOS, with 18.4 % prevalence in the anterior infarct group, 33.3% prevalence in the posterior infarct group, 30.8% of patients with known significant carotid disease, and 54% of patients with vertebrobasilar symptoms. Lower risk groups demonstrated lower disease prevalence, with a prevalence of 4.1% in patients being evaluated for brain aneurysm or AVM, and 3.3% of patients being evaluated for brain hemorrhage. Vertebral arterial ostial stenosis was not observed in patients under 40 years of age, and seen in 12.5% of patients over 70 years of age. Contrast-enhanced MRA demonstrated decreased signal or signal void at the vertebral origins in 20% of patients studied by CE MRA. CT angiography esti-
mated VOS at 0.8% in the CTA population, and yielded 17.8% of studies which were nondiagnostic for evaluation of vertebral origin disease.

CONCLUSION
Even though the population undergoing DSA includes a significant percentage of patients at increased risk for vascular disease, the prevalence of VOS is relatively low at 5.4%. The prevalence of VOS increases with patient age, and is seen more commonly in patients with risk factors such as known posterior circulation infarction (33%) or symptoms suggestive of vertebrobasilar insufficiency (54%). Known carotid disease also correlated with vertebral ostial stenosis (30.8%). These findings together with previous reports suggest that routine clinical MRA significantly overestimates vertebral ostial stenosis (at 20% of the general population) and therefore overestimates disease prevalence. Isolated VOS (VOS in otherwise normal vertebral arteries) was rarely diagnosed in the CTA population. CT angiography demonstrated few cases of vertebral ostial stenosis, with a low recorded prevalence of 0.8%. Prevalence data together with a few illustrative cases where CTA and DSA were obtained on the same patient suggests that CTA underestimates vertebral origin disease. DS angiography continues to be the gold standard for stenosis at the vertebral origin.

KEY WORDS: Vertebral artery, MR angiography, DS angiography

Paper 127 Starting at 4:50 PM, Ending at 4:58 PM
Twelve-Year Experience with Diagnostic Cerebral Angiography: Analysis of Complications
Garfinkle, J. • Cortes, M. • Melançon, D. • Tampieri, D.
McGill University
Montreal, QC, CANADA

PURPOSE
Diagnostic cerebral angiography has played a central role in the diagnosis and planning of treatment in many central nervous system diseases. Our objective was to evaluate retrospectively the rate of complications of diagnostic cerebral angiography.

MATERIALS & METHODS
Data were prospectively collected for a consecutive cohort of 3647 diagnostic cerebral angiography procedures between September 1998 and December 2009. Data collected included patient age, indication for procedure, involvement of a fellow, size of the catheter, type and number of vessels injected, type of anesthesia, contrast medium, period of study during which the procedure was performed, and procedure duration. Complications were recorded as neurologic, systemic, or local (i.e., hematoma).

RESULTS
There were a total of seven neurologic complications (0.19%), two of which were symptomatically persistent (i.e., 7 days or longer) (0.054%). They occurred in procedures performed for a variety of indications. None of the aforementioned variables were found to be related significantly to neurologic complication. Seventy systemic complications occurred (1.92%). Six variables were found to be significantly related to systemic complications: first quartile of study [odds ratio (OR), 8.5]; use of the contrast agent Hexabrix (OR, 11.8); indication of aneurysm or arteriovenous malformation (OR, 3.9 and 3.7, respectively); >1 contrast injection (OR, 2.2); and age <51 (OR, 1.8) (P<0.05 for all). Thirty-one hematomas occurred (0.85%), and they were related significantly to the use of an introducer (OR, 4.9, P<0.001).

KEY WORDS: Cerebral angiography, complications, arteriography

Monday Afternoon
3:30 PM - 5:00 PM
Ballroom 6A

(11b) Demyelinating/White Matter Disease
(Scientific Papers 128 - 138)

See also Parallel Sessions
(11a) Interventional: New Devices
(11c) Vascular, Extracranial, and Intracranial
(11d) Spine: Advanced Imaging Techniques
(11e) Translational Research in Neuroradiology IV, Functional and Diffusion Imaging

Moderators: Christopher P. Hess, MD, PhD
Steven G. Imbesi, MD
Cerebrospinal Fluid Flow Evaluation by Phase-Contrast MR Technique in Multiple Sclerosis

Gorucu, Y.¹ • Albayram, S.² • Balci, B. P.¹ • Hasiloglu, Z. I.² • Yergin, K.¹ • Keser, Z.² • Cagil, E.² • Kiris, A.¹

¹Haseki Training Hospital, Istanbul, TURKEY; ²Istanbul University Cerrahpasa Medical School, Istanbul, TURKEY

**Purpose**
A possible association between chronic cerebrospinal venous insufficiency (CCSVI) and multiple sclerosis (MS) disease has been revealed recently in the discussed vascular MS hypothesis. In a study, it has been shown the alteration of cerebrospinal fluid (CSF) flow in the MS patients with CCSVI. Cerebrospinal fluid flow dynamics have been expected to be affected in the MS patients due to the claimed CCSVI association. In this study, the CSF flow at the level of cerebral aqueduct has been evaluated quantitatively with PC-MRI method to determine whether CSF flow is affected in MS patients.

**Materials & Methods**
Forty patients were included to the study; 32 patients diagnosed as relapsing remitting MS (RRMS) and eight patients with secondary progressive MS (SPMS). The control group was composed of same number, gender and age (± 2) of neurologically healthy subjects. A 1.5 T MR unit (Philips Achieva) 8-channel coiled was used in MR examination. PC-MRI was performed in the axial plan perpendicular to the aqueduct of Sylvius for the quantitative examination of CSF. Parameters such as TR: 24 ms, TE: 14 ms, slice thickness 4 mm, NSA: 2, FOV: 10 cm, matrix 260x182, phase-contrast velocity encoded (Venc = 20 cm/s), 15 degrees of flip angle were used to obtain 12 slices in cardiac phase for images at the axial plane. Caudocranial flow direction was defined as positive and cranio-caudal flow direction was defined as negative. Cardiac triggering was performed retrospectively with finger plethysmography. Quantitative measurements of CSF flow at the level of cerebral aqueduct were carried out in MR workstation with "Q Flow" software. Cerebrospinal fluid flow volume into the third and fourth ventricle, stroke volume and net CSF flow volume were calculated as ml/min to eliminate the problems of pulse rate differences across the individuals and to provide standardization.

**Results**
Cerebrospinal fluid flow volume toward the third and the fourth ventricles and stroke volume were found to be significantly higher in MS patients compared with the control group. Cerebrospinal fluid flow volume toward the third and fourth ventricles, and stroke volume were significantly higher and net CSF flow volume was significantly lower in male MS patients than in healthy male subjects. Even the net CSF flow direction was detected toward the third ventricle in male MS patients. Cerebrospinal fluid flow volume toward the third and the fourth ventricles, and stroke volume were significantly higher in male MS patients than in female MS patients.

**Conclusion**
The significant decrease of the net CSF flow and the shift of the net flow toward cranial direction in MS male patients suggest that progressive increase of CSF reflux toward the third ventricle can cause a shift of the net CSF flow in MS patients. This finding is consistent with the alterations of the CSF flow dynamics in MS patients.

**Key Words:** Multiple sclerosis, cerebrospinal fluid flow, phase-contrast MR

Doppler Waveform Analysis of Jugular Venous Flow in Patients with and without Multiple Sclerosis

Jayaraman, M. V. • Beland, M. D. • Ahn, S. H. • Atalay, M. K. • Rizvi, S.

Warren Alpert School of Medicine at Brown University Providence, RI

**Purpose**
Recent literature has suggested that stenosis of the extracranial venous drainage may play a role in the development of multiple sclerosis (MS), the so-called chronic cerebrospinal venous insufficiency (CCSVI) hypothesis. The purpose of this study was to compare Doppler waveforms in patients with MS with those of controls.

**Materials & Methods**
Institutional review board approval was obtained for this prospective study. A total of 39 patients with MS (Mean age 47.9 ± 11.2 years, 77% female) and 39 control patients (Mean age 50.7 ± 9.5 years, 87% female) underwent ultrasound evaluation using the following protocol: In both supine and upright positions, interrogation of both internal jugular veins was performed in three locations (superior, mid, and inferior jugular vein). For each vessel location spectral Doppler waveforms were recorded and pulsatility indices calculated. Waveform morphology then was assessed in an independent fashion by three board-certified radiologists, blinded to the clinical history of the patient. Images were reviewed in random order and waveforms were assigned one of four morphologies: A - triphasic, B - biphasic, C - monophasic, or monophasic with reflux, or D - irregular or inconsistent waveform. Comparisons between the two patient groups were performed using the Chi squared test. In addition to the subjective analysis, a venous pulsatility index (PI) was calculated for each waveform. Based on literature from hepatic venous studies, a PI < 0.45 was considered to be suggestive of a more central stenosis.

**Results**
Table 1 summarizes waveform analysis for each reader in the superior segment. The difference in waveforms in the superior location between MS patients and controls was statistically significant for all readers. No significant difference was seen in the middle and inferior locations. Mean pulsatility index was 0.81 ± 0.60 in the superior segment for MS patients compared with 1.28 ± 1.03 for controls (p = .0025). No significant difference in PI was seen in middle or inferior jugular segments. A pulsatility index of 0.45 or lower (a threshold which has been validated in studies of hepatic
venoocclusive disease) was seen in 38% of MS patients in the superior segment vs 21 % of controls (p = .035). No differences in these thresholds were seen in mid or inferior jugular segments. Table 1. Waveform categories in superior segment of the Internal jugular vein

<table>
<thead>
<tr>
<th>Flattening</th>
<th>Normal</th>
<th>Mild</th>
<th>Moderate</th>
<th>Severe</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper</td>
<td>0.78 (0.14)</td>
<td>0.80 (0.03)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mid</td>
<td>0.64 (0.55)</td>
<td>0.64 (0.72)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lower</td>
<td>0.84 (0.16)</td>
<td>0.76 (0.13)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Collaterals</td>
<td>0.45 (0.03)</td>
<td>0.28 (0.16)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table II. Pooled Flattening and Collateral Scores

CONCLUSION
Both subjective (waveform analysis by independent readers) and objective (pulsatility indices) criteria show statistically significant differences between MS patients and controls in the superior segment of the internal jugular vein in the supine position. The relationship of this observation to the pathogenesis of MS is unknown, and the possibility exists that these differences may even be the result of the disease process. Further study into a potential relationship between venous abnormalities and MS may be warranted.

KEY WORDS: Multiple sclerosis, CCSVI, jugular vein

Paper 130 Starting at 3:46 PM, Ending at 3:54 PM

Qualitative Assessment of Extracranial Venous Drainage in Multiple Sclerosis Patients and Normal Controls

McTaggart, R. A. • Fischbein, N. J. • Hsiao, A. • Elkins, C. J. • Stefanopoulos, S. • Rosenberg, J. • Dake, M. D. • Zaharchuk, G.
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Stanford, CA

PURPOSE
Chronic cerebrospinal venous insufficiency (CCSVI) hypothesizes an association between venous stenoses/impaired extracranial venous drainage and multiple sclerosis (MS). Published sonographic criteria for CCSVI are controversial and no MR imaging (MRI) data exist to support the CCSVI hypothesis.

MATERIALS & METHODS
To assess differences in internal jugular vein narrowing and the presence and severity of nonintimal jugular (IJ) collateral veins, cohorts of gender and age-matched normal (n = 10) and MS patients (n = 10) underwent axial 2D-TOF neck MRV (flattening) and TRICKS MRA/MRV (collaterals) of the head and neck at 3 T. To best assess non-IJ vein collaterals, highest signal arterial phase images were subtracted from highest signal venous phase images to best approximate venous anatomy. Two experienced neuroradiologists reviewed vascular imaging without any knowledge of cohort status. They assigned scores (normal = 0, mild = 1, moderate = 2, severe = 3) for upper, mid, and low internal jugular vein flattening and the presence and severity of non-IJ collaterals. Kappa was used to assess agreement of the readers. Comparisons between the two cohorts were made using the Wilcoxon rank-sum (Mann-Whitney) test.

RESULTS
Seven women were in each cohort and the mean ages were 44.6 and 45.4 years for the normal and MS cohorts, respectively. The mean EDSS of our MS cohort was 3.75. Eight patients (80%) had relapsing-remitting MS. Axial MRV data were available for all subjects (n = 20). TRICKS data were available for 19 subjects. Reader agreement for IJ vein flattening exceeded that for the presence and severity of collaterals (Table I). Multiple sclerosis patients had statistically significantly greater flattening of the internal jugular veins and, perhaps a consequence, more non-IJ collaterals (Table II).

Table I. Waveform categories in superior segment of the Internal jugular vein

<table>
<thead>
<tr>
<th>Flattening</th>
<th>Normal</th>
<th>Mild</th>
<th>Moderate</th>
<th>Severe</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper</td>
<td>0.78 (0.14)</td>
<td>0.80 (0.03)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mid</td>
<td>0.64 (0.55)</td>
<td>0.64 (0.72)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lower</td>
<td>0.84 (0.16)</td>
<td>0.76 (0.13)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Collaterals</td>
<td>0.45 (0.03)</td>
<td>0.28 (0.16)</td>
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</tbody>
</table>

Table II. Pooled Flattening and Collateral Scores

<table>
<thead>
<tr>
<th>Right side</th>
<th>Left sided</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flattening</td>
<td></td>
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<td>MS</td>
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<td>Collaterals</td>
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CONCLUSION
Our results indicate that MS patients have more extracranial venous stenoses with greater IJ flattening and more extensive non-IJ collaterals than normal patients without MS. The role that this finding plays in the pathogenesis or progression of MS, if any, requires further study.

KEY WORDS: Multiple sclerosis, CCSVI, jugular veins

Paper 131 Starting at 3:54 PM, Ending at 4:02 PM

Magnetization Transfer Ratio Measurement in Determining Verbal Memory in Multiple Sclerosis

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Cleveland, OH

PURPOSE
Magnetization transfer ratio (MTR) is a method of comparing the interactions of protons in various types of tissue with interactions in an unrestricted environment such as water. In multiple sclerosis (MS), the reduction of MTR in white matter is related to degree of demyelination, and has been found to correlate with information processing speed, executive function, episodic memory, and number of failed tests in a battery. An estimated 40-50% of MS patients have some cognitive deficit, and a marker of neuronal integrity that is reliably related to cognition may prove useful in the diagnosis and treatment of MS. The present study focuses on specific loss of verbal memory using a verbal recognition task.

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We hypothesize that white matter injury determined by MTR will be related directly to the degree of memory impairment. Specifically, we expect that white matter MTR will correlate positively with performance on a verbal recognition task.

**Materials & Methods**
The following scans were performed on 13 female and six male right-handed subjects with MS (mean age 40.74 years (8.54); mean EDSS 1.74 (1.21). Anatomical whole-brain T1-weighted inversion recovery turboflash (MPRAGE), two gradient-echo scans, one with and one without MT saturation pulse. Three whole-brain EPI scans were run while subjects engaged in each of two tasks: First, an incidental encoding task (WE), during which subjects were shown 60 words for 2000 ms each asked to decide if each word was abstract or concrete. Subjects were told that they would be asked about the words later. After 20 minutes, two word retrieval (WR) scans were used to measure recognition memory for words seen in the WE scan. Magnetization transfer ratio mode, which corresponds to histogram peak, was calculated for whole-brain white matter. Word retrieval events were split into correct identification (hits), correct rejection, false-positive (misses), and false-negative groups for each subject based on responses. A measure of overall performance was calculated by dividing hits by the total number of previously seen words, dividing the total number of misses by the number of foils, taking the z-score of each number, and subtracting the misses z-score from the hits z-score. This measure is referred to as D'. The correlation between D' and the mode of white matter MTR was calculated for each subject.

**Results**
The whole brain white matter MTR mode was significantly correlated with performance on a word recognition task in 19 MS subjects. Specifically, D' correlated positively with the whole brain white matter MTR mode, (r = 0.6398, p < 0.003).

**Conclusion**
Reduction in MTR reflects underlying white matter damage in multiple sclerosis. The degree of white matter damage correlates directly with impaired cognitive memory performance during a verbal recognition task.

**Key Words:** Multiple sclerosis, magnetization transfer ratio

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**Paper 132 Starting at 4:02 PM, Ending at 4:10 PM**

**Does Iron Accumulate Abnormally in the Deep Gray Matter of Patients with Multiple Sclerosis?**

Achiriloaie, A. F. • Oyoyo, U. • Hadi, E. • Harder, S. L. • Giang, D. • Kido, D.
Loma Linda University Medical Center
Loma Linda, CA

**Purpose**
Previous studies have shown increased iron accumulation in the basal ganglia, thalamus and midbrain in patients with multiple sclerosis (MS); however, they have been performed in small samples. The purpose of this study is to determine whether multiple sclerosis patients exhibit higher iron concentration on susceptibility-weighted imaging (SWI) in the deep gray matter compared to normal subjects.

**Materials & Methods**
We retrospectively reviewed susceptibility-weighted images of 75 patients (66 F/9 M) with a clinical diagnosis of multiple sclerosis (age range 15 to 64 years, median age of 43 years) and 66 normal age-matched control subjects ranging from 18 to 63 years, median age 42 years. The SWI images were obtained on a 1.5 T MR imaging (MRI) scanner in all patients. We measured the relative signal intensities of the head of the caudate, putamen, globus pallidus, thalamus, substantia nigra and red nucleus based on the theory that signal intensity is inversely correlated with iron concentration. The signal intensity was obtained by drawing a region of interest around the structure and dividing the signal intensity in it by CSF intensity. We performed analysis of covariance (ANCOVA) to assess group differences in signal intensity between the MS patients and normal controls in each anatomical structure and globally, by calculating the sum of all structures. Age was included as the covariate, while hemisphere was treated as an additional fixed factor. Statistical analyses were conducted with SAS v9.1.3 (SAS Institute, Cary, North Carolina) at an alpha level of 0.05.

**Results**
Multiple sclerosis patients demonstrated a significantly higher concentration of iron in the head of the caudate than normal subjects (p < 0.05). Red nucleus iron concentration was higher for MS patients than normal controls, but the difference was not statistically significant (p = 0.15). No other anatomical structure (putamen, globus pallidus, thalamus and substantia nigra) demonstrated a significant difference in iron concentration between the groups. No statistically significant difference in total, global iron concentration was found between MS patients and normal controls.

**Conclusion**
This study verifies that there is increased iron accumulation in the head of the caudate and possibly in the red nuclei in patients with multiple sclerosis. However, it does not confirm previous observations of widespread variation in iron accumulation between MS patients and normal controls.

**Key Words:** Multiple sclerosis, iron deposition, susceptibility-weighted images
Imaging of Multiple Sclerosis at 3 T: Increased Diagnostic Yield Using Three-Dimensional Subtraction Imaging

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Ernst-Moritz-Arndt-University Greifswald
Greifswald, GERMANY

PURPOSE
The detection of contrast-enhancing (Gd+) demyelinating lesions is important for the diagnosis and treatment of multiple sclerosis (MS). The aim of our study was to evaluate the applicability of 3D-subtraction MR images for the detection of active MS lesion at 3 T using a 32-channel head coil.

MATERIALS & METHODS
We prospectively included 108 patients (82 female, mean age: 39 ± 12.83 years) with proved multiple sclerosis. MR imaging (MRI) was performed at 3 T using a 32-channel head coil. Follow-up MRI was performed after 3 months. In all patients we acquired axial T2-weighted and T1-weighted f3d images before and 5 minutes after administration of gadobutrol. Precontrast images were subtracted from the postcontrast. Enhancing lesions were counted on pre and postcontrast images. Lesion count was evaluated by two independent neuroradiologist.

RESULTS
Lesion load on T2-weighted images was 12.91 ± 5.15. Using unsubtracted postcontrast images 38 Gd+ lesions (mean: 2.92 ± 2.10) in 13 patients were identified. On subtraction images, 97 Gd+ lesion in 20 patients were detected. In seven of these patients 14 Gd+ lesion were not identified on unsubtracted images. In 10 patients 31 additional Gd+ lesions were detected and in three patients the size of the lesions increased. There was good interrater agreement (κ = 0.83).

CONCLUSION
Using a 32-channel head coil contrast-enhanced 3D subtraction MR images improve the diagnostic yield of MRI at 3 T for the detection of active MS lesion.

KEY WORDS: Multiple sclerosis, subtraction imaging, MR imaging

Diffusion Tensor Imaging Changes Associated with Multiple Sclerosis Treatment

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University of Washington
Seattle, WA

PURPOSE
There are an increasing number of therapies (neuroprotective agents) available for multiple sclerosis but conventional anatomical brain MR imaging (MRI) as assessed by FLAIR lesion burden or contrast enhancement may be relatively insensitive to short-term pharmacologic effects, particularly any improvement. The purpose of this study was to assess longitudinal change with diffusion tensor imaging (DTI) for patients on Natalizumab (Tysabri).

MATERIALS & METHODS
Thirteen patients with clinical diagnosis of multiple sclerosis were followed by serial MRI while on Natalizumab. In each patient, two scans were obtained 6 to 12 months apart. Diffusion tensor imaging was performed at 3 T using a single shot echo-planar 15-direction DTI 2 mm 256 x 256 axial pulse sequence. Diffusion tensor imaging data were processed using FSL (Oxford, UK) to generate DTI tensors, fractional anisotropy values, eigenvalues (L1, L2, L3), and mean diffusivity (MD) for every voxel within the brain. Tract-based spatial statistics (TBSS software as part of FSL) was performed on the DTI data in order to coregister white matter tracts from all subjects and to generate skeletonized white matter maps (all normalized to the same skeleton area) which provides a way to coregister white matter tracts to a common space. The scans also were interpreted by a neuroradiologist for change.

RESULTS
Mean normal-appearing white matter FA values showed an increase (improvement) in 10 of the 13 patients with an average change of 1.2% (P < .5). Radial diffusivity was decreased (improved) in seven patients and showed an average decrease of 0.8% (P < .4). Axial and mean diffusivity values were relatively stable (0.1% increase and 0.4% decrease respectively). The neuroradiology clinical interpretation showed stability in 12 patients and one small new lesion in one patient.

CONCLUSION
Although this is a preliminary study, it suggests the utility of DTI parameters to monitor possible subtle improvement of MS patients on drug therapy. We are assessing clinical correlation and enlarging our study to include patients on other therapies.

KEY WORDS: Multiple sclerosis, diffusion tensor imaging
Functional Homotopy in Multiple Sclerosis Using Resting-State Functional MR Imaging

Ge, Y. • Tang, L. • Zhou, Y. • Kelly, C. • Zuo, X. • Jaggi, H. • Herbert, J. • Milham, M. • Grossman, R. I. • Ge, Y. • Tang, L. • Zhou, Y. • Kelly, C. • Zuo, X. • Jaggi, H. • Herbert, J. • Milham, M. • Grossman, R. I.

New York University Langone Medical Center
New York City, NY

PAPER 135 Starting at 4:26 PM, Ending at 4:34 PM

PURPOSE
Functional homotopy, the high degree of synchrony in spontaneous activity between geometrically corresponding interhemispheric regions, is a fundamental characteristic of the brain’s intrinsic functional architecture. A key feature of multiple sclerosis (MS) is extensive axonal degeneration within the corpus callosum (CC), the white matter tract connecting the cerebral hemispheres. The aim of this study was to determine whether homotopic resting-state functional connectivity (RSFC) is altered in patients with MS using a recently developed voxel-wise analysis of resting-state functional MRI (RS-fMRI) data, named voxel-mirrored homotopic connectivity (VMHC).

MATERIALS & METHODS
Sixteen patients with clinically definite relapsing-remitting MS (females, mean age = 33 years, mean EDSS score = 2.2) and 14 sex/age-matched healthy volunteers were recruited. The patients had a varied degree of symptoms with mean disease duration of 4.2 years, 11 patients showed lesions on the CC or mild atrophy. Resting-state fMRI was performed at 3 T using a gradient-echo EPI sequence (TR/TE = 2sec / 30msec, flip angle = 75o, FOV = 220 x 220 mm2 and matrix size = 128x128). Twenty slices were collected parallel to a line passing through AC-PC line with 5 mm slice thickness and 1 mm gap and positioned to cover the entire cerebrum. In addition, sagittal MPRAGE scans also were performed to acquire high resolution 3D anatomical images. Data were preprocessed using both FSL and AFNI. Voxel-mirrored homotopic connectivity, the Pearson’s correlation between the preprocessed time series of each pair of symmetrical interhemispheric voxels, was computed according to the procedures outlined. The resultant values were z-transformed (using Fisher’s r-to-z transform) and were used for subsequent group-level analysis.

RESULTS
A robust whole brain VMHC (Z>2.3, cluster level p<0.05, corrected) was detected in both groups. Healthy controls exhibited the strongest VMHC within visual, motor and somatosensory cortex, whereas relatively weaker VMHC was observed between homotopic prefrontal and temporo-parietal association areas, particularly dorsolateral and ventrolateral regions which are known to demonstrate lateralization of function related to language, attention and cognitive control. The results of direct comparisons of VMHC (P<0.05) showed that, relative to controls, MS patients exhibited decreased VMHC within many higher-order cognitive regions, including frontal, temporal and occipital lobes (e.g., cingulate gyrus, lingual gyrus, precuneus), and increased VMHC in regions associated with sensory processing and motor control, including the parietal lobes (e.g., supramarginal gyrus, angular gyrus) and motor cortex.

CONCLUSION
Our data provide preliminary evidence of the potential utility of VMHC analyses for the detection of abnormalities of interhemispheric coordination in MS and associated cognitive symptoms. We demonstrated that whole brain homotopic RSFC patterns were altered in patients with MS, with reduced interhemispheric coordination in many higher-order cognitive regions and increased interhemispheric functional connectivity between primary sensorimotor regions. We suggest that these alterations in the brain’s intrinsic functional architecture changes may reflect underlying degeneration of the CC in patients with MS.

KEY WORDS: Multiple sclerosis, resting-state functional MR imaging, homotopy

Diffusion Tensor Imaging in Measuring Axonal Integrity throughout the Fornix in Relation to Multiple Sclerosis and Memory

Modic, M. E. • Koenig, K. A. • Lin, J. • Sakaie, K. • Rao, S. • Trapp, B. • Lowe, M. • Phillips, M.

Cleveland Clinic
Cleveland, OH

PURPOSE
Multiple sclerosis (MS) leads to degeneration of axonal pathways. Diffusion tensor imaging (DTI) has been used to evaluate pathways demonstrating that transverse diffusivity (TD) and longitudinal diffusivity (LD) are correlated with demyelination and axonal damage, respectively. Previous studies showed that DTI measures are correlated with functional connectivity in the transcollosal motor pathway in MS, confirming the relationship between function and axonal integrity. The current work extends these findings by using DTI to examine the integrity of the fornix. Diffusion tensor imaging measures in the fornix have been implicated in episodic memory, and the degeneration of the fornix has been implicated in Alzheimer disease and MS. The fornix is difficult to image using DTI as a cross-sectional diameter is smaller than the typical DTI voxel resulting in partial volume averaging of adjacent structures. The present study will utilize ultrahigh resolution 1 mm isotropic voxel DTI imaging to evaluate the fornix. We hypothesize that DTI measures in subjects with MS will show an increase in TD and LD in the fornix as compared to controls.
**Materials & Methods**

Seven subjects with MS and seven age- and sex-matched controls (MS: mean age 35.86 years (7.65), three males, mean EDSS 2.07; Control: mean age 37.29 years (9.30), three males) were scanned at 3 T. Scans included an anatomical whole-brain T1-weighted inversion recovery turboflash (MPRAGE) and four high angular resolution diffusion imaging (HARDI), or DTI scans (45 slices, 1x1x1, FOV = 192x192, resolution = 192x192, phase partial Fourier = 6/8, b2 = 750, TE/TR = 7700/90, BW = 930). The regions of interest are the bilateral fornices, defined by an anatomical ROI drawn on the T1 anatomical image and warped into DTI coordinates. Fractional anisotropy (FA), TD, LD, and mean diffusivity (MD) images were masked to the white matter mask and the rois and averaged values calculated for each subject.

**Results**

Reliable ultrahigh resolution HARDI data was acquired in all subjects. The fornix was clearly visible diffusion images. Subjects with MS showed higher TD and lower FA in the bilateral fornices. Both LD and MD were higher in patients, though not significantly so (Table 1).

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<tr>
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<th>Patient</th>
<th>Control</th>
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<tr>
<td>Right</td>
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<tr>
<td>TD</td>
<td>949.01</td>
<td>701.9</td>
<td>P=0.07</td>
</tr>
<tr>
<td>LD</td>
<td>1491.54</td>
<td>1352.9</td>
<td>ns</td>
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<tr>
<td>FA</td>
<td>315.68</td>
<td>434.01</td>
<td>P=0.05</td>
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<tr>
<td>MD</td>
<td>1129.85</td>
<td>918.95</td>
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<tr>
<td>TD</td>
<td>910.60</td>
<td>608.69</td>
<td>P=0.04</td>
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<tr>
<td>LD</td>
<td>1453.78</td>
<td>1259.67</td>
<td>ns</td>
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<tr>
<td>FA</td>
<td>327.74</td>
<td>458.67</td>
<td>P=0.02</td>
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<tr>
<td>MD</td>
<td>1091.66</td>
<td>825.68</td>
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**Conclusion**

Ultrahigh resolution diffusion imaging allows for accurate measurement of diffusion parameters without partial volume averaging even in very small fiber pathways such as the fornix. Findings are in line with previous measurements in the fornix and supports the use of ultrahigh resolution diffusion imaging as a viable measure of fornical axonal integrity in MS. This method may provide a useful tool for the evaluation of cognitive and memory disorders in MS patients. Nonsignificant results are likely due to low power, and expect all variables will reach significance with an increased number of subjects.

**Key Words:** Diffusion tensor imaging, multiple sclerosis, fornix
**RESULTS**

The mean (95% confidence interval or CI) of conspicuous image slices was 8.68 (6.61, 11.41) using MIP, higher than those of 3.21 (2.31, 4.48), 1.09 (0.71, 1.68), and 2.08 (1.47, 2.94), using AIP, T2 and FLAIR respectively (p-values<0.05). Thirty-one out of 33 (93.9%) patients showed conspicuous lesions using MIP, higher than those of 72.7%, 51.5% and 45.5% using AIP, T2 and FLAIR respectively (p-values<0.05). The odds of out-performance were 5.6, 10, 10, and 5.6 as MIP being compared against AIP, T2, FLAIR and T2/FLAIR respectively (p-values<0.05). Maximum intensity projection showed more conspicuous image slices in patients with MS, hearing loss/vertigo and sarcoid respectively. The interrater reliability was good with an ICC of 0.60.

**CONCLUSION**

White matter lesions are more conspicuous on axial MIP reconstructions of 3D FLAIR data than they are on corresponding AIP reconstructions, direct FLAIR or direct T2-weighted images.

**KEY WORDS:** Brain MR imaging, maximum intensity projection, multiple sclerosis

**Paper 138 Starting at 4:50 PM, Ending at 4:58 PM**

**Novel Feline Model of Reversible Central Nervous System Demyelination with Functional Recovery: Pathologic and MR Imaging Findings**

Hardin, L. V. • Mossahebi, P. • Hurley, S. • Hosseinbor, A. • Samsonov, A. • Alexander, A. • Duncan, I. D. • Field, A. S.

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Madison, WI

**PURPOSE**

Cats fed an irradiated diet develop profound, widespread central nervous system (CNS) demyelination with severe neurologic dysfunction including ataxia, paresis/paralysis, and blindness - all of which are completely reversible upon return to a normal diet. This study was done to examine the MR imaging (MRI) features of disease and recovery, as well as their pathologic correlates, in this novel animal model.

**MATERIALS & METHODS**

Cats were fed an irradiated (45kGy) diet until overtly symptomatic, then switched to normal food and monitored for signs of recovery. Cats were imaged at baseline, peak disease, and recovery on a 3T clinical scanner using a phased-array knee coil. Acquisitions included T2-weighted, magnetization transfer (MT), and mcDESPOT for myelin water (MW) mapping. Cats were euthanized at each stage for histologic analysis.

**RESULTS**

At peak disease there was widespread vacuolation, breakdown and loss of myelin, especially involving the optic nerves, gray-white matter junction in the brain, and subpial white matter of the spinal cord, with little or no axonal loss or signs of inflammation. These histologic changes manifested on T2-weighted imaging as diffuse cerebral and optic nerve swelling, diffuse white matter T2-hyperintensity resulting in loss and even reversal of gray-white contrast in the brain, and focal subpial T2 hyperintensity within the spinal cord (Figure). Similarly diffuse changes were evident on both MT and MW imaging. Recovered animals demonstrated histologic evidence of widespread remyelination, which was accompanied by partial reversal of MRI changes.

**CONCLUSION**

The unique and remarkable capacity for widespread, endogenous CNS remyelination and functional recovery exhibited by these animals is imageable with clinically relevant hardware/software and thus provides a compelling model in which to study poorly understood mechanisms of myelin repair.

**KEY WORDS:** Demyelination
**Paper 139 Starting at 3:30 PM, Ending at 3:38 PM**

**Vasa Vasorum Enhancement Overlying Carotid Plaque on CT Angiography Correlates with Symptoms in Patients with 50-70% Internal Carotid Artery Stenosis**

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Boston, MA

**PURPOSE**

The degree of internal carotid artery (ICA) stenosis is an established primary risk factor for ischemic stroke, which could be modified with carotid endarterectomy. The benefit of carotid artery endarterectomy in patients with 50-70% stenosis is less clear than patients with >70% stenosis. There is mounting evidence that vulnerable carotid plaque features such as hypodense plaque, large lipid core, thin fibrous cap and neovascularization of the vasa vasorum (VV) also may play an important role in risk stratification. Our purpose was to correlate carotid wall enhancement on CTA-SI with acute ischemic stroke based on NCCT and diffusion-weighted images (DWI), in patients with 50-70% ICA stenosis.

**MATERIALS & METHODS**

A retrospective review of our neuroradiology database was performed to identify all patients with 50-70% ICA stenosis on CTA-SI during a period of 24 months. Two experienced neuroradiologists blindly identified ICA with and without VV enhancement and reviewed both medical charts and immediate brain imaging for the presence of an ischemic stroke on NCCT and DWI, corresponding to the territory of the target ICA. Patients with lacunar, cardioembolic and borderzone infarcts were excluded. Cardiovascular risk factors were compared for both groups with a Fisher Exact test.

**RESULTS**

One hundred and eighty-seven patients and 235 ICAs fulfilled our inclusion criteria. Vasa vasorum enhancement was noted in a total of 119 ICA (50.3%). Eighty-five (36%) ischemic strokes corresponding to the target ICA were identified by NCCT or DWI, and 150 (64%) asymptomatic ICA were identified. The presence of vasa vasorum demonstrated an OR of 2.27, CI 95%, 1.318 to 3.936, P=0.004 (Fisher Exact test two tailed). When the nonenhancing VV group was divided in calcified and noncalcified plaque, although calcified plaque demonstrated a mildly increased frequency in asymptomatic patients, it did not reach statistical significance.

**CONCLUSION**

In patients with 50-70% ICA stenosis, additional stratification of stroke risk may be possible based on the presence of carotid wall enhancement on CTA-SI. Patients with VV enhancement are more likely to be symptomatic, compared to those with no enhancement.

**KEY WORDS:** CT angiography, vulnerable plaque, stroke

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**Paper 140 Starting at 3:38 PM, Ending at 3:46 PM**

**Sex Differences of High-Risk Carotid Atherosclerotic Plaque in Asymptomatic Patients at Various Stages of Stenosis: in vivo 3.0 T MR Imaging Study**

Ota, H.¹ • Reeves, M. J.² • Zhu, D. C.² • Majid, A.² • Collar, A.¹ • Yuan, C.⁴ • DeMarco, J. K.²

¹Tohoku University Hospital, Sendai, Miyagi, JAPAN, ²Michigan State University, East Lansing, MI, ³Sparrow Cardiovascular Surgery, Lansing, MI, ⁴University of Washington, Seattle, WA

**PURPOSE**

According to a histologic study, plaque characteristics of carotid endarterectomy (CEA) specimens differed between sexes, indicating that men had more unstable plaque than women. Those studies only evaluate a limited spectrum of carotid atherosclerosis with severe luminal stenosis. Little is known whether the indicated sex differences exist in carotid arteries with less severe stenosis. Using noninvasive in vivo MR imaging, we sought to evaluate sex differences in the prevalence of complicated carotid plaque characteristics in two groups of arteries with <50% and ≥50% stenosis.

**MATERIALS & METHODS**

One hundred sixty-eight patients(men, 84, women, 84) with asymptomatic carotid stenosis underwent bilateral carotid MR scan on 3.0 T scanner (General Electric) with dedicated four-channel carotid coil. Multicontrast carotid MRI protocol included five different weightings: 3D TOF, precontrast T1-weighted, T2-weighted, 3D inversion-recovery fast spoiled gradient recalled and contrast-enhanced T1-weighted performed 5 minutes after intravenous infusion of 0.15 mmol gadobenate dimeglumine (Bracco Diagnostic Inc., Princeton, NJ) per kilogram of body weight.
at rate of 3ml/sec. After intravenous bolus contrast injection, very high(0.28 mm3) resolution coronal elliptical-centric carotid contrast-enhanced MR angiogram also was performed. Subjects’ demographic data (sex, age, hyperlipidemia, hypertension, history of coronary artery disease, peripheral vascular disease, diabetes mellitus, current statin use and smoking) were collected. On artery basis, presence of complicated American Heart Association type VI (AHA-type VI, plaques with luminal surface defect, hemorrhage/thrombus, or calcified nodules) was documented. Arteries were separated into two groups with <50% and ≥50% diameter stenosis based on findings of contrast-enhanced MR angiogram. Arteries with occlusion, prior CEA or poor image quality were excluded from the image review. The prevalence of AHA-type IV was evaluated between sexes (male vs female) in the two groups using logistic regression analyses. Patient’s demographic data also were included into the logistic regression models as potential confounders. P<0.05 was designated as statistical significance.

RESULTS
Out of 336 carotid arteries, 45 were excluded due to occlusion, prior CEA or poor image quality. Accordingly, 291 arteries (143 with <50% stenosis, men, 45% and 148 with ≥50% stenosis, men, 51%) were included for the analysis. Prevalence of AHA-type VI plaques were 19% for the group with <50% stenosis and 42% for the group with ≥50% stenosis, respectively. In the group with <50% stenosis, male sex (adjusted odds ratio (aOR), 3.12, 95% CI, 1.13, 8.60, p=0.028) and presence of diabetes mellitus(aOR, 4.39, 95% CI, 1.43, 13.47, p=0.010) were significantly associated with presence of AHA-type VI plaque. In the group with ≥50% stenosis, only male sex (aOR, 2.32, 95% CI, 1.11, 4.86, p=0.025) was significantly associated with presence of AHA-type VI plaque.

CONCLUSION
Sex differences were associated significantly with complicated AHA-type VI plaque in arteries not only with ≥50% stenosis but also with <50% stenosis. The higher association of high-risk plaque features in men occurs even with mild-to-moderate carotid stenosis indicating that there is a sex difference in the development of atherosclerotic plaque even during the early stage of the disease. These results also indicate possible important of sex-based management for patients with asymptomatic carotid atherosclerosis.

KEY WORDS: Carotid atherosclerotic plaque, carotid stenosis, sex differences

Paper 141 Starting at 3:46 PM, Ending at 3:54 PM
Prevalence of Complicated Carotid Atherosclerotic Plaques Ipsilateral to Ischemic Cryptogenic Stroke Using High-Resolution MR Imaging

Saam, T.1 • Freilinger, T.1 • Grimm, J.1 • Schindler, A.1 • Schmidt, C.1 • Bamberg, F.1 • Yuan, C.1 • Reiser, M. F.1 • Dichgans, M.1 • Nikolaou, K.1
1University of Munich, Munich, GERMANY, 2University of Washington, Seattle, WA

PURPOSE
Although distinct pathogenetic mechanisms for ischemic stroke have long been recognized, a definite or even probable etiology can not be established in about one third of all patients (“cryptogenic strokes”). Recent studies have shown that high-resolution black-blood carotid MRI (hr-bb-cMRI) is able to identify complicated atherosclerotic AHA lesion type VI (AHA-LT6) with hemorrhage, thrombus or rupture of the fibrous cap with good correlation to histopathology. The purpose of our study was to evaluate the prevalence of AHA-LT6 in carotid arteries of subjects with cryptogenic stroke.

MATERIALS & METHODS
Forty-six consecutive patients (33 men, mean age 71.5±11.9 years) with cryptogenic stroke (n=36) or cardioembolic stroke (n=10, controls) in the anterior circulation and eccentric carotid plaque by ultrasound ipsilateral to the stroke were recruited from our stroke unit. All patients underwent extensive clinical work up (lab, brain MRI, ultrasound, 24-hour ECG, transesophageal echocardiography) to exclude other causes of stroke. All patients received a hr-bb-cMRI at 3.0 T with fat-saturated pre and postcontrast T1-weighted, PD-weighted, T2-weighted and TOF images using surface coils and parallel imaging techniques. Prevalence of AHA-LT6 was determined in both carotid arteries based on previously published MRI criteria by two experienced reviewers who were blinded to the clinical information.

RESULTS
Prevalence of AHA-LT6 in patients with cryptogenic stroke was significantly higher ipsilateral to the stroke (44.4% vs. 5.4%; P<0.001). Two AHA-LT6 plaques (20.0%) were found in the control group, both of them ipsilateral to the ischemic stroke. Of the 20 plaques classified as AHA-LT6, 18 had plaque hemorrhage, two had mural thrombi and nine a rupture of the fibrous cap. The figure shows MR images of a nonobstructive complicated AHA lesion type VI of a 66-year-old male patient with a “cryptogenic” stroke ipsilateral to the lesion. The triangles on the TOF and PD-weighted images point to the site of the plaque rupture. The arrows point to a large lipid/necrotic core with type I hemorrhage which does not cause substantial luminal narrowing (see TOF images on the left).
CONCLUSION
This study suggests that arterioarterial embolism from non-stenotic carotid atherosclerotic plaques play a role in the pathogenesis in a subset of subjects previously diagnosed with a cryptogenic stroke.

KEY WORDS: Stroke, atherosclerosis, plaque imaging

Paper 142 Starting at 3:54 PM, Ending at 4:02 PM
Temporal Evolution of Imaging Findings of Extracranial Craniocervical Arterial Dissection with Clinical Correlation: Midterm Follow Up
Lee, S.  
Mona, M.  
Fawaz, A.  
Hum, B.  
Hreib, K.  
Tilem, M.

Lahey Clinic Medical Center, Burlington, MA, ‘MetroWest Medical Center, Framingham, MA

PURPOSE
Extracranial craniocervical arterial dissection is believed to have a relatively benign natural history and generally is managed with anticoagulation or antiplatelet therapy. The clinical decision on the duration of anticoagulation often is based on follow-up imaging findings. The purpose of this study is to analyze the temporal evolution of vascular imaging findings in extracranial craniocervical arterial dissection patients.

MATERIALS & METHODS
Thirty-two patients (M:F = 23:9, mean age = 49 years) with clinical evidence of craniocervical arterial dissection and at least one of the following suggestive imaging findings on either CT angiography or MR angiography were included. Suggestive imaging findings include: 1) arterial stenosis, 2) arterial occlusion, 3) ectatic change of lumen, 4) pseudoaneurysm, and 5) dissection flap. The temporal evolution of imaging findings were analyzed by two neuroradiologists.

RESULTS
Twenty-five patients had spontaneous dissection (25/32, 78%), and seven patients had a history of trauma (21.8%). Fourteen patients presented with TIA/stroke (14/32, 43.7%), nine patients had neck pain (28.1%), and five patients presented with Horner’s syndrome (15.6%). There were 19 internal carotid artery dissections (59.3%), nine vertebral artery dissections (28.1%), two common carotid artery dissections (6.3%) and two bilateral carotid dissections (6.3%). In 27 patients (84%), at least one follow-up vascular imaging study was available (mean=1.5 years). On presentation, arterial stenosis, arterial occlusion, ectatic change of the lumen, pseudoaneurysm, and dissection flap were identified in 29 (91%), 6 (19%), 6 (19%), 12 (38%) and 16 (50%) respectively. On follow up, arterial stenosis improved in 58% (14/24), worse in 8.3% (2/24) and showed no interval change in 33.3% (8/24). The mean follow-up period which demonstrated lumen narrowing improvement was 77 days (median = 87.5 days). Regarding pseudoaneurysms, there was no change in shape and size of the lesion in 58% (7/12), larger in size in 25% (3/12), smaller in size in 8% (1/12). Two patients developed a new pseudoaneurysm at the dissection site on follow-up imaging. All patients were managed with anticoagulation or antiplatelet therapy since the diagnosis. During the follow-up period, all patients were stable, without any additional neurologic episode except one patient who developed a TIA (3.7%, n = 1/27).

CONCLUSION
Postdissection vascular imaging findings are dynamic. With medical management, more than half of the arterial stenoses after craniocervical dissection improved within a relatively short period of time (about 2.5 months) and the risk of repeated neurologic event appears to be very low.

KEY WORDS: Dissection, temporal evolution

Paper 143 Starting at 4:02 PM, Ending at 4:10 PM
Differentiation of Cervical Arteriopathies Using in vivo High-Resolution MR Imaging
Saam, T.  
Schwarz, F.  
Cyan, C. C.  
Hartmann, M.  
Grimm, J.  
Reiser, M. F.  
Dichgans, M.  
Pfefferkorn, T.  
Nikolaou, K.

University of Munich Munich, GERMANY

PURPOSE
To evaluate the potential of high-resolution black-blood cervical magnetic resonance imaging (hr-bb-cMRI) in differentiating the most common cervical arteriopathies, such as atherosclerosis, arterial dissection and vasculitis.

MATERIALS & METHODS
Thirty consecutive patients were included in this study. Seven patients had giant cell arthritis (GCA) according to the ACR criteria with a cervical manifestation of the disease which was diagnosed by PET/CT. Five patients had severe atherosclerosis (AS) which was confirmed histologically after endarterectomy. Three patients had moderate AS with > 3 mm thickening of the arterial wall and <50% stenosis, which was confirmed by ultrasound and five patients had an arterioarterial embolism (AD) which was confirmed clinically and by imaging at baseline and after 3 months. Furthermore, 10 controls with no evidence of arterial disease were included. All patients received a hr-bb-cMRI at 3.0 T with fat-saturated pre and post-contrast T1-weighted-, PD-weighted-, T2-weighted- and TOF images using surface coils and parallel imaging techniques. One experienced reviewer who was blinded to all clinical information classified both carotid arteries and both vertebral arteries according to the criteria shown in the figure into one of the following categories: GCA, AS, AD or C.
RESULTS
On a patient level the correct diagnosis was made in 29 out of 30 cases (97%). Only one patient of the control group was classified into the group with moderate AS. For the presence or absence of the disease this resulted in a sensitivity, specificity, positive predictive value and negative predictive value of 100%, 90%, 95% and 100%, respectively.

CONCLUSION
This study suggests that hr-bb-cMRI is a clinical useful tool to differentiate between the most common cervical arteriopathies noninvasively.

KEY WORDS: Atherosclerosis, arterial dissection, vasculitis

Paper 144 Starting at 4:10 PM, Ending at 4:18 PM
Internal Jugular Vein Hemodynamics in Patients with Multiple Sclerosis

Kantarci, F. • Albayram, S. • Esenkaya, A. • Hasiloglu, Z. • Saip, S. • Siva, A.
Istanbul University
Istanbul, TURKEY

PURPOSE
To evaluate internal jugular vein (IJV) cross-sectional area (CSA), blood flow volume and reflux in patients with multiple sclerosis (MS).

MATERIALS & METHODS
Forty-four consecutive patients, 17 men and 27 women, with diagnosis of MS were enrolled in the study. The mean age of the patients was 37.4 years (range 20 to 63 years). The grayscale ultrasound (US) and Doppler ultrasound (DUS) findings were compared to that of age- and sex-matched 44 healthy volunteers. The US imaging protocol consisted of CSA measurement of the IJV at the mid-thyroid level. The CSA of the vertebral vein was measured from the extraforaminal portion of the vertebral vein on transverse images. The DUS examination included spectral flow tracings of the IJV at the mid-thyroid level and the vertebral vein at the extraforaminal portion. The blood flow volume of the IJV and vertebral veins on DUS was measured by using the following formula: time averaged maximal velocity/2Xcross sectional area of the IJV. All the measurements were performed in upright and supine positions. Cerebral outflow flow volume was calculated by the sum of the both IJV and vertebral vein flow volumes. All measurements were expressed as mean±standard deviation. Venous reflux at the IJV and vertebral veins were decided from the spectral tracings while the subjects were performing Valsalva maneuver. Venous reflux was accepted when there was retrograde flow more than 0.88 seconds. Statistical analysis included the cerebral outflow flow volume in upright and supine positions among MS patients and control subjects by Wilcoxon-rank sum test. The Mann-Whitney U test was used for statistically significant differences between MS patients and control subjects. A p value of less than 0.05 was used for statistical significance.

RESULTS
The CSA of the IJV of MS patients in upright and supine positions on the left side (0.13±0.09 cm², 0.66±0.46 cm², respectively) was not statistically significant when compared to control subjects (0.18±0.20 cm², 0.69±0.31 cm²). While the CSA on the right side in upright position was not statistically significant between groups (0.11±0.04 cm² vs 0.14±0.09 cm²), it was significantly lower in MS patients in supine position (0.64±0.46 cm²) when compared to control subjects (0.83±0.39 cm²) (p=0.01). The cerebral outflow flow volume was statistically lower in MS patients (upright BFV 431.4±180.8 ml/min, supine BFV 610.6±375.8 ml/min) when compared to control subjects (upright BFV 580.9±407.5 ml/min, supine BFV 810.9±386.6 ml/min) (upright p=0.025, supine p=0.003). Venous reflux testing showed no reflux by Valsalva maneuver in any of the patients and control subjects.

CONCLUSION
This study showed that IJV reflux was not present in MS patients, as it was supposed previously by studies on chronic cerebrospinal venous insufficiency. However, decreased right IJV CSA and cerebral outflow flow volumes suggest a venous drainage abnormality in MS patients. Further studies with large patient population are needed to clarify the relationship between MS and chronic cerebrospinal venous insufficiency.

KEY WORDS: Multiple sclerosis, internal jugular vein, hemodynamic

Paper 145 Starting at 4:18 PM, Ending at 4:26 PM
Time-Resolved Contrast-Enhanced MR Angiography versus Digital Subtraction Angiography in Internal Carotid Artery Stenosis

Okce, E. • Topaloğlu Aşçı, S. • Firat, M. • Acu, B. • Beyhan, M. • Çelikyay, R.
Gaziosmanpasa University
Tokat, TURKEY

PURPOSE
In this study, digital subtraction angiography (DSA) being taken as a reference, the sensitivity, specificity, positive and negative predictive values, and diagnostic accuracy of time-resolved imaging of contrast kinetics (TRICKS) MR angiog-
Contrast-enhanced head and neck MR angiography is a non-invasive and safe method for the evaluation of head and neck vessels. It may be degraded by venous stasis and reflux of contrast into the jugular veins. The purpose of this study is to evaluate the relationship between venous stasis and reflux and the side of injection and other causal factors.

**Materials & Methods**

From April 2009 to November 2010, 22 (16 male, 6 female; mean age 68 years; age range 45-84±10 SD) consecutive patients were included in this study. MR angiography was performed 1.5 T MR (Signa excite HD; GE). The TRICKS MR angiography protocol includes flip angle: 35°, TR: 4.1 msec, TE: 1.6 msec, slice thickness: 1.8 mm, matrix: 320x224, field of view 28x10 cm, and temporal resolution of one frame every 5-6 seconds. Data were acquired continuously for 1 minute. Approximately 20 seconds after the start of the scan, 1.5 ml/s of gadobenate dimeglumine contrast was injected over 20 seconds by using a power injector. Digital subtraction angiography was performed with an angiographic unit (Innova 3100; GE) with an image intensifier matrix of 1000x1000. With use of the Seldinger technique, the tip of a 4-F catheter was placed in the right and left common carotid artery. Two projections (lateral, posteroanterior) were acquired from each ICA. For each projection, 10 mL of iordinated contrast agent was injected at a flow rate of 5 mL/sec by using a power injector. Results of TRICKS MR angiography, and DSA were read independently by two observers. Internal carotid artery (ICA) stenosis was measured on printed hard copies according to the following NASCET method: Stenosis=1−(Minimal Residual Lumen/Distal ICA Lumen Diameter) x 100%, by using a mechanical caliper with a digital display. From the MR angiographic maximum intensity projections, the percentage of ICA stenosis was assessed on sagittal projection, which coincided with the lateral of the DSA projections used. Stenoses demonstrated at each imaging procedure were graded according to the five-point North American Symptomatic Carotid Endarterectomy Trial classification scheme: 0%-29%, 30%-49%, 50%-69%, 70%-99%, and 100% stenosis. The interobserver variabilities of two imaging tests were calculated by using k statistics with the categorized stenosis.

**Results**

All segments throughout in 44 ICAs compared at 56 point of stenosis in TRICKS MR angiography and DSA. The k statistics that reflected the interobserver variability between observers 1 and 2 were very good and similar for two tests: 0.73 for TRICKS MR angiography, and 0.83 for DSA. For observers 1 and 2, sensitivity, specificity, PPV, NPV, and diagnostic accuracy of TRICKS MR angiography are given in the table.

<table>
<thead>
<tr>
<th>Classification</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>PPV</th>
<th>NPV</th>
<th>Diagnostic Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%-29%</td>
<td>82.7%</td>
<td>88.8%</td>
<td>88.4%</td>
<td>82.7%</td>
<td>85.7%</td>
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<tr>
<td>30%-49%</td>
<td>36.3%</td>
<td>92.1%</td>
<td>92.3%</td>
<td>88.8%</td>
<td>91.6%</td>
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<tr>
<td>50%-69%</td>
<td>55.5%</td>
<td>92.1%</td>
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<td>70%-99%</td>
<td>100%</td>
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**Conclusion**

TRICKS MR angiography which has high rates of diagnostic accuracy on determining ICA stenoses could be considered as an alternative for invasive DSA which has higher risk of complications.

**Keywords:** Time-resolved contrast-enhanced MR angiography, internal carotid artery stenosis, digital subtraction angiography
With reflux | Without reflux | P value
---|---|---
Number of patients | 8 | 118 | 0.069
Age [Mean+(SD)] years | 51.57 (+9.239) | 47.18 (+17.625) | 0.069
Sex | Females=2 | Females=30 Males=88 | 0.997
| Males=6 | | |
Hypertension | 6 | 28 | 0.007*
Cardiac disease | 2 | 13 | 0.323
Side of injection | Left = 8 | Left = 57 | 0.005*
| Right=0 | Right=61 | 0.005*
Retrosternal distance (left-arm injection)[mean+(SD)] | 7.2 mm (+3.1) | 12.1 mm (+3.2) | <0.001* 
*These indicate statistically significant values.

For variables marked with *, t test was used. For other variables, Chi square test was used.

MRA of two patients with left-sided injections. A. adequate retrosternal distance. B. No venous reflux in this patient. C. Another patient with decreased retrosternal distance. D. Contrast reflux and opacification of venous system

**Conclusion**

Compression of the left brachiocephalic vein between the sternum and tortuous aorta and proximal vessels may lead to venous reflux that can degrade the quality of contrast-enhanced MR angiograms. This can be avoided by the routine use of right-arm veins for contrast injection.

**Key Words:** MR angiography, reflux, retrosternal distance

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**Quantitative and Qualitative Assessment of Combined Cervical and Intracranial CT Angiography with Reduced Intravenous Contrast Dose**

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**Purpose**

Computed tomographic angiography (CTA) techniques utilizing low dose intravenous (IV) contrast reflect the increased understanding of contrast delivery methods along with new imaging technology such as multidetector CT (MDCT) scanners and dual-head power injectors. The goal of this study was to compare the image quality of combined cervical and intracranial CTA using low-contrast versus high-contrast dose protocols.

**Materials & Methods**

We retrospectively assessed quantitative and qualitative measures of image quality in two groups of 21 consecutive patients who received combined cervical and intracranial CTA on 64+ MDCT scanners with IV iohexol (350mg I/mL). The first group received 125 mL of IV contrast while the second group received 65 mL. Additionally, scanning trigger was lowered from 100 Hounsfield units (HU) to 70 HU in the aortic arch maximizing capture of the arterial bolus in the low-contrast dose protocol. Quantitatively, the opacification (HU) of cervical and intracranial carotid artery segments, middle cerebral artery M1 segments, internal jugular veins, and confluence of sinuses were measured using region of interest measurements for both groups. The calculated difference between arterial and venous opacification at corresponding levels provided a quantitative measure of venous contamination. Statistical analysis was performed on each subgroup using the Welch t-test. Two qualitative measures of image quality - visualization of distal arterial branches and venous contamination - were assessed for each study by three blinded neuroradiologists.

**Results**

Statistical analysis of the quantitative measures demonstrated no significant difference between low- and high-contrast dose CTA in opacification of the right common carotid artery (p=0.03), cervical right internal carotid artery (p=0.02), and cavernous right internal carotid artery (p=0.01). While not statistically significant, a trend toward equivalence between the two protocols in opacification of the left common carotid (p=0.18), cervical left internal carotid artery (p=0.12), and cavernous left internal carotid artery (p=0.16) was identified. The equivalence or difference of M1 segment opacification could not be conclusively assessed. Similarly, no statement could be made about equivalence or difference in calculated cervical or intracranial venous contamination values. There was a statistically nonsignificant trend toward lower opacification of the right (p=0.16) and left internal jugular veins (p=0.25) using the low-dose, early trigger protocol, correlating with our qualitative assessment, and suggesting a decrease in venous contamination. This was characterized by
a 13% drop in mean opacification of the left internal jugular vein on the low-dose protocol versus a <1% drop in the mean opacification of the left internal carotid artery.

CONCLUSION
A low-dose protocol combined cervical and intracranial CTA utilizing 65 mL of IV contrast shows no significant difference in qualitative measures of image quality when compared to a higher IV contrast dose of 125 mL, and may exhibit less venous contamination. These subjective observations are partially validated with statistically significant quantitative findings and trends toward equivalence. Lowering the IV contrast dose not only reduces risk of contrast-induced nephrotoxicity, especially in the setting of follow-up image-guided endovascular therapy, but also has other advantages such as lower cost.

KEY WORDS: CT angiography, intravenous contrast, image quality

Paper 148 Starting at 4:42 PM, Ending at 4:50 PM

50 cc Contrast Protocol for CT Angiography of Head and Neck

Smith, S. D. • Ravi, V. • Belden, C. J.
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PURPOSE
To investigate whether the contrast bolus for computed tomographic angiography (CTA) of the carotids and circle of Willis could be reduced from 80 cc to 50 cc without degradation in vessel opacification or diagnostic quality. A reduction in contrast volume is desirable, particularly in patients with pre-existing renal insufficiency or in patients who may require additional iodinated contrast for other studies.

MATERIALS & METHODS
This study was approved by our institutional review board. Two groups of 30 consecutive adult patients undergoing CTA of the carotids and circle of Willis were selected prior to (A) and following (B) a change in departmental protocol. The groups were similar in age (mean ages 63.0; 61.7 years) as well as sex (70%; 67% male.) All examinations were performed on the same 64-slice MDCT, and imaging parameters other than those described below were unchanged. Both protocols began with a timing bolus of 15 cc contrast (iohexol 350 mg/ml) followed by 20 cc saline flush, injection rate of 4-5 cc/sec. A region of interest was drawn over the carotid at the C3/4 level and time to peak opacification calculated. Group A protocol: 80 cc contrast bolus, 40 cc saline flush. Image acquisition was begun at calculated peak opacification, images were acquired in craniocaudal direction. Group B (changes in bold): 50 cc contrast bolus, 40 cc saline flush. Image acquisition was begun at calculated peak opacification plus 3 seconds, images were acquired in caudocranial direction. Objective evaluation was performed by retrospective review. Density of vascular opacification was recorded at three separate sites: 1) the aortic arch, 2) the most densely opacified vessel in the circle of Willis, and 3) the most opacified intracranial dural venous sinus. Subjective evaluation was performed retrospectively by two observers, each determining whether the images were of sufficient diagnostic quality.

RESULTS
At the aortic arch, Group A had an average vascular attenuation of 367.4 Hounsfield units (HU.) Group B had less contrast opacification, averaging 315.9 HU (p = 0.014). Within the circle of Willis, Group A averaged vascular attenuation of 327.7 HU. Group B had greater contrast opacification, averaging 349.7 HU, though this was not significantly different (p = 0.266). Average dural venous sinus attenuation in Group A was 172.9 HU. These veins were significantly more opacified in Group B, averaging 228.3 HU (p = 0.003). Subjective evaluation revealed no differences between groups in the diagnostic quality of the studies.

CONCLUSION
The contrast bolus for 64-slice CTA of the carotids and circle of Willis can be reduced from 80 cc to 50 cc without a meaningful objective or subjective decrease in the diagnostic quality of the study.

KEY WORDS: Contrast, CT angiography, carotid

Paper 149 Starting at 4:50 PM, Ending at 4:58 PM

Evaluation of the Course and Surgical Landmarks of Vertebral Artery at Craniovertebral Junction in Cases with Occipitalized Atlas: A Prospective Study of 36 Cases

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1University of Michigan, Ann Arbor, MI, 2KEM Hospital, Mumbai, INDIA

PURPOSE
1. To study the course of vertebral artery (VA) at the craniovertebral junction in patients with occipitalized atlas (OA).
2. To study the parameter for safe surgical dissection at the craniovertebral junction in these patients, to avoid the potentially detrimental risk of VA injury.

MATERIALS & METHODS
Preoperative CT angiography (CTA) with 3D volume reconstructions, were performed in 36 patients with diagnosed OA on a 4-slice scanner with 1 mm slices. There were 22 males and 14 females with age range 13-45 years. Course of V2 and V3 segments of VA was studied. Maximum distance of the lateral most end of the V3-VA where it arches over the posterior arch or maximum distance of the extracranial end in cases of fused posterior arch of atlas, was calculated from the midline to determine the parameter for safe surgical dissection. Surgical follow up was performed to determine validity of imaging findings.

RESULTS
Twenty-four of 36 patients with OA, had partial OA with fusion involving posterior arch of atlas. Two of these 24 cases, had unilateral C2 segmental type of vertebral artery. Thus V3-VA of two (approximately 3%) cases (one artery in each) courses below the posterior arch of atlas before intracranial entry, while the contralateral VA courses through
the intraosseous canal in the fused portion of occiput and atlas. Bilateral VAs (n=46) in remaining patients coursed through the intraosseous canal in the fused portion of OA or coursed above the unfused posterior arch in cases of partial OA. Average maximum distance from midline, of the extracranial end (with fused posterior arch) or lateral most end (along unfused posterior arch), of V3-VA, was found as 23.5 mm with wide variation in individual cases.

**CONCLUSION**

Majority (approximately 97%) of VAs course through the intraosseous canal in the fused portion or above the unfused posterior arch, in cases of OA. Some patients can have C2 segmental type of vertebral artery. CT angiography is very useful preoperatively to assess the relations and course of V3-VA with important surgical implications at craniovertebral junction. Using CTA, distance from midline can be calculated, for the lateral most end or extracranial end of V3-VA along the unfused or fused posterior arch of atlas, which averaged 23.5 mm in our study. Surgeons can dissect safely along the posterior arch of atlas, up to this distance from the midline, without damaging VA in such cases.

**KEY WORDS:** Vertebral artery, occipitalized atlas

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**Monday Afternoon**

**3:30 PM - 5:00 PM**

**Room 611 - 612**

(11d) Spine: Advanced Imaging Techniques

(Scientific Papers 150 - 160)

*See also Parallel Sessions*

(11a) Interventional: New Devices

(11b) Demyelinating/White Matter Disease

(11c) Vascular, Extracranial, and Intercranial

(11e) Translational Research in Neuroradiology IV, Functional and Diffusion Imaging

**Moderators:** Andrea Rossi, MD  
Fletch M. Munter, MD

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**Paper 150 Starting at 3:30 PM, Ending at 3:38 PM**

**Neurography Demonstrates that Oxaliplatin Chemotoxicity Impairs Retrograde Axonal Transport**

Schellengerhout, D. • Bredow, S. • LeRoux, L. G.

M. D. Anderson Cancer Center  
Houston, TX

**PURPOSE**

The purpose of our study was to utilize a new imaging technology, neurography, based on the retrograde transport of a molecular imaging agent, to determine if oxaliplatin neurotoxicity affects retrograde axonal transport.

**MATERIALS & METHODS**

Female adult BALB/c mice (n = 8) were treated with oxaliplatin to a cumulative dose of 30 mg/kg by giving 10 divided intraperitoneal doses using a 5 days of treatment, 5-day rest, 5-day administration paradigm. Animals were imaged at baseline and weekly for 149 days after commencement of therapy. Control animals (n = 8 from 8 to 28 days, n = 4 from 35 to 65 days) were mock treated with saline and were imaged similarly out to 65 days. All animals received fluorescently labeled Tetanus Toxin C-fragment (TTc)-Alexa790 (15 ug in 20 uL) via intramuscular injection into the calf muscles at every imaging session. Fluorescent imaging (Xenogen IVIS 200) was used to image the distribution of TTc over 60 minutes, with region of interest (ROI) measurements taken from the thoracic spine to quantitate fluorescent uptake. Region of interest measurements had background activity subtracted, and were normalized to the signal intensity at time = 0.

**RESULTS**

With sham treatment, TTc transport through the sciatic nerve and spinal cord causes the fluorescent signal intensity over the thoracic ROI to gradually increase (Figure, legend indicates number of days after start of study). At 60 minutes the grouped mean normalized fluorescence was 562% (+/-210% SD). With oxaliplatin treatment, transport is abruptly and severely impaired with baseline values of 836%+/-375% falling to 396%+-140%, 247%+-63%, 213%+-58%, 162%+-46%, 147%+-63% with each successive week and stabilizing around 175% (+/-45%) for grouped means from 6 weeks out to the end of the study. The difference between normalized fluorescence grouped mean values from 6 weeks after oxaliplatin treatment to the end of study, and control animals is highly statistically significant (T-test p<0.0001).

**CONCLUSION**

Oxaliplatin causes a rapid and apparently irreversible (to our current follow up of 149 days) decrease of retrograde axonal transport in the sciatic nerves and spinal cord, as demonstrated with a neurographic molecular imaging agent.

**KEY WORDS:** Neurography, neuropathy, nerve imaging
Imaging Retrograde Neural Transport with a Molecular Probe: Neurography

Schellingerhout, D. • LeRoux, L. G. • Bredow, S.
M. D. Anderson Cancer Center
Houston, TX

PURPOSE
To develop an agent for imaging retrograde axonal transport in nerve tissues based on the optical labeling of a fragment of tetanus toxin protein.

MATERIALS & METHODS
A His-tagged recombinant tetanus toxin fragment (TTF) was produced in E.coli, purified, and labeled with a variety of Alexa fluorophors for optical imaging studies. Gel electrophoresis (SDS-PAGE) and quantitative immunodetection studies were performed. Cell uptake studies were performed to assess in vitro efficacy. Labeled TTF was injected into the soleus muscle of C57bl and Balb/C mice, and Wistar rats, and imaging performed with the IVIS 200 (Xenogen). In situ validation was performed with laser scanning confocal microscope FV 1000 (Olympus) utilizing intact glycerol mounted samples, and cryo-sections.

RESULTS
Gel electrophoresis and quantitative immunodetection indicated that the integrity and immune reactivity of the protein was preserved after labeling. Cell uptake assays indicated robust uptake in differentiated PC12 cells. In vivo optical imaging demonstrated the uptake of TTF-Alexa in the sciatic nerve and spinal cord. Progressive uptake and transport of the agent could be seen along the course of the sciatic nerve and spinal cord. Confocal microscopy studies on intact excised nerve segments and cryosections confirmed the compound uptake in nerve fascicles of the sciatic nerve. Axonal nerve uptake and superficial lymphatic uptake were clearly distinguishable, and transport was shown to be nervespecific. Immunohistochemistry on cord sections demonstrated the presence of the agent in spinal cord neurons.

CONCLUSION
Fluorescently labeled TTF is taken up into motor nerve endings after intramuscular injection, and is retrogradely transported in nerve axons. This process can be demonstrated with noninvasive in vivo imaging, and allows nerve anatomy and function to be studied.

KEY WORDS: Neurography, nerve imaging, molecular imaging
CONCLUSION
Preliminary data show diffusion-based detection of nerve injury may be possible. Diffusion-weighted-WB-SSFP detects SI changes, not seen on conventional MRI, in NRG corresponding to level of patient's symptoms. In patients with back pain, DW-WB-SSFP can be performed to detect pathology not otherwise seen on conventional MRI. We expect to have > 15 patients at presentation (ASNR 2011).

KEY WORDS: Spine, wide band ssfp, lumbar spine MR imaging

Paper 153 Starting at 3:54 PM, Ending at 4:02 PM
Improvements in Thoracolumbar MR Imaging with Multitransmit or Parallel Transmission MR on a Clinical 3.0 T MR System
Filippi, C. G.¹ · Oppenheimer, D.¹ · Johnson, J. M.¹ · Burbank, H. N.¹ · Alsofrom, G. F.¹ · Andrews, T.³
¹University of Vermont College of Medicine, Burlington, VT; ³Philips Health Care, Cleveland, OH

PURPOSE
Parallel transmission magnetic resonance imaging (MRI) at 3.0 T improves image quality by reducing dielectric effects with B1 shimming. The purpose of this study was to determine if parallel transmission MR improved signal to noise (SNR) and contrast to noise (CNR) in thoracolumbar spine MR imaging at 3.0 T.

MATERIALS & METHODS
Ten healthy volunteers (9 men, 1 woman, age range of 25-47 years, average age 30.7 years) had lumbar sagittal T1 and T2 MR scans and nine healthy volunteers (6 men, 3 women, age range 16-46 years, average age 30.2 years) had axial T1 and T2 MR scans. Ten healthy volunteers (6 men, 4 women, age range 21-58 years, average age 31.7 years) had thoracic sagittal T1 and T2 images and 10 healthy volunteers (6 men, 4 women, age range 21-58 years, average age 31.4 years) had thoracic axial T1 and T2 imaging. All images were acquired in one session using parallel transmission MR and conventional MRI. Background noise scans were obtained in order to calculate changes in signal to noise ratio (SNR) and contrast to noise ratio (CNR), and statistical significance was determined with 2-tailed student T-test with \( P < .05 \) for significance.

RESULTS
Contrast to noise ratio and SNR showed statistically significant improvement at all levels in the lumbar spine. Signal to noise ratio showed statistically significant improvement at all levels of thoracic spine from T1 to T12 in sagittal and axial imaging. Contrast to noise ratio was improved significantly in sagittal plane but not the axial plane. For lumbar sagittal T1, improvement in CNR with multitransmit MRI was 53% and SNR was 19%. For lumbar axial T1, improvement in CNR was 48% and SNR was 23%. For lumbar sagittal T2, CNR improvement was 38% and SNR was 20%. For lumbar axial T2 scans, CNR percent improvement was 18% and SNR was >100% with parallel transmission MR. For thoracic sagittal T1, improvement in CNR with multitransmit was > 100% and SNR was 18%. For thoracic sagittal T2, improvement in CNR was >100% and SNR was 20%. For thoracic axial T1, no improvement in CNR was seen, and SNR was improved significantly at 42%. For thoracic axial T2, CNR was not improved significantly and SNR was improved significantly to 21%. Scan time duration was decreased by half on axial T1 and T2 images.

CONCLUSION
Parallel transmission MR improves image quality in thoracolumbar spine MR imaging at 3.0 T, which is supported quantitatively by statistically significant improvements in SNR and CNR on sagittal T1 and T2 and axial T1 and T2 in thoracolumbar spine with the only exception being failure to reach quantitatively significant improvements in CNR on axial imaging in the distal thoracic region. There were 50% reductions in scan time on axial T1 and T2 images.

KEY WORDS: Parallel transmission MR, thoracolumbar spine, improved SNR and CNR

Paper 154 Starting at 4:02 PM, Ending at 4:10 PM
Dual Energy Spectral CT of the Instrumented Spine: Tuned Monochromatic Imaging Improves Quality over Traditional Techniques
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PURPOSE
Analysis of the spectral Hounsfield signal behavior of dual energy spectral CT (DECT) scans obtained in the presence of spine instrumentation provides the opportunity for selection of the appropriate energy level to minimize artifact and optimize image quality. In this study, we sought to determine the energy level that would maximize signal-to-noise ratios in the spinal canal of instrumented spines and to compare these tuned monochromatic (MC) images to those produced from routine MC (70 keV ≈ 140 kVp polychromatic) images.

MATERIALS & METHODS
Twenty-five patients who previously had undergone spinal intervention were imaged on a GE CT750HD using DESCT. The data were processed and spectral Hounsfield unit curves were generated based on a region of interest placed in the spinal canal at the level of the spinal hardware. Optimal keV
levels for signal-to-noise ratios (SNRs) were identified in each case and sets of multiplanar tuned MC images were generated at those same levels. These tuned images were compared with standard 70 keV MC images and evaluated for artifact around the hardware, artifact obscuring the spinal canal, and overall diagnostic quality.

**RESULTS**

Evaluation of spectral Hounsfield unit curves demonstrates that optimal SNRs were obtained at a 110 keV energy level. Comparison of tuned MC images to the standard MC 70 keV images demonstrates significant reduction in noise and artifact in the spinal canal. Furthermore, the optimal images for evaluation of the spinal canal were adequate for the assessment of other aspects of the study (e.g., degenerative disease).

**CONCLUSION**

The optimal energy level for imaging the instrumented spine is 110 keV. Monochromatic images tuned to 110 keV produced images with less artifact in the spinal canal and better hardware visualization, with superior overall quality.

**KEY WORDS:** Spine, instrumentation, artifact

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**Paper 155 Starting at 4:10 PM, Ending at 4:18 PM**

**Does MR Myelography with Intrathecal Gadolinium Play a Role in Localization of Spinal Cerebrospinal Fluid Leaks in Patients with Spontaneous Intracranial Hypotension?**

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**PURPOSE**

Standard techniques to evaluate for spinal cerebrospinal fluid (CSF) leaks in the debilitating entity of spontaneous intracranial hypotension (SIH) include conventional and CT myelography as well as radionuclide cisternography. Localization of the CSF leak is critical in directing focal therapy. The use of MR myelography with intrathecal gadolinium has been reported to be a useful adjunct in diagnosis. Our aim was to determine whether MR myelography with intrathecal gadolinium was helpful in localizing spinal CSF leaks in a large case series.

**MATERIALS & METHODS**

A search of the radiology information system retrieved a total of 151 symptomatic patients with clinical suspicion of SIH who were referred for conventional CT myelography to evaluate spinal CSF leak between February 2002 and August 2010. Of these, 49 patients also underwent a total of 53 spine MRIs performed with intrathecal gadolinium. There were 17 male (35%) and 32 female (65%) patients with an average age of 50 years (range 22-80 years). A retrospective review of the imaging and electronic medical record was performed on these 49 patients. Imaging studies reviewed included brain MRI, spine MRI, radionuclide cisternogram, CT myelogram, and gadolinium MR myelogram.

**RESULTS**

Cerebrospinal fluid leaks were not identified on conventional CT myelography in 32 of the 49 patients (groups 1-3). MR myelography confirmed and localized the CSF leak in seven (22%) of these 32 patients including two of three patients with evidence of extradural fluid on MR spine imaging without intrathecal contrast. Sixteen of the 17 patients found to have CSF leak on conventional CT myelography underwent interval focal therapy, and subsequent evaluation with MR myelography often was done to avoid radiation dose associated with repeat CT myelogram. No gadolinium-related complications were observed in any of these patients with an average of 496 days of follow up (range 1-2894 days).


**Conclusion**

Intrathecal gadolinium MR myelography is a useful technique in a highly select patient population who have debilitating symptoms of SIH, a high clinical index of suspicion of spinal CSF leak, and no demonstrated leak on conventional CT myelography. Standard MR of the entire spine and brain also is helpful in the premyelographic evaluation of patients with symptoms of intracranial hypotension. Intrathecal injection of gadolinium contrast remains an off-label use and should be reserved for those patients who fail conventional CT myelography.

**Key Words:** MR myelogram, intrathecal gadolinium, intracranial hypotension

**Paper 156 Starting at 4:18 PM, Ending at 4:26 PM**

**Spinal Dural Arteriovenous Fistulas and Intrathecal Venous Drainage: Correlation of MR Imaging, Catheter Angiography, and Clinical Findings**

Moftakhar, P. • English, J. D. • Dowd, C. F. • Higashida, R. T. • Lawton, M. T. • Douglas, V. • Halbach, V. V. • Hetts, S. W.

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**Purpose**

Spinal dural arteriovenous fistulas (SDAVF), the most common spinal vascular malformation, causes myelopathy via arterialization of the perimedullary venous plexus and subsequent venous congestion of the spinal cord. Prior studies have suggested that the extent of spinal venous drainage from intracranial arteriovenous fistulas correlate with the degree of myelopathy. We hypothesize that the length of the intrathecal vein draining an SDAVF, between the point of fistulization and the point of eventual drainage out of the thecal sac to the epidural venous plexus, correlates with the degree of myelopathy.

**Materials & Methods**

Retrospective review of our tertiary care hospital’s neurointerventional radiology database and medical records was performed under an IRB-approved protocol. Thirty-one patients (25 males, average age 62 years), diagnosed with SDAVF were included for investigation. Radiographic review included identifying the number of levels of spinal cord enhancement and intrathecal vessel enhancement on T1 postcontrast MR imaging (MRI) and number of levels of cord hypertensity and intrathecal flow voids on T2 MRI. The length of the draining vein and outflow points from intrathecal veins to the epidural venous plexus were identified on catheter angiograms. Patient functional status (gait and micturition) was assessed by the Aminoff-Logue disability scale (ALS).

**Results**

Patients whose draining veins were longer than 10 spinal levels on catheter angiography had a greater ALS score (total ALS score 4.9, mean gait score 3.4, mean micturition score 1.5) compared to patient’s with draining veins less than 10 levels (total ALS score 2.5, mean gait score 1.8, mean micturition score 0.6; p-values = 0.006, 0.009, and 0.02, respectively). The length of the draining vein correlated with the ALS score (Pearson correlation for total ALS r = 0.53, p = 0.001, for micturition r = 0.55, p = 0.0006, for gait r = 0.42, p = 0.009). Longer draining veins tended to be associated with more T2 cord changes, T2 flow voids, T1 cord enhancement, and T1 vessel enhancement.

**Conclusion**

The length of the intrathecal draining vein arising from SDAVF correlates with patient functional status. Spinal cord edema and contrast enhancement on MRI correlate with the length of the draining vein. It appears likely that patients with longer intrathecal draining veins develop greater venous congestion and, thus, congestive myelopathy. Patients with shorter intrathecal draining veins with and relatively earlier epidural decompression points to the epidural space, develop less venous congestion and experience milder functional disabilities.

**Key Words:** Spinal, dural, fistula

**Paper 157 Starting at 4:26 PM, Ending at 4:34 PM**

**Ultrafast Dynamic CT Myelography for the Precise Identification of High-Flow Cerebrospinal Fluid Leaks Caused by Spiculated Osteophytes of the Spine**

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**Purpose**

Precise anatomical localization and understanding of the etiology of high flow spinal cerebrospinal fluid (CSF) leaks is required prior to treatment with surgery or percutaneous methods such as a blood patch. This study demonstrates the utility of ultrafast dynamic CT myelography for the precise identification and localization of high-flow CSF leaks caused by spiculated osteophytes originating from the spine.

**Materials & Methods**

This retrospective study reports a series of 17 patients with high flow CSF leaks caused by spiculated spinal osteophytes that underwent ultrafast dynamic CT myelography between March 2009 and December 2010. All patients had a prior
conventional CT myelogram demonstrating high flow leak of indeterminate origin or a large multilevel ventral spinal epidural fluid collection on MR of the spine. There were 10 male and seven female patients with average age of 55 (range 37-74). Lumbar puncture was completed with placement of a spinal needle. The patient then was transferred in a prone Trendelenburg position to the gantry of a 64 or 128-slice CT scanner. The patient’s hips were elevated on a large wedge-shaped foam pad higher than the chest. The shoulders were placed flat on the table, with the head extended slightly. Arms were placed above the head to minimize attenuation of the x-ray beam. Lateral scout was utilized to visualize the entire spine in order to ensure the free downward/cephalad flow of myelographic contrast within the subarachnoid space. Noncontrast CT of the spine was obtained. Ultrafast dynamic CT myelography then was performed with simultaneous slow injection of myelographic contrast into the thecal sac. Up to five serial alternating caudal cranial and cranial caudal CT acquisitions of the cervical, thoracic, and upper lumbar spine were obtained during the contrast injection. Reconstructed images were reviewed at a workstation, in conjunction with the standard 2D images. The value of ultrafast dynamic CT myelography in depicting the CSF leak site and the relationship to adjacent anatomical structures was assessed qualitatively.

RESULTS
In these 17 patients ultrafast dynamic CT myelography was technically successful at precisely demonstrating the site of the CSF leak, the causative spiculated osteophyte piercing the dura, and the relationship of the implicated osteophyte to adjacent structures. Leak sites included 3 cervical, 14 thoracic, and 0 lumbar levels with 15 of the 17 leaks (88%) occurring from the C5 through T7 interspace levels. Information obtained from the ultrafast dynamic CT myelogram was considered useful in all surgically (six patients) and percutaneously (17 patients) treated CSF leaks.

CONCLUSION
Spinal osteophytes penetrating the dura are a more frequent cause of high-flow CSF leaks than previously recognized. Ultrafast dynamic CT myelography adds value beyond standard dynamic myelography or digital subtraction myelography in the diagnosis and anatomical characterization of high-flow spinal CSF leaks caused by osteophytes. This information allows for appropriate planning for percutaneous or surgical treatment. Ultrafast CT myelography provides the spatial and temporal resolution necessary to diagnose and localize spiculated osteophytes as the cause of high-flow CSF leaks.

KEY WORDS: Myelography, leak, osteophyte

Paper 158 Starting at 4:34 PM, Ending at 4:42 PM
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PURPOSE
Syringomyelia is thought to result from alteration in the normal cerebrospinal fluid (CSF) flow. Given the pulsatile nature of the CSF flow, syrinx cavities may be expected to undergo dynamic changes during the cardiac cycle. In this preliminary investigation, we report the ability of cardiac-gated cine-TrueFISP MR imaging to demonstrate such changes.

MATERIALS & METHODS
We performed cardiac-gated cine TrueFISP MR imaging in the sagittal plane through the syrinx cavities in nine patients (3 males, 6 females; age range 3 months - 18 years). Cord cavitation was related to Chiari 1 malformation in seven patients, Chiari 2 malformation in one, and marked hydrocephalus in one. Five patients were imaged prior to any syringomyelia-related surgical intervention. Three patients were evaluated following occipital decompression for Chiari 1 malformation. One patient with Chiari 1 malformation was imaged both before and after occipital decompression. The senior neuroradiologist initially viewed each study in a cine loop, and noted if any pulsatile increase and decrease in the anteroposterior dimension of the syrinx cavity was visible. Superior, middle, and inferior segments of the cavity were assessed individually. The cavities perceived to show a prominent change in their dimension during the cardiac cycle were termed “pulsatile”, while others were considered “nonpulsatile”. In cavities containing horizontal septations, note was made of their craniocaudal motion. Finally, change in the anteroposterior diameter of superior, middle, and inferior segments of the cavity during the cardiac cycle was calculated by measuring the minimum and the maximum diameters for each segment.

RESULTS
The walls of cord cavitations were clearly identifiable in 9/10 studies with the anterior and posterior walls sharply defined from the adjacent CSF. In one patient, the dynamic changes of the cavity could not be defined due to motion artifacts degrading the study. In five cavities noted to be pulsatile, the change in the size of the cavity mainly was evident in its superior aspect. In these cases, the AP diameter of the superior aspect of the cavities changed by a mean value of 1.2 mm (range 0.9-1.5 mm). Corresponding change of only 0.2 mm was noted for both the middle and inferior aspects of the pulsatile syringes. Four non pulsatile syrinx cavities demonstrated a mean change in the AP diameter of 0.1 mm, 0.2 mm, and 0.2 mm for their superior, middle, and inferior aspects. Horizontal septations were seen in six syrinx cavities, with prominent pulsatile craniocaudal motion of these septations seen in two, both with pulsatile syringes. All pul-
satile cavities were seen either in patients needing surgical intervention, or in patients in whom the syrinx cavity had not decreased by the time of the postsurgical imaging.

CONCLUSION
Cardiac-gated cine-TrueFISP images can demonstrate dynamic changes in the morphology of cord cavitations occurring during the cardiac cycle. The extent of such pulsatility varies in different patients, and appears most prominent in the superior aspect of the cavities. Further studies are needed to assess the clinical significance of these differences.

KEY WORDS: Syringomyelia, cerebrospinal fluid, spinal cord

Paper 159 Starting at 4:42 PM, Ending at 4:50 PM

When Should I Do a Dynamic CT Myelography? Predicting Fast Spinal Cerebrospinal Fluid Leaks in Patients with Spontaneous Intracranial Hypotension

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PURPOSE
Some patients with spontaneous intracranial hypotension (SIH) have fast cerebrospinal fluid (CSF) leaks requiring dynamic CT myelography (CTM). However, because dynamic CTM is associated with a higher radiation dose and is performed without the benefit of a tilting table, we have advocated conventional CTM prior to considering a dynamic study. Our aim was to determine how frequently repeat dynamic CTM is required to localize fast CSF leaks and to determine whether findings on head MR imaging (MRI), spine MRI or opening pressure measurements can predict fast spinal CSF leaks in a large case series.

MATERIALS & METHODS
A search of the radiology information system identified 151 patients with clinical suspicion of spontaneous intracranial hypotension who were referred for CT myelography to evaluate for spinal CSF leak between February 2002 and August 2010. A retrospective review of the imaging and electronic medical record was performed on these 151 patients. Head MRI were scored on a 3-point scale of “classic” brain MR with diffuse dural enhancement and “brain sag,” partial findings of either diffuse dural enhancement or evidence of “brain sag,” and normal. The spine MRI was scored on a binary scale for presence or absence of an extradural fluid collection. The opening pressure, when measured, was recorded. The CTM was scored on a 3-point scale of no leak, a slow leak that could be localized on conventional CTM or a fast leak that required dynamic CTM for localization. Six patients had only a dynamic CTM. In these cases, a single neuroradiologist (PHL) reviewed the studies. If there was rapid diffusion of contrast into the extradural space over greater than two spinal segments during the acquisition of the dynamic series, the leak was scored as fast.

RESULTS
Fast CSF leaks were identified in 32 (21%), slow leaks in 36 (24%) and no leak in 83 (55%) of 151 patients (Table 1). One hundred forty-five (96%) began with a conventional CTM while six (4%) went directly to dynamic CTM. Twenty-seven (18%) had both a conventional and a dynamic CTM. There was a significant correlation between spinal extradural fluid and the presence of a fast leak (sensitivity 85%, specificity 83%, p < .0001). There was not significant correlation between fast leak and MRI head (p = 0.25) or opening pressure (p = 0.30).

<table>
<thead>
<tr>
<th>Leak Rate</th>
<th>Spine MRI</th>
<th>Head MRI</th>
<th>Head and Spine Pressure in 151 in 151 Patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fast Leak</td>
<td>Fluid = 23/27 (85%)</td>
<td>Classic = 19/32 (59%)</td>
<td>Fluid + Classic = 12/26 (46%)</td>
</tr>
<tr>
<td>No fluid = Partial = 5/27 (15%)</td>
<td>Not Fluid + Normal = 8/32 (25%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slow Leak</td>
<td>Fluid = 11/20 (55%)</td>
<td>Classic = 12/26 (46%)</td>
<td>Fluid + Classic = 4/16 (25%)</td>
</tr>
<tr>
<td>No fluid = Partial = 5/26 Not Fluid + Normal = 9/26 (35%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No Leak</td>
<td>Fluid = 5/57 (9%)</td>
<td>Classic = 37/78 (47%)</td>
<td>Fluid + Classic = 4/56 (7%)</td>
</tr>
<tr>
<td>No fluid = Partial = 20/78 Not Fluid + Normal = 52/57 (93%)</td>
<td></td>
<td></td>
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<tr>
<td>Predicting fast leak vs</td>
<td>Fluid Classic Fluid + Classic *bivariate analysis on 98</td>
<td></td>
<td></td>
</tr>
<tr>
<td>slow or no leak (n=98)</td>
<td>Sens=85% Spec=58% Fluid + Classic Spec=46% with both head</td>
<td></td>
<td></td>
</tr>
<tr>
<td>p&lt;0.001</td>
<td>p=0.25</td>
<td>p&lt;0.001 and spine MRI</td>
<td></td>
</tr>
</tbody>
</table>

CONCLUSION
Fast leaks occurred in 21% of our patients with SIH and repeat dynamic CTM was performed in 18%. If all patients with spinal extradural CSF would have been sent directly to dynamic CTM, repeat exams would have been avoided in 23 (85%) of 27 patients with fast leaks. However, 16 (21%) of 77 patients with slow or no leaks would have been converted from conventional to dynamic CTM. Spinal MRI is helpful in premyelographic evaluation of SIH.

KEY WORDS: CSF leak, dynamic CT myelography
Direct Venous Spinal Reabsorption of Cerebrospinal Fluid: A New Concept with Serial MR Cisternography in Rabbits

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PURPOSE
According to the recently published studies cerebrospinal fluid (CSF) is permanently produced and absorbed in the whole CSF system. Clusters of arachnoidal villi recently have been shown histologically in the dorsal root of the spinal nerves and are speculated to have a role in reabsorption of CSF. Our aim was to observe direct venous connections between the subarachnoid space and the perispinal veins.

MATERIALS & METHODS
Eleven adult (6-month) New Zealand white male rabbits weighting approximately 3.0 kg each were used for this experiment. After administration of precontrast scans, subarachnoid access was performed percutaneously using a cisternal approach with a 20-gauge IV indwelling cannula. The intrathecal administration of contrast agent Gadopentetik Dimeglumin (Magnevist) was performed through the craniovertebral junction by the cisternal pathway in nine rabbits and by the lumbar pathway in two rabbits, at a flow rate of approximately 0.1 mL/sec by manual injection. MR scans were performed at 15, 60, 120 and 180 minutes after administration of the contrast agent. Axial, coronal and sagittal MR images were on a 1.5 T Achieva MR Unit (Philips Medical System, Netherlands) and with SENSE-8 channel neurovascular coil. MR protocols achieved with T1 FAT SET images.

RESULTS
Direct connections between subarachnoid space and perispinal veins were viewed in all nine rabbits during serial MR cisternography scans. Cervical, thoracical and lumbar veins were affected similarly at different contrast concentrations. No difference between the right and left sides could be seen. Contrast enhancement detected at 15th minute in six rabbits and persisted throughout the experiment. We could not detect an early enhancement at 15 minutes in three rabbits but the venous connection could be visualized in all three after 60 minutes. Low contrast concentrations (1/10 and 1/20 dilutions) were applied to those three rabbits. Interestingly, even with low contrast concentrations we could observe direct connections at 15 minutes after translumbar injection. Rabbit 3 and Rabbit 4 underwent a seizure immediately after contrast application and MR scans could not be performed during the seizure, obviating the 15-minute scan.

CONCLUSION
Despite several histologic and tracing experiments which show evidence for extracranial CSF absorption, a direct connection between the subarachnoid space and spinal veins has not been shown yet. Our study is the first radiologic confirmation of this hypothesis, showing direct spinal venous reabsorption. We believe this data can help solve and understand a longstanding debate about cerebrospinal reabsorption. New conceptual and experimental data will cause the present widely accepted beliefs to be reconsidered. Of course further studies must be done to understand the overall importance of this pathway and its relative importance under physiological and pathologic conditions.

Acknowledgement: The study was supported by Istanbul University Research Projects Department and TUBA.

KEY WORDS: Cerebrospinal fluid, spinal reabsorption, rabbit
Materials & Methods
Resting BOLD images (8 minutes) were obtained in 58 healthy adolescent and adult volunteers. Regions of interest (ROIs) were identified from an anatomical atlas and a finger movement task in each subject in the primary motor cortex and motor activation region of bilateral superior cerebellum. Correlation was measured in the time series of each thalamic voxel with the four seeds. An analogous procedure was performed on a single subject imaged for 10 hours to constrain time needed for single subject optimization of thalamic targets.

Results
Mean connectivity images from 58 subjects showed precisely localized targets within the expected location of the ventral intermediate nucleus of the thalamus, within a single voxel of currently used deep brain stimulation anatomical targets. These targets could be mapped with single voxel accuracy in a single subject with 3 hours of imaging time, although targets were reproduced in different locations for the individual than for the group averages.

Conclusion
Interindividual variability likely exists in optimal placement for thalamic deep brain stimulation targeting of the cerebellar thalamus for essential tremor. Individualized thalamic targets can be precisely estimated for image guidance with sufficient imaging time.

Key Words: Functional connectivity MR imaging, deep brain stimulation, ventral intermediate nucleus of the thalamus

Paper 162 Starting at 3:38 PM, Ending at 3:46 PM
Effect of the Choice of Human Brain Diffusion Tensor Template on Intersubject Spatial Normalization
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Purpose
The purpose of this study was to investigate the effect of the choice of diffusion tensor (DT) template (ICBM811 and IIT22) on the accuracy of intersubject spatial normalization.

Materials & Methods
Two groups of DT data were involved in this study. Group 1 contained minimal artifacts, and consisted of data from 22 healthy subjects, collected with Turboprop on a 3 T MRI scanner. Group 2 contained visible artifacts, and consisted of data from 22 healthy subjects included in the IXI brain database (http://www.brain-development.org), collected with SE-EPI-DTI (acceleration factor of 2) on a 3 T MRI scanner. Data from Group 1 were corrected for motion only, while data from Group 2 were corrected for motion and eddy current distortions. Three different techniques were used for registration to the ICBM81 and IIT2 templates: DTIGUI3, MedINRIA4, and DTITK5. Both groups of DT data were normalized to each template using all registration methods. For each set of normalized data, the mean FA, the coherence of coregistered primary eigenvector pairs1 (COH), the 95% cone of uncertainty1 (COU), and the overlap of eigenvalue-eigenvector pairs1 (OVL) were calculated for each voxel in the brain. Histograms of COH, COU and OVL in white matter (WM) were produced for each set of normalized data. For both groups of data, histograms were compared first among different registration techniques for registration to the same template, and then between templates using the best registration technique for each template. The Kolmogorov-Smirnov (KS) statistical test was used to compare histograms. Differences with p<0.05 were considered significant.

Results
For Group 1 data and registration to the IIT2 template, DTITK resulted in a significantly higher percentage of WM voxels with high COH, low COU, and high OVL values than other registration techniques. For Group 1 data and registration to the ICBM81 template, MedINRIA resulted in more accurate WM DT normalization. Using the preferred registration method for each template, registration of Group 1 data to the IIT2 template resulted in a significantly higher intersubject normalization accuracy in WM than registration to the ICBM81 template (p-values for KS tests were <10-6). For Group 2 data and registration to both templates, MedINRIA was shown to be consistently the preferred registration method. Using MedINRIA for registration of Group 2 data to both templates, registration to the IIT2 template again resulted in a significantly higher intersubject normalization accuracy in WM than registration to the ICBM81 template (p-values for KS tests were <10-6). Finally, using the most preferable registration method for each case, registration of Group 1 data to the IIT2 template was more accurate than registration of Group 2 data to both templates.

Conclusion
First, the registration techniques that result in more accurate DT spatial normalization when registering data with different levels of artifacts to the two templates were determined. It then was shown that, regardless of the artifact content of the DT data, the accuracy of intersubject spatial normalization increases when using the IIT2 template as a reference instead of the ICBM81 template.

Key Words: Brain template, diffusion tensor

Paper 163 Starting at 3:46 PM, Ending at 3:54 PM
Correction for Delay and Dispersion of Bolus Contrast in Quantitative Cerebral Perfusion MR Imaging Using SCALE-Perfusion Weighted Imaging
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1 Northwestern University, Chicago, IL, 2 The Cleveland Clinic, Cleveland, OH

Purpose
Quantitative cerebral perfusion with MR imaging (MRI) using the Bookend technique has been shown reproducible, reliable and accurate. We recently reported a self-calibrated epi perfusion-weighted imaging (SCALE-PWI) pulse sequence that produces online, quantitative cerebral perfusion maps at the scan console without the need for user input,
offline image post-processing or extra T1 “calibration” scans. This facilitated the real-time quantification of cerebral perfusion without the radiation exposure associated with CT perfusion scans. However, in dynamic susceptibility contrast (DSC) perfusion imaging, delay and dispersion of the contrast bolus is known to reduce the accuracy of perfusion values, especially in cases such as ischemic stroke. The goal of this work is to develop a simple means to correct for delay and dispersion effects on the quantitative perfusion maps obtained with SCALE-PWI.

**MATERIALS & METHODS**

We approach the delay and dispersion effect within the context of linear system theory. The new dispersion model is a delay-dependent exponential residue function. A voxel-specific dispersion term is added to the currently used deconvolution model. The magnitude of the dispersion is determined from the contrast arrival time and venous outflow profile. The model then is used to correct the concentration-time curves of all brain voxels with certain arterial tissue delays. The method is implemented in ischemic stroke patients with confirmed infarcts. We performed a retrospective study of results in ischemic stroke patients and compared to expected improvement based on computer simulations.

**RESULTS**

The simulations predict a perfusion measurement accuracy, measured as the ratio of the measured to the true quantitative cerebral blood flow (qCBF) values, of 0.85 ± 0.02, 0.91 ± 0.01 and 0.97 ± 0.01, for MTT = 6, 12 and 24 ms, respectively, obtained with the proposed correction over a range of ATD values (0 to 6 sec). This is compared to 0.45 ± 0.18, 0.54 ± 0.18, and 0.60 ± 0.17, for the same MTT cases, respectively, obtained without delay and dispersion correction. In a representative stroke patient (Figure 1), the proposed method corrects an underestimation of perfusion values in the infarcted brain region (in red): mean qCBF measured in that area is 14.6 ± 16.9 and 24.1 ± 31.7 ml/100 g/min, before and after applying the proposed correction, respectively, resulting in a ratio of 0.61.

**CONCLUSION**

The proposed delay and dispersion correction model shows the potential to quantify cerebral perfusion accurately in a clinical setting when combined with the SCALE-PWI pulse sequence.

**KEY WORDS:** Quantitative cerebral perfusion, delay and dispersion effects, MR imaging

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**Paper 164 Starting at 3:54 PM, Ending at 4:02 PM**

**Denoising in Clinical Functional MR Imaging Increases Localization Accuracy and Statistical Power**

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University Mainz

Mainz, GERMANY

**PURPOSE**

Denoising is the procedure to remove noise from imaging data. Clinical functional MR imaging (fMRI) serves to assist in decision making concerning the further therapeutic treatment of individual patients. Therefore, inherently noisy raw fMRI data need to use both robust experimental paradigms and the procedures that allow maximum accuracy in determining the location of functional activation. Diminished, but still existing activation in disease is the further problem in selecting the threshold for statistically significant activation. We present the technique for denoising the fMRI data based on mutual information contained in the neighborhood of each voxel.

**MATERIALS & METHODS**

We used fMRI data from patients planned for the surgical intervention to determine location of the functional activation concerning motor, speech and memory function (10,10 and 3 respectively). Data were acquired on 3 T MR scanner equipped with 32-channel array coil. High-resolution T1-weighted scan was used as anatomical reference in which low-resolution activation maps obtained from 3 mm isotropic resolution of T2*-weighted EPI images were warped. Processing included: realignment, denoising, estimation of statistical parameter maps with general linear model. Motor, speech and working memory paradigms were made in block design. Importantly, both positive and negative task-correlated activities were taken into account. Specifically, robust negative task correlated activity was present in the functional hippocampus in standard block design 2 back working memory task, and this served as an evidence of brain function for the decision making in case of functional impairment in the medial temporal lobe epilepsy. Raw (realigned) fMRI data contain physiologic and instrumental noise. Spin history makes significant autocorrelation effects in noise. On the other hand, activation is not contained in single voxel, but the task-correlated activity is present in larger areas. Therefore, for each voxel, neighborhood of substantial size was taken and denoising of the data was performed not blindly with isotropic smoothing gaussian kernel but denoising kernel weights were determined with respect to the degree of correlation in time series and robust statistic estimate of denoised signal intensity was used to get more reliable activation maps.

**RESULTS**

Using both classical statistical parametric maps with application of proposed denoising versus Gaussian smoothing, showed in all cases improvement in maximal t values in activated brain regions as well as sharper delineation of border between activated and “nonactivated” in the case of application of denoising step.

**CONCLUSION**

Massive univariate approach in analysis of fMRI data treats independently each voxel in the brain. By using significant mutual information in the time series of neighboring voxels,
substantial amount of the noise can be removed, therefore increasing statistical power of the tests. Arbitrary isotropic smoothing kernel size is avoided in favor of method shaped for more precise localization of brain activation. Furthermore, it can be treated as initial step in unsupervised methods for brain activation and motion artifacts detection/removal such as independent component analysis.

**Key Words:** Functional MR imaging, denoising, clinical

**Paper 165 Starting at 4:02 PM, Ending at 4:10 PM**

**Effect of Statistical Threshold and Spatial Masking on Assessment of Language Lateralization in Epilepsy Patients**

Escalante, B.1,2 • Millare, G.1,2 • Karmonik, C.1,3 • Dulyay, M.3 • Verma, A.1,3 • Grossman, R.1,3 • Fung, S.1,3

1, Methodist Hospital, Houston, TX, 2Baylor College of Medicine, Houston, TX, 3Weill Cornell Medical College, New York, NY

**Purpose**

Determination of language lateralization using functional MR imaging (fMRI) is important for drug-resistant epilepsy patients being considered for epilepsy surgery. However, it is known that the distribution, pattern, and extent of language activation can be dependent on the selected statistical threshold. We therefore investigated the effect of statistical threshold and various spatial masks on laterality index calculation in epilepsy patients undergoing language fMRI.

**Materials & Methods**

Language fMRI using language comprehension and verb generation tasks were obtained in nine patients with temporal lobe epilepsy (6 left-sided and 3 right-sided seizure focus by EEG and interictal FDG-PET localization). Of these, six patients also had Wada tests with language and memory-related tasks. Functional MRI data analysis was performed using AFNI with the brain coregistered to standard atlas. Whole-brain (WB), middle carotid artery (MCA) territory, and temporal lobe masks were applied for each patient, and laterality index \( [LI=(L-R)/(L+R)] \) was calculated using multiple correlation coefficient (r) thresholds ranging between 0 and 1.

**Results**

All but two of nine patients were right-handed. Of six patients who had Wada tests, all demonstrated left-hemisphere language dominance, including one of the left-handed patients. Laterality index calculated using MCA mask consistently generated larger LI than that calculated using WB mask, presumably by removing confounding voxels near midline, including visual cortex. Only two of nine patients demonstrated clear left lateralization with strongly positive LI > 0.2 that increased with r with all masks. One patient (right-handed, right-seizure focus, no Wada) had biphastic LI pattern with all masks (weakly positive with r<0.4 and strongly negative with r>0.6), suggesting possible right-lateralization. Remaining six patients had some atypical lateralization demonstrating weak to intermediate positive LI with WB and MCA masks, and biphaptic or mildly negative LI with temporal lobe mask.

**Conclusion**

Graphing LI as a function of r with application of various spatial masks provides more confident interpretation of language lateralization, potentially identifying patterns of atypical lateralization, and is more objective than calculating LI with fixed statistical threshold. Middle carotid artery mask emphasizes classical areas of language activation along frontal and temporoparietal regions. Temporal lobe mask may be helpful in determining plasticity, transfer or reorganization of language function in patients with temporal lobe epilepsy.

**Key Words:** Epilepsy, functional laterality, language

**Paper 166 Starting at 4:10 PM, Ending at 4:18 PM**

**Diffusion Tensor Imaging in Normal-Appearing White Matter in Malformations of Cortical Development**

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Faculdade de Medicina Sao Paulo, BRAZIL

**Purpose**

The purpose of this study was to evaluate the normal-appearing contralateral white matter in patients with epilepsy caused by malformations of cortical development (MCD) using diffusion tensor imaging (DTI).

**Materials & Methods**

Ten patients with unilateral MCD and ten sex- and age-matched healthy volunteers were selected. MR imaging was performed on a 3.0 T scanner (Achieva Intera, PHILIPS). Diffusion tensor images were acquired in the axial plane with 32 diffusion encoding directions with b-value of 0 and 1000 s/mm². A set of 70 slices of 2 mm thickness without gap, covering the whole brain including cerebellum, was obtained. Fractional anisotropy (FA) and apparent diffusion coefficient (ADC) maps were obtained by using DTI studio software. The region of interest (ROI) was selected in the contralateral normal-appearing white matter and compared with similar regions in control subjects. Differences between these two groups was analyzed by Student's unpaired t-test and a p value less than 0.05 was considered statistically significant.
RESULTS
Patients presented higher levels of ADC than the control subjects (7.713 vs. 7.072, p = 0.005). We have not found statistically significant differences of FA between the groups (0.409 vs. 0.395, p = 0.552). The results are summarized in Table 1.

Table 1. Comparisons of ADC and FA between normal appearing contralateral white matter in patients with MCD and control subjects

<table>
<thead>
<tr>
<th></th>
<th>Patients</th>
<th>Controls</th>
<th>p-value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADC</td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
</tr>
<tr>
<td></td>
<td>7.713</td>
<td>0.519</td>
<td>7.072</td>
</tr>
<tr>
<td>FA</td>
<td>0.409</td>
<td>0.057</td>
<td>0.395</td>
</tr>
</tbody>
</table>

Note: *p-value obtained with Student’s t test. SD = standard deviation, MCD = malformation of cortical development, ADC = apparent diffusion coefficient, FA = fractional anisotropy.

CONCLUSION
Our study indicates more widespread abnormalities in cerebral white matter pathways of patients with MCD, with increased diffusion in the contralateral normal-appearing cerebral hemisphere. Higher ADC values indicate an increase of extracellular space may reflect disrupted microstructural organization and connectivity. We have not found, however, differences in FA, that could be possibly related to the size of our sample or by displacement of white matter tracts by the MCD. High-resolution MR imaging is an extremely important tool in the evaluation of patients with epilepsy caused by MCD and DTI at high field strength has a potential role in detecting subtle abnormalities existing outside the visible lesion.

KEY WORDS: Diffusion tensor imaging, epilepsy, malformation of cortical development

MATERIALS & METHODS
Three subjects provided consent for scanning at 3 T in conformance with IRB regulations. Our goal was to compare SNR and distortion between an 8-channel and (2x16)-channel coil while manipulating the phase encoding (PE) direction and the use of parallel imaging. Additionally, we compared twice-refocused spin-echo (DE) with a single-refocused (SE) Stejskal-Tanner sequence. Two subjects were scanned with: EPI with twice-refocused diffusion preparation, TE=85ms, TR=3s, b=1000s/mm2, 4-10 b=0 images with the following permutations: 8-channel PE left-right with GRAPPA acceleration factor R = 2 (8-CH-LR-R2), 8-CH-SI-R1, 32-CH-LR-R2, 32-CH-SI-R1, and 32-CH-SI-R2. Scan time was identical for each permutation. In addition, one subject was scanned with a very high SNR protocol with 32-CH-SI-R2, once DE and once SE, TE=85ms, TR=3s, b=1000s/mm2, 128x128, 18cm FOV, 2mm thick, 22 slices, 70/10 directions/T2s, 4 repetitions, 32 minutes. Single-refocused acquisition eddy currents were corrected utilizing a modified version of the Haselgrove method. Persistent angular structure (PAS) maps were computed using Camino.

RESULTS
Signal-to-noise ratio for the above permutations was 11.2, 10.5, 10.1, 10.1, and 10.7, respectively. The SNR was slightly higher for 8CH LR R2, but this lacked left-right symmetry. The 32-channel coil with phase SI R2 demonstrated high SNR, minimal distortion due to parallel imaging, and left-right symmetry. Eddy currents were noticeable in the SE images before correction but reduced afterwards. Signal-to-noise ratio for SE and DE was 18.1 and 14.5, respectively. PAS plots are in Figure 1.

CONCLUSION
The 32-channel coil using GRAPPA-accelerated EPI achieved the best balance of high SNR, symmetry, and the least distortion for diffusion imaging. Dual-echo acquisitions removed eddy currents at a significant SNR cost, limiting the applicability to high-resolution targets such as the hippocampus. Instead, a significant incremental gain in SNR was observed with an eddy current corrected single-refocused acquisition. Our final resolution of 1.4 x 1.4 x 2mm may facilitate detailed analysis of hippocampal microcircuitry and pathology.

KEY WORDS: Diffusion, hippocampus, medial temporal
INTRINSIC LANGUAGE-RELATED NETWORK ASSESSED BY TRACTOGRAPHY-BASED SEEDING OF THE SUPERIOR LONGITUDINAL FASCICLUS/ARCULATE FASCICLUS COMPLEX IN RESTING STATE FUNCTIONAL MR IMAGING

Sair, H. I.¹ · Pillai, J. J.¹ · Zaca, D.¹ · Buchbinder, B.²
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PURPOSE

The purpose of this study was to elucidate an intrinsic language functional connectivity network using resting state functional MR imaging (fMRI). Due to inherent spatial variability of language areas across subjects, traditional seed-based methods using a cortical approach may exclude essential language areas in some individuals. We propose utilizing an individual’s inherent anatomically defined network - the white matter tracts as seeds to generate resting state connectivity maps. In this study, seeding was based on the superior longitudinal fasciculus/arcuate fasciculus complex, a tract bundle which demonstrates significant correlation with intraoperative stimulation and transient language dysfunction (Duffau, et al. 2002).

MATERIALS & METHODS

We used resting-state BOLD functional MR imaging (EPI, TR=2s, 210 times points) and diffusion tensor imaging (33 gradient directions and one B0) datasets from a publicly available database consisting of scan-rescan imaging sessions acquired on a 3 T Phillips scanner on 21 healthy adult subjects age 22 to 61 (NITRC Multi-Modal MRI Reproducibility Resource, Landman, et al. 2010). Diffusion tensor matrices were calculated, and tractography was performed on bilateral SLF/AF complexes using Diffusion Toolkit/TrackVis (Massachusetts General Hospital, Boston MA) utilizing a method described by Wakana (Wakana, et al. 2007). Diffusion tensor imaging (DTI) data were registered to the fMRI data using FLIRT (FMRIB’s Linear Image Registration Tool) in FSL (FMRIB’s Software Library, Oxford, UK). Average BOLD fMRI time series were extracted from the voxels containing the endpoints of the SLF/AF tracts. Subject level analysis was performed using FEAT (FMRI Expert Analysis Tool) in FSL, using a General Linear Model-based approach, with each subject’s SLF/AF endpoint time course as the regressor; Z (Gaussianized T/F) statistic images were thresholded using voxels with p<0.05. Higher level group analysis was performed using FEAT; Z (Gaussianized T/F) statistic images were thresholded using voxels with p<0.05. The resulting functional maps were registered and overlayed onto high-resolution T1-weighted images in standard space.

RESULTS

SLF/AF-based correlations demonstrate bilaterally distributed, nearly symmetric networks congruent with known language areas in each subject. The highest correlations were seen in the pars opercularis of the inferior frontal gyri, the lateral aspects of the pre and postcentral gyri (representing language related sensorimotor areas), the superior temporal gyri, Heschl’s gyri, the posterior middle temporal gyri, the cingulate gyri, and the supplementary motor area (SMA). Additional areas of correlation were seen in bilateral middle frontal gyri, long insular gyri, thalami, basal ganglia, the superior and inferior parietal lobules, and bilateral cerebellar hemispheres. Group level analysis mirrored the spatial distribution of highly correlated areas seen in the individual subjects.

CONCLUSION

A tractography-based approach using the endpoints of the SLF/AF complex as the “seed” ROIs can be used to extract an intrinsic language-related network in resting-state functional MRI.

KEY WORDS: Resting state, intrinsic language network, tractography

LANGUAGE FUNCTIONAL MR IMAGING - COMPARISON BETWEEN CORRECTED AND UNCORRECTED DATA ANALYSIS FOR FOUR LANGUAGE TASKS: SENTENCE COMPLETION, VERB GENERATION, SENTENCE COMPREHENSION, AND LEXICAL DECISION

Bermo, M. S. S.¹,² · Faro, S. H.¹,² · Stefanatos, G.¹ · DeMarco, A.² · Conklin, C.² · Nandiraju, D.¹ · Mohamed, F. B.³
¹University of Alexandria, Alexandria, EGYPT, ²Temple University, Philadelphia, PA

PURPOSE

To compare corrected and uncorrected data analysis of fMRI data for four language tasks: two commonly used clinical tasks (sentence completion and verb generation) and two newly developed tasks (sentence comprehension and lexical decision).

MATERIALS & METHODS

Twenty-three right-handed normal volunteers were scanned on a 3 T magnet using a 12-channel head coil. The visual stimuli were delivered through MRI compatible goggles. A blocked design was used to collect BOLD images using a gradient-echo echo planar acquisition of the whole brain with a matrix of 64x64 voxels using a TR of 3 sec, 8 TRs per block, 14 alternating blocks of control and experimental, yielding a total time of 5 minutes 36 seconds per task. The two clinical tasks were: 1) a sentence completion task with scrambled letters as a control and 2) a verb generation task with a blank screen as a rest condition. Neither used an overt response to allow verification of task compliance. In addition we designed two tasks that incorporated closely matched nonverbal control tasks and employed overt response collection to verify compliance: 1) an auditory sentence completion task with scrambled letters as a control and 2) a verb generation task with a blank screen as a rest condition. Neither used an overt response to allow verification of task compliance. In addition we designed two tasks that incorporated closely matched nonverbal control tasks and employed overt response collection to verify compliance: 1) an auditory sentence completion task with a tone-train comprehension task and 2) an auditory lexical decision task with an environmental sound control task. The four tasks were analyzed qualitatively and quantitatively using Statistical Parametric Map (SPM8) software. The total number of clusters, voxel counts and laterality indices (LIs) were compared in all of these tasks with uncorrected p value of 0.001 versus p value of 0.05 corrected for Family Wise Error (FWE).
RESULTS

Comparison of group mean data with corrected and uncorrected p-values is shown in the Table. Three tasks yielded excellent laterality indices. Sentence completion revealed strong overall hemispheric asymmetries in both canonical receptive and expressive language regions (Broca’s area, Wernicke’s area) using both corrected and uncorrected p-values. Verb generation yielded the highest mean t-values. Laterality index computations were greatest when the data were corrected (p < .05) compared to uncorrected (p < .001). The sentence comprehension task showed fairly selective activations in posterior language cortex that were strongly lateralized.

Table 1.

<table>
<thead>
<tr>
<th>Task</th>
<th>Number of voxels</th>
<th>Laterality indices</th>
<th>Number of clusters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sentence completion</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Verb generation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lexical decision</td>
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</tbody>
</table>

CONCLUSION

1. In both clinically used and newly developed language localization paradigms, FWE correction decreased the number of active voxels but did not change the laterality indices. The single exception was Verb Generation which produced higher laterality indices after FWE correction. 2. Sentence completion and verb generation tasks show robust non-selective activation of both major language regions. The newly designed auditory sentence comprehension task produced laterality indices comparable to the clinical tasks. However, this task produced more selective activation of canonical receptive language regions, and also permitted monitoring of task compliance. The lexical decision task showed the smallest activation and was somewhat more variable.

KEY WORDS: Functional MR imaging, language, BOLD

One such variable is the relative fluency of the subjects, which often also correlates with the age of acquisition of the second language. Nevertheless, for highly fluent bilinguals who acquired their second language early, a few comprehension studies have found evidence that there is extensive overlap for the two languages in the classical language areas, (i.e., Broca’s and Wernicke’s areas). In contrast, in a task that required speech output, the second language elicited additional activation in the left putamen.

MATERIALS & METHODS

Seven right-handed bilingual (2 women and 5 men, primary non-English and secondary English-speaking) individuals performed fMRI noun-verb association tasks in both primary native language and English. The primary native languages were French in two subjects, Italian in one subject, Spanish in three subjects, and Turkish in one subject. Our control group included 20 right-handed individuals with English as their primary language. The images were obtained on a 3 T MRI scanner, for anatomical localization a standard whole-brain T1-weighted 3D SPGR sequence was acquired for each subject and the echo-planar activation maps were overlaid on corresponding structural slices. The functional images were T2*-weighted, echo-planar, single-shot pulse sequences with a matrix size of 64 x 64, echo time (TE) of 40 ms, flip angle of 90°, and an in-plane resolution of 5 x 5. A total of 74 images were acquired for adjacent 5 mm-thick axial slices in an interleaved mode with a repetition time of 5 s. Twenty consecutive axial images (5 mm thick) were acquired covering the extent of the brain. The first two images of each slice were discarded to assure that the MR signal had reached equilibrium on each slice. Images were analyzed using Func-Tools software (General Electric, Milwaukee, WI), according to a block-design model, in which the magnitude of the BOLD effect was measured in terms of when the subject was actively performing the task blocks, minus the BOLD effect for the rest periods. Random effects method was employed for group analysis.

RESULTS

In bilingual subjects the activation topography during a semantic task demonstrates significant statistical differences for nonnative language task, but no significant difference in the primary language. English-speaking subjects demonstrated activation in classical language areas, (i.e., Broca’s and Wernicke’s areas).

CONCLUSION

Our results suggest that the neural networks involved in semantic language processing are different for nonnative language as compared to native language.

KEY WORDS: Semantic language, Functional MR imaging, bilingual
Effect of Resting-State Functional MR Imaging Repetition Time on Accuracy of Computed Graph Theory Network Metrics

Whitlow, C. T. • Maldjian, J. A.
Wake Forest University School of Medicine
Winston-Salem, NC

PURPOSE
Graph theory network analysis methods applied to resting-state functional magnetic resonance imaging (RS-fMRI) blood oxygen level dependent (BOLD) data have begun to shed light upon changes in the central nervous system (CNS) at the level of whole-brain distributed network connectivity that appear to underlie a variety of neurodegenerative and psychiatric disorders. Using RS-fMRI for graph theoretical analysis requires collection of rapid whole brain time-series data to identify low frequency statistical interdependences between brain regions or voxels. Such data typically are acquired using short repetition times (TR) of 2 seconds or less over a several minute data collection interval. No studies to date, however, have investigated the effects of relatively longer TR intervals on accuracy of graph theory network metrics. Computation of accurate network metrics from fMRI data collected at longer TR intervals (e.g., 3-6 seconds) would allow the application of graph theory methods to other functional neuroimaging methods that are performed more frequently clinically than BOLD imaging, such as arterial spin labeling (ASL) MRI. The purpose of this study, therefore, was to evaluate the effect of increasing TR on accuracy of computed graph metrics. We hypothesized that graph theory network metrics would be accurately calculated using TR intervals longer than those used in standard RS-fMRI BOLD sequences, which would open the door for implementing these analysis techniques on clinical ASL data.

MATERIALS & METHODS
An institutional ethics committee approved this study. Thirty-one normal control subjects from a larger study of traumatic brain injury were scanned in a 1.5 T GE scanner using an 8-channel head coil (GE Medical Systems, Milwaukee, WI, USA) for collection of structural anatomical (3D SPGR) MRI and RS-fMRI BOLD data, using a TR of 2 seconds. These data then were resampled to generate within subject BOLD datasets with incrementally longer TRs of 4, 6, and 8 seconds. All data were motion-corrected and normalized to a standard template using SPM. A binary adjacency matrix for each TR across subjects was generated at a network cost of 0.3 from which common graph theory network metrics (clustering coefficient, characteristic path length, local efficiency, global efficiency, and small-worldness) were computed. A one-way between groups analysis of variance was conducted to explore the impact of TR on computed network metrics.

RESULTS
There were no statistically significant differences between graph network metrics computed from BOLD data across TR of 2 to 8 seconds, as follows: clustering coefficient [F(3,120)=.168, p=.918]; characteristic path length [F(3,120)=.265, p=.850]; local efficiency [F(3,120)=.306, p=.821]; global efficiency [F(3,120)=.595, p=.620]; and small-worldness [F(3,120)=1.047, p=.375].

CONCLUSION
Accurate graph metrics can be computed across a wide range of TR. These data are important because they suggest that graph theoretical analyses may be conducted using other fMRI methods, such as clinical ASL perfusion imaging, which acquire brain time-series data at a TR of 3-6 seconds. Translation and broad clinical implementation of graph theoretical analysis techniques may lead to the discovery of novel functional imaging markers that improve the ability to diagnose disease and predict outcomes associated with central nervous system dysfunction.

KEY WORDS: Graph theoretical analysis, resting-state functional MR imaging

Monday Afternoon
5:00 PM - 6:30 PM
Ballroom 6 B/C

(12) SNIS Programming: Perfusion Imaging for the Stroke Interventionalist (SAM* Session - #2) (AR)

(172) Perfusion Imaging for Stroke Intervention: 2011

— Max Wintenmark, MD

(173) Perfusion Imaging: Methodological Limitations in Differentiating the Core and Penumbra Limits Utility in Stroke Intervention

— R. Gilberto Gonzalez, MD, PhD

(174) Intra-Arterial Stroke Therapy: Wouldn’t Treat without Knowing the Status of the Penumbra

— Ansaar T. Rai, MD

(175) Penumbral Imaging Is Costing Time and Hence Brain

— Albert J. Yoo, MD

(176) Discussion

Moderators: Jeffrey L. Sunshine, MD, PhD
Colin P. Derdeyn, MD

*Qualified by the American Board of Radiology in meeting the criteria for self-assessment toward the purpose of fulfilling requirements in the ABR Maintenance of Certification Program Date: 4/11.
Perfusion Imaging for Stroke Intervention: 2011
Max Wintermark, MD

Learning Objectives
Upon completion of this presentation, participants will be able to:
1) Review the fundamentals of perfusion imaging in stroke patients.
2) Review the respective advantages and limitations of CT and MR imaging for perfusion imaging.
3) Discuss the potential use of perfusion imaging to select acute stroke patients for reperfusion therapy.
4) Discuss the steps required to validate and expand the use of perfusion imaging in stroke care.

Presentation Summary
Imaging has revolutionized acute ischemic stroke diagnosis and management. Previously, anatomical (structural) imaging modalities, typically noncontrast computed tomography (CT), were used to assess the presence or absence of acute ischemic stroke and exclude stroke mimics such as hemorrhage and neoplasms. With the development of functional (or physiologic) imaging modalities such as perfusion imaging, stroke has been redefined from an all-or-none process to a dynamic and evolving process. In particular, the advent of efficacious thrombolytic therapies such as intravenous tissue plasminogen activator (IV-tPA) has served as the impetus to better define the so-called ischemic penumbra or “tissue at risk” and thus better select those patients who would be more amenable to successful therapy. Perfusion imaging involves dynamic acquisition of sequential slices on a cine mode during intravenous administration of nonionic iodinated contrast material. Perfusion imaging allows rapid, noninvasive, quantitative evaluation of cerebral perfusion. Based on the multicompartmental tracer kinetic model, dynamic perfusion imaging is performed by monitoring the first pass of an iodinated contrast agent bolus through the cerebral circulation. Perfusion imaging allows to distinguish the infarct core from the penumbra. Multimodal imaging - including vascular imaging and perfusion imaging - allows for the assessment of the four Ps (parenchyma, pipes, perfusion, and penumbra). Noncontrast CT or FLAIR/GRE allows to rule out hemorrhage, CTA or MRA identifies intracranial thrombus, and perfusion CT or diffusion-/perfusion-weighted MR imaging can differentiate between “at-risk” (the so-called “penumbra”) and irreversibly damaged brain tissue. A multimodal imaging stroke protocol might be used to properly select those patients that might be amenable to reperfusion therapy. Several studies have suggested favorable clinical outcomes with thrombolytic therapies which were selected using imaging criteria.

Perfusion Imaging: Methodological Limitations in Differentiating the Core and Penumbra Limits Utility in Stroke Intervention
R. Gilberto Gonzalez, MD, PhD

Presentation Summary
Successful neurointervention is necessary, but not sufficient to produce good outcomes in acute stroke patients with a major artery occlusion. Modern neuroimaging can identify those patients who are most likely to benefit from intervention, but a critical review of the evidence reveals that not all methods are equivalent in producing the information critical for patient selection. The evidence indicates that outcomes depend on the following in order of importance: symptom severity, the artery occluded and the size of irreversibly injured brain. In patients with high NIHSS scores and an occlusion of an ICA, proximal MCA or basilar artery, the most important determinant of successful outcome with recanalization is the size of the infarct before the procedure. The most reliable indicator of acute infarct is diffusion-weighted imaging (DWI). Hypodensity on noncontrast CT is reliable, but not sensitive. Methods based on perfusion MRI or CT are unreliable for determination of infarct core. As future reimbursement policies change with an emphasis on outcomes, and not just on the occurrence of a procedure, the proper use of neuroimaging in patient selection will become essential.

Intra-Arterial Stroke Therapy: Wouldn’t Treat without Knowing the Status of the Penumbra
Ansaar T. Rai, MD

Penumbral Imaging Is Costing Time and Hence Brain
Albert J. Yoo, MD

Learning Objectives
Upon completion of this presentation, participants will be able to:
1) Review the indications for endovascular reperfusion therapy in acute ischemic stroke.
2) Appraise the clinical evidence for stroke perfusion imaging and address its limitations in patients with proximal artery occlusions.
3) Discuss the evidence for alternative imaging approaches in predicting the response to endovascular therapy.

Presentation Summary
Reperfusion therapy is the only proven treatment for acute ischemic stroke. Endovascular approaches have emerged as an effective means for revascularization of major strokes due to proximal intracranial artery occlusions (PAO) (1-2). The major clinical criteria for performing intra-arterial therapy (IAT) are a significant neurologic deficit secondary to PAO, the absence of a large, well established infarct on noncontrast CT and treatment within 8 hours of onset. These criteria have not been well validated in clinical efficacy studies, and available data suggest that outcomes using this approach are highly variable and often poor. To improve outcomes, advanced neuroimaging methods are used increasingly to identify those patients who are likely to benefit from reperfusion. However, despite extensive investigation, it remains unclear whether “penumbral imaging” using diffusion and perfusion MR imaging or CT perfusion leads to improved clinical outcomes. The mismatch hypothesis has yielded conflicting results in various trials of intravenous therapy. In the setting of proximal occlusions amenable to IAT, a more significant challenge to the use of a perfusion imaging mismatch is its nonspecific characterization of hypoperfused tissue. Recent evidence suggests that the pretreatment core infarct size alone may be sufficient for predicting the clinical response to endovascular reperfusion (4-6). Ongoing studies aim to test both approaches.
Monday Afternoon
5:00 PM - 6:30 PM
Room 606-609

(13) ASSR Programming: Comprehensive Spine Review: Tumor, Infection and Traumatic Injury of the Spine

(177) Intradural Spine Tumors
— Meng Law, MD

(178) Spinal Infections
— Majda M. Thurnher, MD

(179) Whiplash Injuries
— Johan W. M. Van Goethem, MD

Moderators: Timothy J. Biega, MD
Adam E. Flanders, MD

Intradural Spine Tumors
Meng Law, MD

Learning Objectives
Upon completion of this presentation, participants will be able to:
1) Describe the most common intradural spine tumors, in particular intramedullary tumors and extramedullary, intradural lesions.
2) Differentiate between neoplastic and non-neoplastic lesions.
3) Recognize the role of advanced imaging, in particular, MR spectroscopy, diffusion tensor imaging, perfusion and permeability imaging in differentiating between different spine lesions.

Presentation Summary
The presentation will provide an overview of the common (and some of the less common) intradural spine tumors. These will be divided into intramedullary tumors which compose primarily of ependymomas, astrocytic tumors, vascular tumors such as hemangioblastomas; as well as extramedullary tumors such as meningiomas, neurofibromas, metastases etc. An important part of the lecture will focus on the imaging characteristics which can help to differentiate the various pathologies in particular neoplastic lesions from non-neoplastic lesions such as primary, secondary causes of demyelination, vascular and congenital lesions of the spinal canal. Finally the application of advanced MRI techniques such as MR spectroscopy, diffusion tensor imaging, perfusion and permeability imaging in differentiating between different intradural spine lesions (1-3).

References

Spinal Infections
Majda M. Thurnher, MD

Presentation Summary
The fact that delay in diagnosis of spinal infections may lead to irreversible neurologic deficits increases the responsibility of radiologists to promptly recognize infections in different spinal compartments. A delay in the diagnosis is usually due to a subtle presentation and absence of the systemic signs of infection. Constant back pain, without a history of trauma, is worrisome. The most common source of infection is direct spread to the blood system; often from an unknown primary site. A systematic review of the most common spinal infections and their typical imaging findings will be given. Predisposing factors, routes of infection, common causative agents, and clinical manifestations will be discussed. MR imaging is the primary imaging method for the evaluation and monitoring of spinal infection. Newer imaging techniques, such as diffusion-weighted imaging (DWI), diffusion tensor imaging (DTI), and MR perfusion, show promising results in the differentiation between infectious and neoplastic diseases.

References

Whiplash Injuries
Johan W. M. Van Goethem, MD

Presentation Summary
Whiplash is one of the most common mechanisms of injury to the cervical spine and cord. Eighty percent of cervical injuries are isolated soft tissue injuries, including ligamentous sprains and intervertebral disk injuries. The mechanisms of sprains are usually flexion, extension, or a combination where flexion follows extension (whiplash injury). Although the term whiplash is used by many to refer to the cluster of events following this incident, it was first used by Harold Crowe in 1928 only to describe the manner in which a head is moved suddenly to produce a sprain in the neck. Bony damage and other serious injuries are sometimes excluded from this definition. Whiplash injuries are impor-
Disability.

Injuries cause substantial signal changes in craniovertebral arteries and transverse ligament, are associated with pain and ligaments and membranes. Such lesions, especially in the injuries remain to be determined. Cervical roentgenography cannot be relied upon either to definitively determine the true extent and severity of cervical injuries in trauma victims, or to exclude cervical injuries in these patients. The more routine use of computed tomography (CT) increases the detection of fractures but often fails to determine or visualize the cause for a whiplash syndrome. MR imaging is able to assess different types of soft-tissue lesions related to whiplash injuries, and is especially useful in the evaluation of intervertebral disks, cervical ligaments and spinal cord. One of the key problems in imaging whiplash-injured patients is the lack of knowledge of the underlying pathology of the trauma. Some recent biomechanical studies seem to indicate that a whiplash injury is not so much a hyperextension/hyperflexion injury than that it really is a combined axial loading and rotation around an abnormal center of rotation, resulting in anterior-diskal-distraction injuries and posterior-facet-compression lesions. Some research therefore is focused in detecting either disk/endplate lesions using MDCT and/or MR imaging, or facet (micro-) fractures using MDCT. Other studies have focused on ligamentous injuries of the craniocervical junction. They show that whiplash injuries cause substantial signal changes in craniovertebral ligaments and membranes. Such lesions, especially in the alar and transverse ligament, are associated with pain and disability.

Monday Afternoon
5:00 PM - 6:30 PM
Ballroom 6A

(14) Translational Research in Neuroradiology, V/Advanced Imaging Seminar: Microstructural Brain MRI

(180) DTI and HARDI

Jeffrey I. Berman, PhD

Dr. Jeffrey Berman is currently Research Assistant Professor of Radiology, Children's Hospital of Philadelphia and University of Pennsylvania School of Medicine. Dr. Berman's education is as follows: BSE, University of Pennsylvania, School of Engineering and Applied Science (Double Major: Bioengineering & Electrical Engineering) - 2000; PhD, University of California, Berkeley & University of California, San Francisco, Joint Bioengineering Graduate Program (Bioengineering) - 2005.

Presentation Summary
This presentation will address the differences between DTI and high angular resolution diffusion imaging (HARDI). HARDI and DTI both use the random motion of water to probe the 3D microstructure of brain tissue. However, HARDI is superior to DTI in its discrimination of complex crossing white matter fibers. Strategies for acquiring and reconstructing HARDI will be reviewed. Examples of current capabilities and clinical applications of HARDI and HARDI fiber tracking will be shown.

Diffusion: Beyond Stroke
Brian D. Ross, PhD

Dr. Brian Ross is Professor of Radiology and Biological Chemistry at the University of Michigan School of Medicine; Co-Director of the Center for Molecular Imaging. Dr. Ross has over 140 peer-reviewed publications.

Presentation Summary
Diffusion-weighted imaging (DWI) offers insight into cellular edema, density and cyto-architecture by way of sequences sensitive to water mobility affected by these features. This feature provides an opportunity to apply this imaging modality for assessing cancer treatment response. Single-shot echo-planar imaging is certainly the most widely used technique, although specialized multishot approaches may offer advantages. Outside of the brain, however, greater tissue motion usually necessitates use of single-shot techniques. Baseline signal to noise ratio (SNR) and diffusion anisotropy drive the choice of diffusion sensitivity (i.e., “b-value”) and multiplicity in gradient directions. There is also a variety of techniques to analyze diffusion data driven by the specific clinical/scientific application. Basic analyses to exhibit relative mobility as normalized DWI and apparent diffusion coefficient (ADC) maps are useful for lesion detection and diagnosis. However, more elaborate quantitative analyses are typically employed in oncology where the distinction between viable cellular, edema, and necrotic zones are desirable for treatment planning. Serial changes in tissue cellularity in response to therapy are also measurable by diffusion using various quantitative methods that include whole-tumor ADC average, histogram analysis, and pretreatment vs. post-treatment voxel-based differences. This lecture will provide an overview of the applications of DWI in oncology as a therapeutic response imaging biomarker using examples from animal tumor models and clinical trials.
Quantitative Susceptibility Mapping

Yi Wang, PhD

Dr. Yi Wang (B.S. 1986 in Nuclear Physics from Fudan University, Ph.D. 1994 in Medical Physics from University of Wisconsin, and postdoc at Mayo Clinic) joined the faculty of Cornell University in 1997. Currently Dr. Wang is a Fellow of the American Institute for Medical and Biological Engineering and the Faculty Distinguished Professor of Radiology and Biomedical Engineering at Cornell University. Dr. Wang’s work includes pioneering cardiac navigator method, which forms the foundation for current high-resolution cardiac MRI, and originating time-resolved MRA and bolus chase peripheral MRA, which have become used routinely in clinical practice. His major research interests currently include MRI technology development and clinical and biological applications. His laboratory is actively developing rapid acquisition techniques for time-resolved dynamic imaging, navigator methods for suppressing motion artifacts, and segmentation methods for image analyses. Recently, Dr. Wang’s laboratory has been pioneering MRI of tissue magnetic property, quantitative susceptibility mapping (QSM), by solving the field-to-source inverse problem. This QSM removes blooming artifacts in T2* MRI and enables accurate absolute quantification of iron and calcium depositions, gadolinium in contrast-enhanced studies, and targeted contrast agents in molecular MRI. Quantitative susceptibility mapping holds promising applications in cerebral hemorrhage and neurodegenerative diseases.

Presentation Summary

In MR imaging (MRI), the susceptibility inhomogeneity so far has been regarded as a source of artifacts, such as causing hypointensity in the gradient echo imaging. We propose to make use of the magnetic field information in the typically ignored phase data in MRI to generate quantitative susceptibility mapping (QSM) by solving the magnetic field to susceptibility source inverse problem. This QSM removes blooming artifacts in T2* hypointensity, in SWI and blurring in R2* map, and enables accurate localization quantification of tissue magnetic susceptibility source, such as depositions of iron and calcium, and distributions of deoxyhemoglobin and IV administered gadolinium.
Tuesday Morning
6:45 AM - 7:40 AM
Ballroom 6 B/C

(E003) Excerpta Extraordinaire: Interventional
(Scientific Papers 183 - 193)

See also Parallel Session
(E004) Excerpta Extraordinaire: Adult Brain II

Moderator: Walter S. Lesley, MD, FACR

Paper 183 Starting at 6:45 AM, Ending at 6:50 AM
Preceding Intravenous Thrombolysis Facilitates Endovascular Mechanical Recanalization in Large Intracranial Artery Occlusion

Fesl, G. • Patzig, M. • Brueckmann, H. • Lutz, J. • Holtmannspoetter, M. • Dichgans, M. • Opherk, C. • Pfefferkorn, T.
University of Munich
Munich, GERMANY

PURPOSE
Acute occlusions of the large intracranial seem to be relatively resistant to intravenous thrombolysis (IVT). Therefore, multimodal approaches combining IVT with endovascular mechanical recanalization (EMR) are increasingly applied. In this setting IVT may facilitate subsequent EMR. To test this hypothesis we analyzed the influence of IVT on net intervention time in subsequent EMR.

CASE REPORT
In this retrospective monocentric analysis we compared net intervention time with and without preceding IVT in all patients treated by EMR within 8 hours of stroke onset between 01/2003 and 06/2010. Net intervention time was defined as the interval between onset of endovascular thrombus manipulation and successful vessel recanalization.

IMAGING FINDINGS
We identified 65 eligible patients, 35 of them were treated by IVT prior to EMR. Recanalization was achieved in 26 patients with (74%) and 23 patients without preceding IVT (77%). In the case of successful recanalization, net intervention time was significantly shorter in patients with preceding IVT (24.8 ± 22.8 vs. 44.2 ± 40.5 minutes; p<0.05). This difference remained significant after restricting analysis to the patients treated by the Penumbra Stroke System© (n = 32). After 3 months, patients with preceding IVT were more likely to be functionally independent (mRS ≤ 2) than those without (p<0.05).

SUMMARY
Our findings suggest that preceding IVT may shorten intervention time in patients treated by EMR. However, due to the retrospective design of our study, these findings have to be interpreted with caution and need confirmation in a larger patient population.

KEY WORDS: Endovascular mechanical recanalization, intravenous thrombolysis, stroke

Paper 184 Starting at 6:50 AM, Ending at 6:55 AM
Cranio-Cervical Arterial Dissections as Sequelae of Chiropractic Manipulation: Patterns of Injury and Management

Albuquerque, F. C. • McDougall, C.
Barrow Neurological Institute, Neurosurgical Associates
Phoenix, AZ

PURPOSE
Chiropractic manipulation of the cervical spine is a known etiologic mechanism of cranio-cervical arterial dissections. Previous reports have focused on conservative treatment modalities for these injuries. In this study, we describe the patterns of arterial injury and their management in the modern endovascular era.

CASE REPORT
We reviewed our prospectively maintained endovascular database to identify patients presenting with cranio-cervical arterial dissections after chiropractic manipulation. Specific factors assessed included: time to symptomatic presentation, location of the injured arterial segment, neurologic symptoms, endovascular treatment, surgical treatment, clinical outcome, and radiographic follow up.

IMAGING FINDINGS
Thirteen patients, including eight women and five men ranging in age from 30 to 54 years (mean 41 years), presented with neurologic deficits and/or head and neck pain typically within hours or days of chiropractic manipulation. Arterial dissections were identified along the entire course of the vertebral artery, including the origin through the V4 segment. Two patients had V4 dissections that continued rostrally to involve the basilar artery. Two patients had dissections of the carotid artery, including one with cervical artery injury and one with a dissection of petro-cavernous segment. Stenting...
was performed in six cases and thrombolysis of the basilar artery in one case. Three patients underwent emergent cerebellar decompression because of impending herniation. Five patients were managed medically with either anticoagulation or antiplatelet therapy. Clinical follow up was obtained in all patients and averaged 19 months in duration. Three patients had permanent neurologic deficits while the remaining 10 recovered completely. Radiographic follow up was obtained in all but the two most recently treated patients. All stents were widely patent on follow up.

**Summary**

Chiropractic manipulation of the cervical spine can produce dissections involving the cervical and cranial segments of the vertebral and carotid arteries. These injuries are frequently severe, often requiring endovascular stenting and cranial surgery. Those patients suffering strokes are typically left with permanent neurologic injury.

**Key Words:** Chiropractic, dissections, management

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Paper 185 Starting at 6:55 AM, Ending at 7:00 AM

**CT-Guided Percutaneous Translaminar Approach for Blood Patching: Case Report and Technical Note**

Albayram, S.¹ • Abuzayed, B.¹ • Hasiloglu, Z. I.¹ • Selcuk, H.² • Cagil, E.¹ • Keser, Z.¹ • Kaynar, M.¹

¹Istanbul University, Istanbul, TURKEY, ²Bakirkoy Dr. Sadi Konuk Research and Education Hospital, Bakirkoy, Istanbul, TURKEY

**Purpose**

The aim of this study describes a novel and simple technique for performing epidural blood patch (EBP) by percutaneous CT-guided translaminar approach in challenging cases where interlaminar approach is not possible.

**Case Report**

A 24-year-old woman who had medical history of multiple spinal surgeries and instrumentations for the treatment of scoliosis (Fig. 1A), was presented with acute and severe orthostatic headaches. Neurologic examination was normal.

**Imaging Findings**

Brain MR imaging showed mild durar thickening and enhancement. Computed tomography (CT) myelography revealed cerebrospinal fluid (CSF) leakage in the level of T3 vertebra. First, EBP was performed under fluoroscopy guidance and second one CT-guided. However, multiple attempts failed to enter the epidural space through the interlaminar space due to the extensive instrumentation of the spine and the profound structural bone abnormalities. Epidural blood patch was performed successfully by CT-guided translaminar approach by using Ostycut trephine needle (Angiomed®/Bard, Karlsruhe), with no complications (Fig.1B).

**Summary**

In cases of orthostatic headache after spinal surgery neuroimaging studies must be considered presumed the presence of a dural tear and CSF leakage as a complication of the surgery. Also, the percutaneous translaminar approach is a novel and simple technique for applying EBP, and can be considered in cases where interlaminar approach is not possible due to the presence of the extensive instrumentation of the spine and the profound structural bone abnormalities.

**Key Words:** Intracranial hypotension syndrome, epidural blood patch, translaminar approach

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Paper 186 Starting at 7:00 AM, Ending at 7:05 AM

**Stenting of Dural Sinus Stenoses for Treatment of Pediatric Idiopathic Intracranial Hypertension**

Shaibani, A.¹ • Ryan, M.¹ • Reilly, C.¹ • DiPatri, A.¹ • Rahmani, B.¹ • Hurley, M.¹ • Miller, J.¹ • Ansari, S.¹

¹Northwestern University Feinberg School of Medicine, Chicago, IL, ²University of Chicago Pritzker School of Medicine, Chicago, IL

**Purpose**

Description of endovascular treatment of idiopathic intracranial hypertension (IIH) in children.

**Case Report**

Two patients referred to a single neurointerventionalist with extensive experience in pediatric neurointervention. Patient A: 12-year-old male with normal body habitus, who failed medical therapy, with continued double vision, decreased visual acuity and severe daily headaches. CT venography (CTV) demonstrated bilateral transverse sinus stenosis. The patient underwent direct venography with pressure measurements showing a prestenotic pressure of 35 mm Hg and a gradient of 13 mmHg across the stenosis. The dominant right transverse sinus was stented with a 9 mm stent (Zilver, Cook). Immediate prestenosis pressure decreased to 21 mm Hg. Patient B: 7-year-old female, history of tuberous sclerosis and seizures, presented with papilledema and decreased visual acuity despite medical therapy. MR venography showed bilateral transverse sinus stenosis. The dominant left transverse sinus was stented with an 8 mm nitinol stent (Xpert, Abbott). The prestenosis venous pressure was 28 mmHg with a 16 mm gradient across the stenosis. Poststent the gradient decreased to 4 mmHg.
**Summary**

Intracranial hypertension, previously known as pseudotumor cerebri, is defined by the International Headache Society as a syndrome of raised intracranial pressure without clinical, laboratory or radiologic evidence of intracranial pathology. The latter part of this definition is misleading as many of these patients have transverse sinus stenosis on conventional and cross-sectional venography (CTV or MRV). Patients are often young, obese females and the typical presentation includes headaches, visual disturbances, and papilledema. Glaucoma is a sequela that can result in insidious vision loss that is severe in up to 25%. Initial management includes weight loss and oral acetazolamide but progressive symptoms, particularly vision loss, indicate further therapies: pharmacologic (topiramate, corticosteroids, and furosemide) and surgical (serial lumbar punctures, ventriculoperitoneal or lumbo-peritoneal CSF shunts, and optic nerve sheath fenestration). Several case series have reported good results with stenting of the stenotic transverse sinus in adult IIH patients. We describe the youngest reported two such patients, aged 7 and 12 years old, who underwent unilateral dominant transverse sinus stenting for relief of persistent visual disturbance and papilledema despite medical therapy. Discussion: The cause or effect relationship between IIH and transverse sinus stenosis remains controversial but recently the pendulum has swung towards endovascular treatment of the sinus stenosis. This is due, at least partially, to the long-term complications and malfunction associated with ventricular shunts. Reported technical success rates for endovascular treatment are high, but long-term outcomes are still unavailable. Conclusion: Endovascular stenting of stenosis of the dominant transverse sinus in children with IIH is technically feasible with good short- and medium-term results. Further investigation is necessary.

**Key Words:** Idiopathic intracranial hypertension, pseudotumor cerebri, stent

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**Imaging Findings**

Patient A: A 1-month follow-up venogram was performed demonstrating a pressure of 13 mm Hg with no gradient. Five-month CT venography demonstrates continued stent patency. The patient’s double vision and papilledema have resolved completely. His headaches have decreased in frequency and severity. Patient B: Ophthalmologic exam 3 weeks posttreatment revealed resolution of papilledema. Four-month venography revealed continued stent patency and normal intracranial venous pressures.

**Case Report**

Spontaneous intracranial hypotension is a well described clinical entity that displays an array of symptoms but is characterized by the uniform subjective experience of postural headache. A 35-year-old male presented to the emergency department with neck pain, postural headache, nausea and photophobia that preceded the lumbar puncture applied during initial investigations. Conservative treatment and multiple epidural blood patches failed to provide long-term relief of symptoms once a CSF leak was confirmed. Direct visualization of contrast leakage under fluoroscopy with digital subtraction allowed for accurate localization of CSF leakage prior to definitive surgical management.

**Imaging Findings**

Characteristic head MR findings of pachymeningeal thickening and enhancement, as well as caudal displacement of the brain, established a diagnosis of intracranial hypotension. An MR spine documented ventral and dorsal epidural collections with signal characteristics of CSF within the lower thoracic spine but a nuclear medicine CSF flow study did not identify a dural leak. Conventional and digital subtraction myelography performed in the prone and left lateral decubitus position did not reveal epidural contrast leakage but some epidural contrast pooling was noted following patient repositioning in the right lateral decubitus position. A CT myelogram performed immediately subsequent revealed extensive epidural contrast, suggesting a dorsal site of leakage. Prior to surgical management, a lumbar drain was placed and used for myelography with digital subtraction with the patient in the supine position. Two dorsal sites of CSF leakage were directly visualized in real time.

**Summary**

Digital subtraction myelography can be performed with the patient in a supine position via a lumbar drain. This may facilitate direct visualization of contrast extravasation, allowing for accurate localization of dorsal CSF leaks.

**Key Words:** CSF leak, digital subtraction myelography

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**Paper 187 Starting at 7:05 AM, Ending at 7:10 AM**

**Supine Digital Subtraction Myelography for the Demonstration of a Dorsal Cerebrospinal Fluid Leak**

Carstensen, M. H. • Leung, A.

London Health Sciences Centre
London, ON, CANADA

**Purpose**

To present a novel myelographic approach of localizing a dorsal site of cerebrospinal fluid (CSF) leakage by infusing iodinated contrast via a lumbar drain with the patient in a supine position.

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**Paper 188 Starting at 7:10 AM, Ending at 7:15 AM**

**Pitfall of Cervical Epidural Steroid Injection: Periligamentous Injection**

Kinder, E. A. • Jackson, S. M. • O’Callaghan, M. G.

Via Radiology
Seattle, WA

**Purpose**

 Epidural steroid injection (ESI) is a procedure commonly performed to alleviate diskogenic radiculopathy, and is increasingly being performed using CT guidance. At our institution we have found that even experienced radiologists performing CT-guided cervical ESI may be tempted to inject into a space adjacent to or within the ligamentum flavum which mimics the epidural space. This presentation will increase awareness of this potential pitfall and may help reduce inadvertent periligamentous injection during CT-guided cervical ESI.
**Case Report**

A 47-year-old male with headache presented after initial CT evaluation at an outside facility demonstrated obstructive hydrocephalus secondary to a hyperattenuating posterior fossa lesion.

**Imaging Findings**

The patient underwent a craniotomy, but during surgical resection, significant bleeding was encountered and an intraoperative biopsy diagnosed a plasma cell leukemia, confirmed with a bone marrow biopsy. The surgical resection was aborted and chemotherapy was initiated.

**Summary**

Intracranial plasma cell leukemia is a rare, aggressive form of an extramedullary plasma cell leukemia that can be very differentiable from benign meningiomas on cross-sectional and angiographic imaging. As opposed to meningiomas, treatment strategies for plasma cell leukemias are nonsurgical including chemotherapy, steroids, radiation, and stem cell transplantation. We present a rare case of CNS plasma cell leukemia mimicking a meningioma in which the patient was referred for possible preoperative embolization prior to surgical resection. Although embolization was aborted in the presence of dangerous collateral pathways from the feeding ascending pharyngeal arteries, a potential complication from the embolization of intracranial plasma cell leukemia was averted. Reducing tumor vascularity to a plasma cell leukemia with endovascular techniques may limit the adequate delivery of chemotherapy and thus treatment efficacy. An exhaustive diagnostic analysis is advocated for avidly enhancing and vascular dural-based tumors prior to initiating endovascular embolization. It is important to note the procedure is contraindicated in leukemias and lymphomas in which treatment is primarily medical versus the surgical resection of meningiomas and dural metastases.

**Key Words:** Embolization, meningioma, plasma cell leukemia

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**Paper 189 Starting at 7:15 AM, Ending at 7:20 AM**

Central Nervous System Plasma Cell Leukemia Mimicking Meningioma: Contraindication to Preoperative Embolization

*Papers 189 Starting at 7:15 AM, Ending at 7:20 AM*

**Purpose**

To report a case of central nervous system (CNS) plasma cell leukemia mimicking a meningioma and discuss potential complication of preoperatively embolizing such lesions.

**Case Report**

A 47-year-old female with right upper extremity radiculopathy referred for C5/C6 cervical ESI. CT ESI performed using a 25 G spinal needle with test Omipaque 300 injections.

**Imaging Findings**

Subsequent MRI confirmed a homogeneously enhancing, T2 isointense and extra-axial bilobed mass (2.9 x 2.8 x 3.2 cm) in the premedullary cistern abutting the inferior half of the clivus with extensive mass-effect, displacement of the medulla, compression of the 4th ventricle, and obstructive hydrocephalus. The V4 segments of the vertebral arteries were encased in the central aspect of the mass. Preoperative angiography, temporary balloon occlusion of the right vertebral artery, and possible preoperative embolization was requested by the neurosurgery service. Digital subtraction angiography (DSA) identified moderate tumor vascularity supplied from the ascending pharyngeal arteries. However, the presence of prominent collateral pathways to the internal carotid artery and right vertebral artery via the clival branches and odontoid arcade respectively precluded safe embolization. The patient tolerated 30 minutes of temporary balloon occlusion of the right vertebral artery just distal to the PICA origin by clinical examination. Subsequently, the patient underwent a craniotomy, but during surgical resection, significant bleeding was encountered and an intraoperative biopsy diagnosed a plasma cell leukemia, confirmed with a bone marrow biopsy. The surgical resection was aborted and chemotherapy was initiated.

**Summary**

Intracranial plasma cell leukemia is a rare, aggressive form of an extramedullary plasma cell leukemia that can be very difficult to differentiate from benign meningiomas on cross-sectional and angiographic imaging. As opposed to meningiomas, treatment strategies for plasma cell leukemias are nonsurgical including chemotherapy, steroids, radiation, and stem cell transplantation. We present a rare case of CNS plasma cell leukemia mimicking a meningioma in which the patient was referred for possible preoperative embolization prior to surgical resection. Although embolization was aborted in the presence of dangerous collateral pathways from the feeding ascending pharyngeal arteries, a potential complication from the embolization of intracranial plasma cell leukemia was averted. Reducing tumor vascularity to a plasma cell leukemia with endovascular techniques may limit the adequate delivery of chemotherapy and thus treatment efficacy. An exhaustive diagnostic analysis is advocated for avidly enhancing and vascular dural-based tumors prior to initiating endovascular embolization. It is important to note the procedure is contraindicated in leukemias and lymphomas in which treatment is primarily medical versus the surgical resection of meningiomas and dural metastases.

**Key Words:** Embolization, meningioma, plasma cell leukemia

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**Paper 190 Starting at 7:20 AM, Ending at 7:25 AM**

Hydrophilic Polymer Emboli Associated with Neuroendovascular Procedures

*Papers 190 Starting at 7:20 AM, Ending at 7:25 AM*

**Purpose**

Hydrophilic polymer-coated catheters and wires are used widely for neurointerventional diagnostic and therapeutic procedures. Recent reports of hydrophilic polymer emboli have brought attention to the safety of these endovascular devices.
**CASE REPORT**

Patient 1 presented with a right middle carotid artery (MCA) M1 segment thromboembolic occlusion with associated hypoperfusion in the right MCA distribution. The patient underwent endovascular intervention using the following equipment and thrombectomy devices: 6F Cook Shuttle sheath, 5 Terumo glidcatheter, 035 Terumo glidewire, 054/041/032 Penumbra aspiration catheters and separators, Synchro-2 microwires, Xpedion microwire, and Hyperglide balloon. Due to resulting large right hemispheric infarct and elevated intracranial pressure, a decompressive hemicraniectomy and right frontal-temporal lobectomy was required. Histopathology specimens demonstrated areas of severe frontal lobe infarction and intravascular organized thrombus that was peculiarly marred with foci of nonpolarizable, basophilic foreign material. Patient 2 initially presented with vertigo and underwent extensive imaging evaluation that included diagnostic carotid/cerebral angiogram with the following equipment: 5F Terumo glidcatheter and 035 Terumo glidewire. The patient returned 1 month later with large acute intraparenchymal hemorrhage in the right temporal lobe with associated mass effect and 8 mm midline shift. A right frontal-temporal craniotomy with tissue biopsy was performed to exclude amyloidosis. Further clinical and imaging evaluations were negative for an underlying etiology for the patient’s intracranial hemorrhage. Although the histopathology specimens found no evidence of vasculitis, amyloidosis, or tumor, intravascular thrombotic foci of nonpolarizable, basophilic foreign material was identified, resembling the findings in patient 1.

**IMAGING FINDINGS**

We report two interesting cases of a complex neurointervention and routine diagnostic cerebral angiogram that were complicated with hydrophilic polymer emboli. Surgical histopathology specimens in both patients demonstrated identical organizing intravascular thrombi with foci of foreign material resembling hydrophilic polymer emboli.

**SUMMARY**

We provide further evidence that hydrophilic-coated catheters or wires may be the origin of these iatrogenic emboli with the potential for grave complications, requiring further investigation and reassessment of their safety.

**KEY WORDS:** Hydrophilic catheters, polymer emboli

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**CASE REPORT**

We prospectively evaluated 20 consecutive patients (9 females and 11 males) with known or suspected BVMs who underwent magnetic resonance imaging (MRI) studies of the brain which included PCSWI to assess for the presence of arteriovenous shunting (AVS). Eighteen patients also underwent time-of-flight and contrast-enhanced magnetic resonance angiography (TOFMRA, CEMRA) and 17 underwent routine precontrast susceptibility-weighted imaging (SWI). All patients underwent catheter digital subtraction angiography (DSA) without therapeutic interventions between the MRI and DSA. The presence of AVS in the PCSWI or SWI sequence was determined by the presence of signal hyperintensity in the venous structures adjacent to the BVM. We also measured the accentuation of abnormal signal hyperintensity in these venous structures on the PCSWI images by calculating the PCSWI/SWI signal intensity ratios for the most prominent such venous structure.

**IMAGING FINDINGS**

A total of 20 BVMs were identified by DSA (10 newly diagnosed arteriovenous malformations with AVS, 4 dural arteriovenous fistulas with AVS, 4 treated arteriovenous malformations with residual AVS and 2 complex developmental venous anomalies without AVS). In one patient, no BVM or AVS was identified by DSA. Postcontrast susceptibility-weight imaging was 100% sensitive and 100% specific with 100% positive predictive value (PPV) and 100% negative predictive value (NPV) for the detection of AVS. In contrast, SWI was only 73% sensitive and 100% specific with a 33% NPV and 100% PPV for the detection of AVS. Time-of-flight MRA was 60% sensitive and 100% specific with an NPV of 14% and a PPV of 100%. Contrast-enhanced MR angiography was 89% sensitive, 33% specific with an NPV of 33% and a PPV of 91%. Even in those patients with positive SWI or CEMRA studies, the PCSWI studies were more useful in depicting crucial AVS patterns such as retrograde flow in superior ophthalmic veins or additional deep draining veins in cerebral parenchymal AVMs. There was improved contrast on the PCSWI with a mean PCSWI/SWI signal intensity ratio in the most prominent early draining venous structure in patients with AVS of 1.44 ± 0.39.

**SUMMARY**

Postcontrast susceptibility-weighted imaging appears to be superior to SWI, TOFMRA and CEMRA for the detection of AVS in BVMs. Hence, this novel sequence may be useful in the initial diagnosis and follow-up of patients with BVMs to detect AVS.

**KEY WORDS:** Susceptibility-weighted imaging, arteriovenous malformations, arteriovenous fistulas

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**Paper 191 Starting at 7:25 AM, Ending at 7:30 AM**

**Postcontrast Susceptibility-Weighted Imaging: A Novel Technique for the Evaluation of Brain Vascular Malformations**

Jagadeesan, B. D. • Delgado Almandez, J. E. • Benzinger, T. L. S. • Moran, C. J.

Washington University in St. Louis Olivette, MO

**PURPOSE**

To explore the utility of postcontrast susceptibility-weighted imaging (PCSWI) for the detection of arteriovenous shunting (AVS) in brain vascular malformations (BVMs).
Incidence of Small Ruptured Aneurysms in a Series of Patients with Acute Subarachnoid Hemorrhage Undergoing Endovascular Treatment in a Tertiary Referral Center during a Consecutive 5-Year Period

Jagadeesan, B. D. • Delgado Almandoz, J. E. • Loy, D. N. • Cross, D. T. • Derdeyn, C. P. • Moran, C. J.
Washington University in St. Louis
Olivette, MO

PURPOSE
To retrospectively assess the incidence of small ruptured aneurysms (less than 3 mm in size) in patients with acute subarachnoid hemorrhage (ASAH) treated with endovascular coil embolization over a 5-year period in a tertiary referral center.

CASE REPORT
We retrospectively reviewed the size of the ruptured aneurysms in all the patients who had presented to our institution with ASAH and had subsequently undergone emergent ECE during a 5-year period from 2005 to 2010. Maximum diameter of these aneurysms previously had been recorded in a prospectively maintained quality assurance database. These measurements were based on the size of the framing coil which was used for ECE. With regard to ECE, in patients with more than one aneurysm, the aneurysm thought to be responsible for the ASAH was coiled based on distribution of the blood in the subarachnoid space. We also treated the other aneurysms in these patients, if they were amenable to ECE during the same procedure or if we could not clearly distinguish the ruptured aneurysm from the others. No patients had a prior known history of ASAH.

IMAGING FINDINGS
During the period from 2005 to 2010, we performed a total of 702 ECE procedures at our institution. Of these, 248 (35.3%) were performed emergently in 274 patients (201 females and 73 males, mean age = 53.5 ± 16.1 years) with a ruptured aneurysm and ASAH. In 12 patients, we performed parent artery sacrifice. In 14 patients, we were unsuccessful in ECE. Of the aneurysms treated with ECE, 209 (84.2%) were 7 mm or less in size and 85 (34.2%) were 3 mm or less in size. Only 15.8% were 8 mm or larger in size.

SUMMARY
The majority of ruptured aneurysms treated with ECE for ASAH at our institution were 7 mm or less in size and more than one third of them were 3 mm or less in size. These findings suggest that the data from the ISUIA trial which reported that the risk of ASAH from aneurysms less than 7 mm in size is very low must be interpreted with caution. Further, our data suggests that conventional catheter digital subtraction angiography must remain the gold standard in the evaluation of patients presenting with ASAH given the reported inherent limitations of CT angiography in the detection of small aneurysms, particularly those less than 3 mm in size.

KEY WORDS: Aneurysms, subarachnoid hemorrhage, endovascular treatment

Transcirculation Endovascular Treatment of Cerebral Aneurysms

Albuquerque, F. C. • McDougall, C.
Barrow Neurological Institute, Neurosurgical Associates
Phoenix, AZ

PURPOSE
Unfavorable anatomy can preclude embolization of intracranial aneurysms. Transcirculation techniques, in which a catheter is navigated from one side of the brain to the other or from the anterior to the posterior circulation, are alternative pathways for primary or balloon/stent-assisted coiling. We report the largest experience in coil embolization of aneurysms using these techniques.

CASE REPORT
We reviewed our endovascular database from 2006 to 2009 and identified 18 patients who had aneurysms treated with transcirculation techniques.

IMAGING FINDINGS
Eight patients had anterior and 10 had posterior circulation aneurysms. Overall, eight patients were treated with stent-assisted coiling and nine with balloon-assisted coiling, including one patient treated with a “kissing balloon” technique. Of the nine patients treated with balloon-assistance, one also was stented at the conclusion of aneurysm coiling. One patient with a left V4 aneurysm was treated with coiling alone via a bilateral vertebral artery (VA) approach. In 14 patients, the anterior communicating and posterior communicating arteries were used as conduits. In four patients, both VAs were traversed to treat two V4 aneurysms and two posterior inferior cerebellar artery aneurysms. One permanent complication (5.6%), a death, occurred as a result of treatment. Complete or near complete (>95%) embolization was achieved in all patients.

SUMMARY
Transcirculation techniques are effective pathways for embolization of complex aneurysms. Although technically challenging, these techniques are associated with an acceptably low rate of complications when compared to the natural history of the treated lesion.

KEY WORDS: Endovascular, transcirculation, aneurysms
Pathologic Contrast Enhancement of the Oculomotor and Trigeminal Nerves Caused by Intracranial Hypotension Syndrome

Albayram, S. • Asik, M. • Hasiloglu, Z. • Dikici, A. • Erdemli, H. • Toprak, M. • Altintas, A.
Istanbul University
Istanbul, TURKEY

**PURPOSE**
To present a case of pathologic contrast enhancement of the oculomotor and trigeminal nerves associated with intracranial hypotension syndrome.

**CASE REPORT**
A 32-year-old female who underwent caesarean section 6 months prior to presentation under spinal anesthesia, was referred to our neurology clinic because of severe headache, neck and back pain, and weakness. After 1 month, her headache worsened and neck pain, tinnitus, diplopia, and paresthesia of the face appeared and the patient was hospitalized under the neurology service. The findings of physical examination were headache in the upright position and relieved in the horizontal position and also, paralysis of third cranial nerve (CN3). The case history suggested intracranial hypotension syndrome because the patient underwent spinal anesthesia and the clinical and MR imaging findings disappeared after blood patch therapy. As a result, we feel that there is thickening and pathologic contrast enhancement of these intracranial nerves are caused by intracranial hypotension syndrome.

**IMAGING FINDINGS**
On cranial MR imaging, intracranial hypotension syndrome is characterized by dural thickening and contrast enhancement, subdural effusion, engorgement of the venous structures, sagging or downward displacement of the brain, and pituitary hyperemia. In most of the characteristic cases, there is extradural collection, dural thickening/contrast enhancement, dilation of the extradural and dural veins, spinal dural collapse, meningeal diverticuli, C1-C2 retrodural collection, syringomyelia, and collection in the spinal nerve roots. We presented a 32-year-old patient whose cranial MR imaging showed bilateral pathologic contrast fixation of CN3 and CN5 and described a new imaging finding in intracranial hypotension syndrome. MR myelography showed the tract at the level extending to the hypodermis and causing cerebrospinal fluid (CSF) leakage. After blood patch therapy, follow-up MR imaging showed that the contrast enhancement in CN3 and CN5 resolved.

**SUMMARY**
The differential diagnosis of severe headache, neck pain, diplopia, and facial paresthesias with pathologic contrast enhancement of the intracranial nerves on MR imaging is broad, and includes benign and malignant neoplastic conditions, infectious conditions, postinfectious demyelinating diseases, granulomatous diseases, and postradiation neuritis. Although clinical findings related to CN3 and CN5 have been described in intracranial hypotension, pathologic contrast enhancement of these nerves has not. We believe that the MR imaging findings were related to intracranial hypotension syndrome because the patient underwent spinal anesthesia and the clinical and MR imaging findings disappeared after blood patch therapy. As a result, we feel that there is thickening and pathologic contrast enhancement of these intracranial nerves are caused by intracranial hypotension syndrome.

**Paper 194 Starting at 6:45 AM, Ending at 6:50 AM**

**Pathologic Contrast Enhancement of the Oculomotor and Trigeminal Nerves Caused by Intracranial Hypotension Syndrome**

Albayram, S. • Asik, M. • Hasiloglu, Z. • Dikici, A. • Erdemli, H. • Toprak, M. • Altintas, A.
Istanbul University
Istanbul, TURKEY

**RARE BUT FATAL COMPLICATION OF CARdio-ABLATION THERAPY**

Potter, G. M. • Moore, G. R. W. • Graeb, D. A.
University of British Columbia
Vancouver, BC, CANADA

**PURPOSE**
To show a rare but fatal central nervous system (CNS) complication following cardio-ablation.

**CASE REPORT**
A 43-year-old male, with a history of multiple failed radiofrequency ablation procedures for atrial fibrillation, presented to ER with sudden onset of right leg pyramidal weakness and right nasolabial flattening, associated with pyrexia. INR was 4.0. Blood cultures grew streptococcus oralis, streptococcus sanguis, neisseria sica and staphylococcus aureus. Five weeks prior to this, the patient underwent left atrial ablation using a transseptal puncture; ablation was noted to be difficult due to left atrial enlargement. CT head and CT angiography on admission were normal. Immediately following the CT, the patient developed significant upper gastrointestinal bleeding leading to cardiac
arrest, with successful resuscitation. He subsequently stabilized in ICU, with a clinical diagnosis of presumed small anterior cerebral artery stroke or TIA. Later that day, he developed further massive upper GI bleeding, leading to emergency gastroscopy followed by laparotomy and oversewing of a Mallory-Weiss tear at the gastro-esophageal junction. Postoperative CT showed severe diffuse ischemic-hypoxic injury and intracranial air. The patient was pronounced brain dead following CT. Autopsy revealed a 1cm fistula between the left atrium and mid-esophagus containing thrombus. Post-mortem brain examination showed: (1) diffuse ischemic-hypoxic encephalopathy and a hemorrhagic infarct in the left frontal lobe (felt to represent the pathologic correlate of the initial right hemiparesis); (2) left hippocampal and right cerebellar hemorrhages/infarcts, consistent with a recent cardioembolic source; (3) right occipital cerebritis with intravascular cocci, consistent with an origin from atrio-esophageal fistula; and (4) multifocal leptomeningitis, in keeping with septic seeding. The intracerebral air observed on the CT scan during life was believed to have been the result of embolization from the atrio-esophageal fistula. It was postulated that subarachnoid air may have resulted from dissection of embolized air through necrotic vessel walls and thence necrotic subpial parenchyma.

**IMAGING FINDINGS**
Postlaparotomy CT head showed diffuse parenchymal low attenuation with loss of gray-white differentiation, generalized sulcal effacement and mild ventricular compression, in keeping with diffuse ischemic-hypoxic injury. In addition, there were multiple locules of parenchymal (arrow) and subarachnoid air, with further locules of air in the internal cerebral veins.

**SUMMARY**
This case demonstrates a rare but fatal CNS complication of cardio-ablation therapy, with formation of an atrio-esophageal fistula leading to septic cardioembolic emboli, cerebritis, leptomeningitis and intracranial air embolization.

**KEY WORDS**: Atrio-esophageal fistula, air embolization, cardio-ablation

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**Paper 196 Starting at 6:55 AM, Ending at 7:00 AM**

**Intraventricular Cavernous Angioma: An Unusual Intraventricular Mass Presenting with Obstructive Hydrocephalus**

Lensing, F. D. • Vandergriff, C. • Layton, K. • Herzog, S. • Doughty, B. • Gupta, M. • Opatowsky, M.

Baylor University Medical Center
Dallas, TX

**PURPOSE**
To illustrate the unusual intraventricular presentation of a relatively common intracranial vascular malformation. To discuss intraventricular cavernous angioma, its presentation, imaging features and differential diagnostic considerations.

**CASE REPORT**
A 33-year-old female with chronic history of migraine headaches associated with menstruation. Over the weeks prior to presentation, she developed new worsening headaches with increasing frequency. Following imaging workup, the patient was taken to the operating room for resection of an intraventricular mass.

**IMAGING FINDINGS**
Noncontrast head CT demonstrated a 1.3 cm hyperdense mass in the region of the Foramen of Monro with resultant hydrocephalus (Figure 1). Susceptibility-weighted imaging from MRI brain demonstrated susceptibility artifact associated with the lesion (Figure 2). TI-weighted postcontrast MRI demonstrated a heterogeneously enhancing mass at the Foramen of Monro. Nearby vascular malformations, including a developmental venous anomaly and a punctate cavernous angioma of the left caudate head, also were noted.
SUMMARY
Surgical resection of the lesion was performed, and pathology demonstrated cavernous angioma. The differential diagnosis for intraventricular masses at the Foramen of Monro is broad and classically includes choroid plexus papilloma, ependymoma and central neurocystoma. The presence of susceptibility artifact within an intraventricular mass should prompt a search for additional nearby vascular malformations, as the suggestion of intraventricular cavernous angioma by the neuroradiologist carries important prognostic information for the patient and important preoperative considerations for the neurosurgeon.

KEY WORDS: Cavernoma, angioma, intraventricular

Isolated Cortical Vein Thrombosis as an Unusual Stroke Presentation

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Leeds Radiology Academy
Leeds, UNITED KINGDOM

PURPOSE
Highlight the clinical and radiographic features of cerebral venous thrombosis in the absence of sinus thrombosis that allow us to make a prompt diagnosis.

CASE REPORT
We report a previously fit and well 41-year-old woman presenting to the emergency department with 3-day history of headache and mild left arm weakness. Computed tomography (CT) demonstrated reduced attenuation in the superficial right parietal lobe with edema. Patient underwent further evaluation with MR imaging (MRI)-MR venography (MRV) which demonstrated right parietal cerebromalacia with minor hemorrhagic debris and an under-filling cortical vein extending from the area of gliosis in the right parietal lobe to the superior sagittal sinus. However, the major venous sinuses were patent.

IMAGING FINDINGS
Cranial CT (not shown): Noncontrast study shows a hyperdense cortical vein and petechial hemorrhage. Contrast-enhanced CT and CT venography (CTV) shows irregular vein with loss of enhancement and enlarged collateral channels. MR findings: Figure 1. Sagittal T1-weighted imaging: hyperintensity (clot) in cortical vein with surrounding edema. T2-weighted imaging and FLAIR images show clot in the cortical vein with secondary signs of venous hypertension. T2* GRE: Hypointense clot with blooming artifact and venous hemorrhage. Figures 2 and 3. MR venography (MRV) shows nonfilling of cortical vein at site of hyperintensity on T1-weighted imaging.

SUMMARY
The clinical diagnosis of isolated cerebral vein thrombosis is elusive and often delayed. High index of suspicion is required when CT and conventional MRI findings demonstrate ischemia and/or hemorrhage that do not follow the classical arterial boundaries, especially if subcortical. Such findings should prompt further evaluation with CTV, MRV and conventional angiography for equivocal cases.

KEY WORDS: Stroke, venous
Reversible Cervical Internal Carotid Artery Vasospasm in a Patient with Atypical Migraines

Silver, J. M. 1,2 • Hart, B. L. 3 • Carlson, A. 3 • Roy, G. 3

1University of Vermont, Burlington, VT, 2University of New Mexico, Albuquerque, NM

Purpose

Although intracranial vasospasm is well known, spontaneous and recurrent vasospasm of the extracranial carotid arteries is a rare condition. We report a case of recurrent spontaneous cervical internal carotid artery (ICA) vasospasm in a patient with a pre-existing atypical migraine, as well as new onset nonobstructive cardiac ischemia with cardiomyopathy.

Case Report

A 55-year-old woman experienced four episodes of transient right-sided hemiparesis with aphasia, each lasting for 10 to 15 minutes. Medical history was significant for recent non-ST elevation MI for which she underwent cardiac catheterization with no evidence of coronary artery disease, subsequent anticoagulation, and several occurrences of unilateral numbness and tingling of her face, arms, and legs over the last 30 years. Dissection was excluded by imaging and clinical correlation, and clinical and laboratory markers for vasculitis were not present. Multiple imaging modalities over 4 weeks demonstrated fluctuating patterns of narrowing of the left and right cervical ICAs, without evidence of cerebral vasospasm or infarction. At one point a planned stenting of the right ICA was canceled when angiography revealed a normal appearance of the previously narrowed vessel but occlusion of the previously normal left ICA. The patient was treated with a long-acting nitrate and a tapering course of prednisone. A month later during outpatient follow up she denied any further symptoms, and repeat imaging showed complete resolution of ICA stenoses.

Imaging Findings

Outpatient MRI (designated here as day1) showed narrowing of the left cavernous ICA, and nonspecific white matter changes. MR imaging and MR angiography on day 23 showed normal left ICA and occlusion of the right cervical and intracranial ICA, also confirmed on CTA on day 24. Angiography on day 27 showed a nearly normal appearance of the right ICA but occlusion of the left cervical ICA. MR angiography on day 28 showed narrowing but flow of the left cervical ICA. MR angiography of the head and neck 1 month later, after nitrate and steroid therapy, was nearly normal.

Summary

Spontaneous and recurrent vasospasm of the extracranial carotid arteries rarely is reported. This patient had fluctuating findings of bilateral cervical ICA narrowing that changed over several weeks, and then within the space of a few days. There are intriguing clues to pathophysiology in atypical migraines, but the precise mechanism remains unclear. Cervical carotid vasospasm is a diagnosis of exclusion. Given this patient’s unique cardiac and neurologic history, we believe she may suffer from a diffuse form of vasospasm affecting the coronary, cervical, and intracranial vasculature.

Key Words: Vasospasm, carotid artery

Bilateral Absence of the Common Carotid Arteries with Separate Origins of the Internal and External Carotid Arteries Detected by CT Angiography: Case Report

Supsupin, E. P. • Bonfante-Mejia, E. E. • Choi, J. M. • Sitton, C. W. • Hochhauser, L.

University of Texas Medical School at Houston Houston, TX

Purpose

We report a rare case of bilateral absence of the common carotid arteries (CCAs) with separate origins of the internal carotid (ICAs) and external carotid arteries (ECAs). This is the first CTA portrayal of this phenomenon to our knowledge. Only two such cases were reported previously. The first described in 1784 by Malacarne involved a double aortic arch with independent origins of the ICAs and ECAs from each of these arches. The only other case in 1978 described exclusive origins of the bilateral ICAs and ECAs with a single arch on conventional angiography. Agenesis of both CCAs is shared by our case. However, an added feature involving a common origin of the left ICA and LVA makes our case unique. Neither of the previous reports described this additional variant. Common origin of the left ICA and LVA was once observed, but not in this setting. Persistence of the ductus caroticus with involution of the 3rd aortic arch is the most commonly accepted mechanism for this spectacle.

Case Report

A 25-year-old Hispanic man had undergone cervical spinal fusion. Concerns of injury to the LVA following screw placement prompted a CTA, revealing this interesting anatomy.

Imaging Findings

CT angiography demonstrates absence of both CCAs with independent origins of the ICAs and ECAs on each side, individually ascending into the neck as separate vessels. The right ECA and ICA separately emanate from the innominate artery (IA) proximal to the right subclavian artery (RSCA) origin. On the left, the ECA directly originates from the aortic arch, whereas the left ICA and LVA arise from a single vessel trunk off the arch.
**Summary**

We report a rare case of bilateral CCA agenesis that is distinct from those published earlier. To our knowledge, this is the first CTA illustration of this phenomenon.

**Key Words:** Absence of both common carotid arteries, bilateral common carotid artery agenesis, common origin left carotid and vertebral art

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**Paper 200 Starting at 7:15 AM, Ending at 7:20 AM**

**Spontaneous Intracranial Hypotension Due to Intradural Thoracic Osteophyte with Superimposed Disk Herniation: Report of Two Cases**

Hasiloglu, Z. • Abuzayed, B. • Imal, A. • Cagil, E. • Keser, Z. • Albayram, S.

Istanbul University

Istanbul, TURKEY

**Purpose**

To describe two cases of spinal osteophytes with superimposed disk herniation which can cause spinal tear with resultant cerebrospinal fluid (CSF) leakage and spontaneous intracranial hypotension (SIH) syndrome.

**Case Report**

Case 1: A 32-year-old woman presented with diffuse headache, neck pain, stiffness and nausea. Headache was posture-related type, intensifying when standing upright and relieving when lying in supine position. Case 2: A 42-year-old healthy woman presented with headache, dizziness, vertigo, nausea and vomiting. The headache was present in the upright position. Physical and neurologic examination revealed no abnormalities.

**Imaging Findings**

Case 1: Cranial magnetic resonance imaging (MRI) showed evidence of dural thickening and enhancement. We applied computed tomography (CT) myelography to the patient, who possibly had SIH according to clinical and cranial MRI findings, for searching etiology of CSF leakage and spontaneous intracranial hypotension (SIH) syndrome. Spinal CT and CT myelography revealed a large osteophyte with disk herniation in the thoracic level of T2-T3 with obvious CSF leakage in the same level. The patient underwent an epidural blood patch (EBP) under fluoroscopic guidance. Four months after the procedure the patient showed complete recovery. Follow-up MR imaging indicated complete resolution of dural thickening and enhancement. Case 2: Cranial MRI showed evidence of dural thickening and enhancement. Spinal CT and CT myelography revealed osteophytes with disk herniation in the thoracic levels of T5-T6 and T11-T12 and objective CSF leakage. The patient underwent an EBP under fluoroscopic guidance. The patient described significant improvement of the complaints. Follow up after 6 months of the procedure showed complete resolution of dural thickening and enhancement.

**Summary**

Spontaneous intracranial hypotension is a clinical syndrome in which absolute or relative hypovolemia of the cerebrospinal fluid results in various neurologic symptoms. On cranial MRI, SIH is characterized by dural thickening and contrast enhancement, subdural effusion, engorgement of the venous structures, and sagging or downward displacement of the brain. The etiology of spontaneous CSF leaks often remains unknown. However, it is believed that the most common cause is the fragility of the spinal meninges at the level of the radicular nerve root sleeve. Spinal pathologies can cause this tear with resultant CSF leakage and SIH, which include spinal trauma, degenerative diseases and spinal surgery. Uncommonly, SIH is developed by osteophyte due to disk herniation without any other pathology. In this study, we reported two cases of SIH secondary to spinal dural tear due to intradural thoracic osteophyte with superimposed disk herniation, with the absence of other pathologies, which were treated successfully with EBP.

**Key Words:** Spontaneous intracranial hypotension, spinal osteophyte, headache

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**Paper 201 Starting at 7:20 AM, Ending at 7:25 AM**

**Intravitreal Silicone Oil Migration into the Subarachnoid Space and Ventricles: A Case Report**

Chen, J. X. • Nidecker, A. E. • Aygun, N. • Gujar, S. • Gandhi, D.

Johns Hopkins Hospital

Baltimore, MD

**Purpose**

For over five decades, silicone has been used as an endotamponading agent in vitreoretinal procedures to prevent recurrent retinal detachment or vitreal hemorrhage. While no normal connection exists between intraocular space and posterior neural elements of the eye, migration of silicone oil posterior to the lamina cribosa into areas of the optic nerve and subarachnoid space can occur. Knowledge of this phenomenon remains limited in the radiologic community, which can lead to misinterpretations of imaging findings. We thus present a case of intravitreal silicone oil migration via the optic pathways into the subarachnoid space and ventricles.

**Case Report**

A 39-year-old man with blindness secondary to diabetic retinopathy had multiple admissions over the course of 23 months for fall-related injuries, recurrent headaches, and exacerbation of his underlying medical conditions. Between all admissions, six noncontrast head CTs, one head MRI, and one cerebral angiogram were performed for repeated con-
cern for intracranial hemorrhage. During each admission, the patient exhibited nonspecific symptoms that resolved by the time of discharge and never developed focal neurologic deficits despite abnormal imaging findings. Comprehensive review of imaging findings and pertinent literature was confirmatory for the diagnosis of intravitreal silicone oil migration.

**IMAGING FINDINGS**

Over the course of several studies, the silicone oil could be observed migrating from the intraocular space to the optic nerve, optic chiasm, and ventricular system, demonstrating the ability of the oil to penetrate into the subarachnoid space in certain patients. On CT, the silicone oil appeared hyperdense, and shifted amongst nondependent regions of the ventricular system between studies. MR imaging (MRI) demonstrated intraventricular floating droplets with signal drop-out on GRE, hyperintensity on T1 and T2 sequences, and chemical shift artifact. The described CT and MRI characteristics also were observed for the intraocular silicone oil.

**SUMMARY**

Intraventricular silicone oil migration is a distinctly rare phenomenon that has been seldomly described in radiologic literature. It can be distinguished radiographically from other potential substances like blood or air by CT attenuation level, shift artifact on MRI, globular shape, and nondependent migration characteristics. The presented case illustrates the importance of considering this diagnosis when encountering abnormal intraventricular imaging findings in a patient with stable neurologic status and pertinent history of vitreoretinal interventions or disease. Prompt identification of silicone oil through knowledge of its radiographic appearance in these cases will help to avoid unnecessary imaging and hospitalization time.

**KEY WORDS:** Silicone, ventricles

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**Paper 202**

Starting at 7:25 AM, Ending at 7:30 AM

**Spontaneous Intracranial Hypotension Presenting with Isolated Vestibulo-Cochlear Symptoms**

Jung, M. W. • Narang, J. • Patel, S. C. • Seidman, M. • Jain, R.

Henry Ford Hospital
Detroit, MI

**PURPOSE**

Spontaneous intracranial hypotension diagnosis is often one of exclusion, but the characteristic features are the presence of an orthostatic headache in combination with low cerebrospinal fluid (CSF) pressure and diffuse pachymeningeal enhancement on cranial magnetic resonance imaging (MRI). Additional symptoms have been reported including dizziness, hearing loss, and tinnitus, thought to be due to transmission of the abnormal CSF pressure across Reissner’s membrane to the perilymph of the cochlea. We present two cases that illustrate the importance of neuroimaging in the evaluation of patients with isolated vestibulo-cochlear symptoms due to spontaneous intracranial hypotension.

**CASE REPORT**

Case 1 describes a 67-year-old male with left greater than right hearing loss for 6 months, nasal congestion and an abnormal ABR. He denied headache or orthostatic symptoms. He had a history of gastric cancer treated with chemotherapy and radiation. He had a history of fall 2 years prior with left maxillary sinus fracture and small subdural hematoma. He underwent LP with a low opening CSF pressure. Case 2 is a 58-year-old male who presented with a 3-year history of right greater than left hearing loss and developed right side tinnitus and dizziness "when turning his head to look up". He denied headache and a history of trauma.

**IMAGING FINDINGS**

MR imaging showed diffuse pachymeningeal enhancement with sagging of diencephalon and flattening of the pons belly, suggesting intracranial hypotension in both cases. No other middle or inner ear abnormality was seen.

**SUMMARY**

Although orthostatic headache is the most common clinical feature in intracranial hypotension, rarely patients with spontaneous intracranial hypotension can present with isolated vestibulo-cochlear symptoms. These clinical symptoms often mimic other diseases such as Meniere. MR imaging is essential in assisting in the diagnosis of this disease entity.

**KEY WORDS:** Intracranial hypotension, hearing loss, MR imaging
Can a Statin’s Effects on the Brain Be Measured by Perfusion and Spectroscopy?

Moser, F. G. • Izadi, K. • Binesh, N. • Saidian, L. • Prasad, R. • Pressman, B. D. • Cohen, R. M.

Cedars-Sinai Medical Center
Los Angeles, CA

PurPOSE
The statin drugs are used for lowering blood cholesterol levels. It has been noted that they have a positive side effect that might slow the progression of dementia, especially Alzheimer disease. Here we performed a preliminary study to see if the effects of statins on the brain can be quantified by MR imaging (MRI) using perfusion and spectroscopy or more specifically, the changes in cerebral blood volume (CBV) and metabolite concentrations.

CASE REPORT
Eighteen volunteers with high blood cholesterol were recruited. They were divided into two groups. The first group contained individuals who wanted to use a statin (Liptor mainly) to lower their cholesterol levels with diet alone. All volunteers went through a screening test and a baseline MRI-MRS. The MRI mainly consisted of brain perfusion (T2*) and a fast EPI sequence following the administration of a single dose of gadolinium-based contrast agent. The perfusion was postprocessed with Siemens software to obtain relative CBV (rCBV) and relative cerebral blood flow (rCBF). The rCBV was normalized with respect to healthy white matter for the between subjects comparison. The MRS was done with single voxel spectroscopy (SVS) at three different locations in the brain, namely the hippocampus, the parietal cortex and the posterior cingulated gyrus. The spectra were fitted with LC-Model.

IMAGING FINDINGS
The spectra from all three locations were compared. There was no significant change between the initial scan and the 3-months follow up in both groups. The same results also were obtained when comparing the normalized CBVs, i.e., there was no significant change at any measured location between the two scans. This could be due to the following facts: 1) small size of samples, 2) the time between the baseline and follow-up scan is not enough to see any changes, 3) the change (if any) in CBV or metabolites concentrations is very small as compared with fluctuation and noise of measurement, or 4) statins have no effect on the cerebral MRS or perfusion.

SUMMARY
The study showed no significant changes in brain metabolites level or the cerebral blood volume, when we compare the baseline exam with the 3-months follow-up scan for either of our groups. A further study is required to establish the validity of these results, which would incorporate a larger group of subjects (to reduce SD) and also scan the subjects at three stages (baseline, 3 months and 1 year follow up).

KEY WORDS: Statin, dementia, metabolites
Acute hemorrhagic leukoencephalopathy is a rare and usually fatal disease that requires early diagnosis to direct appropriate treatment. Findings range from demyelination with petechial hemorrhages to gross white matter hemorrhages. Sparing of the cortex is striking. T2* (especially susceptibility-weighted imaging) should be considered in suspected cases of ADEM and AHLE to improve sensitivity for recognition of this entity.

**KEY WORDS:** Acute, hemorrhagic, leukoencephalitis
Tuesday Morning
8:45 AM - 10:15 AM
Ballroom 6 B/C

(16) Plenary Session: Socioeconomic Programming: Hot Topics

(207) *2011 J. Arliss Pollock, MD Memorial Lecture
— Patrick A. Turski, MD

(208) Federal Health Reform 2011: The Impact of Neuroradiology Practice
— Frank J. Lexa, MD

(209) Certificate of Need: The Good, The Bad, and The Not So Ugly
— Suresh K. Mukherji, MD, FACR

Moderator: Patrick A. Turski, MD

*Contributions of Arliss Pollock to the ASNR and Introductions

2011 J. Arliss Pollock, MD Memorial Lecture
Patrick A. Turski, MD

Presentation Summary
This socio-economic session is held in honor of J. Arliss Pollock, MD a pioneering neuroradiologists who passed away in 2007. All neuroradiologists since the founding of the American Society of Neuroradiology (ASNR), have benefited from the proactive efforts put forth by Dr. Pollock both in his practice and his unending work for the ASNR. A true visionary, he was one of the first physicians specializing in neuroradiology. He introduced cerebral angiography into the community setting and he offered unique perspective in multiple areas. Perhaps his greatest contribution was his leadership and willingness to carve out a new presence for the ASNR in the area of socioeconomics. For years, he led the ASNR in health policy efforts that impact neuroradiology practice and assured proper representation of neuroradiology interests at the AMA CPT Editorial Panel Advisory Committee and the Relative Value Scale Update Committee (RUC). These multispecialty committees create codes for new technologies and procedures and develop values that set the physician reimbursement rates. ASNR is forever indebted to Dr. Pollock’s contribution in the Clinical Practice Committee, Appropriateness, Standards, Guidelines, Government Relations, Utilization, and clinically relevant technology. In 2001, he received the ASNR’s highest award, the Gold Medal for his exceptional leadership and contributions to the society. We dedicate a session each year at the annual meeting to recognize his leadership and commitment to neuroradiology.

Federal Health Reform 2011: The Impact of Neuroradiology Practice
Frank J. Lexa, MD

Presentation Summary
In 2010, a historic bill was signed into law by the President of the United States that substantially transforms health care delivery during the subsequent decade. This address will start with an introduction to the key elements of this bill and how it affects those of us in neuroradiology. The economic, social, political and cultural drivers of health care reform in its current form will be discussed. In addition, we will review the key challenges that will drive future reforms regardless of shifts between the two dominant political parties in the USA. We then will focus on two specific aspects of Federal health reform that will likely have substantial impact on the practice of neuroradiology: Accountable Care Organizations (ACO) and Comparative effectiveness research (CER). We will review the current concepts of what ACOs may look like when they are launched in January of 2012 and how neuroradiologists and their groups may participate in them. We will close by analyzing how CER will be constructed within the current Federal system and how it may evolve over time and change the practice of our specialty.

Certificate of Need: The Good, The Bad, and The Not So Ugly
Suresh K. Mukherji, MD, FACR

Presentation Summary
There are numerous strategies for attempting to control health care costs. One of the most commonly used approaches at the state level are Certificate of Need (CON) regulations. This presentation will review the history of CON. It also will provide detailed insight to how CON functions at the state level including the composition of various committees and interested constituencies.
Tuesday Morning
10:45 AM - 12:30 PM
Ballroom 6 B/C

(17a) Cerebrovascular Occlusive Disease
(Scientific Papers 210 - 222)

See also Parallel Session
(17b) Spine: Trauma, Spinal Cord & Degenerative
(17c) Interventional: Thrombolysis/Stroke
(17d) Brain: New Techniques/Post Processing
(17e) Adult Brain: Neoplasms

Moderators: Bruno A. Policeno, MD
Pamela W. Schaefer, MD

Paper 210 Starting at 10:45 AM, Ending at 10:53 AM
Influence of Choice of Arterial Input Function on Perfusion Parameter in Perfusion CT

Rassner, U. • Wilder, M. • Shah, L.
University of Utah
Salt Lake City, UT

PURPOSE
CT perfusion is used for stroke imaging to identify tissue at risk. However, no agreement exists on how to distinguish infarction from penumbra as some use relative and others use absolute measurements. Perfusion calculations assume that an arterial input function (AIF) measured in one vessel is representative for the entire brain. We investigated whether choice of AIF affected perfusion calculations and whether certain parameters were less affected by different AIFs.

MATERIALS & METHODS
Sixty-one consecutive CT perfusion studies performed on a Siemens Definition or Definition AS with 4D spiral technique were processed with AIFs in both middle cerebral arteries and the anterior cerebral artery using deconvolution on a Siemens Syngo Workstation. Exclusion criteria were motion and inadequate AIF. Absolute and relative cerebral blood flow and volume (CBF and CBV) and mean transit time (MTT) were calculated for each AIF in areas with supratentorial CBF/CBV mismatch and the corresponding area in the opposite hemisphere or from both entire hemispheres in absence of CBF/CBV mismatch. A 2-tailed Mann-Whitney Test was used to determine statistical significance.

RESULTS
Average deviation (AD) in percent for absolute right and left CBF (mL/100 g/min were 4.2±3.5 and 4.4±4.0, respectively, and 2.1±3 for relative CBF; 2.3±2.2 and 2.4±2.0 for absolute left and right CBV(mL/100 g), respectively, and 1.1±1 for relative CBV; 5.1±3.9 and 5.4±4.4 for absolute right and left MTT(sec), respectively, and 2.2±2.8 for relative MTT. Choice of AIF had a significantly smaller influence on relative CBF, CBV and MTT compared to absolute measurements. Absolute and relative CBV had smaller AD than absolute CBF and MTT. No significant AD difference was seen between absolute or relative CBF and MTT. In a subset of cases (Figure 1 ICA occlusion) different AIFs resulted in a large change in perfusion parameters, which affected whether certain areas did or did not meet criteria for tissue at risk. In these cases, collateral flow led to dispersed contrast curves in some vessels, and AIFs from nonaffected vessels led to higher MTT and lower CBF calculation.

CONCLUSION
Relative CBF, MTT and CBV were significantly less affected by choice of AIF than absolute measurements. Cerebral blood volume was significantly less affected than CBF and MTT. Importantly, in some cases with stenosis/occlusions and collateral flow, the choice of AIF greatly influenced perfusion calculations and determination if areas fulfilled criteria for tissue at risk. Recognition of this phenomenon can prevent erroneously categorizing parenchyma as tissue at risk.

KEY WORDS: Perfusion, stroke, tissue at risk
Comparison of Qualitative CT Perfusion Data Using Three Different Perfusion Processing Programs

Wu, S. P. • Rivas Rodriguez, F. F. • Myles, J. • Khalatbari, S. • Hoeffner, E. G.

1University of Michigan Medical School, Ann Arbor, MI, 2University of Michigan Health System, Ann Arbor, MI, 3University of Michigan, Ann Arbor, MI

PURPOSE
To correlate qualitative CT perfusion (CTP) values for cerebral blood flow (CBF), cerebral blood volume (CBV) and mean transit time (MTT) using three processing software programs.

MATERIALS & METHODS
CT perfusion exams on 27 patients with acute and chronic cerebrovascular disease were processed by two readers using Perfusion 3 software on an Advantage Workstation (GE Healthcare, Buckinghamshire, England), Vitrea 2 CT Brain Perfusion conventional singular value decomposition (SVD) software and Vitrea 2 CT Brain Perfusion delay-insensitive SVD (SVD+) software (Vital Images, Minnetonka, MN). The same source data were used for all programs. The perfusion maps for each program were evaluated by each reader to determine if perfusion parameters were normal or not normal for six cortical (bilateral ACA, MCA and PCA) and two deep (bilateral basal ganglia) vascular territories. Due to high prevalence rate of normal values, Kappa statistics would not be a reliable measure of agreement. Instead intrarater agreement for each CTP variable and interrater agreement between the two readers were assessed using proportion of positive agreement (PPOS) and prevalence adjusted bias adjusted kappa (PABAK).

RESULTS
The intrarater agreement for CBV was good for both readers between all programs. For CBF, Reader 1 had good agreement for GE vs SVD+ and moderate agreement for SVD vs SVD+ and for GE vs SVD. Reader 2 had moderate agreement for CBF between all programs. For MTT, Reader 1 had good agreement between all programs and Reader 2 had moderate agreement between all programs (Table 1). The interrater agreement for CBV was good across all programs. For CBF the interrater agreement between programs was moderate for GE and SVD and good for SVD+. There was moderate agreement across all programs for MTT (Table 2).

Table 1: Intrarater agreement between programs

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<thead>
<tr>
<th>Reader</th>
<th>Program 1</th>
<th>Program 2</th>
<th>PPOS</th>
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<td>0.97</td>
</tr>
<tr>
<td></td>
<td>GE</td>
<td>SVD+</td>
<td>0.99</td>
<td>0.56</td>
<td>0.97</td>
</tr>
<tr>
<td></td>
<td>GE</td>
<td>SVD</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
</tbody>
</table>

Table 2: Interrater agreement between two readers

<table>
<thead>
<tr>
<th>Program</th>
<th>PPOS</th>
<th>κ</th>
<th>PABAK</th>
</tr>
</thead>
<tbody>
<tr>
<td>MTT</td>
<td>0.96</td>
<td>0.50</td>
<td>0.87</td>
</tr>
<tr>
<td></td>
<td>0.95</td>
<td>0.55</td>
<td>0.81</td>
</tr>
<tr>
<td></td>
<td>0.93</td>
<td>0.29</td>
<td>0.73</td>
</tr>
<tr>
<td>CBF</td>
<td>0.99</td>
<td>0.32</td>
<td>0.96</td>
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<tr>
<td></td>
<td>0.95</td>
<td>0.53</td>
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<tr>
<td></td>
<td>0.93</td>
<td>0.33</td>
<td>0.75</td>
</tr>
<tr>
<td>CBV</td>
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<td>0.98</td>
</tr>
<tr>
<td></td>
<td>0.98</td>
<td>0.49</td>
<td>0.92</td>
</tr>
<tr>
<td></td>
<td>1.00</td>
<td>1.00</td>
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</table>

CONCLUSION
Qualitative assessment of CBV values showed high intrarater and interrater agreement among the three processing programs. Cerebral blood flow and MTT had moderate to good intrarater and interrater agreement among the three processing programs.

KEY WORDS: CT perfusion, postprocessing, cerebrovascular disease

Prevalence of Missed Infarcts and Other Inaccurate Findings at CT Perfusion for Acute Stroke Patients

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Medical University of South Carolina
Charleston, SC

PURPOSE
To retrospectively evaluate the performance of a multimodal CT protocol in patients presenting with acute stroke symptoms.
Two hundred twenty patients who underwent a multimodal CT protocol, including noncontrast CT, CT perfusion (CTP), and CT angiography of the head and neck for suspicion of acute stroke at a single institution over a 6-month period were reviewed retrospectively. The results at multimodal CT were compared with follow-up MRI, CT, and angiographic data to determine prevalence of inaccurate findings and reasons for which discrepant results occurred.

**RESULTS**

One hundred of 220 patients (45%) had focal perfusion abnormalities at CTP. Of the patients who did not have an abnormal perfusion scan, a total of 22 patients (21.4%) had infarct on follow-up MRI or CT. Of these, seven (6.8%) were due to lesions entirely beyond the perfusion scan range, 11 (10.7%) of the patients had small lesions (<2 cm), and five patients (4.8%) had perfusion sequences compromised by bolus timing or motion artifact. Of the patients with focal perfusion abnormalities at CTP, eight patients had no infarct on follow-up imaging (8/117 - 6.8%). These were felt to be due to chronic hypoperfusion (n=5), major intracranial stenosis successfully treated with angioplasty (n=1), chronic cortical lesions (n=1) and acute extracranial carotid dissection (n=1).

**CONCLUSION**

CT perfusion as part of a multimodal CT protocol for acute stroke triage has limitations, and incomplete coverage appears to be responsible for the false negative perfusion findings in less than 1/3 of cases. Small lesion size seems to be a much more common reason, while technical challenges in data acquisition and postprocessing are responsible in a small minority of cases.

**KEY WORDS:** CT perfusion, acute stroke

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We retrospectively analyzed 89 consecutive anterior circulation stroke patients treated with intra-arterial thrombolysis or mechanical thrombectomy over 5 years at two academic hospitals.

**RESULTS**

There were 44 females and 45 males, with a mean age of 67.9 years. Mean NIHSS at presentation was 15 (Range 2-29). The pretreatment imaging included noncontrast CT (NCCT) alone in 40 patients, NCCT, CTA and CT perfusion (CTP) in 40 patients, CT angiogram (CTA) in eight patients, and MRI including diffusion-weighted imaging (DWI) and perfusion-weighted imaging (PWI) in one patient. The most commonly occluded arteries were M1 segment (41 patients) and M2 segment (25 patients). Treatment was solely intra-arterial Tissue Plasminogen Activator (tPA) infusion in 66 patients, mechanical thrombectomy (MT) alone in four patients and a combination of tPA and MT in 19. Successful recanalization to Thrombolysis in Cerebral Ischemia (TICI) 2b/3 was achieved in 39 patients (44%). Recanalization rates were similar in patient with and without perfusion imaging, 43.9% and 43.8%, respectively. Overall rate of PH2 was 6/89 (6.7%), and the in-hospital mortality rate of patients with PH2 was 83.3%. All patients with PH2 were female, which did meet statistical significance (p=.01). Four of the patients with PH2 had Internal Carotid Artery Terminus or M1 occlusions, and two had M2 occlusions. All six of the patients suffering PH2 received intra-arterial TPA and one patient received both intra-arterial TPA and mechanical thrombectomy. Concomitant administration of GPIIb-IIIa inhibitors did not increase the rate of significant hemorrhage with a rate of 5.9% with IIb-IIIa inhibitors and 8.1% without. Only one of the six patients with PH2 was recanallized successfully to a TICI 2b/3 level. Rates of PH2 in patients with and without perfusion imaging prior to treatment were 7.3% and 6.3%, which did not meet statistical significance.

**CONCLUSION**

Availability of pretreatment CTP did not result in a statistically significant reduction in PH2 or increased recanalization rates in intra-arterial stroke therapy. Further research into the utility of CTP in intra-arterial stroke therapy is warranted. Elimination of CTP has potential for savings in time to treatment, cost, contrast and radiation.

**KEY WORDS:** Acute ischemic stroke, CT perfusion, thrombolysis
Mean Transit Time Reduction in Irreversible Infarct Core on Delay Sensitive and Delay Insensitive CT Perfusion: Confirmation with Coregistered Diffusion-Weighted Imaging

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Minneapolis, MN

PURPOSE
Recent CT perfusion (CTP) literature suggests differences exist in cerebral blood flow (CBF) and mean transit time (MTT) values obtained from singular value decomposition (SVD) delay sensitive (sSVD) versus delay insensitive (dSVD) postprocessing algorithms in infarcts due to tracer delay effects, while cerebral blood volume (CBV) is similar. We have noted patients with visually low MTTs within infarcts using both algorithms. Thus, we set out to describe CTP parameter values within acute infarcts that have a visually low MTT by using coregistered diffusion-weighted imaging (DWI).

MATERIALS & METHODS
Twenty-nine CTP examinations <8 hours postonset having DWI MRI at <24 hours and infarct size >2.5 cm were included over 1 year. After coregistration to thickness/level of the CTP examination, a neuroradiologist outlined the entire visually bright DWI infarct region of interest (ROI), the visually low CBV ROI, and the visually low MTT ROI (based on dSVD, if present). Cerebral blood volume, CBF, and MTT then were retrieved from those 3 ROIs, and from the normal side, on both sSVD and dSVD algorithms. Relative CBV (rCBV) and CBF (rCBF) were obtained (abnormal divided by normal side), and relative MTT by subtracting (abnormal - normal side).

RESULTS
The mean DWI-bright ROI area was 9.11 cm², the mean visually low CBV ROI 6.48 cm², and the mean visually low MTT ROI 3.25 cm². All visually low MTT ROIs occurred within a larger area of elevated MTT and decreased CBF. Visually low MTTs occurred to some degree in 8/29 (27.59%) of infarcts on sSVD, if present. Cerebral blood volume, CBF, and MTT then were retrieved from those 3 ROIs, and from the normal side, on both sSVD and dSVD algorithms. Relative CBV (rCBV) and CBF (rCBF) were obtained (abnormal divided by normal side), and relative MTT by subtracting (abnormal - normal side).

CONCLUSION
Visually low MTTs occur in most DWI-positive infarcts on dSVD. Cerebral blood volume is truly lower in such “visually low” MTT regions. Thus, a low MTT is likely an artifact resulting from dangerously low (near-zero) CBV being divided by a near-zero CBF to yield a variable MTT. Thus, this could be another marker of infarct “core”.

KEY WORDS: CT perfusion, mean transit time, diffusion-weighted imaging

CT Angiography and Clinical Outcome in Acute Ischemic Stroke Patients with Completely Occlusive Proximal Middle Cerebral Artery Lesions Treated with Intravenous Tissue Plasminogen Activator

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Houston, TX

PURPOSE
Computed tomography angiography (CTA) is employed in acute ischemic stroke (AIS) for evaluation of proximal vascular stenosis or occlusion. When completely occlusive proximal lesions are present, opacification of the distal vasculature is variable. We evaluated the outcome of patients treated with intravenous tissue plasminogen activator (IV tPA) as it relates to distal vascular (Sylvian branch) opacification, in an attempt to demonstrate an easily reproducible prognostic factor.

MATERIALS & METHODS
Retrospective review of our stroke registry identified AIS patients treated with IV tPA (7/07 to 2/10). Those proceeding to intra-arterial chemical or mechanical thrombolysis were excluded. CT angiography data were reviewed to select patients with proximal middle cerebral artery (MCA) lesions (i.e., M1 or internal carotid bifurcation ‘T’ lesions). The Thrombolysis in Myocardial Infarction scale (0-3) is used widely to grade lesion severity in AIS. A subset of TIMI 0 (completely occlusive) proximal MCA lesions was identified. CT angiography data were reviewed to determine the degree of MCA territory opacification distal to the TIMI 0 lesion (0 = none, 1 = partial, 2 = complete). Correlation was made to the modified Rankin scale at patient discharge.
RESULTS
Thirteen AIS patients with TIMI 0 proximal MCA occlusions were identified, all of whom were treated with IV tPA. Three (23%) lacked opacification of distal Sylvian branches at CTA. Of these, 2 subsequently underwent hemicraniectomy and 2 expired within 48 hours. Modified Rankin scale (mRS) at discharge was 5.3 ± 1.1. Of the 10 with partial or complete Sylvian branch opacification distal to the TIMI 0 proximal MCA lesion, none underwent hemicraniectomy and mRS at discharge was 4.7 ± 0.9. There was one death before discharge in this group.

Table: Outcome

<table>
<thead>
<tr>
<th></th>
<th>Absent Sylvian opacification</th>
<th>Partial/complete Sylvian opacification</th>
<th>All TIMI 0 MCA lesions</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>3 (23%)</td>
<td>10 (77%)</td>
<td>13</td>
</tr>
<tr>
<td>Hemicraniectomy</td>
<td>2</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Expired During</td>
<td>2</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>mRS at Discharge</td>
<td>5.3 +/- 1.2</td>
<td>4.7 +/- 0.9</td>
<td>4.8 ± 1.0</td>
</tr>
</tbody>
</table>

CONCLUSION
No statistically significant difference in discharge mRS was shown amongst patients with TIMI 0 proximal MCA lesions treated with IV tPA (p = 0.352). While those without CTA opacification of distal Sylvian branches were more likely to undergo hemicraniectomy, no significant difference in the rate of death before discharge was observed.

KEY WORDS: Stroke, CTA, IV tPA

Paper 216 Starting at 11:33 AM, Ending at 11:41 AM
Combining Diffusion- and Perfusion-Weighted Imaging with NIH Stroke Scale Thresholds to Predict Outcome in Acute Ischemic Stroke: A Better Method to Select Patients for Reperfusion Therapy?

Massachusetts General Hospital
Boston, MA

PURPOSE
In a recent study from our institution, combining diffusion-weighted imaging (DWI) and mean transit time (MTT) with NIH Stroke Scale Score (NIHSSS) thresholds predicted outcome accurately in acute ischemic stroke (AIS) patients. Diffusion-weighted imaging volume >72mL or NIHSSS > 20 predicted poor outcome, whereas MTT volume <47mL and NIHSSS < 8 predicted good outcome. We sought to validate this method in a larger cohort and to evaluate its potential to select patients for reperfusion therapy.

MATERIALS & METHODS
We investigated 162 consecutive anterior circulation AIS patients who underwent MR imaging (MRI) within 9 hours of stroke onset. Diffusion-weighted imaging and MTT lesion volumes were measured, and receiver operating characteristic (ROC) curve analysis was performed. Three-month outcome was dichotomized into good (mRS 0-2) versus poor (mRS 3-6). Mismatch was defined as (MTT-DWI)/DWI*100, and >20% was considered significant.

RESULTS
Ninety-three patients (57.4%) had good outcome. Ninety-five (58.6%) underwent reperfusion therapy (IV and/or IA). There were no differences in age (p = 0.26), gender (p = 0.96), side of involvement (p = 0.75), time to imaging (p = 0.79), and significant mismatch (p = 0.85) between patients with good versus poor outcome. Baseline NIHSSS (16 vs. 8), DWI (69.1 vs. 19.0mL) and MTT volume (197.4 vs. 80.5mL, all p < 0.0001) were higher in patients with poor outcome. Diffusion-weighted imaging volume >72mL or MTT volume <47mL was found in 77/162 patients (47%, prognostic yield), and outcome was predicted accurately in 89.6% (69/77). For NIHSSS < 8 or > 20, prognostic yield was 34% with 93.7% accuracy. Receiver operating characteristics analysis demonstrated 94.6% and 100% specificity for DWI >72mL and NIHSSS >20 to predict poor outcome, and 94.2% and 91.3% specificity for MTT <47mL and NIHSSS <8 to predict good outcome. Areas under the curve (AUC) for DWI, MTT and NIHSSS were 0.797, 0.830, and 0.851, respectively, and were larger than for mismatch (AUC = 0.492, p = 0.01). Combining clinical and imaging thresholds led to 90.2% accuracy with 63% (102/162) prognostic yield, regardless of treatment (Figure A). In the 84% of patients who had >20% mismatch, our thresholds predicted outcome (good: 58.4%, poor: 41.6%) with 89.6% accuracy and 56.6% yield. In patients with ≤20% mismatch, outcome (good: 72%, poor: 28%) was predicted with 92% accuracy and 96.2% yield (Figure B).

CONCLUSION
The previously published predictive thresholds demonstrated high prognostic accuracy in this larger, independent cohort. Using these criteria, outcomes appear predictable in approximately two thirds of patients. The remaining third (with DWI < 72mL, MTT > 47mL, 8 < NIHSSS < 20) may be target candidates for reperfusion given their indeterminate a priori outcomes. This model better identifies patients who may benefit from reperfusion than the mismatch concept alone.

KEY WORDS: Prediction, outcome, stroke
**Paper 217 Starting at 11:41 AM, Ending at 11:49 AM**

**Comparison of Arterial Spin Labeling and Bolus Perfusion-Weighted Imaging for Detecting Mismatch in Acute Stroke**

Elmogy, I. S. ¹ • Fischbein, N. J. ² • Albers, G. W. ² • Zaharchuk, G. ²

¹Mansoura Advanced Radiology Center, Mansoura, EGYPT, ²Stanford University, Stanford, CA

**Purpose**

Perfusion-weighted imaging is widely used to evaluate brain perfusion in acute stroke. As many patients cannot receive gadolinium-based contrast agents, a noncontrast approach such as arterial spin labeling (ASL) could be useful. This study compares the agreement of ASL-DWI and PWI-DWI mismatch classification in acute ischemic stroke.

**Materials & Methods**

All patients with brain MRI studies between January and October 2010 were evaluated. Inclusion criteria were: symptom onset <48 hours, DWI lesion >10 ml, and acquisition of both PWI and pseudocontinuous ASL. All studies were performed at 1.5 T. Diffusion-weighted imaging and PWI were assessed using RAPID mismatch software, which automatically calculates DWI and PWI (Tmax>=6s) volumes. Patients were separated into three groups based on DEFUSE criteria (1) “reperfused” (DWI >80% PWI); (2) “matched” (DWI >80% but <120% PWI or <10 ml); and (3) “mismatched” (DWI <120% PWI). Two reviewers classified ASL-DWI qualitatively into the same categories, blinded to DWI-PWI results, with subsequent consensus read. Kappa for agreement was calculated both for readers and for the two methods.

**Results**

Forty studies in 38 patients met the inclusion criteria (mean age 61 years, range 29-86). ASL in six patients (15%) was noncontributory due to either severe borderzone sign (n=4) or motion artifact (n=2). In the 34 remaining studies, mean DWI lesion size was 64 ml (range 11-196). Interrater agreement for ASL-DWI mismatch status was high (κ=0.72, unweighted; κ=0.77, linearly weighted). The ASL-DWI and PWI-DWI mismatch status agreed in 18/34 cases (53%). Misclassifications due to ASL overestimation of the PWI lesion size occurred in 14 of the remaining 16 studies. In the last two patients (who had the smallest lesion sizes), ASL-DWI was read as reperfusion and PWI-DWI was read as matched. Agreement between methods was only fair-to-moderate (κ=0.30, unweighted; κ=0.37 linearly-weighted).

**Conclusion**

Arterial spin labeling and PWI agree about 50% of time regarding mismatch status in patients with acute ischemic stroke. In almost all discrepant cases, ASL overestimates the size of the PWI lesion. This is almost certainly due to the increased sensitivity of ASL in the setting of mild arterial arrival time delay. Improved ASL methodologies and use of higher field strength are likely necessary before ASL can be recommended for routine use in acute stroke.

**Key Words**: Arterial spin labeling, perfusion, stroke

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**Paper 218 Starting at 11:49 AM, Ending at 11:57 AM**

**Susceptibility-Weighted Imaging in Acute Ischemic Stroke: Combined Study with MR Perfusion-Weighted Imaging for Prediction of Stroke Progression**

Kao, H. ² • Tsai, F. ² • Hasso, A. ¹

¹University of California, Irvine Medical Center, Orange, CA, ²Tri-Service General Hospital, National Defense Medical Center, Taipei, TAIWAN

**Purpose**

Cerebral ischemic stroke is one of the most fatal and leading cause of disability despite advanced medical therapy. The goal of modern thrombolytic treatment is to salvage reversible ischemic penumbra, in which the blood flow is reduced but not lethal. Ischemic penumbra is defined most commonly with combined use of MR diffusion-weighted imaging (DWI) and dynamic susceptibility contrast MR perfusion-weighted imaging (PWI). However, perfusion studies may not be available for every patient in a variety of clinical situations. Susceptibility-weighted imaging (SWI) has a potential ability to reflect increased oxygen extraction fraction as metabolic information of the ischemic brain area by presence of prominent asymmetric hypointense vessels (HV). The aim of this study was to verify whether SWI was able to replace PWI to predict ischemic penumbra and subsequent infarct progression.

**Materials & Methods**

The study was approved by our institutional review board and conformed to scientific principles and ethical standards. In an organized registry of our stroke center, we retrospectively reviewed consecutive cases with acute stroke admitted from January 2009 and September 2010. Inclusion criteria were cases with ischemic stroke, concurrent MR sequences of PWI, DWI, and SWI within 24 hours of symptom onset, and follow-up MR or CT more than 5 days after symptom onset available for assessment of stroke evolution. We had 16 cases (7 male and 9 female; mean age, 65.7 years, SD, 16.3 years) fulfilling the criteria for analysis. Two neuroradiologists qualitatively compared the areas of prolonged mean transit time (MTT) on PWI with corresponding restricted diffusion areas on DWI to determine the ischemic penumbra (MTT/DWI mismatch). Extents of the asymmetric HV on SWI were compared with DWI (SWI/DWI mismatch) and MTT maps (SWI/MTT mismatch). We also documented mismatches among SWI, CBF map and DWI. Follow-up CT or MR fluid attenuation inversion recovery (FLAIR) images or CT were compared with initial DWI to assess progression of ischemic stroke.
RESULTS
Mean transit time/DWI and SWI/DWI mismatches were both significantly related with infarct progression ($P = 0.01$ and 0.001 respectively, Fisher’s exact test). The ability of the SWI and PWI to predict infarct progression is similar by using SWI/DWI and MTT/DWI mismatches ($P = 1.0$, McNemar’s test). Cases with ischemic penumbra evidenced on MTT/DWI mismatch showed SWI/DWI mismatch except for one case, in which the infarct did not expand. None of the cases with matched SWI-DWI or MTT/DWI showed infarct progression. The CBF/DWI mismatch was not associated with infarct progression ($P = 0.42$, Fisher’s exact test). The accuracies in prediction of infarct progression were 87.5% for SWI/DWI mismatch, 75% for MTT/DWI mismatch, and 62.5% for CBF/DWI mismatch.

CONCLUSION
Susceptibility-weighted imaging has a potential to be an alternative of PWI to assess metabolic condition and intrinsic collaterals as penumbra. Further prospective studies are needed to evaluate its role in guiding thrombolytic therapies for patients with acute ischemic stroke.

KEY WORDS: Ischemic stroke, susceptibility-weighted imaging, penumbra

Paper 219 Starting at 11:57 AM, Ending at 12:05 PM
Brain Collateral Estimation Using Dynamic Susceptibility Contrast Enhancement with Digital Subtraction Angiography Validation
Lee, Y. Z. • Eldeniz, C. • Jones, T. B. • Solander, S. • Huang, D. • Faber, J. E. • An, H. • Smith, J. K.
University of North Carolina at Chapel Hill
Chapel Hill, NC

PURPOSE
Pial collateral vessels play an important role in tissue survival after a cerebral ischemic event, although capacity varies among patients. Collateral flow can be assessed using digital subtraction angiography (DSA) as the extent of retrograde perfusion of the cerebral artery tree whose trunk is obstructed. However, conventional MR techniques are limited, and standard perfusion parameters, such as cerebral blood flow (CBF) and mean transit time (MTT), are unlikely to be sufficiently sensitive. Our goal was to develop a straightforward technique to estimate collateral flow capacity using MR dynamic susceptibility contrast (DSC) perfusion acquisitions, and to compare this technique to measurements derived from DSA.

MATERIALS & METHODS
Patients receiving DSA and MR DSC within 1 week with ischemic strokes were analyzed. The MR DSC data were de-identified and transferred for postprocessing software written in Matlab. Cerebral blood flow, MTT and Tmax DSC measurements were calculated using the oSVD method using manually selected arterial input functions. Cerebral blood flow and MTT maps were normalized by mean values from the contralateral side to generate nCBF and nMTT maps. No normalization was performed on the Tmax maps. Each perfusion parameter then was assigned a specific color channel (nCBF = blue, nMTT = red, and Tmax = green) to combine the maps into a composite “collateralization map”. These maps then were scored for collateral-dependent flow; areas with high collateralization were green (long Tmax, with normal CBF and MTT) versus yellow (normal CBF, long MTT and Tmax). Tissue with normal flow is then black, and severe flow compromise is white. The dominant pattern of the collateralization map then was identified. Independently, DSA collateral scores were identified blindly using a technique described in the literature. A score of 1-5 was given based on the degree of retrograde collateral-dependent flow, with higher scores representing poor collateral conductance. The relationship between these values for each patient then was evaluated.

RESULTS
Thirteen patients with a mean age of 53 +/- 17 years were evaluated. The dominant collateral perfusion pattern was readily found for each DSC data set using the technique. An correlation r-value of 0.81 ($P < 0.05$) was obtained between the gold standard DSA and the DSC-derived scores.

CONCLUSION
The standard perfusion parameters, CBF and MTT, represent the dynamic perfusion parameters which commonly are measured using DSC type techniques. These two parameters, however, are not known to be sensitive to changes that are specific to collateral flow. Tmax, however, is more likely to be sensitive to the delay dispersion caused by collateral flow. We demonstrate a method of combining the information in these parameters to identify collateral flow capacity in stroke patients.

KEY WORDS: Collateral circulation, dynamic susceptibility contrast, digital subtraction angiography

Paper 220 Starting at 12:05 PM, Ending at 12:13 PM
Progression of Blood-Brain Barrier Permeability in Patients with Acute Ischemic Stroke: From Acute to Early Subacute Phase
Huang, K.1 • Mikulis, D.2 • Silver, F.2 • Kassner, A.1
1University of Toronto, Toronto, ON, CANADA, 2Toronto Western Hospital, Toronto, ON, CANADA

PURPOSE
Blood-brain barrier (BBB) disruption following ischemia-reperfusion in stroke is associated with clinically important consequences including hemorrhagic transformation (HT). Previous data on BBB permeability changes after acute ischemic stroke (AIS) are limited to the first several hours and virtually nonexistent in the subacute phase (days to weeks). We therefore reviewed our existing data that included data points from 1 hour to several days. Precise knowledge of BBB dynamics after ischemic stroke is of importance in considering future treatment possibilities including BBB leakage-blocking agents, and neuroprotective and neurorestorative strategies. The purpose of this study was to evaluate the time course of BBB disruption from acute to early subacute phase of AIS. We hypothesized that BBB permeability measured by DCE-MRI would continuously
increase with time, a response caused initially by direct ischemic endothelial injury and subsequently by inflammatory reaction.

**Materials & Methods**

Thirty-nine patients (18 females, 21 males, 28-99 years) were included in the analysis. All patients received DCE-MRI as part of their acute stroke work up and were imaged on a 1.5 T GE MR system (GE Healthcare, Milwaukee, USA) equipped with 8-channel head coil. Twelve of 39 patients had follow-up DCE-MRI. One of 39 developed a new lesion at follow-up scan and was counted as two data points. Total data points were N = 52. DCE-MRI parameters were as follows: dynamic 3D-GRE, FOV = 240 mm, 128 x 128 matrix, slice thickness = 5 mm, TR = 5.9 ms, TE = 1.5 ms, FA = 35°, temporal resolution = 9 sec, volumes = 31, acquisition time = 4.48 min. Data were analyzed on an independent workstation using in-house software (MR analyser) developed in MATLAB (MathWorks, Natick, MA). Regions of interest (ROIs) based on areas of ischemia were identified as regions of reduced diffusion on apparent diffusion coefficient maps. Coefficients of BBB permeability estimates (KPS) were calculated using a unidirectional, two-compartment kinetic model. Mean KPS values (+ SEM) were recorded for each ROI and each patient. KPS data were divided into three groups according to time between imaging and stroke onset and compared using a one-way ANOVA.

**Results**

MR images in the first 16 hours showed mean KPS values in the lesion of 0.72 mL/100g/min. Scans taken between 16-50 hours showed mean KPS values in the lesion of 1.4 mL/100g/min, which was statistically significant when compared to MRIs taken in the first 16 hours (1.38 ± 0.30 vs 0.72 ± 0.06 mL/100g/min, P = 0.0007). After 50 hours, mean KPS values of the lesion decreased significantly (1.38 ± 0.30 vs 0.64 ± 0.10 mL/100g/min, P = 0.01).

**Conclusion**

Surprisingly, BBB permeability decreased after 50 hours. We believe that this represents transient stabilization of the initial ischemic endothelial BBB injury that stabilizes and reverses as a result of reperfusion. The defect may again reappear due to the inflammatory phase in subsequent days to weeks after injury for which we currently do not yet have confirmatory data.

**Keywords:** Stroke, blood-brain barrier, MR imaging.
Mean KPS measures were similarly elevated in HT cases (1.21±0.53 versus 0.56±0.27 mL/min/100g, P=0.0002). AUC50-140 was not significantly different between patients who did or did not receive rtPA (451.82±360.58 versus 443.81±333.48, P=0.95). In contrast, mean KPS values were significantly increased in patients who received rtPA (1.01±0.39 versus 0.63±0.52, P=0.04).

**CONCLUSION**
Both quantitative and semiquantitative DCE parameters are capable of differentiating AIS patients who proceeded to HT versus those who did not. Measuring the AUC50-140 seems to be a computationally efficient surrogate of the more accurate KPS and is definitely superior to a previously reported IAUC. This study highlights the importance of optimizing AUC analysis towards the underlying pathophysiology of BBB breakdown in AIS.

**KEY WORDS:** Stroke, AUC, MR imaging

**Paper 222 Starting at 12:21 PM, Ending at 12:29 PM**

**Validation of Tracer-Delay Sensitive and Insensitive Deconvolution-Based CT Perfusion Postprocessing Algorithms Using Coregistered Diffusion-Weighted Imaging in Hyperacute Infarcts**

McKinney, A. M. • Lohman, B. • Truwit, C. L.
University of Minnesota & Hennepin County Medical Centers
Minneapolis, MN

**PURPOSE**
A recent study on dynamic CT perfusion (CTP), and its precursor, suggest that in acute infarcts, there will be significant decreases in cerebral blood flow (CBF) and increases in mean transit time (MTT) values when obtained from “delay-sensitive” deconvolution-based algorithms as compared to “delay-insensitive” algorithms; differences in cerebral blood volume (CBV) may exist, but to a lesser degree. However, that study involved a relatively small number of patients (n=10), and CTP was not compared to diffusion-weighted imaging (DWI). Thus, we set out to test these observations in a larger number of patients by focusing only on delay-sensitive and delay-insensitive deconvolution-based algorithms (deconvolution algorithms have traditionally been the most validated algorithm) from two vendors using four different techniques total, by obtaining various CTP measurements within coregistered DWI-positive regions.

**MATERIALS & METHODS**
Thirty-four CTP examinations performed <8 hours after symptom onset and having DWI MRI at <24 hours and infarct size >2.5cm were included over 1 year. DWIs were coregistered to the CTP examination. A neuroradiologist outlined the entire visually bright DWI infarct region of interest (ROI). That ROI was used to recover CBV, CBF, and MTT from the CTP examination, and repeated on the normal side, using four deconvolution-based postprocessing algorithms: delay-sensitive iterative singular value decomposition (sSVD), delay-insensitive iterative SVD (dSVD), delay-sensitive noniterative deconvolution (sDCV), and block-circulant SVD (bSVD). Relative CBV (rCBV) and CBF (rCBF) were calculated (abnormal divided by normal side), and relative MTT (rMTT=abnormal-normal side).

**RESULTS**
Within DWI-bright ROIs the mean rCBVs for sSVD, dSVD, sDCV, and bSVD, respectively, were: 0.750, 0.662, 0.603, and 0.713. The mean rCBFs for sSVD, dSVD, sDCV, and bSVD, respectively, were: 0.408, 0.551, 0.214, and 0.355. The mean rMTT and the percent increase were: +3.22sec (+93.0%), +0.76sec (+15.6%), +11.93sec (+289.8%), and +8.08sec (+139.7%), respectively. Notably, eight patients had measured increases in CBV on sSVD, five on dSVD, five on sDCV, and three on bSVD, likely related to early reperfusion, as the corresponding MTT was severely elevated in each. There were significant differences between algorithms for CBF and MTT (both p<0.001, ANOVA), but not for rCBV (p=0.09).

**CONCLUSION**
Cerebral blood flow and MTT are significantly higher in tracer delay-sensitive deconvolution-based algorithms such as sSVD and sDCV, relative to dSVD and bSVD. Cerebral blood volume does not change significantly between algorithms. However, it is not yet determined whether such “exaggerated” decreases in CBF or elevations in MTT using "delay-sensitive" techniques (such as with sDCV) are of clinical utility.

**KEY WORDS:** CT perfusion, diffusion-weighted imaging, stroke
**Paper 223 Starting at 10:45 AM, Ending at 10:53 AM**

**MR Imaging of Cauda Equina Injury in an Experimental Animal Model: Early Changes**

Obukhoff, D.¹ • Samim, M.² • Nieto, J.² • Ohlsson, M.² • Sayre, J.² • Christe, K. L.³ • Havton, L.² • Villablanca, P. J.¹

¹University of California Los Angeles, Los Angeles, CA, ²University of California Los Angeles, Santa Monica, CA, ³University of California Davis, Davis, CA

**PURPOSE**

Our purpose was to determine if MRI can characterize nerve signal intensity (NSI) and cross-sectional area (CSA) changes following nerve avulsion and replantation in nonhuman primates.

**MATERIALS & METHODS**

Adult subjects (n=8) underwent L6, L7, S1 and S2 ventral root avulsion followed by surgical replantation into the spinal cord, with or without a bridging peripheral nerve graft, and preoperative and 6-week postoperative 1.5T MR scanning employing noncontrast T2-weighted, and pre and postcontrast T1 sequences (Figure). Using the region of interest technique, comparative CSA and NSI ratios of the affected and control intradural ventral roots were obtained, and pre and postoperative, left to right (L:R) and ipsilateral (L:L,R:R) differences compared.

**RESULTS**

Ventral root specific CSA ranges were identified (p<0.001). Comparing to contralateral controls at baseline, no statistically significant differences in mean axial T2-weighted, axial T1-weighted postcontrast NSI, axial T2-weighted or T1-weighted postcontrast CSA of the treated nerve roots were identified (p=0.12-0.80). Comparing pre to postoperative scans, there were statistically significant increases in L:R (p<0.001) and L:L axial T2W (p<0.001), L:R axial T1-weighted postcontrast CSA comparisons (p<0.001), and L:L NSI on the axial T1-weighted postcontrast sequences (p<0.001-0.002). The change in the slope of the CSA and NSI L:R nerve root ratios as % per month was greatest in the first 40 days post injury and repair. It ranged from 0-81% for affected nerve CSA and NSI values (Table).

<table>
<thead>
<tr>
<th>Root</th>
<th>T2W Precontrast</th>
<th>T1 Postcontrast</th>
<th>Percentage Change</th>
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<td>L7</td>
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**CONCLUSION**

We identified ventral root specific CSA ranges, and statistically significant increases in ventral root CSA and NSI when comparing surgical to control intradural lumbosacral ventral roots at 6 weeks post nerve avulsion injury and surgical replantation, with rapid increases in both measures for affected roots noted within the first 40 days post-treatment.

**KEY WORDS:** Cauda equina injury, MR imaging, spinal nerve root graft
MR Imaging of Cauda Equina Injury in an Experimental Animal Model: Longitudinal Model

Obukhoff, D.¹ • Samim, M.¹ • Nieto, J.¹ • Ohlsson, M.¹ • Sayre, J.¹ • Christe, K. L.² • Havton, L.¹ • Villablanca, P. J.¹
¹University of California Los Angeles, Los Angeles, CA, ²University of California Davis, Davis, CA

PURPOSE
To characterize longitudinal changes in MR imaging (MRI) features following nerve avulsion and reimplantation of cauda equine nerves using an experimental nonhuman primate model.

MATERIALS & METHODS
We employed a cauda equina injury model where ventral lumbosacral nerve roots (L6-S2) were unilaterally avulsed from the conus medularis (n = 8). In three subjects this was followed by an immediate reimplantation of the avulsed roots into the ipsilateral lateral funiculus, while in five subjects an intercostal nerve graft was used. Preoperative lumbar MR at 1.5 T was performed to obtain basal signal intensity and enhancement values. Postoperative imaging was performed at 1, 3, 6, 12, 24, 48, and 104 weeks postoperatively. Following MR identification of each lesioned ventral nerve root using its intradural and intraforaminal course, target parameters, including intradural lumbosacral nerve cross-sectional area (CSA) on both axial T2 and T1-weighted postcontrast sequences, axial T2-weighted nerve signal intensity (NSI), and degree of nerve enhancement on axial T1-weighted postgadolinium sequences were obtained by two independent blinded readers. Left to right nerve differences were evaluated using a two-tailed t-test and the Wilcoxon Ranked test.

RESULTS
We identified distinct time-dependent changes in MR nerve CSA and NSI when comparing the affected to contralateral control nerves (Figure 1). We identified time-dependent wave forms with an early steep slope increases in ventral affected to contralateral unaffected nerve root ratios for CSA ranging between 120-220%, peaking at 6 weeks postoperatively, and demonstrating initial slope change rate of 63-81% per month, followed by a gradual normalization by 18 months postoperatively. In contrast, NSI on postcontrast sequences peaked earlier (3 weeks) than CSA changes, exhibited smaller ranges (120-130%), demonstrated a lower rate of initial slope change of 30-48% per month, and normalized by 3 months postoperatively (Figure 1). High intra and interoperator reliability scores were obtained for all measures (CSA 0.923 and 0.903, NSI 0.802 and 0.790).

CONCLUSION
1.5 T MRI is able to characterize longitudinal changes in CSA and NSI of avulsed and reimplanted ventral nerve roots. Cross-sectional area changes were larger and had a faster initial rate of change, had a later onset and a more prolonged normalization interval, as compared to NSI, which peaked and normalized earlier, were less pronounced, and exhibited a somewhat lower initial rate of increase.

KEY WORDS: Cauda equina injury, MR imaging, spinal nerve root graft

Application of Diffusion Tensor Imaging as a Surrogate for Neurologic Deficit in Spinal Cord Injury

Zohrabian, V.¹ • Zussman, B.¹ • Frangos, A.¹ • Mathews, J.¹ • Lackey, J.¹ • Dresner, M. A.² • Lai, S.¹ • Marino, R.¹ • Gorniak, R.¹ • Flanders, A. E.¹
¹Thomas Jefferson University Hospital, Philadelphia, PA, ²Philips Healthcare, Philadelphia, PA

PURPOSE
Current methods to assess degree of spinal cord damage following spinal cord injury (SCI) rely principally on the results of an accurate neurologic examination. Reliability of the neurologic examination varies depending upon the experience of the examiner, the level of patient cooperation/communication. Conventional MR imaging (MRI) has been shown to have inherent value as a surrogate for the neurologic examination; however, it does not assess directly the integrity of remaining white matter after injury. Assessment of damaged but potentially salvageable white matter is of great therapeutic interest. Diffusion tensor imaging (DTI) has been postulated to provide a direct correlate of white matter integrity and may offer greater precision in assessing neurologic deficit after injury over neurologic examination alone. The purpose of this study is to identify the most favorable DTI parameters that could serve as a surrogate for neurologic injury.

MATERIALS & METHODS
Thirty-eight patients after blunt cervical spine injury with evidence of intramedullary edema and/or hemorrhage were evaluated on a 1.5 T scanner (Philips Achieva) within 24 hours. Fourteen normal controls also were assessed. The DTI
sequence consisted of 40, 4 mm axial images with 0.4 mm gap using a single-shot spin-echo EPI acquisition: FOV: 20 cm, B-value: 500, 6 directions, TR/TE 2500/75 msec, scan time: 3:40. In-plane axial resolution achievable was 1.7 x 1.7 mm. The upper/lower boundaries of the injury zone were mapped relative to matching DTI images. Manual regions of interest (ROIs) were drawn by two trained observers to incorporate the entire cross-section of spinal cord. Fractional anisotropy (FA), ADC, primary eigenvector (lambda 1) and radial diffusivity (lambda 23) were measured for each contiguous slice in each patient. Diffusion tensor imaging metrics for the injury zone, the length and location of the injured segment were compared to admission motor index scores (MIS), neurologic level of injury (NLI) and the ASIA impairment scale (AIS). Nonparametric testing was utilized (Kruskal-Wallis) to assess for significant difference in DTI metrics grouped by AIS. Regression was performed to assess relationship of DTI metrics and injury length and location to leg MIS and arm MIS.

RESULTS
The patient cohort included a range of impairments: AIS A (13); AIS B (9), AIS C (7) and AIS D (9). Neurologic level of injury (NLI) ranged from C2 to C8 with majority (30) between C3 and C5. The mean diffusion values stratified by each AIS group (A-D) and normals (N) were - FA: (A) 0.72+/-.08, (B) 0.71+/-.12, (C) 0.67+/-.05, (D) 0.70+/-.11, (N) 0.69+/-.05 and ADC: (A) .91+/-.02, (B) 0.96+/-.035, (C) 1.18+/-.037, (D) 1.2+/-.0.37, (N) 1.11+/-.013. Nonparametric testing showed significant difference in ADC(p = 0.005), lambda1(p = 0.003) and lambda23 values(p = 0.003) for the injury zone grouped by AIS; however, there was no significant difference in FA values. Significant differences were identified in injury zone length(p = 0.002), ADC(p = 0.0006), lambda1(p = 0.0002) and lambda23(p = 0.002) for patients grouped into motor complete and motor incomplete injuries, whereas no significant difference was identified for FA or injury zone location(p = 0.83).

CONCLUSION
Principle components of diffusivity and ADC may provide better objective capability to discriminate severity of neurologic deficit in SCI than fractional anisotropy.

KEY WORDS: Diffusion tensor imaging, spinal cord injury

Paper 226 Starting at 11:09 AM, Ending at 11:17 AM

Zohrabian, V.1 • Zussman, B.1 • Frangos, A.1 • Mathews, J.1 • Lackey, J.1 • Lai, S.1 • Dresner, M. A.3 • Marino, R.1 • Gorniak, R.1 • Flanders, A. E.1
1Thomas Jefferson University Hospital, Philadelphia, PA, 2Philips Medical Systems, Cleveland, OH

PURPOSE
Diffusion tensor imaging (DTI) metrics are purported to provide a quantifiable assessment of myelin integrity in the spinal cord. Several studies have shown that alterations in DTI values in spondylotic myelopathy, neoplastic cord compression and demyelination correlate with clinical functional deficits. Moreover, studies have shown that in systemic diseases like multiple sclerosis, even normal-appearing brain and spinal cord white matter on conventional MR imaging (MRI) exhibit objective evidence of DTI variation when compared to normal controls which has been suggested to be a "fingerprint" of undetected disease. Prior animal and human studies of DTI applied to spinal cord injury (SCI) have suggested that perturbations of DTI values persist beyond the boundaries of the injury zone. The purpose of this analysis is to determine if there is objective evidence that the DTI metrics measured in normal-appearing tissue beyond the boundaries of the SCI injury zone are consistently different from a control population.

MATERIALS & METHODS
Thirty-eight patients after blunt cervical spine injury with evidence of intramedullary edema and/or hemorrhage were evaluated on a 1.5 T scanner (Philips Achieva) within 24 hours. Fourteen normal controls also were assessed. The DTI sequence consisted of 40, 4 mm axial images with 0.4 mm gap using a single-shot spin-echo EPI acquisition: FOV: 20 cm, B-value: 500, 6 directions, TR/TE 2500/75 msec, scan time: 3:40. The upper/lower boundaries of the injury zone were mapped relative to matching DTI images. All DTI images outside of the injury zone (designated "uninjured") were mapped. Manual ROIs were drawn by two trained observers to incorporate the entire cross section of spinal cord for all sections. Fractional anisotropy (FA), apparent diffusion coefficient (ADC), primary eigenvector (lambda 1) and radial diffusivity (lambda 23) were measured for each contiguous slice in each patient. Paired t-tests using Satterthwaite method were performed to determine whether there were significant differences in DTI metrics between uninjured cord and controls.

RESULTS
The patient cohort included a range of impairments: 22 motor complete and 16 motor incomplete. There was a significant difference (or trend toward significance) in FA (p = 0.08) and lambda 23 (p < 0.0001) values for all voxels in the whole spinal cord (injury zone + uninjured) compared to controls whereas ADC (p = 0.22) and lambda 1 (p = 0.31) were not significantly different. In addition, for all injuries collectively there was no significant difference demonstrated in mean FA (p = 0.42), ADC (p = 0.42), lambda 1 (p = 0.22) and lambda 23 (p = 0.65) between the voxels identified in the injury zone and the uninjured tissue.

CONCLUSION
Findings suggest that there is a DTI "envelope" that extends beyond the injury zone in SCI not visible on conventional MRI. The extent of this DTI envelope and its relationship to functional deficit and potential for recovery requires better definition. A better understanding of the entire DTI map in SCI could provide additional metrics to objectively define SCI with MRI.

KEY WORDS: diffusion tensor imaging, spinal cord injury
Observer-Related Variability in Spinal Cord Diffusion Tensor Imaging Metrics: Implications in Clinical Research

Lai, S. • Lackey, J. • Zohrabyan, V. • Zussman, B. • Dresner, A. • Shi, J. • Frangos, A. • Natale, P. • Flanders, A. • Lai, S. • Lackey, J. • Zohrabyan, V. • Zussman, B. • Dresner, A. • Shi, J. • Frangos, A. • Natale, P. • Flanders, A.

Thomas Jefferson University Philadelphia, PA

Purpose
While the application of diffusion tensor imaging (DTI) in spinal cord (SC) diseases has been illustrated in multiple published studies, there are no "standard" scanning methodologies nor established analytical methods to produce consistent results. For DTI to become clinically relevant, the ability to produce reliable and reproducible data is paramount. A limitation of current postprocessing techniques is that region-of-interest (ROI) generation is semiautomated and therefore is susceptible to subjective variability. The purpose of this study is to examine the magnitude of variation induced by human error on identical datasets.

Materials & Methods
Sixty-one cervical SC DTI datasets (1 dataset/patient) were analyzed, including 49 cervical SC injured patients, and 12 trauma patients without evidence of cervical SC injury. Each DTI sequence (one b = 0, T2-weighted image, and six diffusion-weighted images with diffusion gradient applied in six noncollinear directions) was performed in axial plane and collected 24-55 slices. The SC was segmented independently by two unequally proficient analysts utilizing in-house software. Each analyst was instructed to manually trace the perimeter of the SC on the T2-weighted images, excluding cerebrospinal fluid on every image where the SC was identifiable and to skip images where the SC landmarks were not reliably identified. Fractional anisotropy (FA), mean diffusivity (MD), longitudinal diffusivity (LD), and transverse diffusivity (TD) were generated for each defined ROI. Paired t-test was conducted on a slice-by-slice and full dataset basis between the diffusion metrics and sizes of the ROIs defined by the two analysts.

Results
Among the 61 datasets, the two analysts were successful in circumscribing an ROI around the SC for the identical slices in 39 datasets, while in the other 22 datasets, the axial slices were not concordant between analysts. Using only the commonly identified slices, significant differences (p<0.05) were found between the two analysts in 25, 16, 34, 30, 36 datasets for ROI size, FA, ADC, LD, and TD, respectively, suggesting that substantial variation in calculated values was introduced by human intervention (FA, LD, ADC, TD, in the order of lower to higher sensitivity). Table 1 listed the gross comparison between the diffusion metrics of the SC segmented by the two analysts when all the 61 datasets were included, showing statistically significant difference in each diffusion parameter, even though individually, 45, 31, 27, 25 datasets did not have significant difference in FA, LD, ADC, and TD, respectively.

Conclusion
Difference in ROIs generated by different users of varying skillsets lead to substantial variation in the measured spinal cord diffusion parameters. Caution must be exercised when comparing diffusion metrics of the spinal cord manually segmented by different users, especially when comparing different patient groups. Introducing more automation into the process may help to reduce the magnitude of observed error.

Key Words: Cervical spinal cord, diffusion tensor imaging, reproducibility

MR Imaging of Acute Odontoid Fractures: Is Marrow Edema Helpful in Diagnosing "ACUTE" Nature of Fracture and Predicting Healing?

Peri, N. • Papavassiliou, E. • Rojas, R. • Bhatelia, R.
Beth Israel Deaconess Medical Center Brookline, MA

Purpose
To assess (1) the extent of marrow edema and other associated MR imaging (MRI) findings in acute odontoid fractures (2) if initial presence or absence of marrow edema correlates with healing on follow up

Materials & Methods
IRB-approved retrospective evaluation of patients with acute odontoid fractures who had concurrent CT and MRI from 1999-2008 was performed. Marrow edema at the fracture site was assessed on sagittal STIR images as: (a) none, (b) linear-limited to the fracture cleft and (c) diffuse. Associated injuries were noted at (1) interspinous ligaments (2) posterior or spinous soft tissues (3) spinal cord. Presence and extent of marrow edema at presentation was correlated with healing on follow up.

Results
Eighteen patients (11- type 2; 7- type 3 odontoid fractures) were included in the study. Marrow edema was absent in 4 (22%), linear-limited to fracture cleft in 11 (61%), and diffuse in 3 (17%). Increased interspinous ligament STIR signal at C1-2 was seen in 78%; it was seen in all patients with absent or diffuse edema, and in 63% of those with linear edema pattern limited to fracture cleft. Increased posterior spinous soft tissue signal and prevertebral soft tissue swelling were noted in 50%; spinal cord edema in 17% all of whom had type 3 odontoid fractures and other cervical or thoracic bony spine injuries in 28%. Eleven of 18 had follow-up imaging 1 month or later using plain radiographs or CT; two of these had no marrow edema - one had near complete healing at 8 month and the other had partial healing at
2 month follow up. However, the extent of healing was variable between those with linear and diffuse types of marrow edema, seen as absent or partial healing.

**Conclusion**

In contradistinction to elsewhere in the skeletal system, marrow edema is absent or little in acute odontoid fractures. Hence, it may be necessary to look for additional MR findings to determine the acute nature of these fractures. Increased signal in the interspinous ligaments at C1/2 can be helpful in identifying the acute nature of the odontoid fractures. Though several factors are involved in healing of the fractures, MRI findings at presentation may play a role in speculating healing.

**Key Words:** Odontoid, MR imaging, acute fracture

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**Paper 229 Starting at 11:33 AM, Ending at 11:41 AM**

**Spinal Cord MR Imaging in Clinically Isolated Syndromes**

Rovira, A. • Auger, C. • Vert, C. • Tintore, M. • Mitjana, R. • Huerga, E. • Sastre-Garriga, J. • Montalban, X.

Hospital Vall d’Hebron

Barcelona, SPAIN

**Purpose**

Spinal cord (SC) MRI in the initial diagnostic work up of patients with clinically isolated syndromes (CIS) is performed routinely in many institutions. However, little is known about the prevalence of SC demyelinating lesions in patients with CIS, and the added diagnostic value of SC MR imaging in demonstrating dissemination in space in these patients. The purpose of this study is to determine the prevalence of SC lesions in CIS patients and to assess the added diagnostic value of SC MR imaging in these patients.

**Materials & Methods**

From November 2006 to March 2010, CIS patients were included in a prospective study. Patients underwent brain and SC MR imaging for diagnostic purposes within 3-5 months after symptoms onset. The brain MRI protocol included transverse T1-weighted conventional spin-echo and dual-echo fast spin-echo images. For SC MRI, sagittal fast spin-echo dual-echo T2-weighted and sagittal T1-weighted spin-echo images also were obtained. Brain and SC contrast-enhanced T1-weighted images were obtained in patients who demonstrated focal brain white matter lesions. Clinical assessment included age, gender, and topography at CIS onset. Two neuroradiologists assessed, by consensus and blinded to clinical data, the number and location of high signal PD/T2 lesions, and gadolinium enhancing T1-weighted lesions, both in the brain and in the SC. Criteria for dissemination in space, as defined in the McDonald criteria for the brain, were met in 43% of the patients. This percentage increased to only 46% when SC MRI abnormalities also were taken into account. In SC CIS these criteria were met in 47%, increasing to 53% when SC MRI were considered; while in non SC CIS fulfillment increased from 26% to 29%. Only two patients (3%) with a non SC CIS and a normal brain MRI demonstrated SC lesions.

**Conclusion**

Spinal cord MR imaging in CIS patients has a minor contribution in demonstrating dissemination in space as defined in the McDonald criteria. Given this very low yield, SC MRI should not be performed as part of the routine diagnostic work up of non SC CIS patients, but could be considered when brain MRI findings demonstrate focal lesions not fulfilling criteria for dissemination in space.

**Key Words:** Multiple sclerosis, spinal cord, MR imaging

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**Paper 230 Starting at 11:41 AM, Ending at 11:49 AM**

**3T Evaluation of Multiple Sclerosis Plaques of the Cervical Cord: STIR vs Double Echo TSE**

Shapiro, M. D. • Lees, J.

Neuroskeletal Imaging of Winter Park

Winter Park, FL

**Purpose**

To determine which of three pulse sequences - turbo STIR (TSTIR), proton density (PDTSE), or turbo T2SE (T2TSE) pulse sequence - is superior at 3 T for delineating in the sagittal plane multiple sclerosis plaques involving the cervical cord. Previously STIR at 3 T was proved superior to T2TSE with fat saturation.

**Materials & Methods**

Prospectively 75 consecutive patients with the suspected or proved diagnosis of MS had their cervical spine scanned on a Siemens Verio 3 T MRI system. All patients were scanned in the sagittal plane with both turbo STIR as well as PD&T2 turboSE pulse sequences with 2.5 mm slice thickness and 320x256 matrices in addition to other routine sagittal and axial T1- and T2-weighted pulse sequences in the axial plane. All scans were reviewed by one CAQ neuroradiologist.

**Results**

In all patients combined, 104 MS plaques were demonstrated on the TSTIR sagittal sequence. Ninety-eight were identified on the PDTSE sequence and 89 were seen on the T2TSE. No plaque was identified on the combined PDTSE and T2TSE that also was not seen on the T2STIR sequence.
Separate but closely adjacent plaques were better separated on the TSTIR sequence despite the fact that the turbo factor is longer on the TSIR sequence.

**Conclusion**

At 3 T, turbo STIR is the best pulse sequence in the sagittal plane for detecting MS plaques in the cervical cord. PDTSE is superior to T2TSE.

**Key Words:** 3T, MS, spinal cord

**Paper 231 Starting at 11:49 AM, Ending at 11:57 AM**

**Temporal Evolution and Attributes of Annular Pathology in a Young Population**

Parsons, M. S. • Pilgram, T. K. • Sharma, A.

Mallinckrodt Institute of Radiology
Saint Louis, MO

**Purpose**

Annular fissures in general and radial fissures in particular play an important part in disk degeneration. The aim of this study was to evaluate the differences in the characteristics and temporal evolution of radial and nonradial annular fissures in a young population.

**Materials & Methods**

Sixty-three patients (40 females, 23 males) with a mean age of 30 years (range 14-40 years) were selected in whom two MRIs of the lumbar spine were available. The MRIs had been done at a mean interval of 30 months (range: 3-85 months). T12-L1 through L5-S1 disks were evaluated for each patient for the presence of annular fissures. The annular fissures were categorized as radial if the signal of the fissure was noted to be in direct continuity with the central hyperintensity of the disk on T2-weighted turbo spin-echo images. All fissures were graded on a 4-point scale based on their conspicuity and on a 5-point scale based on their extent. The initial and the follow-up studies were compared to assess the change in the conspicuity of the fissures and the appearance of any new herniation. The prevalence of new herniation was compared for disks without annular fissures, disks with nonradial fissures, and disks with radial fissures.

**Results**

On the initial examination, annular fissures were present in 68.2% of disks and 75.2% of all fissures were radial. There was no age predilection for presence or type of annular fissure. Annular fissures were significantly more common in males, and were more likely to be radial in that population (p = 0.01). There was a significant difference in the segmental distribution of radial and nonradial fissures, with caudal predominance of radial fissures (p<0.0001). The radial fissures were significantly more extensive and more conspicuous than the nonradial fissures. On the follow-up examination, 76.5% of disks with nonradial fissures and 62.4% of disks with radial fissures remained stable. Conspicuity decreased in 11.6% of all fissures and increased in 18.6%. Radial fissures showed a significantly higher rate of new disk herniation on the follow-up study (p=0.0001). No association between the presence of a nonradial fissure on a prior examination and subsequent disk herniation was noted.

**Conclusion**

There were significant differences in the segmental distribution, sex predilection, conspicuity, and extent of radial annular fissures when compared to nonradial fissures. The significantly higher prevalence of radial fissures in the load-bearing portion of the lumbar spine may indicate the role of stronger mechanical forces in formation of such fissures. While the radial fissures are predisposed to develop herniation at the site of the fissure over time, no such significance can be attributed to the nonradial fissures.

**Key Words:** Annular fissure, herniation

**Paper 232 Starting at 11:57 AM, Ending at 12:05 PM**

**MR Spectroscopy of Human Cervical Spondylosis at 3 T**

Gebara, N. V. • Nagarajan, R. • Thomas, A. • Ellingson, B. • Langston, H. • Salamon, N.

University of California Los Angeles Medical Center
Los Angeles, CA

**Purpose**

Cervical spondylosis is a disease process frequently evaluated with MR imaging (MRI); however, conventional MRI provides only gross morphologic evaluation of the spinal cord. In this study, we assess the utility of MR spectroscopy (MRS) in detection of spinal cord damage at the biochemical level, before the appearance of gross myelomalacia.

**Materials & Methods**

A total of 21 patients (12 females and 9 males, mean age 59.2 years) with various degrees of cervical spondylosis and 10 healthy control subjects (5 male, 5 female, mean age 40 years) were included in the study. The subjects were scanned in a 3 T Siemens Trio MR scanner and routine MRI of the cervical spine was obtained. The sagittal T2-weighted images were reviewed for morphologic signs of myelomalacia, including T2-weighted signal abnormality and decreased cord caliber. The diameter of the spinal cord and spinal canal also were measured at every cervical disk level from C1-2 to C7-T1. These data then were used to calculate the mean subaxial cervical space for the cord index (MSCSAC), calculated by subtracting the sagittal diameter of the cord from the sagittal diameter of the canal at the disk-space level. Then, single voxel MR spectroscopy was preformed at the C2 vertebral body level, where the spinal canal is largest, with an average voxel size of 1.72 ml (7 x 7 x 35 mm3). Metabolites were quantified by the frequency domain fitting LC model algorithm. The NAA, choline, myoinositol, glutamine-glutamate complex and lactate levels were reviewed.

**Results**

We divided the patients into two groups, those with morphologic signs of myelomalacia (10) and those without conventional MRI findings of myelomalacia (11). We compared the SAC values and MRS metabolite profiles between the two groups and with the normal control group. A significant increase in the total choline ratio (GPC + PCh) was found in both patient groups (0.486 +/- 0.167 in the myelomalacia group and 0.405 +/- 0.088 in the nonmyelomalacia group) compared to the normal controls (0.309 +/- 0.083, p-value=0.049). Also, although not statistically significant, there was
a trend of elevated choline, decreased NAA, and increased lactate in the myelomalacia group compared to the non-
myelomalacia group, as expected. Lastly, there was a trend of increased total myoinositol and glutamine-glutamate
complex in the nonmyelomalacia group, which was not seen in the myelomalacia group or in the normal control group.
The SAC values in the nonmyelomalacia group were decreased uniformly throughout the cervical spine with values
less than 4 mm (nl 6.7 +/- 0.8) from the C2-C3 through C6-C7 seen in eight out of 11 patients. In the myelomalacia
group, the SAC values were less uniform, sometimes with significant deviations in values seen at only one or two disk-
space levels.

CONCLUSION
This study suggests that elevated glutamine/glutamate and myoinositol peaks can be detected on MRS in patients with
chronic spinal stenosis without myelomalacia. These may be useful physiologic markers of spinal cord damage in chronic
spondylosis. Further study will be needed to evaluate the useful physiologic markers of spinal cord damage in chronic
spondylosis. Further study will be needed to evaluate the

KEY WORDS: Cervical spondylosis, MR spectroscopy

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Paper 233 Starting at 12:05 PM, Ending at 12:13 PM
Degenerative Related Cervical Myelopathy: Imaging Features with Unique Enhancement Pattern

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PURPOSE
Myelopathy of the cervical cord is a common complication related to degenerative disk disease. Cord signal changes
associated with degenerative disk disease are variable and can be associated with abnormal cord enhancement. The
imaging features can be confusing, with inflammatory and neoplastic processes of the spinal cord. The purpose of this
study is to evaluate the radiologic features and enhancement pattern of degenerative related cervical myelopathy.

MATERIALS & METHODS
We retrospectively reviewed 32 patients with degenerative related cervical myelopathy who had undergone magnetic
resonance (MR) imaging between May 2006 and July 2010. Common indications for MR imaging included: pain, sensory
changes and motor dysfunction. The imaging features on T1- and T2-weighted images along with the enhancement
pattern were evaluated. Intravenous contrast material was given in 26 patients and follow-up studies were available in
14 patients.

RESULTS
Cord signal changes are variable and probably reflect a combination of venous congestion and/or inflammation in the early stage, followed by myelomalacia with cord atrophy in the chronic stage. Radiologic changes in the early stages can involve the entire cross section of the cord and are seen only on T2-weighted images, or can be seen on T1- and T2-weighted images. A ring-like enhancement pattern can be seen involving the periphery of the cord with sparing of the central aspect of the cord. This enhancement pattern is unique and is different than the enhancement pattern seen in inflammatory or neoplastic processes of the cord. Radiologic changes in the chronic stage usually are seen involving the central gray matter or the lateral/dorsal cord. No enhancement is seen in this stage.

CONCLUSION
Radiologic appearance of cervical cord myelopathy related to degenerative disk disease can simulate the appearance of many inflammatory and neoplastic processes of the cervical cord. A ring-like enhancement of the cord seen in association with the degenerative changes is unique and is helpful in suggesting the imaging changes are related to the degenerative process.

KEY WORDS: Degenerative, cervical myelopathy, enhancement

Paper 234 Starting at 12:13 PM, Ending at 12:21 PM
Odontoid-Lateral Mass Asymmetry on CT in Pediatric Trauma: Do We Need to Further Investigate?

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PURPOSE
Cervical spine injuries in children are more frequent in the upper cervical spine. When assessing this region in trauma patients, radiologists may encounter odontoid-lateral mass asymmetry. The asymmetry without fracture could be due to head rotation, or might signify atlanto-axial rotatory fixation/subluxation or ligamentous injury. In a pediatric ED practice, it might be difficult to decide whether further work up should be advised. Therefore the purpose of this study is to try to set guidelines for further investigation of odontoid-lateral mass asymmetry in cervical spine CT studies of pediatric trauma patients.

MATERIALS & METHODS
In order to study the significance of odontoid-lateral mass asymmetry we compared measurements of the atlanto-axial joint in (1) pediatric trauma patients that underwent cervical CT scan and had definite C-spine clearance,and (2) patients known to have atlanto-axial pathology without fracture. We assumed that odontoid-lateral mass asymmetry would be present in both groups. The groups were matched for age, sex and severity of traumatic insult and were collected retrospectively and consecutively from our clinical data as follows: A. Fourteen children (8 females, 6 males) diagnosed with C1-2 ligamentous injury or atlanto-axial rotational fixation/subluxation; those constituted the diseased group. B. Fifty-six children who underwent cervical spine CT to rule out traumatic injury, and their final outcome was definite cervical spine clearance either by additional imaging or by clinical follow up in which no further issues were found. This group served as our nondiseased trauma group. For each patient clinical data were collected and the following parameters were measured on CT scans: 1. anterior atlanto-dental interval (ADI), 2. Odontoid-lateral mass interval and
3. the angle of rotation of the a) head, b) C1 and c) C2 relative to the CT table. Statistical tests were used for categorical and quantitative variables as well as multivariate analysis by the logistic regression.

RESULTS
A statistically significant difference (P<0.001) was found between the groups in the presence of cervical tenderness and torticollis. Additionally there was significant difference in the median ADI value which was 3 ± 1 mm in the diseased group and 2 ± 0.6 mm in the nondiseased trauma group. The degree of head rotation was significantly higher in the diseased group. Using multivariate analysis the presence of cervical tenderness and abnormal ADI were the most significant variables that differentiated between the groups.

CONCLUSION
Odontoid-lateral mass asymmetry without fracture in the absence of cervical tenderness and with normal ADI is likely not indicative of traumatic insult and usually should not be investigated further.

KEY WORDS: Trauma

Paper 234a Starting at 12:21 PM, Ending at 12:29 PM
Diffusion and Cerebrospinal Fluid Flow MR Imaging in the Evaluation of Cervical Spondylosis

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BACKGROUND
Among patients with cervical spondylosis, routine MR imaging with T2-weighted imaging has a low sensitivity for detection of cervical myelopathy. Patients with cervical stenosis or myelopathy have been evaluated separately with MR diffusion-weighted imaging (DWI) with apparent diffusion coefficient (ADC) maps and cerebral spinal fluid (CSF) flow studies. DWI with ADC may be more sensitive in detecting early cervical myelopathic changes compared to T2 weighted sequences. Evaluation of CSF flow in cervical myelopathy demonstrates variations in CSF flow dynamics and spinal cord motion. Simultaneous acquisition of DWI and CSF flow data in evaluation of cervical stenosis has not been previously performed.

PURPOSE
To evaluate patients with cervical stenosis with DWI and CSF flow studies.

MATERIALS & METHODS
Patients with clinical symptoms of cervical stenosis were referred by neurologists and neurosurgeons for MR imaging (General Electric 1.5 Tesla Signa and Philips 1.5 Tesla Gyroscan Intera): Axial and Sagittal T2 (TR 2300; TE 100; NEX 8; FOV 20; 256 x 512 Matrix; slice thickness 3/0.3mm; ETL 16); Sagittal Cine CSF Flow (TR 14; TE 11; FOV 20; 196 x 256 matrix; velocity encode 5 cm/s; slice thickness 8mm; peripheral pulse gated); Sagittal DWI with ADC map (multishot SE; EPI 9; TE 18; peripheral pulse gated; FOV 22; 128 x 128 matrix; slice thickness 4/0.5mm; b-value 400 sec/mm2). ADC maps were obtained utilizing existing software available on the MRI scanner. Images were reviewed by two neuroradiologists blinded to the patients’ clinical examination. Images were evaluated for degree of canal stenosis, spinal cord T2-weighted signal abnormality, DWI/ADC abnormality, CSF flow restriction in the subarachnoid space, and spinal cord motion. Correlation was made to the neurological examination and clinical records.

RESULTS:
Twenty patients underwent MR imaging: (8 male, 12 female; mean age 65.5 years; range 46-76 years). All patients had radiographic evidence of cervical spinal stenosis (1 mild, 4 moderate, 14 severe). All patients were symptomatic, with 11 patients having clinical signs and symptoms of myelopathy and the remainder with nonmyelopathic signs and symptoms. 14 patients underwent surgical decompression while 6 patients were managed conservatively. Mean clinical follow up was 24 months. In 14 of 20 patients, at the site of stenosis, CSF flow imaging was able to detect presence of abnormal spinal cord motion defined as focal segmental asynchronous motion of the spinal cord and abnormal elevation of spinal cord velocity > 0.6 cm/s. 7 of 20 patients had abnormal spinal cord motion without T2-weighted signal abnormality, and 3 of 20 patients had abnormal spinal cord motion without abnormal elevation of ADC in the spinal cord. The sensitivity, specificity and positive predictive value for detection of myelopathy was: T2-weighted images (63%, 44%, 58%); Abnormal increased ADC (73%, 33%, 57%); Abnormal spinal cord motion (73%, 33%, 57%); Abnormal increased ADC and/or abnormal spinal cord motion (91%, 22%, 59%). 10 of 14 patients improved following surgical decompression, while 4 of 14 patients were unchanged or worse following decompression, all of whom demonstrated abnormal spinal cord motion on presurgical imaging (Fisher exact test p=0.126).

CONCLUSION
DWI and CSF flow studies are sensitive modalities in evaluation of cervical stenosis. Increased cord DWI, attenuated CSF flow and abnormal cord motion are observed in patients with spinal stenosis with or without cord T2 signal abnormality. The detection of myelopathy may be improved when CSF flow imaging is combined with diffusion weighted imaging. The absence of abnormal cord motion may prove to be a useful prognostic indicator. Further evaluation and modeling of CSF flow dynamics in symptomatic patients without T2 signal abnormality may be helpful.
Early Experience in the Treatment of Unruptured Intracranial Aneurysms with a Novel Microporous Membrane-Covered Flow-Diverting Stent: Immediate Results and Mid-Term Follow Up

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PURPOSE
To report our initial clinical experience with a microporous membrane-covered flow-diverting stent in the treatment of unruptured anterior circulation intracranial aneurysms.

MATERIALS & METHODS
Between September 2006 and December 2010, patients with unruptured intracranial internal carotid artery aneurysms were treated with a hydrophilic balloon mounted microporous polyurethane membrane covered stent (X*Calibur™, Merlin MD, Singapore) at seven centers in Europe and Brazil according to a prospective, single-arm investigational protocol. This novel aneurysm occlusion device (AOD) provides 60-70% surface area coverage, nearly twice that of conventional flow-diverting metal stents. All patients were premedicated with clopidogrel and aspirin and anticoagulated intraoperatively with heparin. Clopidogrel and aspirin were continued for a minimum of 3 months postprocedure and aspirin indefinitely. Modified Rankin Score (mRS) at the xix European centers and angiographic results at all seven centers were assessed postprocedure and at 6 months.

RESULTS
Twenty-eight patients were entered in the protocol (27 females) ranging in age from 26 to 77 years. Two aneurysms were treated previously with coils. Aneurysm size was ≥ 25 mm for 3, 12-24 mm for 10, and < 12 mm for 15. Twenty-five were wide-neck saccular and three fusiform. Aneurysm location was cavernous in eight, ophthalmic in 12 and supraclinoid in eight. Twenty-one stents were implanted at the target site in 17 patients. In 11 patients treated early in this experience, technical failure occurred due to inability to advance AOD to target site (6), inability to properly deploy AOD at target site (n=2) or unavailable AOD size (n=2). In one aborted case technical failure was due to distal guidewire perforation prior to AOD introduction. Three patients required treatment with two telescoping stents to bridge the aneurysm neck. There were 17 covered side branches (13 ophthalmic, 2 posterior communicating, 1 meningeal, and 1 anterior choroidal). Follow up ranged from 0.2 to 50.7 (mean 25.5) months. There were two procedure-related deaths, one due to parent artery rupture during balloon inflation and one due to distal vessel perforation with guidewire. There were no permanently disabling ischemic strokes. At last follow-up mRS was 0-2 in 100% of evaluable European patients. In a subgroup of patients with symptomatic large (n=1) and giant (n=2) aneurysms brain MR imaging obtained at 6 months showed near complete disappearance of the aneurysm mass. One of 17 stented patients had parent artery occlusion that was rescued by thrombolytic therapy and thrombectomy. All covered side branches remained patent at last angiographic follow-up. Two of 17 stented patients developed asymptomatic in-stent stenosis ≥ 50% at 6 months. Ninety-100% aneurysm occlusion was achieved in 12/17 stented patients (71%) immediately postprocedure. Complete aneurysm occlusion was present in 13/15 (87%) eligible patients at 6 months. The two incomplete occlusions were associated with chronic warfarin anticoagulation for atrial fibrillation in one case and poor stent apposition treated with prolonged heparin anticoagulation in the other. There were no aneurysm ruptures.

CONCLUSION
Microporous membrane-covered flow-diverting stents achieve high rates of complete aneurysm occlusion with patency of parent arteries and covered side branches. Advantages include progressive resolution of aneurysmal mass effect.

KEY WORDS: Intracranial aneurysm, endovascular flow diverter stent, Merlin MD
Mechanical Recanalization with the Solitaire Device in Acute Stroke

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PURPOSE
The purpose of this study was to demonstrate a new approach to the use of a self-expanding stent in the treatment of acute ischemic stroke.

MATERIALS & METHODS
Thirty-eight consecutive patients with acute intracerebral artery occlusions were treated with a self-expandable intracranial stent, which was withdrawn in its unfolded state. For this technique, we used the Solitaire AB/FR, which is the only intracranial stent that is fully recoverable. Ten patients had an occlusion of the basilar artery, 23 had a middle cerebral artery occlusion, and five had terminal carotid artery occlusions; six of these had to be treated first for an acute occlusion originating in the internal carotid artery. Recanalization results were assessed by follow-up angiography immediately after the procedure. Neurologic status was evaluated before and after treatment (90-day follow up) according to the National Institutes of Health Stroke Scale and modified Rankin scale.

RESULTS
Successful revascularization was achieved in 34 of 38 (89%) patients [thrombolysis in cerebral infarction (TICI) 2a/b and 3]. There was immediate flow restoration in 36 of 38 (94%) cases after deployment of the device. The stent was removed in its unfolded state in all patients. The mean time from stroke symptom onset to recanalization was 277 minutes, with a standard deviation of 118 minutes. Mean National Institutes of Health Stroke Scale score on admission was 19.4, with a standard deviation of 5.7. Twenty-three of the patients (60.5%) improved by >10 points on the National Institutes of Health Stroke Scale at discharge, and 44% showed a modified Rankin scale score of 0-2 at 90 days. Mortality was 18%. In one case, an asymptomatic intracranial hemorrhage was detected on control computed tomography, and three patients had a symptomatic intracranial hemorrhage.

CONCLUSION
Withdrawal of an unfolded, fully recoverable, intracranial stent yielded very promising angiographic and clinical results. It combines the advantages of prompt flow restoration and mechanical thrombectomy.

KEY WORDS: Acute stroke, mechanical recanalization, Solitaire

Long-Term Clinical and Angiographic Follow Up after Primary Angioplasty for Symptomatic Middle Cerebral Artery Stenosis

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PURPOSE
The purpose of this study is to report the results of long-term clinical and angiographic follow up after primary intracranial angioplasty for symptomatic middle cerebral artery (MCA) stenosis.

MATERIALS & METHODS
We retrospectively analyzed the clinical and angiographic data of 79 patients from single institution treated with primary angioplasty without stenting for symptomatic MCA stenosis over a 11-year time period (4-132 months; median, 70.5 months). A neurovascular imaging study (conventional angiography or CT angiography or MR angiography) was performed in 45 of 76 patients after a mean period of 4.3 years. Angiographic restenosis was defined as greater than 50% stenosis on follow-up neurovascular imaging study. Patient records were reviewed for periprocedural complications, angiographic findings and follow-up clinical data.

RESULTS
Technical success was achieved in 68 (86.1%) of 79 patients. The 30-day major stroke or death rate was 3.8% (3 of 79) and any stroke or death rate was 6.3% (5 of 79). There were two periprocedural deaths (2.5%). During long-term follow up, ipsilateral minor stroke occurred in one of 76 patients (1.3%) and contralateral stroke in three patients. There was no ipsilateral major stroke or neurologic death. Angiographic restenosis occurred in eight of 45 patients (17.8%). Of these patients, no one showed clinical recurrence of ischemic symptoms during follow-up period.

CONCLUSION
This study demonstrates that the risk of recurrent ischemia is very low after primary angioplasty in patients with symptomatic MCA stenosis. In addition, angiographic restenosis is not associated with clinical recurrence of ischemic symptoms during follow-up period.

KEY WORDS: Acute stroke, angioplasty
Paper 238 Starting at 11:09 AM, Ending at 11:17 AM

Safety and Effectiveness of Emergency Carotid Artery Stenting for a High-Grade Carotid Stenosis with Intraluminal Thrombus under Proximal Flow Control in Hyper-Acute and Acute Stroke Setting

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PURPOSE

The purpose was to investigate the feasibility, safety, and effectiveness of emergency carotid artery stenting (eCAS) for high-grade carotid stenosis with intraluminal thrombus (ILT) under or without proximal flow control (PFC).

MATERIALS & METHODS

Included for the analysis were acute ischemic stroke patients 1) who were admitted between 2001 and 2009, 2) who had serious neurologic symptoms, 3) without large diffusion-weighted imaging lesions, 4) high-grade carotid stenosis with ILT and 5) who underwent eCAS. Patients had undergone eCAS without PFC until 2004 (group C) and have undergone eCAS under PFC since 2004 (group P). National Institutes of Health Stroke Scale (NIHSS) on admission, NIHSS just before CAS, 7-day NIHSS after CAS, and 3-month modified Rankin Scale (mRS) were investigated between two groups.

RESULTS

Forty-nine patients underwent eCAS, and eight of the 49 patients had high-grade stenosis with ILT. Four of the eight patients belonged to group C, and four of the eight patients belonged to group P. Probable distal embolism associated with eCAS occurred in two cases of group C; however did not occur in group P. In groups C and P, 7-day NIHSS (median) was 15 and 5 (p<0.05), 3-month mRS (median) was 4 and 2 (p<0.05), respectively, although there were no significant differences in NIHSS on admission and just before CAS between the two groups.

CONCLUSION

In acute stroke patients suffering from high-grade carotid stenosis with ILT, eCAS under PFC is safer and more effective in achieving favorable clinical outcome than eCAS without PFC.

KEY WORDS: Emergency carotid artery stenting, intraluminal thrombus, proximal flow control

Paper 239 Starting at 11:17 AM, Ending at 11:25 AM

Relationship between MR Imaging/Perfusion-Weighted Imaging Findings and 3-Month Clinical Outcome of the Acute Ischemic Patients who Underwent Endovascular Reperfusion Therapy for Internal Carotid or Middle Carotid Artery Occlusion

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PURPOSE

The purpose of our study was to investigate relationship between MR imaging/perfusion-weighted imaging findings and 3-month clinical outcome following endovascular reperfusion therapy in acute ischemic stroke patients with occlusion of the internal carotid artery (ICA) or the middle cerebral artery (MCA).

MATERIALS & METHODS

We retrospectively analyzed the acute stroke patients 1) who were admitted to our institution from January 2004 to June 2010, 2) with serious neurologic symptoms of NIHSS score of 8 or more, 3) who had total occlusion of the ICA or MCA displayed by MR angiography (MRA) with diffusion-weighted imaging (DWI)/perfusion-weighted imaging (PWI) mismatch and 5) who underwent emergency endovascular reperfusion therapy within 8 hours from stroke onset. We investigated patient's baseline features, emergency MRI findings, successful recanalization defined as TICI 2B or 3, and 3-month modified Rankin scale (3M-mRS). We used DWI-ASPECTS for DWI findings and time-intensity-curve (TIC ) types for PWI findings. Regions of interest were set at symmetrical positions of the bilateral MCA territories and time-intensity-curves (TICs) were calculated and the type of TICs were classified into four patterns with time to peak (TP) and value of the peak signal (PV). Comparing the affected side with the contralateral side, we defined type 1 as TPa>TPc and PVa≥PVc, type 2 as TPa>TPc and PVa<TPc and PVa<PVc, type 3 as TPa=TPc. The primary outcome was mRS of 0-2 at 3 months, and secondary outcome was death within 3 months from onset. We assessed pretreatment predictors for these outcomes by using logistic regression analysis.

RESULTS

Seventy-nine patients were analyzed. Their median age was 77 years, women were 30 patients, mean admission NIHSS was 17.9 ± 5.1, median DWI-ASPECT score was 7, 63 patients had cardiogenic stroke, successful recanalization was achieved in 38 patients (54.0%), and median 3M-mRS was 3. Twenty-three patients (32%) had 3M-mRS of 0-2 and 11 patients (37%) died within 3 months. Perfusion-weighted imaging-TICs of types 1, 2, 3 and 4 were in 13, 37, 21 and 0 patients, respectively. Type of PWI-TIC was correlated significantly to 3M-mRS (r = -0.24, P = 0.047). The higher PWI type were, the lower 3M-mRS were. Logistic regression analysis demonstrated that independent predictors of favorable clinical outcome (3M-mRS of 0-2) were DWI ASPECTS (OR,0.66 ; 95%C1,0.47-0.92, P = 0.014) and age but types of PWI-TIC were not, whereas independent pre-
dictors of death within 3 months from onset were type of PWI-TIC (OR 8.20; 95% CI 1.15-58.30, P = 0.035) and admission NIHSS.

**Conclusion**
In ischemic stroke patients who underwent endovascular reperfusion therapy for the ICA or MCA occlusion within 8 hours from onset, type of PWI-TIC was the significant predictor for death within 3 months from onset.

**Key Words:** Reperfusion therapy, perfusion-weighted image, ischemic stroke

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**Paper 240 Starting at 11:25 AM, Ending at 11:33 AM**

**Susceptibility Vessel Sign on T2*-Weighted Imaging as a Predictor of Clinical Outcome after Acute Reperfusion Therapy in Acute Basilar Artery Occlusion**

Tajiri, H. • Mori, T. • Iwata, T. • Miyazaki, Y. • Nakazaki, M. Shonan Kamakura General Hospital Stroke Center Kamakura City, JAPAN

**Purpose**
Acute basilar artery occlusion (BAO) has been associated with high morbidity and mortality if not recanalized. Magnetic susceptibility effect of deoxygenated hemoglobin in red thrombi may result in hypointense signals on T2*-weighted gradient-echo images at 1.5 T. The purpose of our retrospective study is to investigate whether or not susceptibility vessel sign of the basilar artery (SVS-BA) on T2*-weighted images can predict clinical outcome after emergency reperfusion therapy (ERT) in patients where MR angiography (MRA) suggests the BA occlusion.

**Materials & Methods**
Included for retrospective analysis were patients as follows: (1) study period was from November 2005 to March 2010, (2) who were admitted to our institution within 24 hours from stroke onset, (3) who underwent emergency MR imaging including diffusion-weighted imaging, T2*-weighted imaging, MRA at 1.5 T and asymptomatic acute BAO was diagnosed by MRA, (4) whose NIHSS score on admission was 5 or more. Excluded were patients (1) in whom diffusion-weighted images showed extensive high signal intensity area in pons or cerebelli, (2) who presented NIHSS score of less than 5, (3) who were comatose on admission, (4) who had contraindications for ERT. They were divided into two groups according to presence (group P) or absence (group A) of SVS-BA on T2*-weighted imaging. The relationships between the presence of BA-SVS and patients' baseline characteristics on admission (age, gender, stroke subtypes), onset to admission time (OTA time), onset to treatment time (OTT time), NIHSS on admission (NIHadm), NIHSS on the 7th day (NIH7th), modified Rankin Scale at 3 months (3M-mRS), survival rate at 3 months (3M-Surv) and estimated lengths of BAO on emergency MRA (eMRA) were investigated. Estimated lengths of BAO were graded according to eMRA as follows: grade 0, normal; grade 1, visualized approximately half or more; grade 2, visualized approximately less than half; grade 3: not visualized. TIMI grades 0 and 1 were defined as recanalization failure, TIMI grades 2 or 3 as successful recanalization.

**Results**
During the study periods, 23 patients were included for analysis. Among them, 21 patients underwent endovascular treatment and two were treated with IV rt-PA. In P (n = 10) and A (n = 13) groups, age (median) was 83 and 74 years (p = 0.153), man (%) was 80 and 67 (p = 0.640), cardiogenic (%) was 30 and 46 (p = 0.669), OTA time (median) was 1.3 and 1.5 hours (p = 0.664), OTT time (median) was 6.3 and 4.5 hours (p = 0.710), NIHadm (median) was 21 and 22 (p = 0.306) and BAO grade (median) was 2 and 1 (p<0.05), respectively. In P and A groups, NIH7th (median) was 23.5 and 6.0 (p<0.01), 3M-mRS (median) was 5 and 2 (p<0.05), and 3M-Surv (%) was 80 and 85% (p = 1.000), respectively.

**Conclusion**
Clinical outcome following emergency reperfusion therapy for the basilar artery occlusion was better in patients without SVS-BA on T2*-weighted imaging than with SVS-BA.

**Key Words:** Acute basilar artery occlusion, emergency reperfusion therapy, susceptibility vessel sign

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**Paper 241 Starting at 11:33 AM, Ending at 11:41 AM**

**Comparison of C-Arm CT Cerebral Blood Volume Measurement and MR Diffusion Imaging in a Canine Stroke Model**

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**Purpose**
Cerebral blood volume (CBV) measurement performed with conventional helical CT is predictive of diffusion restriction on MR imaging. C-arm CT (CACT) CBV measurement after IV contrast injection has been shown to compare well with CBV measurements performed via conventional perfusion CT. The purpose of this experiment was to compare CBV maps obtained with a CACT using both IV and intra-arterial (IA) contrast injection and determine how well they correlated with regions of diffusion restriction in a canine stroke model.

**Materials & Methods**
After creating an MCA stroke, CBV imaging was performed with CACT after IV and IA contrast injection followed by MR diffusion imaging at 1.5, 2.5, 3.5 and 4 hours after stroke using a Siemens Neuro and Angio Miyabi suite. The images were transferred to an independent workstation for postprocessing. Contrast density measurements were performed in the common carotid arteries bilaterally at each time point on both IA and IV injection to compare contrast density between IA and IV contrast administration. After coregistration of the MRI and CT data sets, CBV measurements were performed in multiple locations in each cerebral hemisphere. Maximum intensity projection (MIP) images also were created of the cerebral vasculature from the same data set used for the CBV acquisition.
RESULTS
There was good correlation between the CT contrast density in the carotid arteries on both IA and IV injection (P < .001). There was good visual correlation between the areas of MR diffusion restriction and the regions of decreased CBV on both the IA and IV studies. The MIP reconstructions from IV and IA contrast injections provided 3D images demonstrating the occluded MCA.

CONCLUSION
In the canine model, IA and IV contrast injection were comparable in terms of contrast density and CBV measurements. The CBV maps corresponded well with the regions of MR diffusion restriction. The same data set used for CBV maps can be used to create CT angiographic images suitable for diagnosis of medium-size vessel occlusions.

KEY WORDS: C-arm CT, cerebral blood volume, MRI diffusion

R E S U L T S
There was good correlation between the CT contrast density in the carotid arteries on both IA and IV injection (P < .001). There was good visual correlation between the areas of MR diffusion restriction and the regions of decreased CBV on both the IA and IV studies. The MIP reconstructions from IV and IA contrast injections provided 3D images demonstrating the occluded MCA.

Figure: Maximum intensity projection reconstruction using CBV data set demonstrating left MCA vessel occlusion (white arrow).

CONCLUSION
In the canine model, IA and IV contrast injection were comparable in terms of contrast density and CBV measurements. The CBV maps corresponded well with the regions of MR diffusion restriction. The same data set used for CBV maps can be used to create CT angiographic images suitable for diagnosis of medium-size vessel occlusions.

KEY WORDS: C-arm CT, cerebral blood volume, MRI diffusion

Paper 242 Starting at 11:41 AM, Ending at 11:49 AM
Performance of Mechanical Thrombectomy Device Affected by Histologic Characteristics of Thromboemboli
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PURPOSE
A recent study shows that majority of the thromboemboli recovered from stroke patients showed complex histologic findings with fibrin-rich component and erythrocyte-rich component. The purpose of this study is to evaluate if the performance of a mechanical thrombectomy device is affected by the histologic characteristics of thromboemboli, using a swine stroke model.

MATERIALS & METHODS
Two histologically different types of experimental clot, erythrocyte-rich vs fibrin-rich clot, were injected into a total of 16 branches of extracranial arteries in five swine. Eight vessels were occluded with erythrocyte-rich clot (Group A) and eight were occluded with fibrin-rich clot (Group B). Mechanical thrombectomy using the Merci Clot Retrieval Device® was performed after occlusion of the vessels, and angiographic results were evaluated by: 1) the number of attempts required to achieve final angiographic result, 2) final TIMI grade, and 3) presence of distal embolism.

RESULTS
A total of 48 mechanical thrombectomy procedures were performed. Average attempts to achieve TIMI grade II or III recanalization were 2.75 times in Group A and 4.5 times in Group B (p<0.001). Mean time to recanalization was longer in Group B (81.5 min) than in group Group A (15.5 min; p<0.01). Every vessel in Group A showed recanalization defined as a final TIMI grade of II or III, (100%) whereas only three out of eight samples (37.5%) achieved recanalization in Group B.

CONCLUSION
Vessel occlusion caused by fibrin-rich clot resulted in a significantly lower recanalization rate, lower final TIMI score and longer mean recanalization time. The angiographic outcome of mechanical thrombectomy appears to be significantly influenced by the histologic characteristics of the occluding thromboembolus.

KEY WORDS: Mechanical thrombectomy, acute stroke, histologic analysis

Paper 243 Starting at 11:49 AM, Ending at 11:57 AM
Efficacy and Safety of Thrombectomy Devices in Mechanical Recanalization for Acute Ischemic Stroke: Preclinical Evaluation
Chueh, J. Y. • Wakhloo, A. K. • Gounis, M. J.

University of Massachusetts Worcester, MA

PURPOSE
The performance of the MERCI and Penumbra systems has been investigated in animal models and clinically. It was found that, without adjunctive therapies, the recanalization rate and clinical outcome of these devices still could be improved. Microcatheter deliverable self-expanding stents (SES) are navigated easily in the tortuous cerebrovascular, and are deployed at lower radial as compared to the balloon expandable stents. The favorable outcome presented in a prospective trial of primary intracranial stenting for acute ischemic stroke (AIS) suggested the potential utility of the SES in the treatment of AIS. Ultrasonically driven waveguide has been used for thrombus ablation applications in the peripheral vasculature, and tended to expand to the ablation of the thrombotic materials in cerebral arteries. Testing these
devices in an experimental model not only provides information on thrombus-device interaction but also helps device selection in different clinical scenarios. The aim of this study is to design a model system of cerebrovascular occlusion that allows realistic testing of the above-mentioned mechanical thrombectomy devices.

**Materials & Methods**

The proposed model system was composed of an anatomically representative internal carotid artery (ICA)/middle cerebral artery (MCA) vascular replica, a clinically validated embolus analogue (EA), and physiologic hemodynamic conditions. The MERCI L5 Retriever, Penumbra aspiration system, SES, and ultrasound waveguide device were evaluated in terms of the efficacy and safety. The SES was partially deployed to ensnare the EA, followed by EA retrieval. The primary efficacy endpoint was the amount of blood flow restored, and the secondary endpoint was the ability to achieve recanalization. The primary safety endpoint was an analysis of clot fragments and their size distribution by Coulter principle.

**Results**

The Penumbra system achieved the highest recanalization rate (80%) followed by the MERCI L5 Retriever (67%), SES (17%) and ultrasound waveguide device (0%). Partial flow restoration was observed with the use of the Penumbra (90.8 ± 5.5%) in four experiments, MERCI (100%) in four experiments and SES (87%) in one experiment after procedure (maximum number of attempts = 2). Temporary flow restoration (29.3 ± 6.4%) was recorded when the SES was expanded during the procedure. A 2000 µm aperture with a sensitivity range between 200 to 1600 µm detected that the number and size of the particles generated by the Penumbra system were greater (average number of 16) and larger (average diameter of 310.5 µm) as compared to those produced by other devices. However, no EA fragments had dimension greater than 1000 µm, and mean size of the small and large particles were between 22.3 to 26.6 and 215.7 to 310.5 µm, respectively, depending on the device used.

**Conclusion**

A physiologically realistic model system of MCA occlusion was created for evaluation of the thrombectomy devices. The recanalization rate of the thrombectomy device was related to the ability of the device to capture the EA during removal of the device and the geometry of the cerebrovascular anatomy. The risk of the embolic shower was influenced by the mechanism of action for the thrombectomy device.

**Key Words:** Acute ischemic stroke, thrombectomy, model system

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**Paper 244 Starting at 11:57 AM, Ending at 12:05 PM**

**Safety of Protected Carotid Artery Stenting in High-Risk Patients with Severe Carotid Artery Stenosis and MR Imaging-Depicted Carotid Intraplaque Hemorrhage**

Yoon, W. • Moon, Y. • Kim, S. • Kang, H.

Chonnam National University Hospital
Gwangju, KOREA, REPUBLIC OF

**Purpose**

Carotid intraplaque hemorrhage (IPH) is found in unstable plaque and can be detected by using MR imaging. The safety of carotid artery stenting (CAS) in patients with IPH has not been studied. The aim of this study is to determine the safety of CAS with the use of an emboli-protection device in high-risk patients with severe carotid artery stenosis and MRI-depicted carotid IPH.

**Materials & Methods**

We retrospectively reviewed the prospective database of 91 consecutive patients with severe carotid stenosis and high-risk features who were treated with protected CAS. Seventy-eight of these patients underwent both preoperative MRI and time-of-flight (TOF) MR angiography and were included in this study. Intraplaque hemorrhage was defined as presence of high signal intensity within the carotid plaque greater than 150% of the signal intensity of adjacent neck muscle on source images of TOF MR angiography. The primary outcome was the combined incidence of adverse cerebrovascular and cardiac events at 30 days after CAS, including death, stroke, and myocardial infarction (MI). Association between presence of IPH and the incidence of primary outcome was investigated.

**Results**

Intraplaque hemorrhage was detected on TOF MR angiography in 30 patients (38.5%). Carotid IPH was found more frequently in patients who had transient ischemic attack or stroke before CAS (66.7%) than in asymptomatic patients (41.7%) (p = .038). Overall, 30-day ipsilateral stroke or MI or death rates were 6.6% (6 of 91). Four had a minor stroke, and none had a major stroke within 30 days after CAS. One patient with IPH died of an acute myocardial infarction during coronary intervention at day 2. One patient without IPH died of an acute subarachnoid hemorrhage at day 1. There was no mortality related to ischemic complication. The 30-day ipsilateral stroke, myocardial infarction, or death rates were not significantly different between the IPH (10%) and the non-IPH (6.25%) group, p > .05. A multivariate analysis identified one variable as independently associated with the primary outcome: diabetes as a risk factor [odds ratio (OR), 36.9; 95% CI, 1.89 to 720.04].

**Conclusion**

This study demonstrates that carotid stenting with use of an emboli-protection device can be performed safely in high-risk patients with severe carotid stenosis and unstable carotid plaque.

**Key Words:** Stroke, carotid stenosis
Paper 245 Starting at 12:05 PM, Ending at 12:13 PM

Feasibility of Cerebral Blood Volume Imaging by Flat Detector Computed Tomography in Comparison to Multislice Perfusion CT in Acute Stroke Patients: First Experience

Struffert, T.1  •  Deuering-Zheng, Y.2  •  Engelhorn, T.1  •  Kloska, S.1  •  Göltz, P.1  •  Ott, S.1  •  Strother, C.1  •  Schwab, S.1  •  Doerfler, A.1

1University Erlangen-Nuremberg, Erlangen, GERMANY, 2Siemens AG Healthcare Sector, Forchheim, GERMANY, 3University of Wisconsin, Madison, WI

PURPOSE
We tested the hypothesis that postprocessing of a new flat detector CT application (Neuro PBV) would allow to detect cerebral blood volume (CBV) lesions (FD-CT CBV) and other findings (FD-CT) in acute stroke patients directly after endovascular treatment within the angio suite and would correlate with multislice CT and perfusion CT (PCT).

MATERIALS & METHODS
In 12 patients FD-CT CBV and CT imaging (pre- and post-treatment) were reviewed retrospectively. Volumes of stroke lesions in FD-CT CBV and CT were calculated. In 9 patients mean CBV values of the stroke region and opposite brain region were measured in FD-CT CBV and PCT. Flat detector CT images were reviewed for hemorrhage or contrast extravasation.

RESULTS
We found a high correlation of CBV lesion volume in FD-CT CBV and infarct volume in post treatment CT (r= 0.97, p<0.01). Absolute CBV measurements of CBV lesions in FD-CT CBV and PCT were of comparable values and showed a good correlation (r=0.81, p<0.05). In five patients contrast material extravasation was visible in FD-CT. Hemorrhage did not occur.

CONCLUSION
The new FD-CT application allows recognition of CBV lesions during endovascular treatments and compares well with PCT and CT. The ability to assess cerebral perfusion within the angiographic suite may improve the management of ischemic stroke patients and evaluation of efficacy of dedicated therapies.

KEY WORDS: Flat detector CT, perfusion CT, stroke

Paper 246 Starting at 12:13 PM, Ending at 12:21 PM

Endovascular Revascularization in the Acute Rabbit Common Carotid Artery Thromboembolic Occlusion Model

Mehra, M. • Chueh, J. Y. • O’Callaghan, J. • Wakhloo, A. K. • Gounis, M. J.

University of Massachusetts Worcester, MA

PURPOSE
Clot lysis resulting in early re-establishment of the cerebral blood flow has been associated with improved functional outcomes and decreased mortality in acute ischemic stroke (AIS). There is an emerging interest in stenting, angioplasty, and mechanical clot disruption as treatment options. Their use in combination with intra-arterial fibrinolytic therapy offers the possibility of expedited revascularization, reduced thrombolytic dose and a decreased hemorrhagic risk. However, data from clinical and preclinical studies are lacking to show efficacy and vascular safety of these treatment modalities. We developed a rabbit common carotid artery (CCA) thromboembolic occlusion model to assess the efficacy and the histologic vessel response to these intervention techniques.

MATERIALS & METHODS
New Zealand white (NZW) rabbits were selected for this work due to the similar response to tPA as compared with humans. New Zealand white rabbits were anesthetized and a >50% luminal stenosis of the CCA was created bilaterally with 3-0 silk (arrows, A). Allogenic clot was injected through a 6F guide catheter, and lodged consistently in the CCA proximal to the stenosis (arrow, B - selective CCA injection). The stenosis was released 1 hour postclot injection allowing sufficient time for clot-vessel lumen interaction. Digital subtraction angiography was performed to confirm the occlusion and assess the thrombolysis in cerebral infarction (TICI) score. Each vessel either received balloon occlusion, endovascular stent deployment or microcatheter-directed fibrinolytic therapy for treatment. The primary endpoint was flow restoration. The secondary treatment endpoint was the final TICI score, time to revascularization and the vascular safety of the device by assessing the histologic response on luminal scanning electron microscopy (SEM) and hematoxylin and eosin (H&E) staining.

RESULTS
We successfully created consistent thromboembolic occlusions with TICI 0 flow at a predetermined location within the target vessel. Balloon angioplasty when used alone achieved a maximum of TICI 2A angiographic score; however, often it failed to recanalize the CCA. Primary stent deployment achieved immediate flow restoration with a TICI 3 angiographic score. Catheter-directed fibrinolytic therapy achieved a TICI 2B recanalization grade using a total dose of 4mg tPA. Vessels with balloon angioplasty and catheter-directed Alteplase revealed an intact internal elastic lamina with endothelial desquamation on H&E. The luminal surface on the SEM revealed an exposed subendothelial matrix with no evidence of intimal disruption.
CONCLUSION
A model of thromboembolic occlusion was described in the rabbit CCA which allows in vivo assessment of endovascular performance and vascular safety of mechanical and thrombolytic revascularization devices.

KEY WORDS: Acute ischemic stroke, endovascular treatment, model system

Paper 247 Starting at 12:21 PM, Ending at 12:29 PM
Study of a New Generation of Penumbra Aspiration Devices: The 054 SPEED Trial

Gerber, J.1 • Frei, D. F.2 • Bellon, R.2 • Dooley, G.2 • Turk, A.3 • Heck, D.4 • Hui, F.4 • Joseph, G.5 • Jahan, R.6 • Miskolczi, J.7 • Carpenter, J.9 • Grobelny, T.10 • Goddard, J.11 • Leader, B.12 • Bose, A.12 • Sit, S. P.12

1University of Dresden, Dresden, GERMANY, 2Swedish Medical Center, Englewood, CO, 3Medical University of South Carolina, Charleston, SC, 4 Forsyth Medical Center, Winston-Salem, NC, 5 Cleveland Clinic, Cleveland, OH, 6Presbyterian Hospital, Charlotte, NC, 7University of California Los Angeles Medical Center, Los Angeles, CA, 8Holy Cross Hospital, Fort Lauderdale, FL, 9West Virginia University Medical Center, Morgantown, WV, 10Christ Hospital, Oak Lawn, IL, 11Fairview Southdale Hospital, Edina, MN, 12Penumbra Inc., Alameda, CA

PURPOSE
The Penumbra System is a mechanical thrombectomy device indicated for the revascularization of large vessel occlusion in acute ischemic stroke. Reported herein are results of a study to assess the extent to which a new generation of reperfusion catheters with a larger internal diameter (0.054 inch) affects on-the-table safety, accessibility, and overall aspiration efficiency/speed of the System.

MATERIALS & METHODS
This was a retrospective case review of 53 consecutive patients with large vessel occlusion in the brain who were treated with the larger Penumbra System 054 catheter at nine centers in the U.S. Main inclusion criteria were presentation for treatment within 8 hours of symptom onset and an occlusion of a treatable cerebral vessel. The primary endpoints were time of aspiration and rate of complete revascularization as measured by the TIMI scale. Results from the Penumbra Pivotal* trial that utilized the smaller catheters (0.026 to 0.041 inch) were used as the historical control.

RESULTS
The results indicate that the patients treated with the 054 reperfusion catheter have a significantly shorter time required for aspiration and a higher rate of TIMI 3 scores than those in the Pivotal trial.

<table>
<thead>
<tr>
<th></th>
<th>PIVOTAL* (N=125)</th>
<th>054 (N=53)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (mean)(years)</td>
<td>64</td>
<td>63</td>
</tr>
<tr>
<td>Female</td>
<td>49%</td>
<td>60%</td>
</tr>
<tr>
<td>Baseline NIHSS (median)(range)</td>
<td>18(8-34)</td>
<td>18(4-31)</td>
</tr>
<tr>
<td>Time from Symptom Onset to Groin Puncture (median)(hrs)</td>
<td>4.1</td>
<td>4.8**</td>
</tr>
<tr>
<td>Time from Groin Puncture to End of Aspiration (median)</td>
<td>97 min</td>
<td>52 min**</td>
</tr>
<tr>
<td>Time Required for Aspiration (median)</td>
<td>45 min</td>
<td>14 min**</td>
</tr>
<tr>
<td>Preprocedure TIMI 0-1</td>
<td>100%</td>
<td>98%</td>
</tr>
<tr>
<td>Postprocedure TIMI 0-1</td>
<td>18%</td>
<td>11%</td>
</tr>
<tr>
<td>Postprocedure TIMI 2</td>
<td>54%</td>
<td>47%</td>
</tr>
<tr>
<td>Postprocedure TIMI 3</td>
<td>27%</td>
<td>42%**</td>
</tr>
<tr>
<td>Symptomatic ICH</td>
<td>11.2%</td>
<td>9.4%</td>
</tr>
<tr>
<td>Number of Patients with Procedural Serious Adverse Events</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>90-Day mRS &lt;2</td>
<td>25%</td>
<td>36%</td>
</tr>
</tbody>
</table>

*Stroke 2009;40:2761-2768 **P< 0.05 vs. PIVOTAL

CONCLUSION
These results demonstrated that increasing the internal diameter of the Penumbra Reperfusion Catheter to 0.054 inch can enhance aspiration efficiency and speed, leading to a shorter aspiration time and a more complete revascularization without affecting safety or accessibility.

KEY WORDS: Stroke, mechanical thrombectomy, SPEED
Tuesday Morning
10:45 AM - 12:30 PM
Room 611/612

(17d) Brain: New Techniques/Post Processing
(Scientific Papers 248 - 260)

See also Parallel Sessions
(17a) Cerebrovascular Occlusive Disease
(17b) Spine: Trauma, Spinal Cord & Degenerative
(17c) Interventional: Thrombolysis/Stroke
(17e) Adult Brain: Neoplasms

Moderators: Vivek Prabhakaran, MD, PhD
Pratik Mukherjee, MD

Paper 248 Starting at 10:45 AM, Ending at 10:53 AM

Diffusion Kurtosis Imaging of Normal Pressure Hydrocephalus

Pawar, R. V. • Kong, S. E. • Jenson, J. H. • Golomb, J. B. • Babb, J. S. • George, A. E.

¹New York University Langone Medical Center, New York, NY, ²New York Medical College, Valhalla, NY, ³New York University School of Medicine, New York, NY

PURPOSE
Normal pressure hydrocephalus (NPH) is an often disabling disorder in the elderly, associated with motoric deficits that can respond to treatment. Ninety percent of shunted NPH patients at our institution, show improvement in gait impairment, underscoring the importance of correct diagnosis, and identification of potential shunt responders. With diffusion tensor imaging (DTI), the impact of NPH on white matter can be better understood by studying the diffusivity of water molecules. Diffusion tensor imaging reflects a Gaussian probability distribution function (PDF), which assumes a homogenous substrate. In vivo, the diffusivity of water molecules is non-Gaussian, and “kurtosis” is the dimensionless metric for quantifying true water PDF. Diffusion kurtosis imaging (DKI) metrics serve as markers of structural complexity and myelin integrity of both white matter (WM) and gray matter. We examine the utility of DKI in identifying patients with NPH who are likely to respond to shunting. We report a study comparing DKI measures of NPH patients compared with normal age-matched controls.

MATERIALS & METHODS
Retrospective review of NPH patients (N=9) and normal age-matched controls (N=7). Studies included standard sequences with DTI and DKI utilizing three b values and 30 directions performed on a Siemens Avanto 1.5 T unit; TR=4500, TE=96, b=0, 1000, 2000. Diffusion kurtosis imaging maps were processed to provide mean kurtosis (Kmean), radial kurtosis (Krad), and axial kurtosis (Kax) measures utilizing MATLAB. Employing contrast-enhancing T1-weighted imaging, regions of interest (ROI) points were localized on the b0 DKI images coregistered to the processed maps utilizing MRICron. Regions of interest included the bilateral frontal and parietal WM, bilateral posterior limbs of the internal capsules, and genu and splenium of the corpus callosum. An unequal variant t-test was used to compare the groups (NPH versus controls) with respect to each measure at each location and in terms of each measure averaged over locations.

RESULTS
Kax, Krad and Kmean are listed as overall values of the ROIs in NPH patients versus controls with accompanying SD (95% confidence interval of upper and lower limits. Discussion: Diffusion kurtosis imaging is an extension of DTI that stems from the quantification of the diffusional non-Gaussianity of water. A report of DTI in acute hydrocephalus demonstrated effects on the periventricular WM, with net increase in FA from increased parallel diffusivity and decreased radial diffusivity. Chronic compression ultimately leads to demyelination and diminished neuronal transmission. Diffusion kurtosis imaging shows potential as a tool that can differentiate the etiology of ventriculomegaly, especially since NPH-related dementia and Alzheimer disease (AD) may overlap. A recent longitudinal study of one patient with NPH prospectively analyzed with DKI demonstrated decreased kurtosis values with increasing hydrocephalus.

DKI values (NPH versus Normal)

<table>
<thead>
<tr>
<th></th>
<th>DKI values (NPH versus Normal)</th>
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<tbody>
<tr>
<td></td>
<td>NPH SD</td>
</tr>
<tr>
<td>Kax</td>
<td>0.6</td>
</tr>
<tr>
<td>Krad</td>
<td>1.08</td>
</tr>
<tr>
<td>Kmean</td>
<td>0.84</td>
</tr>
</tbody>
</table>

CONCLUSION
Normal pressure hydrocephalus patients show statistically significant decrease in DKI measures compared with normal controls. We believe that DKI holds promise regarding characterization of NPH and identification of potential shunt responders.

KEY WORDS: Diffusion kurtosis imaging, normal pressure hydrocephalus, hydrocephalus
Assessment of Cerebrospinal Fluid Flow Dynamics Using Phase-Contrast MR Imaging in Spontaneous Intracranial Hypotension

Hasiloglu, Z. I. 1 • Albayram, S. 1 • Gorucu, Y. 2 • Selcuk, H. 3 • Cagil, E. 1 • Erdemli, H. E. 1 • Imal, A. E. 1

1 Istanbul University, Istanbul, TURKEY, 2 Haseki Research and Education Hospital, Istanbul, TURKEY, 3 Bakirkoy State Hospital, Istanbul, TURKEY

PURPOSE
Spontaneous intracranial hypotension (SIH) is a clinical condition presenting with postural headache. Cerebrospinal fluid (CSF) flow dynamics have a key role in the pathogenesis of SIH. Phase contrast MR imaging (PC-MRI) is a noninvasive technique that can be used to quantify variations of CSF flow during the cardiac cycle. The aim of this study is the assessment of CSF flow dynamics using a PC-MRI in SIH.

MATERIALS & METHODS
Twenty-five patients with definitive diagnosis of SIH according to The International Classification of Headache Disorders criteria, were evaluated with PC-MRI. Twelve of the patients were female, other 13 patients were male, ranging in age from 23 to 61 years (mean, 40.84 years). The control group were female, other 13 patients were male, ranging in age from 23 to 61 years (mean, 40.84 years). The control group was composed of same number, gender and age of neurologically healthy subjects. MR images were acquired by using a 1.5 T unit (Philips Achieva, Best, The Netherlands) with an 8-channel head coil. Phase-contrast-MRI was performed in the axial plan perpendicular to the cerebral aqueduct for the quantitative examination of CSF. The PC-MRI parameters included velocity encoding (Venc) = 20 cm/s, FOV = 100mm, slice thickness = 4 mm, image matrix size = 256x256, TR = 24 ms, TE = 14 ms, NSA = 2, flip angle = 15 degrees and 12 frames per cardiac cycle with peripheral retrospective pulse gating. Caudocranial flow direction was defined as negative and craniocaudal flow direction was defined as positive. Quantitative measurements of CSF flow at the level of cerebral aqueduct was carried out in MR workstation with "Q Flow" software. Cerebrospinal fluid flow volume into the third and fourth ventricle, stroke volume, and net CSF flow volume were calculated as ml/min to eliminate the problems of pulse rate differences across the individuals and to provide a standardization. Peak systolic velocity and peak diastolic velocity values were calculated as cm/sec. In the comparison of the groups, Mann-Whitney U test was used for analysis of numerical datas and Chi-square test for analysis of nominal datas. A p-value of less than 0.05 was used for statistical significance.

RESULTS
Cerebrospinal fluid flow volume toward the third and the fourth ventricles and stroke volume were found to be lower in SIH patients compared with the control group, statistically significant. Also, this situation is valid for peak systolic velocity and peak diastolic velocity values, in the comparison of the control group and SIH patients. On the other hand, there was no significant difference for the net CSF flow volume values between two groups, statistically.

CONCLUSION
In SIH cases, stroke volumes, CSF flow volumes toward the third and the fourth ventricles, peak systolic velocity and peak diastolic velocity values were lower than values of the control group regarded as statistically significant. We think that these findings will contribute to better understanding of clinic and pathogenesis of SIH cases.

KEY WORDS: Phase-contrast MR imaging, cerebrospinal fluid flow dynamics, spontaneous intracranial hypotension

Reliability of TrueFISP Imaging for Qualitative and Quantitative Assessment of Tonsillar Pulsatility

Parsons, M. S. • Pilgram, T. K. • Sharma, A.
Mallinckrodt Institute of Radiology
Saint Louis, MO

PURPOSE
MR imaging using cardiac-gated balance steady-state free-precession technique recently has been utilized to demonstrate pulsatile movement of brain structures during the cardiac cycle with excellent spatial, contrast, and temporal resolution. For diseases affecting the flow of cerebrospinal fluid (CSF) across the foramen magnum, this technique can provide a useful means of objectively assessing the pulsatile motion of cerebellar tonsils. However, the intra and interobserver agreement of such measurements has not been studied. The purpose of this study was to examine the intra and interobserver agreement in both the qualitative perception of degree of tonsillar motion and the direct measurement of maximal craniocaudal translation of cerebellar tonsils.

MATERIALS & METHODS
Forty-four patients were identified who had cine TrueFISP imaging done of the foramen magnum (24 were male and 20 female). The mean age was 11.8 years. The examinations were performed on a 1.5 T scanner. A slice thickness of 5 mm at the midline was performed with 25 partitions obtained during the cardiac cycle. To evaluate tonsillar motion both qualitatively and quantitatively, two neuroradiologists evaluated the cases independently on two occasions more than 2 weeks apart. Qualitative perception of tonsillar pulsatility was graded on a 3-point scale. Quantitative assessment of tonsillar motion was performed by measuring the difference between the highest and lowest position of the inferior cerebellar tonsillar margin during a cine loop.

RESULTS
Two of the 44 patients were excluded due to imaging artifacts. Intraobserver agreement for qualitative assessment of tonsillar motion was near-perfect (kappa of 0.81 and 1). Interobserver agreement for qualitative assessment of tonsillar motion was excellent (kappa of 0.72 for first read and 0.8 for the second). Objective measurement of tonsillar motion between the two readers was likewise excellent, with fitted lines close to 1:1. A correlation between qualitative perception of tonsillar motion and quantitative assessment of tonsillar motion was observed. Minimal tonsillar pulsatility (grade 1) corresponded to a measurement of tonsillar motion between 0.3 mm and 0.9 mm for
both readers. Marked tonsillar pulsatility (grade 2) corresponded to a measurement of tonsillar motion between 1.1 mm and 2.7 mm.

**Conclusion**

Cardiac-gated balance steady-state free-precession MR imaging technique allows for qualitative and quantitative measurements of tonsillar pulsatility in a reproducible manner with substantial to perfect intraobserver and interobserver agreement. This technique could have useful clinical and research ramifications for disease states in which evaluation of tonsillar motion is of interest.

**Key Words:** TrueFISP, cerebellar tonsils

**Paper 251 Starting at 11:09 AM, Ending at 11:17 AM**

**Independent Component Analysis of Diffusion Tensor Imaging Reveals Multivariate Microstructural Correlations of White Matter in the Human Brain**

Li, Y. • Yang, F. • Nguyen, C. • Cooper, S. • LaHue, S. • Venugopal, S. • Mukherjee, P.

University of California San Francisco
San Francisco, CA

**Purpose**

A recent diffusion tensor imaging (DTI) tractography study demonstrated that specific patterns of correlation exist in microstructural parameters such as FA across major white matter tracts in the normal adult brain. However, this prior research was limited to whole-tract DTI parameters in only 12 axonal pathways using pairwise correlations. In this investigation, we perform a whole-brain multivariate analysis of microstructural white matter correlations at the voxel scale using independent component analysis (ICA) of tract-based spatial statistics(TBSS).

**Materials & Methods**

Fifty-three normal adult volunteers (mean age 30.7 ± 8.8 years, 31 men, 44 right-handed) underwent 3 T DTI with 55 directions at b=1000. Preprocessing, including motion correction and brain extraction, as well as DTI parameter mapping were conducted in FSL. Direct registration of individual FA volumes to the FMRIB58 template was applied and the mean FA image and mean FA skeleton were computed in TBSS. To improve signal-to-noise ratio (SNR), the group FA skeleton was smoothed by a Gaussian kernel with FWHM=9 mm but confined to the skeleton. The global FA variation was removed by subtracting the mean FA from the group FA data. Principal component analysis was applied to retain the first 25 principal components, thereby preserving 74.5% of the total variance. FastICA was applied to this dimension-reduced FA data to estimate 25 independent components. Voxel correlation values in each component were normalized to have unit spatial variance, thresholded at 2.5 standard deviations, and displayed in color in MNI152 atlas space on the 3D T1-weighted image, thresholded at 2.5 standard deviations, and displayed in color in MNI152 atlas space on the 3D T1-weighted image. The voxel with the strongest FA correlation in most of the IC white matter tracts, tract segments, and/or homologous pairs of tracts.

**Results**

The dominant feature of each IC map could be grouped into at least five classes, corresponding to supratentorial commissural pathways (Figure a), supratentorial projection pathways (Figure b), neocortical association pathways (Figure c), limbic association pathways (Figure d), and thalamic, brainstem, and cerebellar white matter (Figure e).

**Conclusion**

In this work, we present an ICA parcellation of normal brain white matter based on the multivariate correlations of voxelwise FA values across subjects, thereby greatly improving on the pairwise tract-scale microstructural correlations. Independent component analysis of voxel-based DTI, HARDI, or DSI parameter maps might provide an interesting alternative to tractography for feature extraction in studying the normal microstructure of human white matter as well as the abnormal white matter microstructure found in neurologic and psychiatric disorders.

**Key Words:** Diffusion tensor imaging, independent component analysis, fiber tractography

**Paper 252 Starting at 11:17 AM, Ending at 11:25 AM**

**Perfusion CT Postprocessing: Common Pitfalls and How to Avoid Them!**

Brehmer, W. • Geraghty, S. R. • Bernhard, M. • Wintermark, M.

University of Virginia
Charlottesville, VA

**Purpose**

Perfusion CT (PCT) processing is more and more automated. However, automated PCT algorithms are not perfect and in any case need to be set up initially. This may lead to errors in the processed PCT maps that can negatively impact their interpretation. Similar issues can happen when PCT datasets are processed manually by nonexperts, such as technologists, or by busy residents on call at night. The goals of this presentation are to review commonly encountered errors in the processing of PCT studies and how to avoid them.

**Materials & Methods**

We retrospectively reviewed the PCT studies performed during the last 6 months at our institution. Perfusion CT datasets typically are processed using a semi-automated algorithm by the CT technologists who are following a standard operating
procedure, saved as color screen captures in a DICOM format, and pushed to the PACS for review by a neuroradiologist. We identified the subset of cases where the initial processing was incorrect and where the neuroradiologist had to reprocess the PCT datasets. The reasons why the processing had to be repeated were recorded, and subsequently distributed into appropriate categories.

RESULTS
The main categories of PCT processing errors were the following: incorrect selection of the arterial input function, incorrect selection of the venous output, lack of identification of slices with significant motion artifact, inappropriate use of the delay-corrected deconvolution, inappropriate windowing of the regions of interest. In our presentation, we will show the incorrect initial PCT maps, explain what is incorrect and why, provide processing strategies to avoid these mistakes, and show the final, correct set of PCT maps.

CONCLUSION
Neuroradiologists who interpret PCT studies need to be familiar with potential pitfalls in terms of processing that can adversely affect the interpretation of the PCT maps, and potentially lead to incorrect diagnosis. There are a limited number of such pitfalls, and simple tips can be applied to avoid them.

KEY WORDS: Perfusion CT, postprocessing

Paper 253 Starting at 11:25 AM, Ending at 11:33 AM
Unified Approach to Combine Arrival Time Sensitive and Insensitive Perfusion Parametric Maps for Evaluation of Perfusion Augmentation in Acute Stroke Therapy: A Pilot Study Using MTT-sSVD vs MTT-bSVD

Liu, S. • Soares, B. P. • Sankaranarayanan, V. • Dillon, A. • Dillon, W.
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San Francisco, CA

PURPOSE
Dynamic CT and MR perfusion shows promise in monitoring cerebral flow in acute stroke therapy. Two general strategies exist for processing this data based on whether the delay in arrival time of contrast to ischemic tissue is accounted for or not. These include tracer arrival time-sensitive algorithm (standard singular value decomposition [sSVD]) and tracer arrival time-insensitive algorithm [block-circulant singular value decomposition (bSVD)]. Each method, however, has important limitations. The sSVD may produce erroneous cerebral blood flow (CBF) decrease and mean transit time (MTT) increase in areas where tracer arrival is simply delayed without any changes in CBF/MTT, while bSVD yields stable CBF and MTT values even with tracer delay, but the sensitivity for detecting ischemic lesion is decreased. In order to improve accuracy of assessment for perfusion augmentation in acute stroke therapy, we used combined findings on MTT maps processed with sSVD and bSVD algorithms.

MATERIALS & METHODS
Institutional review board approval and informed consent were obtained. Seventeen acute stroke patients underwent two MR perfusion imaging procedures, separated by a mean interval of 6 hours. Dynamic susceptibility contrast-enhanced MR perfusion data were processed using two deconvolution algorithms, sSVD (arrival time sensitive) and bSVD (arrival time insensitive) by using perfusion mismatch analyzer (PMA, supported by ASIST-Japan). Paired perfusion MTT maps were reviewed side by side on each patient by two neuroradiologists. A perfusion score on MTT-sSVD or MTT-bSVD maps was recorded when a difference in the area of prolonged MTT changed greater than 20% visually (score=better, stable, worse). A third recorded composite score was assigned based on which algorithm demonstrated better or worse outcomes compared to the other. Correlation between the perfusion score and the change in NIHSS at 12–24 hours from baseline was analyzed.

RESULTS
Thirteen of 17 patients had similar changes in perfusion scores on paired MTT-sSVD and MTT-bSVD maps. Four patients (23.5%) had different perfusion results when comparing MR perfusion data set processed using sSVD and bSVD algorithms (Table). Discrepancies of MTT changes may occur depending on which perfusion algorithms are used. These included improved perfusion on MTT-sSVD vs stable on MTT-bSVD, improved perfusion on MTT-bSVD vs stable on MTT-sSVD, worse on MTT-bSVD vs stable on MTT-sSVD, or worse on MTT-sSVD vs stable on MTT-bSVD. Frequently, reflecting collateral flow changes from fast to slow or in opposite way.

Conclusio
MR perfusion imaging may be misinterpreted if only a single perfusion algorithm is used. Combining arrival time-sensitive and insensitive perfusion parametric maps to assess perfusion augmentation can minimize such errors. This work may help improve the current clinical practice and significantly improve accuracy and sensitivity of perfusion data in monitoring acute stroke therapy. This was a pilot study in a small sample size, which needs validation in a larger sample population.

KEY WORDS: Brain perfusion, arrival timing insensitive, stroke
Paper 254 Starting at 11:33 AM, Ending at 11:41 AM

Dual-Energy CT in Patients after Intra-Arterial Thrombolysis or Thrombectomy Differentiates between Contrast Enhancement and Intracranial Hemorrhage

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¹Maastricht University Medical Centre, Maastricht, NETHERLANDS, ²Siemens Healthcare, Forchheim, GERMANY

Purpose
Identification of hemorrhage at regular CT scanning after intra-arterial thrombolysis can be difficult due to the presence of iodinated contrast, which is administered during the cerebral angiography at the time of thrombolysis or thrombectomy. The aim of this study is to evaluate the ability of dual-energy CT (DE-CT) to discriminate between contrast enhancement and intracranial hemorrhage after intra-arterial thrombolysis for middle cerebral artery occlusion.

Materials & Methods
Six patients with acute middle cerebral artery stroke underwent intra-arterial thrombolysis with urokinase and/or thrombectomy. One patient with a basilar artery occlusion underwent thrombectomy of the basilar artery. During the procedure intra-arterial iodinated contrast material was administered. A control CT was performed 1 to 17 hours after the intervention. A dual-energy CT protocol (Somatom Definition Flash, Siemens Healthcare Germany) was used for simultaneous imaging at 80 and 140 kV (tube A: 80 kV, 310 eff mAs; tube B: 140 kV, 155 eff. mAs). Mixed energy images (Figure 1) were generated and used for regular CT reporting. Additional virtual noncontrast images (Figure 2) and iodine maps were calculated using a dedicated brain hemorrhage algorithm. Follow-up unenhanced CT was used as standard of reference.

Results
The mixed images showed parenchymal hyperdense areas compared to gray matter in five patients. The virtual noncontrast image was suggestive of an intracranial hemorrhage in one patient, whereas the iodine overlay images were suggestive of contrast enhancement in four patients. Two out of these four patients showed hemorrhagic transformation of the infarction at follow up. Two of the seven patients showed no hyperdensity on the postprocedural scan. The areas with contrast enhancement were part of the area of infarction at follow up.

Conclusion
Dual energy CT is a promising technique for the differentiation of intracranial hemorrhage and contrast enhancement in patients after intra-arterial thrombolysis for cerebral infarction.

Key Words: Dual energy CT, stroke, hemorrhage

Paper 255 Starting at 11:41 AM, Ending at 11:49 AM

Characterizing “In Situ Thrombus” in Intracranial Vasculature with Susceptibility-Weighted Imaging

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Purpose
To review the application of susceptibility-weighted imaging (SWI) in characterizing thrombus in intracranial vessels. We highlight cases in which SWI offered direct in situ visualization of the thrombus and hence improved diagnostic accuracy in addition to standard MRI brain imaging protocols.

Materials & Methods
A retrospective review of MRI studies with SWI sequence for stroke patients was performed from March 2009 to March 2010. Two blinded radiologists reviewed each case with agreement by consensus in order to try and establish imaging features or patterns, which highlight the potential of SWI in identification of in situ thrombus. We hypothesize that thrombus contains coagulated blood with less oxygen and hence predominantly contains deoxyhemoglobin. Imaging was performed using a 1.5 T Siemens Magnetom Symphony Tim syngo MR B17. Imaging parameters are as follows: T2 SWI 3d axial sequence, slices per slab 32, FoV read 230 mm, FoV phase 81.3%, slice thickness 4.00 mm, TR 55 ms, TE 40.0 ms. The additional scanning time was approximately 3 minutes. Images were sent to the local PACS as a separate phase, magnitude, Minip and SWI images.

Results
We identified 25 cases of thrombi in the intracranial vessels. These included nine middle cerebral artery (MCA), six vertebral artery, four posterior inferior cerebellar artery (PICA), two aneurysm thrombosis, four cerebral venous thrombosis. Acute thrombi were seen as low signal linear foci of blooming due to high deoxyhemoglobin content. Affected vessel showed “Vascular susceptibility sign”. The improved contrast resolution of blood products and vasculature offered by this sequence assisted in characterizing the exact location of the thrombus and adds specificity to the diagnosis. This technique involves no use of gadolinium and challenges conventional method of MR angiography where thrombi are seen as filling defects.
CONCLUSION
Susceptibility-weighted imaging sequence is extremely sensitive to blood products and has additional diagnostic value in evaluating patients with suspected intracranial vascular pathologies. On SWI fresh thrombus contains a high concentration of deoxyhemoglobin and appear hypointense. Traditional MRA can demonstrate proximal arterial occlusion well; however, distal thrombo-emboli often are difficult to visualize. Susceptibility-weighted imaging offers added advantage by direct visualization of thrombo-emboli in smaller intracranial vessels and with an accurate determination of its location. This application has the potential for influencing decisions regarding specific neurointervention and revascularization therapies.

KEY WORDS: Susceptibility-weighted imaging, thrombus, stroke

Paper 256 Starting at 11:49 AM, Ending at 11:57 AM

MR Thermometry of Brain Tumors: Tissue Partial Volume Effects

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PURPOSE
Noninvasive thermometry of brain tumors may represent a novel biomarker of pathophysiology and response to treatment. Temperature relates to tissue hemodynamics and metabolism. These properties can both affect and be affected by therapy. There are issues surrounding the accuracy of MR thermometry, relating to calibration and partial volume effects within relatively large voxels. We examined the relationship of temperature to enhancement and necrosis within a voxel using a novel segmentation technique.

MATERIALS & METHODS
Four patients with histology proved glioblastoma multiforme were imaged preoperatively on a 3 T Philips Achieva Scanner. Precontrast coronal FLAIR and 3DTFE inversion recovery (IR1150) images were acquired. Postcontrast, a 3DTFE T1-weighted image (3DGd) was acquired. Single voxel point-resolved spectroscopy (PRESS) (16x16x16mm TE=60 ms TR=1500ms f=1024 NSA=64) was acquired in three locations: enhancing tumor (ET), peritumoral edema (PE), and contralateral normal-appearing white matter (NAWM). Enhancing tumor was circumscribed manually on the 3DGd image, with necrosis segmented by manual thresholding of this volume of interest (VOI) to exclude enhancement. Peritumoral abnormality was segmented manually on the FLAIR image. Following coregistration and subtraction from the IR1150 image, FSL’s automated segmentation tool (FAST v4.1) was used to segment gray matter (GM), white matter (WM), and cerebrospinal fluid (CSF). The spectroscopy voxel VOIs were generated using in-house Matlab code, and the percentages of each tissue class within were determined. Temperatures (T) were calculated from the chemical shift of water relative to N-acetyl aspartate (NAA).

RESULTS
The figure shows the six-tissue segmentation with a spectroscopy voxel placed on the enhancing lesion, and a scatter plot of percentage voxel necrosis and enhancement against T for tumor voxels. There is a positive linear relationship between T and enhancement (R²=0.695,) with a corresponding inverse relationship between T and necrosis (R²=0.685.) The table shows T calculated in each spectroscopy voxel, and the percentage of enhancement and necrosis within each tumor voxel.

![Image of six-tissue segmentation]

<table>
<thead>
<tr>
<th>Patient</th>
<th>NAWM T (°C)</th>
<th>Edema T (°C)</th>
<th>Tumor T (°C)</th>
<th>Enhancement (%)</th>
<th>Necrosis (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>38.8</td>
<td>39.1</td>
<td>44.1</td>
<td>85.1</td>
<td>0.5</td>
</tr>
<tr>
<td>2</td>
<td>36.5</td>
<td>40.1</td>
<td>41.9</td>
<td>38.9</td>
<td>13.6</td>
</tr>
<tr>
<td>3</td>
<td>37.7</td>
<td>43.3</td>
<td>40.3</td>
<td>51.5</td>
<td>2.5</td>
</tr>
<tr>
<td>4</td>
<td>36.7</td>
<td>37.3</td>
<td>37.6</td>
<td>31.0</td>
<td>64.8</td>
</tr>
</tbody>
</table>

CONCLUSION
MR thermometry in enhancing lesions may reflect underlying tumor behavior, with an increase in enhancement and a decrease in necrosis within a voxel producing higher measured temperatures. Further work is required to investigate the effects of voxel content on thermometry.

KEY WORDS: Glioblastoma, temperature, segmentation

Paper 257 Starting at 11:57 AM, Ending at 12:05 PM

Comparison of Reformatted Thin Slice NCCT Images with Thick Slices in the Detection of Posterior Fossa Lesions: Are More and Thinner Slices Always Better?

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Boston, MA

PURPOSE
It is well documented in the current literature that thin section NCCT improves lesion detection accuracy and is valuable in minimizing artifacts such as volume averaging, where anatomy is rapidly changing in the z direction such as the posterior fossa. These limitations are secondary to anatomical barriers that result in beam hardening, streak artifact and thick slices that limit the ability of the technique to detect smaller lesions commonly seen in posterior fossa structures. Image reformating to thinner slices, (1.25 mm), is being used in many institutions for improved evaluation of the posterior fossa for...
detection of smaller lesions; however, at the expense of additional postprocessing and interpretation time. Our purpose was to compare conventional 5 mm thick NCCT of the head to reformatted 1.25 mm images in detecting posterior fossa lesions by using conventional MR imaging (MRI) as the reference standard.

**Materials & Methods**

This was an institutional review board-approved retrospective study. We identified 179 consecutive patients from our emergency department who received correlated conventional 5 mm helical head NCCT with 1.25 mm reformatted images, and conventional MRI. Patients with both positive and negative findings within the posterior fossa by MRI were included. Two neuroradiologists blinded to the MRI data and clinical history randomly reviewed the conventional and thin section NCCT images for the presence or absence of a lesion utilizing a 5-point scale. MR imaging results were correlated with those of NCCT and receiver-operator characteristic curves (ROC) were constructed.

**Results**

On MRI there were 91 patients with and 88 patients without imaging findings of posterior fossa lesions. Thin section NCCT was 45% sensitive and 84% specific for detecting posterior fossa lesions PPV: 74, NPV: 60. Thick section NCCT was 42% sensitive and 83% specific, PPV: 76, NPV: 59. The area under the ROC curve was .66 for thin section NCCT and .66 for thick section NCCT, demonstrating no significant difference (P = .98, not significant) (See graph).

**Conclusion**

Although it has been established that thin section is valuable in minimizing volume averaging and artifacts within the posterior fossa, evaluation of reformatted thin section CT did not offer a significant advantage in distinguishing posterior fossa lesions over conventional 5 mm thick NCCT. This conclusion may be relevant for a busy emergency room setting, to help minimize technologist and radiologist time in reformattting and reviewing these additional images.

**Key Words:** Thin reformats, NCCT, posterior fossa

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**Paper 258 Starting at 12:05 PM, Ending at 12:13 PM**

**Dynamically Collimated C-Arm Flat Panel Detector CT Imaging for Focused Region-of-Interest Reconstruction and Radiation Dose Reduction**

Fung, S. H.,1,2 Chang, Y.,1,4 Pino, R.,1 Hui, E. S.,1,4 Zhou, X.,1,4 Alvarado, M. V.,1 Benndorf, G.,1,2 Diaz, O. M.,1,2 Klucznik, R. P.,1 Xiong, Z.,1,2 Wong, S. T.,1,2 Li, K. C.,1,2

1The Methodist Hospital, Houston, TX, 2Weill Cornell Medical College, New York, NY, 3Texas A&M University, College Station, TX, 4University of Texas Health Science Center, San Antonio, TX, 5Baylor College of Medicine, Houston, TX

**Purpose**

C-arm flat panel detector CT (FPCT) applications such as 3D rotational angiography (3DRA) commonly are used in the neuroangiography suite. Presently, FPCT operation from vendors allows only limited longitudinal collimation, which exposes significant amount of head to radiation. We investigated the feasibility of dynamic collimation during FPCT acquisition to reduce unnecessary radiation dose to the patient, and to assess image quality of reconstructed collimated region-of-interest (ROI) by applying a cone-beam CT reconstruction algorithm with truncation correction.

**Materials & Methods**

We obtained whole head 3DRA with 275 frames acquired over 220° from a patient with left paracilindric internal carotid artery aneurysm. Dynamically-collimated 3DRA was simulated by applying transverse collimation to each frame around a 7 cm cylindrical ROI centered on the aneurysm. Radiation dose to eyes, bone, brain, pituitary, and skin was calculated per frame without and with collimation using Monte Carlo simulation (EGSnrc) based on geometry and tube setting information from the C-arm system (Siemens Axiom Artis dBA). Radiation dose also was measured in the center and periphery of a Perspex CTDI phantom using similar FPCT settings without and with static lead collimators to frame a 7 cm cylindrical ROI in the center of the phantom. Cone-beam CT reconstruction was performed using Feldkamp-Davis-Kress (FDK) algorithm without and with truncation correction based on raised-cosine windowed symmetric mirroring extrapolation.

**Results**

Significant Compton scatter is present outside the collimated ROI with majority of absorbed dose by bone (2.2x average head) due to relatively higher fraction of photoelectric effect with 80 kVp spectrum photons. Radiation doses calculated using Monte Carlo simulation were similar to those measured with the CTDI phantom. Simulation calculations indicate 60%, 70%, 45%, 38%, 27%, and 53% dose reduction to the contralateral eye, ipsilateral eye, bone, brain, pituitary, and skin, respectively, by applying dynamic transverse collimation. Phantom measurements also showed up to 60-70% dose reduction in the periphery with collimation. CT reconstruction of collimated ROI without truncation correction produced significant truncation artifacts that appear as bright peripheral band obscuring structures along the boundary of the ROI. We found consistent near-complete removal of artifact after applying truncation correction, resulting in...
nearly identical gray level measured using voxel-by-voxel comparison between noncollimated and collimated CT images.

**CONCLUSION**

Dynamically-collimated whole head FPCT with truncation correction applied to CT reconstruction algorithm can reduce radiation dose by as much as 60-70% to various structures of the head, including eyes, while producing diagnostically acceptable images similar to those without collimation.

**KEY WORDS:** Cone-beam computed tomography, image processing, computer-assisted, radiation dosage

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**Iterative Reconstruction in Brain MDCT: Utility or Futility?**

Riccelli, L. P. • Go, S. • Pollock, J. • Stevens, D. • Bardo, D. M. E.

Oregon Health and Science University
Portland, OR

**PURPOSE**

Iterative reconstruction (IR) is an image reconstruction method newly incorporated into CT. When blended with traditional filtered back projection (FBP), IR can be used to reduce image noise or to reduce radiation dose by lowering mAs or kV in standard MDCT brain protocols. The purpose of this study was to investigate the diagnostic quality of combinations of FBP and IR in helically acquired brain MDCT. Patients were referred for examination through a busy University Medical Center emergency department, Level 1 trauma service, and inpatient services for diagnosis of acute or chronic intracranial abnormalities including head trauma, intracranial hemorrhage (ICH), and stroke, and in the acute postoperative period.

**MATERIALS & METHODS**

This study was approved by our institutional review board. During initial evaluation of a newly installed MDCT scanner equipped with IR software, (Ingenuity CT with IDose⁴, Philips Healthcare, Cleveland, OH), 468 helically acquired brain MDCT examinations were performed; 201 were reconstructed with blends of FBP/IR (80/20, 40/60, and 60/40) in addition to the 100% FBP standard reconstruction. Subjective diagnostic image quality (gray-white matter differentiation, conspicuity of diagnosed intracranial abnormality, and diagnostic certainty) was determined by three board-certified neuroradiologists using a 3-point scale (1-nondiagnostic, 2-diagnostic, and 3-excellent). Objective image noise and CT number (HU) were measured using ROIs placed in deep white matter and gray nuclei. Statistical analysis was performed using paired t-test and Bland-Altman plots.

**RESULTS**

The most common diagnoses included stroke or ischemia (n = 101), trauma (n = 72), altered mental status (n = 49), and known or chronic hemorrhage (n = 53). In our cohort, 103 patients were diagnosed with normal brain CT results or with unchanged known or chronic intracranial findings and 20 patients who underwent brain CT were diagnosed with acute ICH. A sample of our subjective and objective results comparing patients with acute hemorrhage and normal findings is as follows: There was a strong subjective diagnostic image quality preference for low blends of FBP/IR (80/20) over higher blends. A choice of FBP over the blended FBP/IR images was statistically significant for image quality (p = 0.001) and for diagnostic certainty (p<0.01) by all three neuroradiologists. Conspicuity of acute hemorrhage did not differ in FBP and FBP/IR images. ROI data in FBP and blended FBP/IR reconstructions showed insignificant changes in image noise (p = 0.55) and HU (p = .085).

**CONCLUSION**

In helically acquired brain MDCT low blends of FBP/IR are preferred and the method of image reconstruction did not alter conspicuity of hemorrhage, image noise, or HU measurements in gray and white matter. Although performing image reviews in a nonblinded manner may influence results, there was a highly significant choice for FBP rather than FBP/IR blended image reconstruction for image quality and diagnostic certainty.

**KEY WORDS:** Iterative reconstruction, filtered back projection, helical brain MDCT

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**Model-Based Iterative Reconstruction of Dose-Reduced CT Neuroangiography Improves Spatial Resolution and Reduces Noise**

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Mount Sinai Medical Center
New York, NY

**PURPOSE**

The relatively high radiation dose associated with CT neuroangiography recently has drawn a great deal of attention. Adaptive statistical iterative reconstruction (ASIR) is a commercially available reconstruction technique that, compared to filtered back projection (FBP) methods typically used in CT, provides a reduction in image noise and improvement in low contrast detectability (LCD). Model-based iterative reconstruction (MBIR) is a new reconstruction technique that, compared to ASIR methods, provides an improvement in...
in spatial resolution and further reduction in image noise allowing for even lower dose imaging with the same, or better, diagnostic value.

**MATERIALS & METHODS**

A retrospective review of ASIR-based dose-reduced CTA images was made with images reconstructed with conventional FBP and MBIR. For this analysis we used 11 CT angiograms (6 of the head and 5 of the neck) and had two neuroradiologists evaluate the resulting maximum intensity projection (MIP) images for edge definition and vessel conspicuity. Also the overall diagnostic value was evaluated using the reconstructed average image (thickness of 5 mm for head and 3 mm for neck). In addition, images reconstructed with FBP, ASIR, and MBIR were compared quantitatively for image noise.

**RESULTS**

Clinical head and neck CTA images reconstructed with MBIR demonstrated better than expected edge definition in 91% of cases (20/22), better than expected vessel conspicuity in 64% of cases (14/22), and better than expected diagnostic value in 27% of cases (6/22). When using 2D maximum intensity projections as compared with images reconstructed with ASIR or FBP. The clinical MBIR images showed significantly less noise than ASIR or FBP (p < 0.0005) for both CTA head and CTA neck.

**CONCLUSION**

Model-based iterative reconstruction image quality for CTA of the head and neck was equivalent or superior to ASIR and FBP utilizing a reduced dose protocol optimized for ASIR (40% dose reduction compared to standard FBP). Model-based iterative reconstruction images were visually sharper and contained less noise than those with ASIR or FBP. Clinical Relevance/Application: Application of MBIR to CTA of the head and neck produces higher quality images and permits imaging with lower radiation levels; consequently, patients will be exposed to a lower radiation dose.

**KEY WORDS**: Model-based iterative reconstruction, CT neuroangiography, ASIR

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**Tuesday Morning**

**10:45 AM - 12:30 PM**

**Room 602/603/604**

**(17e) Adult Brain: Neoplasms**

(Scientific Papers 261 - 273)

See also Parallel Session

(17a) Cerebrovascular Occlusive Disease

(17b) Spine: Trauma, Spinal Cord & Degenerative

(17c) Interventional: Thrombolysis/Stroke

(17d) Brain: New Techniques/Post Processing

**Moderators:** Andrei I. Holodny, MD

Thomas Zacharia, MD

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**Paper 261 Starting at 10:45 AM, Ending at 10:53 AM**

**Multimodal Approach from MR Imaging Dynamic Susceptibility Contrast Imaging in Differentiation of Lymphoma, Metastases and Glioblastoma**

Mangla, R. • Kolar, B. • Zhong, J. • Zhu, T. • Ekholm, S.

University of Rochester

Rochester, NY

**PURPOSE**

We have studied the role of mean and max relative cerebral blood volume (rCBV) and min, max and mean percentage signal recovery (PSR) measurements obtained from dynamic susceptibility contrast perfusion maps in enhancing and perienhancing regions and have tried to differentiate the lymphoma, GBM and metastases from each other. The ultimate goal was to test which parameter or combination of parameters could be more help in differentiating these three groups of lesions.

**MATERIALS & METHODS**

The retrospective study included 66 patients, 39 male and 27 female (age range from 27-82 years). These were continuous cases from our database with 22 each pathologically proved cases of primary central nervous system (CNS) lymphomas, GBM and metastases were included. Relative cerebral blood volume, mean PSR, min PSR and max PSR were calculated from dynamic susceptibility contrast imaging. We investigated the classification accuracy of the various perfusion parameters using ROC analysis.

**RESULTS**

Low rCBV and signal recovery in perienhancing region of metastases was noted as compared to GBM and lymphoma. The enhancing region PSR was distinctively better than two with Az of 0.93. The mean and min PSR with Az of 0.938
respectively showed better area under the curve than rCBV (Az.534, 95% CI: 0.391-0.676) in differentiating of metastases from GBM and lymphoma (P <0.0001). The area under the curve was modest for rCBV with Az of 0.7958 in differentiating lymphoma from metastases and GBM. The mean perienhancing PSR was better than with Az of 0.8498, but no significant difference was found between the two. Max PSR yielded the best ROC characteristics with an area under the ROC curve (A<sub>z</sub> of 0.933 (95% CI: 0.877-0.99) in differentiating lymphoma from metastases and GBM. Maximum PSR was better than rCBV in distinguishing lymphoma from GBM and metastases (p < 0.01). ANOVA analyses showed F values of 11.1, 29.9, 23.4, 39.3 and 18.4 for lesion rCBV, mean PSR, max PSR, min PSR and perilesional rCBV respectively for differentiation of these tumors.

CONCLUSION
Max PSR in the enhancing lesion is the best parameter in differentiating lymphoma from metastases and GBM. Mean and min PSR of the enhancing lesion are better parameters in differentiating metastases from lymphoma and GBM.

KEY WORDS: Percentage signal recovery, MR perfusion, lymphoma

Brain Metastasis from Prostate Cancer

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New York, NY

PURPOSE
Prostate cancer most commonly metastasizes to the bone and lymph nodes. Less commonly described are primary prostate metastases to the brain. The purpose of this study is to describe the distribution and imaging characteristics of brain metastases in patients with prostate cancer.

MATERIALS & METHODS
An institutional database was searched retrospectively for patients with prostate cancer and a suspected brain metastasis on MR imaging (MRI) from 2000 to 2010. From an initial cohort of 145 patients, we excluded patients with other primary malignancies (41 lung, 14 bladder, 7 colon, 5 renal, 8 glioma, 24 other) or with secondary brain involvement by bone or dural disease (n = 22). The final study cohort consisted of 24 patients with a mean age of 72.6 years (range, 58-84 years). All patients had pathologic evidence of metastatic prostate cancer, either of the brain lesion (n = 5) or of a systemic lesion (n = 19). The initial MRI scans were reviewed and the brain lesions were characterized according to location, signal intensity, hemorrhage, and enhancement pattern. A chart review was performed to determine prostate staging and survival.

RESULTS
Nineteen patients had adenocarcinoma of the prostate; the others had sarcoma (n=1), neuroendocrine (n=1), small cell (n=2), or neuroendocrine and small cell (n=1). The mean time from prostate cancer diagnosis to brain metastasis was 57.6 months. At time of brain metastasis diagnosis, 100% had bone metastases, 88% lymph node metastases, and 83% lung or liver metastases. Brain metastases were multifocal in 67%, solid in 83%, hemorrhagic in 25%, and diffusion restricted in 25%. The frontal lobe was the most common location at 38%. Leptomeningeal disease was found in 8%. The mean survival after brain metastasis was 4.1 months (range, 0.2-19.2).

CONCLUSION
Prostate cancer metastases to the brain usually occur in the setting of disseminated bone and soft tissue metastases. They are multiple in two thirds, and hemorrhagic in one quarter. Recognition of this uncommon pattern is important for making clinical management decisions and for patient counseling. Additional work is necessary to investigate possible biologic differences between the primary prostate tumors and the brain metastases, and examine the potential contributing effects of chemotherapy.

KEY WORDS: MR imaging, prostate, brain metastasis

Preoperative Evaluation of Grading of Meningiomas: Diagnostic Efficacy of Diffusion-Weighted Imaging and Arterial Spin Labeling

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Fukuoka, JAPAN

PURPOSE
To evaluate the value of diffusion-weighted imaging (DWI) and arterial spin labeling (ASL) for grading of intracranial meningiomas.

MATERIALS & METHODS
This retrospective study included 44 patients (26 female and 18 male, age range; 30-83 years old, median 57) with pathologically proved meningiomas. All patients underwent DWI and ASL preoperatively on 3 T MRI. The tumor volume, the minimum apparent diffusion coefficient (mADC) and the
maximum tumor blood flow (mTBF) were calculated. These were compared with histopathologic grades. Statistical analysis was performed with Mann-Whitney U test. P value less than 0.05 was considered as statistically significant. Receiver operating characteristic (ROC) analysis and stepwise linear discriminant analysis also were performed.

RESULTS
Thirty-three meningiomas were diagnosed as WHO grade I, 10 as Grade II, and 1 as Grade III. High-grade (Grades II and III) meningiomas [59.4 ± 55.2 (cm³)] were larger than low-grade (Grade I) meningiomas [18.0 ± 24.0 (cm³)] (P<0.05). High-grade meningiomas showed lower mADC [0.72 ± 0.12 x 10⁻³ (s/mm²)] than low-grade ones [0.85 ± 0.18 x 10⁻³ (s/mm²)] (P<0.05). High-grade meningiomas showed higher mTBF [315.7 ± 323.8 (mL/100 g/min)] than low-grade ones [214.0 ± 157.9 (mL/100 g/min)] without a statistically significant difference (P>0.05). Receiver operating characteristic analyses resulted in area under the curve values of 0.796 for tumor volume, 0.753 for mADC, and 0.614 for mTBF, and 0.840 for combination of mADC and mTBF.

CONCLUSION
The tumor volume and mADC were different in between high- and low-grade meningiomas, however, mTBF was not. A combination of mADC and mTBF showed better diagnostic performance than each parameter.

KEY WORDS: Meningioma, diffusion-weighted imaging, arterial spin labeling

Paper 264 Starting at 11:09 AM, Ending at 11:17 AM
Pituicytoma, Spindle Cell Oncocytoma and Granular Cell Tumor: Clarification and Meta-Analysis of the World Literature since 1893
Covington, M. F. • Chin, S. S. • Osborn, A. G.
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Salt Lake City, UT

PURPOSE
Primary nonadenomatous pituitary gland tumors are rare, poorly understood entities with a history of confusing nomenclature. The 2007 WHO classification of central nervous system (CNS) tumors clarified and redefined criteria for pituicytoma, codifying it as a separate diagnostic entity distinct from granular cell tumor (GCT). The 2007 update also added a new entity--spindle cell oncocytoma (SCO)--to the spectrum of nonadenomatous sellar neoplasms. The purpose of our study was to apply the new WHO criteria to published cases, elucidate imaging findings that might distinguish these uncommon neoplasms from each other and determine whether they can be distinguished as separate from the pituitary gland itself.

MATERIALS & METHODS
An exhaustive PubMed search identified 145 potential cases (81 GCTs, 48 pituicytomas, and 16 SCOs). Histology and/or written reports from each case were reviewed by a board-certified neuropathologist (SC) who reclassified cases according to the new WHO criteria, resulting in a total of 112 pathologically-documented cases (64 GCTs, 35 pituicytomas and 13 SCOs). Histologic images were of too poor quality to analyze in seven cases received through interlibrary loan (3 GCTs, 2 pituicytomas and 2 SCOs). Of the 112 documented cases, only 58 (30 GCTs, 22 pituicytomas and 6 SCOs) had imaging illustrations. These were reviewed by a senior neuroradiologist (AO) and findings including location (suprasellar/infundibulum and/or intrasellar/pituitary gland), configuration (round or infiltrating and separation from the pituitary gland), density/signal intensity, and enhancement characteristics were tabulated.

RESULTS
Only pituicytoma ever presented as a purely intrasellar lesion (7/33). Most pituicytomas were either suprasellar (13/33) or both intra and suprasellar (13/33). Granular cell tumors were either suprasellar (28/45) or both intra and suprasellar (17/45). All SCOs were both intra and suprasellar (13/13). Only 25% of pituicytomas (6/22) and GCTs (7/30) were round and clearly separate from the pituitary gland. Seventy-five percent of all tumor entities were infiltrating and could not be separated from the underlying pituitary gland (39/52). CT findings were available for only the GCTs. The majority (18/20) were hyperdense compared to adjacent brain and enhanced homogeneously (11/13). Forty-three cases had one or more MR sequences illustrated. The majority of all entities were isointense compared to brain on T1-weighted imaging (34/43). Pituicytomas were generally hyperintense on T2-weighted imaging (6/8) whereas GCTs were predominately isointense (10/17). No reclassified cases of SCO had T2-weighted scans. Most pituicytomas enhanced strongly and homogeneously (14/19); enhancement patterns for the other two entities were mixed (12/23 GCTs and 5/7 SCOs demonstrated heterogeneous enhancement).

CONCLUSION
As 75% of cases could not be distinguished as separate from the pituitary gland itself (including all cases of SCO), not only could these cases not be distinguished from one another based on imaging, but they also could not be separated from other entities such as macroadenoma and hypophysitis. Therefore, preoperative diagnosis is problematic and definitive diagnosis requires tissue confirmation. However, preoperative suspicion for pituicytoma is high for lesions that are purely intrasellar and clearly separate from the pituitary gland on imaging. Suspicion for either pituicytoma or GCT is high for those purely suprasellar lesions that are also separate from the pituitary gland on imaging.

KEY WORDS: Pituitary, pituicytoma, sellar neoplasms
Initial Post-Therapeutic Imaging Patterns and Long-Term Outcome of Acoustic Tumor Radiosurgery

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PURPOSE

Neuroimaging is helpful in fine-tuning the strategy of radiosurgery. The current study was aimed for this purpose by evaluating the long-term tumor morphologic outcome based on sequential baseline and follow-up MR imaging.

MATERIALS & METHODS

We retrospectively reviewed 163 patients (female: male = 100:63, age 49 years, 11-79 years) with acoustic tumors treated by Gamma Knife radiosurgery from January 1993 to June 2006 in our institute. The mean tumor volume, defined as the sum of tumor segmentation on all tumor slices based on Gd-enhanced spin-echo T1-weighted MR images (3 mm slice thickness, no gap) was 4.49 (0.15-22.1) ml before radiosurgery, and the mean imaging follow-up time was 77.5 (36-177) months. Same imaging protocol and volumetric measurement were performed at every follow-up time point.

The postradiosurgical tumor enhancing pattern was defined as 1) constant homogeneous enhancement (CE), and 2) initial loss central enhancement (LE). The postradiosurgical volume change was defined as 1) transient tumor expansion (TE), if >10% tumor volume increase as compared to the baseline was observed, and 2) stable or tumor shrinkage (TS). Tumor volume ratio (TVR), tumor volume at follow up divided by baseline tumor volume, was used to define radiosurgical outcome.

RESULTS

Initial loss central enhancement was found in 114 patients (70%), while TE in 91 (56%) patients. The irradiation dose, pretreatment tumor volumes, and previous treatments showed no significant difference among the groups. There was no significant relationship between TE and LE (p=0.825), nor were these MR imaging changes and the pre-radiosurgical tumor volume (p=0.062, and 0.995, for enhancing pattern and volumetric changes, respectively). The TVR was larger in LE group than CE group in the initial 5 years (p=0.000, 0.018 and 0.019 at 12th, 18th and 30th months, respectively), but after the 5th postradiosurgical year, there was a tendency of smaller TVR in LE group, although the difference did not reach statistical significance.

CONCLUSION

Postradiosurgical enhancing patterns of acoustic tumors were not correlated significantly with tumor volumetric changes. The presence of constant enhancement might indicate better long-term outcome, while presence of transient tumor enlargement did not indicate worse prognosis in acoustic tumor radiosurgery. The longitudinal imaging study is important in refining acoustic tumor radiosurgery.

KEY WORDS: Acoustic tumor, radiosurgery, MR imaging

MR qBOLD Measurements of Cerebral Oxygen Extraction Fraction in Metastatic Tumors

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PURPOSE

To evaluate cerebral oxygen extraction fraction (OEF) in metastatic tumors using qBOLD MR. Imaging methods that can give us more information regarding the in vivo biology of metastatic tumors may help improve our ability to predict which patients will respond to therapy.

MATERIALS & METHODS

Fifteen subjects (9 F) with metastatic tumors undergoing treatment with stereotactic radiosurgery (SRS) were recruited prospectively to a longitudinal imaging study. Primary tumors included breast cancer (3), lung cancer (8), renal cell carcinoma (1), and melanoma (1). MR imaging was performed pre- and post-SRS treatment. Imaging visits at baseline and 3 months included quantitative blood oxygen level dependent (qBOLD) MR imaging in addition to standard pre and postcontrast brain tumor protocols. Subsequent imaging visits were performed as part of standard of care. After offline postprocessing in Matlab, the OEF maps were registered to the clinical MR with use of a semiautomated technique. Regions of interest were generated to include enhancing tumor, surrounding edema, and contralateral normal appearing white matter. For each region, ratios of tumoral OEF to normal white matter in the contralateral hemisphere (OEFr) were obtained. Six-month outcomes (response, progression, or necrosis) were determined based upon pathology (when available) or imaging (using MacDonald Criteria).
**RESULTS**
Baseline OEFr was similar for breast cancer (CA), lung CA, and melanoma (1.15, 1.13, and 1.07, respectively) compared to renal cell carcinoma (RCC, 2.06). Greater variability in OEFr was demonstrated post-SRS: breast CA 0.74, lung CA 1.11, melanoma 0.15, RCC 1.57 (Figure 1). Patients who responded to therapy had a higher baseline OEFr (1.44) compared to those who progressed (1.07). This trend also was present for the 3-month post-treatment OEFr, with a mean of 1.22 in the responder group and 0.93 in the group with tumor progression.

**CONCLUSION**
This study evaluates the baseline and early post-treatment qBOLD signal in patients with metastatic brain tumors. Both baseline and post-treatment OEFr varied by primary tumor type. There was a trend towards lower OEFr in both baseline and early post-SRS scans in the group of patients with tumor progression. Although limited by the small number of subjects, this data suggests that OEFr may offer important in vivo information about tumor biology that may ultimately be useful as an adjunct imaging test in patients with brain tumors.

**KEYWORDS:** metastatic, OEF, oxygen

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**Paper 267 Starting at 11:33 AM, Ending at 11:41 AM**

**Cell Invasion, Motility, and Proliferation Level Estimates Derived from Serial Diffusion MR Images as a Novel Imaging Biomarker for Malignant Gliomas**

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David Geffen School of Medicine
Los Angeles, CA

**PURPOSE**
Microscopic invasion of tumor cells and undetected tumor proliferation is the primary reason for a dismal prognosis in glioblastoma patients. Identification and quantification of spatially localized brain regions undergoing high rates of cell migration and proliferation is critical for improving patient survival; however, there are currently no noninvasive imaging biomarkers for estimating proliferation and migration rates of human gliomas in vivo. To accomplish this, we developed CIMPLE (cell invasion, motility, and proliferation level estimates) image maps using serial diffusion MR imaging scans and a solution to a glioma growth model equation, which allows for direct spatial quantification of microscopic tumor proliferation and migration.

**MATERIALS & METHODS**
CIMPLE maps were created for 53 patients with gliomas with WHO II-IV. MR spectroscopy estimates of choline-to-N-acetylaspartate rate were compared to cell proliferation estimates from CIMPLE maps. Additionally, CIMPLE map estimates of proliferation were tested as predictive biomarkers for progression-free (PFS) and overall survival (OS) in 26 patients treated with bevacizumab.

**RESULTS**
Voxel-wise estimates of cell proliferation rate predicted spatial regions of future contrast enhancement in 35% of patients. Regions with the highest cell proliferation rate were clustered along the edge of contrast-enhancing regions. Significant differences were found between WHO grade II and III-IV (malignant) tumors for both proliferation rate and cell motility (diffusion) rates. Mean proliferation rate was able to stratify patients with early and late PFS as well as OS.

**CONCLUSION**
CIMPLE maps represent a novel imaging biomarker of quantifying and visualizing the level of aggressive malignant behavior and predicting patient survival.

**KEYWORDS:** CIMPLE maps, glioblastoma, diffusion MR imaging

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**Paper 268 Starting at 11:41 AM, Ending at 11:49 AM**

**Apparent Diffusion Coefficient Histogram Analysis Predicts Outcome in Multicenter Trial of Bevacizumab for Recurrent Glioblastoma**

Pope, W. B. • Ellingson, B. • Cloughesy, T. • Lai, A. • Kim, H. J. • Nghiemphu, P. • Young, J. R. • Xue, X. • Goldin, J.

University of California Los Angeles
Los Angeles, CA

**PURPOSE**
Previously, apparent diffusion coefficient (ADC) histogram analysis has been used to predict response to Bevacizumab in patients with recurrent glioblastoma in a single-institution study. In the current work we assess the ability of ADC histogram analysis to stratify overall survival in patients with recurrent GBM enrolled in a multicenter trial of Bevacizumab.
**MATERIALS & METHODS**

All patients enrolled in this retrospective study signed institutional review board-approved informed consent. The patients were part of the BRAIN study for glioblastoma. Following standard therapy at initial presentation (maximal tumor resection, radiation therapy and temozolomide treatment) they were treated either with Bevacizumab alone or with Bevacizumab and irinotecan at first or second relapse. Enhancing tumor volumes were segmented on postcontrast T1-weighted images on pre-Bevacizumab treatment scans using a semiautomated, adaptive thresholding technique so that all pixels above the threshold value were selected as previously described. The resulting regions of interest (ROIs) encompassing the entire enhancing tumor volume were visually verified and mapped to the ADC images for histogram analysis using a two-mixture normal distribution. Mean values for the lower peak (ADC\(_L\), lower curve mean) then were generated and tumors were dichotomized using a cut-off for mean ADC\(_L\) of 1209. The proportion of values within the lower curve (i.e., lower curve proportion: LCP) also was generated. Tumors with ADC\(_L\) < 1209 and LCP >= 0.71 are referred to as "Low and Narrow". Cox models and the Kaplan-Meier method with log-rank were used for statistical analysis.

**RESULTS**

Patients with available diffusion imaging and clinical data were used for the analysis (n = 97). Diffusion classifiers stratified both progression-free and overall survival using the Kaplan-Meier method (Figure 1, p = 0.02). Cox proportional hazard modeling demonstrated that the hazard ratio for overall survival in the Low and Narrow group was 2.1 (P=0.003) that of the remainders. The median (+/-IQR) survival of the Low and Narrow group was 231 (+/-352) days, whereas the median (+/-IQR) survival of the rest was 329 (+/-420) days. None of the 11 long-term survivors (> 900 days) were in the Low and Narrow group.

**CONCLUSION**

Our results confirm that, even without standardization of image acquisition, ADC histogram analysis is a predictive biomarker of Bevacizumab response in patients with recurrent glioblastoma. Implications for future multicenter study design will be discussed.

**KEY WORDS:** Glioblastoma, diffusion, Bevacizumab

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**Paper 269 Starting at 11:49 AM, Ending at 11:57 AM**

**Perfusion CT Assessments Of The Peri-Enhancing Brain Tissue In High Grade Gliomas**

Stecco, A. • Amatuzzo, P. • Cignini, E. • Fabbiano, F. • Brambilla, M. • Krengli, M. • Carriero, A.

ASO Maggiore della Carità

Novara, ITALY

**PURPOSE**

To identify tumoral infiltration of peri-enhancing brain tissue in patients with glioblastoma by means of perfusion computed tomography (PCT), cerebral blood volume (CBV) and Permeability Surface (PS). Patients and methods: The study involved ten lung and breast cancer patients with brain metastases and eight patients with surgically treated glioblastomas who were candidates for radiotherapy. After a non-contrast enhanced CT head scan (gantry tilt 0°) had been used to localise the region, both groups underwent PCT with the injection of 50 mL of non-ionic contrast (370 mgI/mL) at a rate of 4 mL/s through a 20G intravenous line. Five seconds into the injection, a continuous cine scan was started (80 kVp, 190-200 mA, 8x5 sections, and one second/rotation for a duration of 45 seconds). Using a manually tracked region of interest, CBV and Ktrans were calculated in the lesion area with contrast enhancement (ENH), two concentric areas of perilesional edema (edema 1 and edema 2), and normal, appearing white matter (NAWM) and normalized using symmetrical areas in the contralateral hemisphere.

**RESULTS**

No significant differences were found for nCBV and nPS in NAWM regions between patients with glioblastoma and glioma. Statistically significant differences in nPS (p<0.005) were found between the typically vasogenic perimetastasis edema of the lung and breast cancer patients and the edema with the possible presence of tumoral tissue around the gliomas. On the contrary no significant differences were detected in the same areas for nCBV.
Table 1: NCBV and nPS values in the glioma patients at T0 and T1 and the patients with metastases

<table>
<thead>
<tr>
<th>T0</th>
<th>T1</th>
<th>MET</th>
<th>P value (MET vs T0)</th>
<th>P value (MET vs T1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NAWM nCBV</td>
<td>1.11±0.41</td>
<td>1.22±0.24</td>
<td>1.08±0.29</td>
<td>0.85 (NS)</td>
</tr>
<tr>
<td>NAWM nPS</td>
<td>1.22±0.58</td>
<td>1.07±0.47</td>
<td>0.92±0.11</td>
<td>0.18 (NS)</td>
</tr>
<tr>
<td>EDEMA 2 nCBV</td>
<td>1.06±0.46</td>
<td>0.99±0.17</td>
<td>1.09±0.12</td>
<td>0.21 (NS)</td>
</tr>
<tr>
<td>EDEMA 2 nPS</td>
<td>1.63±1.90</td>
<td>1.14±0.33</td>
<td>0.54±0.25</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>EDEMA 1 nCBV</td>
<td>2.87±0.72</td>
<td>1.71±1.02</td>
<td>1.35±0.06</td>
<td>0.79 (NS)</td>
</tr>
<tr>
<td>EDEMA 1 nPS</td>
<td>4.11±3.42</td>
<td>3.49±2.43</td>
<td>0.29±0.24</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>ENH nCBV</td>
<td>2.92±0.90</td>
<td>2.93±1.42</td>
<td>19.67±8.7</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>ENH nPS</td>
<td>17.28±26</td>
<td>28.17±49.25</td>
<td>45.62±24.66</td>
<td>0.016</td>
</tr>
</tbody>
</table>

### Conclusion

Perfusion CT can analyze the histopathologic substrate below the hypodense peritumoral halo and differentiate the one due to vasogenic edema from the one at least partially affected by neoplastic infiltration using the PS figure of merit. In our study, CBV resulted less informative than PS in defining neoplastic content inside the hypodense perilesional halo. These findings can be used to integrate plans for radiation therapy and/or surgery.

**Key Words:** CT perfusion, glioma, metastasis

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**Predicting Two-Year Survival Using Cerebral Blood Volume Measurements by Perfusion-Weighted MR Imaging in Gliomas**

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**Purpose**

Our aim is to determine whether relative cerebral blood volume (rCBV) measurements can serve as an adjunct to histopathologic grading in the assessment of cerebral gliomas. Our hypothesis is that rCBV measurements provide useful information to predict disease progression and 2-year survival.

**Materials & Methods**

We retrospectively evaluated 36 patients (19 male, average age 44.5 years) with newly diagnosed treatment naïve cerebral glioma (2 WHO grade I, 19 WHO grade II, 6 WHO grade III, 9 WHO grade IV; 25 astrocytomas, 11 oligodendroglial tumors) who underwent brain MR imaging (MRI) on 1.5 T scanner. First-pass dynamic susceptibility-weighted contrast-enhanced perfusion MR images were obtained and CBV maps were calculated. Relative CBV measurements (maximum tumor CBV/contralateral white matter CBV) were calculated off-line in consensus by two neuroradiologists. Karnofsky performance score at the time of the scan and progression-free survival were recorded. Receiver operating characteristic (ROC) curves and Kaplan-Meier survival curves were calculated for rCBV and histologic grade.

**Results**

Relative CBV measurements were significantly different (p = 0.002) between gliomas without progression (2.15 ± 1.25) and with clinical and radiologic progression (5.10 ± 2.90) over the course of a 2-year follow up. The optimal rCBV cut-off value in the identification of gliomas with progression within 2 years was 2.95 (sensitivity 72.2%, specificity 81%). Relative CBV > 2.95 was found to be a significant predictor of 2-year progression-free survival (chi-square = 12.82, p < 0.001), comparable with WHO grade > 2 (chi-square = 18.60, p <0.001). Four patients with histologic diagnosis of high-grade glioma (3 WHO grade III and 1 WHO grade IV) and with maximum rCBV lower than 2.95 had progression-free survival of 337, 1709, 1876, and 2536 days.

**Conclusion**

Dynamic susceptibility-weighted rCBV measurements can be used to predict 2-year progression-free survival in patients with gliomas, independent of pathologic findings.

**Key Words:** Perfusion-weighted MR imaging, cerebral blood volume, glioma
Paper 271 Starting at 12:05 PM, Ending at 12:13 PM

Correlating Conventional and T2* Perfusion MR Imaging with MGMT Promoter Status and EGFRvIII Status in Glioblastoma Patients

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PURPOSE
Despite multimodality treatment, the prognosis of patients with glioblastoma remains dismal. In recent years, new therapeutic developments and clinical trials have focused on tailoring treatment protocols according to specific genetic mutations. Methylation of the O6-methylguanine DNA methyltransferase (MGMT) promoter has been shown to be associated with improved survival outcomes in patients on temozolomide, the standard first-line chemotherapy for GBM patients. In addition, targeted therapies may benefit patients with expression of the epidermal growth factor receptor variant III (EGFRvIII). As assays for these genetic markers are not widely available and can require large volume tissue sampling, we sought to determine whether MR imaging (MRI) could play a role in the noninvasive prediction of MGMT methylation and EGFRvIII expression status.

MATERIALS & METHODS
We retrospectively identified 77 consecutive glioblastoma patients with known MGMT promoter status, of which 69 had known EGFRvIII expression status. All patients underwent preoperative conventional MRI, and 50 patients underwent T2* dynamic susceptibility contrast (DSC) MRI perfusion. Conventional MRI scans were reviewed and the following tumor features were assessed: 1) sharp border; 2) cystic/necrotic change; 3) nodular enhancement; 4) T2-isointense signal; 5) diffusion restriction; 6) hemorrhage; 7) multifocal discontinuous enhancement; and 8) subependymal enhancement. Dynamic susceptibility contrast perfusion maps and T2* signal intensity time curves were evaluated and the following measures of tumor perfusion were recorded: 1) maximum relative cerebral blood volume (rCBV); 2) peak height (PH); 3) relative peak height (rPH); and 4) percent signal recovery (PSR). The imaging metrics were correlated to MGMT and EGFRvIII status using univariate analyses with Chi-square, Fisher’s exact, or Wilcoxon rank-sum tests.

RESULTS
The MGMT promoter was methylated in 31 patients (40.3%) and unmethylated in 46 patients (59.7%). None of the perfusion metrics or conventional MRI signs were correlated with MGMT methylation status with p>.59 and p>.09, respectively. EGFRvIII expression was present in 27 patients (39.1%) and absent in 42 patients (60.9%). Patients with EGFRvIII expression had higher median rCBV (3.6) than patients without expression (2.8) with p = .04. Percent signal recovery was marginally significant (p = .047). The other perfusion metrics and the eight conventional MRI signs did not show a correlation with EGFRvIII status with p>.10 and p>.15, respectively.

CONCLUSION
Molecular and genetic profiling is emerging as the standard of care for patients with newly diagnosed glioblastoma. These results suggest a role for DSC MRI perfusion in identifying patients with EGFRvIII gene expression, which may be amenable to targeted treatments. Additional work is necessary to confirm these results and isolate new imaging biomarkers that can predict clinically relevant glioblastoma genetic subtypes to facilitate individualized treatment strategies.

KEY WORDS: Glioblastoma, GBM, MR imaging

Paper 272 Starting at 12:13 PM, Ending at 12:21 PM

Glioma Grading: The Role of Combined Perfusion MR Imaging and Single-Voxel MR Spectroscopy Compared to Conventional MR Imaging

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PURPOSE
To assess the contribution of combined perfusion MR imaging (MRI) and single-voxel MR spectroscopy (MRS) in grading primary gliomas compared with conventional MRI.

MATERIALS & METHODS
Thirty-two patients with primary cerebral glioma underwent conventional MRI, dynamic contrast-enhanced T2*-weighted perfusion MRI and single-voxel proton MRS. Gliomas were graded as low or high based on conventional MRI. The rCBV measurements were obtained from regions of maximum perfusion normalized between tumor and healthy tissue. Metabolite ratios ([Cho]/[Cr], [Cho]/[NAA], [NAA]/[Cr]) were measured with TE: 34 ms. Tumor grade determined with the three methods then was compared with that from histopathologic grading. Logistic regression and ROC analyses were performed to determine which parameters best increased diagnostic accuracy (sensitivity, specificity, positive and negative predictive values).

RESULTS
Statistically significant differences were found for rCBV tumor/normal tissue ratio, and NAA/Cr ratio in tumor and Cho/Cr ratio in tumor between low- and high-grade tumors. The best performing single parameter for glioma grading was normalized rCBV value. Combined rCBV tumor/normal tissue ratio and NAA/Cr tumor ratio increased overall accuracy in glioma grading. Receiver operating characteristic curves demonstrated a rCBV tumor/normal tissue ratio of >1.16 and NAA/Cr tumor ratio of <0.44 has the higher probability for a neoplasm to be a high-grade glioma.

CONCLUSION
The rCBV measurements and metabolite ratios both individually and in combination can increase the accuracy when compared with conventional MRI alone in determining glioma grade. The best performing parameter was found to be the rCBV measurements. Threshold values can provide a means for guiding treatment and predicting postoperative patient outcome.
Relationship between MR Imaging Features, Gene Expression Subtype, and Histopathologic Features of Glioblastomas

Hwang, S. N. 1 • Clifford, R. 2 • Holder, C. A. 1 • Huang, E. 2 • Hammoud, D. 2 • Nicolasjilwan, M. 1 • Raghavan, P. 2 • Wintermark, M. 2 • Gutman, D. A. 2 • Moreno, C. 2 • Cooper, L. 1 • Freymann, J. 1 • Kirby, J. 2 • Krishnan, A. 1 • Dehkharghani, S. 2 • Jaffee, C. C. 2 • Saltz, J. H. 1 • Flanders, A. E. 1 • Brat, D. J. 1 • Buetow, K. H. 2

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PURPOSE
To investigate imaging characteristics of primary glioblastomas that predict gene expression subtype and/or microscopic histopathologic features.

MATERIALS & METHODS
As part of The Cancer Genome Atlas (TCGA) MR imaging (MRI) characterization project of the National Cancer Institute (NCI), at least three neuroradiologists (from a panel of six) independently reviewed each MRI of 75 glioblastoma patients in the TCGA database. All images were evaluated according to 26 imaging features (VASARI feature set, https://wiki.nci.nih.gov/display/CIP/VASARI). Multireader assessment of each tumor was reduced to a single score for each feature. Sixty-nine of the tumors were classified as proneural, neural, classic, or mesenchymal based on gene expression (Verhaak, Cancer Cell 17, 90-110, 2010). As proneural classification is associated with improved outcome, the groups were reduced to “proneural” versus “non-proneural.” Also, 28 biopsy specimens from these tumors were rated independently on the basis of digitized pathologic slides by two neuropathologists (from among a panel of eight). Each of 18 features (e.g., microvascular hyperplasia) was rated as absent, present, or abundant. For initial assessment, the pathology ratings were reduced to two groups - “absent” versus “present/abundant”. Associations of the 26 VASARI features with gene expression subtype and the 18 histopathologic features were investigated using Fisher’s exact test and Student’s t-test.

RESULTS
Fisher’s exact test demonstrated a significant association between minimal enhancing tumor (≤5% proportion of the overall tumor) and proneural classification (p=0.0006). It also demonstrated a significant association between a >5% proportion of necrosis and the presence of microvascular hyperplasia in pathology slides (p=0.008). Student’s t-test demonstrated a difference in the mean maximum tumor dimension (based on T2 signal) of tumors with absent microvascular hyperplasia versus tumors with present/abundant microvascular hyperplasia (p=0.001), 61 mm versus 86 mm, respectively. This suggests that larger tumor size relates to the presence of microvascular hyperplasia. No other significant associations were found.

CONCLUSION
These results suggest an association between proneural subtype of glioblastoma and smaller proportion of tumor enhancement. Overall tumor size and proportion of necrosis (derived from MR images) were associated with the presence of microvascular hyperplasia. This supports the observation that hypoxia related to necrosis induces microvascular hyperplasia.

KEY WORDS: Glioblastoma, MR imaging, genomics
Minimally Invasive Fusion of the Thoracic and Lumbar Spine

Kent B. Remley, MD

Presentation Summary
Thoracic and lumbar spinal fusion procedures are indicated for a variety of procedures including degenerative disk disease, degenerative spondylolisthesis, and segmental instability. There is an increasing trend towards the performance of minimally invasive surgery (MIS) procedures in the spine based on the perceived advantages of these techniques; reduction in blood loss, decrease in postoperative infection rates and wound healing complications, reduction in postoperative pain, and reduced hospital stay presumably leading to overall decrease in health care costs. Disadvantages include the steep learning curve for some techniques, reliance on image guidance and neuromonitoring, cost of hardware, implants and biomaterials, as well as the limited data regarding comparison with standard open techniques. Some researchers also have called into question the published results of various MIS techniques, often sponsored or supported by industry financial assistance, as unfairly biased. Pedicle screw instrumentation for segmental fixation has been the traditional method for posterior spinal fixation, in conjunction with posterolateral fusion or interbody fusion. Many companies now have systems for percutaneous placement of pedicle screw fixation. More recently, there has been increasing interest in minimally invasive and percutaneous techniques for facet joint fixation/fusion, providing an attractive option in this regard. Minimally invasive surgery/percutaneous techniques for placement of interbody constructs also are available. These include direct lateral, posterolateral, and direct axial/trans-sacral approach for placement of bone graft/graft substitutes and interbody devices in the lumbar spine. A posterolateral technique also has been developed for the thoracic spine. Autogenous bone graft has been the accepted gold standard for spinal fusion since the work of Phenmister more than 50 years ago. The effectiveness of autogenous bone graft generally is attributed to the presence of three properties: osteoinduction, osteoconduction and osteogenesis. Osteogenesis refers to the presence of cells that directly form bone tissue. Osteoinduction is the ability to stimulate formation of bone at a site where bone tissue does not occur naturally, while osteoconduction indicates the presence of a scaffold or framework to support the environment of bone growth. Autogenous bone graft, when used for spinal fusion, usually is harvested from the iliac crest. Many disadvantages have been raised for the use of ICBG in open spinal fusion procedures, and negate many of the advantages of MIS/percutaneous techniques for spinal fusion, including the limitations of bone quality in patients with osteoporosis. This presentation will review the rationale for using MIS/percutaneous techniques for thoracic and lumbar fusion with emphasis on treatment of disorders of the aging spine. Current MIS/percutaneous treatment options will be presented; including available interbody constructs, posterior stabilization hardware options, and biomaterials available for bone grafting and augmentation of the spine. Finally, future directions regarding percutaneous treatment of spinal disorders, including vertebral body replacement and options for the cervical spine will be presented.

References

New Materials and Devices for Vertebroplasty
A. Orlando Ortiz, MD, MBA

Presentation Summary
Osteoporotic Vertebral Compression Fracture Biomechanics: Center of gravity moves forward; Change in balance - • Increased risk of fall; • Decreased gait velocity; Large bending moment created - Posterior; • Muscles and ligaments must counterbalance increased bending moment; • Increased muscle fatigue - Anterior; • Increased axial loading; increased fracture risk. What else happens? Vertebral body - Endplate fracture. Intervertebral disk - Annular disruption; • Edema - Unstable disk - endplate complex. Spinal ligaments - Strain - Tears. Paraspinal muscles - Strain - Tears. Primary Objectives of Vertebral Augmentation: Pain relief - Fracture stabilization; • VCFs exhibit disruption - Anterior column - Vertebral endplate. Vertebral fracture reduction - Height restoration - Correction of kyphosis. Vertebral body reconstruction - Anterior column stabili-
tion - Endplate stabilization - Implant (cement) within the vertebral body. Secondary Objectives: To prevent further vertebral collapse which 1. Leads to further loss of height, a. Odds ratio for development of new VCF increases to 20.6 when patient height loss >4.0 cm (Siminoski K, et al. Osteoporosis Int 2005; 16:403-410); 2. Is associated with fractures at adjacent levels; 3. Results in progressive kyphosis. Definitions: Vertebral body reconstruction - Restore; • Vertebral body strength using an implant - Repair defects; • Fractures, • Clefs - Re-establish/align; • Vertebral body height; • Vertebral endplate - Orientation - Function. VCFs are not all the same - Etiology; • Osteoporosis - Primary - Secondary; » Steroids; • Osteonecrosis; • Neoplastic; • Traumatic - Age; • Acute; Chronic. Should we be managing different lesions and lesion locations with alternative approaches and treatments? Examples: • Steroid associated oVCF; • T-L junction fracture; • Endplate fracture; • Fracture in young patient; • Chronic painful VCF; • Adjacent level fractures; • Pathologic VCF. EQUIPMENT: Directional needles - Unilateral approach - Directed; • needle placement; • cement injection; • Cook; • 19cm 13g curved needle; • 10cm 10g guide needle. AVAflex Needle - Nitol; • 19cm 11g - Blunt end; • Anterior lumen - Coaxial insertion. Osseo Curved Needle. Equipment: Bone filler needles - Coaxial - Maintain access needle patency - Increases control of cement injection - Plunger >> CDS. Equipment: Cavity creators - Create space in the vertebral body - Working cavity subsequently filled with bone cement - Facilitates controlled cement delivery. Kyphoplasty: 1. Needle placement: Coaxial vs Single Step; Create channel for IBT (Inflatable balloon tamp). 2. IBT: Balloon preparation; Balloon inflation; Balloon deflation. 3. Cement: Preparation/Delivery; • Meticulous fluoroscopy; • Place BFD tip in distal portion of the working cavity; • Slowly advance stylet into BFD in order to introduce opacified cement into working cavity in retrograde fashion. Balloon Tamps: KyphX® Latitude™ Curettes; Other implants: Implants; StaXx FX; Kiva VCF Treatment System; Unilateral approach - Transpedicular. 5mm access cannula: Flexible PEEK-OptimaR implant delivered over nitinol wire - Implant customizable to any length up to 4 loops. Less PMMA - PEEK. Reduced extravasation - Controlled cement delivery. Preservation of cancellous bone. Potential for fewer adjacent level fractures. Structural support for use with biologies. Bone Allograft: Cements - Bio-ceramic cement. Cortoss - Mix on demand - Ideal working time - Controlled delivery - Possible biomechanical benefit - Calcium sulfate cement; HA Cement. Synthetic hydroxapatite - Calcium phosphate based biomaterial - Osteoconductive. Increased radiopacity: Cements. Confidence “Ultra-High Viscosity” PMMA - No liquid phase - Immediately putty-like High viscosity state - Long working time - Radiopaque. High Viscosity Cement: 1. Eliminate virtually any down time waiting for cement to thicken prior to injection; 2. Improved visibility during injection; 3. Improved control of cement due to viscosity (lower creep rate). 4. Consistency throughout procedure: Immediate high viscosity after mixing; Ready to be injected in 2-3 minutes; Long working time: 15 minutes; In vivo set time: 10 minutes. Other hydraulic CDS: Hand gun pump mechanism to push thick cement through injection cannula; Extra long injection tubing - Increases operator distance from the fluoroscopy field. Controlled Cement Delivery: Use of PMMA. RF energy used to increase cement viscosity. Hydraulics used to deliver the thicker cement. Conclusions - Summary: Equipment - Curved injection needle; - Coaxial bone fillers; Cavity creators; - Curettes; Implants; - PMMA. Higher viscosity - Bioceramic - PEEK - Morcelized bone allograft.

REFERENCES

Facet Arthropathy: Treatment Options
Blake A. Johnson, MD, FACR

PRESENTATION SUMMARY
Degenerative arthropathy of the zygapophyseal (facet) joints is an important source of neck, head and back pain. Isolating facet joints as the cause of symptoms is difficult, however, because there are no specific markers of facet joint-related pain. Further, imaging studies do not always correlate with clinical findings. Diagnosis and treatment of facet joint syndrome is accomplished most accurately using fluoroscopic or CT-guided procedures. Diagnostic blocks can be performed targeting either the facet joint or the median branch of the dorsal ramus (facet nerve). Before an intra-articular injection, facet arthrography is performed to document needle position and to evaluate the morphology of the facet joints. Following arthrography and filming, a local anesthetic and steroid are injected into the joint being investigated and the patient is monitored for relief of symptoms. As an alternative to injecting the joint space itself, the facet nerve (medial branch of the dorsal ramus) can be anesthetized. A facet nerve block is preferred to a joint injection for patients who are candidates for radiofrequency neurotomy, because a positive response to a facet nerve block best correlates with subsequent improvement following radiofrequency lesioning at the same location. For this procedure, the needle is directed to the facet nerve using reliable bony landmarks. In the cervical spine, this is along the center of the articular pillar. In the lumbar spine, it is at the junction of the superior articular process and the transverse process. After needle placement, a small dose of contrast (3-.5 cc) is injected to exclude venous opacification. Contrast should remain localized adjacent to the needle tip. Following injection of contrast and filming in at least 2 planes, 0.5 - 1.0 cc's of local anesthetic with or without a steroid suspension are injected. The patient is monitored thereafter for response and assessed at 20-30 minutes postinjection. Patients who respond with significant pain relief (75% or better) are the best candidates for a subsequent radiofrequency (RF) ablation procedure. The pathophysiology of facet joint pain, the technical aspects of facet blocks, radiofrequency neurotomy and radiographic anatomy will be emphasized in this session.

REFERENCES


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**Tuesday Afternoon**

1:30 PM - 3:00 PM
Room 606 - 609

(19) SNIS Programming: Head and Neck Intervention

(278) Vascular Lesion of the Head and Neck: Imaging Characteristics

— Paul A. Caruso, MD

(279) Non-MRI Guided Percutaneous Intervention

— Gary M. Nesbit, MD

(280) MR Guided Percutaneous Intervention

— Daniel P. Hsu, MD

(281) Intra-Arterial Chemotherapy: A Primary Treatment for Cancer of the Head and Neck

— Charles W. Kerber, MD

Moderators
Allan L. Brook, MD
Gregg H. Zoarski, MD

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**Vascular Lesion of the Head and Neck: Imaging Characteristics**

*Paul A. Caruso, MD*

**Non-MR Imaging-Guided Percutaneous Intervention**

*Gary M. Nesbit, MD*

**Presentation Summary**

Accurate direct puncture access to vascular lesions of the head and neck is critical to successful embolization treatment and complication avoidance. Options include: tactile guidance, fluoroscopic guidance, sonographic guidance, CT guidance, or MR guidance. These approaches are relatively straightforward for aspiration or biopsy; however, angiographic injection of the needle is crucial to the evaluation of direct puncture treatment of head and neck vascular lesions being embolized or sclerosed to assess the vascular filling and determine the appropriateness and volume of treatment material to inject. Palpation, fluoroscopic and sonographic localization work well for superficial lesions or those with an acoustic window or radiographic landmark, but CT or MR guidance is the only method where deep lesions can be localized consistently and adequately. Angiographic C-arms are incompatible in the MR suite, except in rare integrated systems, which makes CT the method of choice in these cases where other methods fail. This requires either a combined CT/angiographic suite or limiting the angiography by using a portable angiographic C-arm in the CT scanner suite. The advent of Cone-beam CT acquisitions using dedicated angiographic systems allows the performance of these procedures with CT guidance and excellent angiographic capability. We will discuss these various methods to access head and neck vascular malformations and tumors, and their contribution in lesion treatment.

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**MR Guided Percutaneous Intervention**

*Daniel P. Hsu, MD*

**Presentation Summary**

Image-guide interventions are a mainstay in current medical practice. Despite wide-spread use of MR imaging for diagnostic purposes, MR-guided interventions are relatively rare for myriad reasons. We will explore the current state of percutaneous MR-guided neurointervention as well as potential areas for growth.

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**Intra-arterial Chemotherapy: A Primary Treatment for Cancer of the Head and Neck**

*Charles W. Kerber, MD*

**Presentation Summary**

Squamous cancer of the throat is a disheartening disease. Despite our best efforts, the long-term survival rate remains only 15% to 40%, and surgical cures often decrease the quality of life as they often remove swallowing and speech organs. A better understanding of tumor dynamics and the discovery that thiosulfate can neutralize cisplatin led us to develop a treatment plan that combines a rapid superselective high-dose intraarterial delivery of cisplatin (CDDP), simultaneous intravenous infusion of its antagonist, thiosulfate, and radiation therapy. Patients with advanced head and neck squamous cancer entered our protocol after a multidisciplinary evaluation that included CT or MR imaging. Forty-two patients constituted the first cohort. After baseline angiography, an arterial acceptance test determined the maximum infusion rate that the tumor's nutrient artery would accept. We then infused CDDP at that rate, usually taking about 3 to 5 minutes, while the antagonist thiosulfate was circulating intravenously. In the second cohort of 85 patients with stage 3 or 4 previously untreated and unresectable disease, local radiation was added to the treatment plan. The radiation dose (180-200 cGy/d x 35) was delivered regionally on the basis of the known radiosensitizing effect of CDDP.
Cohort 1 allowed us to develop the infusion technique and to establish a dose quantity and delivery frequency. When 150 mg/m² was administered weekly for 4 weeks, no severe toxicity was found. In cohort 2, 72 (92%) of the remaining 78 patients had complete disappearance of their tumor. Seventeen severe toxic events were associated with 323 femoral catheterizations. One patient died of unrelated pulmonary embolus, precluding follow-up evaluation. Six patients had neurologic sequelae, three with transient and three with permanent strokes. Rapid superselective chemotherapy with CDDP combined with a circulatory systemic antagonist allowed delivery of an antitumoral drug directly into the lesion while protecting the kidneys and bone marrow from the agent’s systemic effects. Use of a dose regimen of 150 mg CDDP/m² per week for 4 weeks resulted in the disappearance of a large percentage of advanced squamous cancers, while preserving speech and following organs in every patient.

**Tuesday Afternoon**

1:30 PM - 3:00 PM  
Room 611/612

(20) ASFNR Programming: Resting State fMRI Connectivity

(23) Resting State fMRI: Historical Perspectives and the Connectome Project  
— Bharat Biswal, PhD

(284) It’s a Small World After All  
— Christopher T. Whitlow, MD, PhD

(285) Methodologic Issues and Clinical Applications  
— Joseph A. Maldjian, MD

Moderator: Joseph A. Maldjian, MD

Resisting State fMRI: Historical Perspectives and the Connectome Project  
Bharat Biswal, PhD

Presenting Summary  
Improvement in hardware and software has enabled the rapid sequential acquisition of high resolution MR images. This has enabled researchers to acquire brain images as the participants perform task/stimulus presented to them. In this lecture, we will discuss the various methods currently used to optimize and detect brain regions associated during resting state. Further, its application both in neurosciences and clinical applications will be presented.

**It’s a Small World After All**  
Christopher T. Whitlow, MD, PhD

Presenting Summary  
Mathematical models for computational network analysis based upon graph theory have risen to the forefront of the investigation of brain connectivity as a complex distributed system. Graph theoretical analysis provides a mathematical description of a network that is composed of numerous “nodes” (vertices) related to one another by “edges” (connections). Connectivity within the brain, therefore, can be modeled as a network of nodes representing brain regions or voxels, with edges representing inter-regional or inter-voxel connections (1-2). Networks characterized by many short-distance neighboring connections and a few long-distance connections were first described by Watts and Strogatz (3) and called “small-world” networks based upon similar properties of complex social connectivity. Just as the double helix has been found to underlie the organizational architecture of genetic structure across species, small-world network topologies are being shown to underlie the organizational architecture of all manner of complex biological systems, including the fundamental structural and functional architecture of brain connectivity. Graph theory network analyses applied to blood oxygen level-dependent data extracted from resting-state functional magnetic resonance imaging have begun to shed light upon changes in the central nervous system at the level of whole-brain distributed network connectivity associated with a variety of neurodegenerative and psychiatric disorders, such as Alzheimer disease, schizophrenia, epilepsy, and multiple sclerosis (4-5). The educational objectives for this presentation are to introduce and describe basic concepts of network theory, including fundamentals of brain connectivity and commonly used network metrics.

**Methodologic Issues and Clinical Applications**  
Joseph A. Maldjian, MD

Presenting Summary  
Task-based functional MRI (fMRI) has been the mainstay of functional imaging studies with an extensive body of literature in both clinical and research applications. Recently, resting-state fMRI (RS-fMRI) has been gaining in popularity. Unlike task-based studies, RS-fMRI provides the opportunity to identify underlying brain regional network connectivity without concern for task performance. Methodologies for analysis of RS-fMRI have moved beyond simple seed-based correlation analysis, and now involve whole brain analyses using a variety of techniques including principal component analysis, independent component analysis, and more recently, graph theoretic analyses. This talk will focus on some of the methodologic issues common to these analyses and evolving clinical applications for RS-fMRI.
Tuesday Afternoon
1:30 PM - 3:00 PM
Ballroom 6A

(21) ASHNR Programming: Pediatric Head and Neck

(286) Congenital Malformations of the Temporal Bone
— Caroline D. Robson, MB, ChB
(287) Maxillofacial Congenital Malformations
— Manohar M. Shroff, MD
(288) Congenital Anomalies of the Neck
— Bernadette L. Koch, MD

Moderator: Timothy L. Larson, MD

Congenital Malformations of the Temporal Bone
Caroline D. Robson, MB, ChB

PRESENTATION SUMMARY
Congenital Malformations of the Temporal Bone. I. Clinical presentation and Imaging: Hearing impairment or physical abnormality; MDCT and MR imaging. II. Development of the external and middle ear vs inner ear. III. External and middle ear anomalies CT report details: 1. Distinguish between stenosis vs atresia of EAC; 2. Describe nature and thickness of the atresia plate; 3. Describe degree of mastoid pneumatization; 4. Detect middle ear space hypoplasia/anomaly; 5. Detect erosive opacities indicating cholesteatoma; 6. Evaluate for malformed/fused/rotated ossicles (abnormal in all to some degree); 7. Detect stenosis or atresia of oval window; 8. Detect anomalous VII CN course and possible dehiscence of VII channel; 9. Inner ear anomalies (usually indicates syndromic etiology); 10. Mandibular condyle size/position (hypoplasia indicates syndrome); 11. Assess for low placement of tegmen/middle cranial fossa dura. IV. Syndromic cases: Hemifacial microsomia, Treacher Collins. V. Inner ear malformations. VI. Causes of profound SNHL in infancy: 50% Environmental (e.g., CMV, prematurity etc.), 50% Genetic, 30% Syndromic (e.g., Pendred syndrome, BOR, CHARGE, etc.), 70% Nonsyndromic (e.g., Connexin 26 mutation). VII. Radiologic classification and examples of cochlear malformations: •Complete labyrinthine aplasia, •Cochlear aplasia, •Cochlear hypoplasia, •Common cavity malformation, •Cystic cochleovestibular anomaly and incomplete partition type I (IP-I), •Incomplete partition type II (IP-II) and enlarged vestibular aqueduct, •Cochlear modiolar deficiency, •Cochlear nerve canal stenosis or atresia and cochlear nerve hypoplasia/aplasia. VIII. Anomalies of the vestibule and semicircular canals: •Complete labyrinthine aplasia, •Hyoplasia of the vestibule, •Malformed or absent SCC, •Globular vestibule & SCC. IX Syndromes: characteristic imaging findings: •EVA and Pendred syndrome: SLC26A4 mutation, •X-linked stapes gusher (DFNX2): POU3F4 mutation, •Branchio-oto-renal syndrome: EYA1 gene mutations, •CHARGE syndrome: CHD7 chromodomain mutations, •Trisomy 21, •Apert syndrome, •Waardenburg syndrome.

REFERENCES

Maxillofacial Congenital Malformations
Manohar M. Shroff, MD
Dr. Manohar Shroff, FRCPC, is a staff pediatric neuroradiologist at the Hospital for Sick Children and an Associate Professor in Medical Imaging at the University of Toronto. He is the Neuroradiology Program Director and Fellowship Program Director for the Department of Medical Imaging at the University of Toronto and also is currently the interim chief of Diagnostic Imaging at the Hospital for Sick Children in Toronto

PRESENTATION SUMMARY
Congenital anomalies of the midface originate during transformation of the first pair of pharyngeal arches into adult structures. Congenital maxillofacial anomalies generally result from a combination of inadequate migration and inadequate formation of facial mesenchyme. Understanding embryologic development of the midface is important to understanding the basis of such anomalies and associated syndromes. Imaging approaches including the use of 3D CT will be discussed. Three-dimensional CT provides a general overview of the congenital anomaly, which is easy to understand both for the radiologist and the referring physician, whereas thin multiplanar images provide the additional detail necessary to complete the work up. Additionally, such 3D data often are very useful for life-sized model formations for surgical planning. The spectrum of such congenital anomalies includes congenital nasal masses (such as dermoids, gliomas, encephaloceles); choanal and pyriform aperture stenosis, various facial clefts and first pharyngeal arch syndromes associated with unilateral or bilateral maxillofacial hypoplasia.

Congenital Anomalies of the Neck
Bernadette L. Koch, MD

PRESENTATION SUMMARY
The most common congenital anomalies involving the neck are cysts resulting from abnormal embryogenesis involving the thyroglossal duct (TGD), lymphatic primordia or the branchial apparatus. When the basic embryology of these structures is understood, a reasonable differential diagnosis can be achieved based on the location and the imaging characteristics of the cystic mass. Thyroglossal duct cysts are anomalies of the thyroglossal duct. They are most commonly midline in position and occur anywhere along the duct.
from the foramen cecum at the base of the tongue to the level of the thyroid bed. Lymphatic malformations are congenital vascular malformations that may be macrocystic or microcystic, unilocular or multilocular, located in a single space or transpatial. Lymphatic malformations are the most common cystic neck mass to undergo spontaneous intraleisional hemorrhage and therefore may contain fluid-fluid levels. Lymphatic malformations do not significantly enhance, unless they are part of a mixed vascular malformation, in which the venous or arteriovenous malformation component will enhance. Branchial apparatus anomalies are the result of abnormal embryogenesis involving one or more of the mesodermal branchial arches, endodermal pharyngeal pouches and/or ectodermal branchial clefts (grooves). Potential anomalies may be in the form of sinus tracts, fistulae or cysts. Sinus tracts usually communicate externally, rarely internally. Fistulae communicate both externally and internally and result from persistence of both a branchial cleft and a pharyngeal pouch. The majority of anomalies that require imaging are branchial apparatus cysts (BACs) arising from the first, second or third branchial apparatus. First branchial apparatus cysts are near the external auditory canal, pinnae and/or the parotid gland. The differential diagnosis of a solitary cyst within or superficial to the parotid gland also should include parotid epithelial cysts, primary cystic neoplasm and necrotic or suppurrative lymph node. Second branchial apparatus anomalies account for up to 95% of all branchial apparatus anomalies and the majority are cysts. The most common location is anterior to the sternocleidomastoid muscle, posterior to the submandibular gland and lateral to the carotid sheath. Third branchial apparatus cysts are rare. In the upper neck, they occur posterior to the common or internal carotid artery and in the lower neck they occur in the anterior triangle. Thymic cysts are rare remnants of the third branchial pouch. The cyst may be anywhere along the tract of the thyropharyngeal duct, from the angle of the mandible to the upper mediastinum, frequently closely associated with the carotid sheath.

Tuesday Afternoon

3:30 PM - 5:00 PM
Ballroom 6 B/C

(23a) Adult Brain: Neoplasms II: Gliomas
(Scientific Papers 290 - 300)

See also Parallel Session
(23b) New Devices & Arteriovenous Malformations/Fistulae
(23c) Pediatrics: Brain Ischemia and Its Consequences
(23d) Spine: Intervention and Other
(23e) Socioeconomics & Anatomy

Moderator: TBD

Paper 290 Starting at 3:30 PM, Ending at 3:38 PM

Vessel Size Imaging Evaluation in Recurrent Glioblastoma Multiforme Using a Multiple Spin and Gradient-Echo Perfusion Bolus Contrast Sequence

Andre, J. B. • Schmiedeskamp, H. • Zaharchuk, G. • Straka, M. • Christen, T. • Recht, L. • Bammer, R.
Stanford University School of Medicine
Stanford, CA

PURPOSE

Multimodality treatment options result in difficulty distinguishing glioblastoma multiforme (GBM) tumor growth/recurrence from radiation necrosis. Dynamic susceptibility-contrast gradient-echo (GE) perfusion measurements of relative cerebral blood volume (CBV) can distinguish tumor recurrence from radiation necrosis. Spin-echo (SE) and GE images have varying sensitivities to vessel diameter due to static or dynamic dephasing regimes. Spin echo is only sensitive to capillaries (~25 μm), while GE’s sensitivity is roughly twice that of SE, and increases with vessel size. Here, the ratio of GE and SE relaxation rates (AR2*/AR2) correlates with vessel diameter. In this prospective, IRB-approved pilot study, a combined dynamic bolus contrast multiecho SE and GE (SAGE) EPI sequence allows simultaneous evaluation of R2 and R2* changes for relative vessel size imaging (VSI), with the goal of evaluating cerebral blood volume and VSI with respect to GBM recurrence versus radiation necrosis, enabling a more timely modification in therapy, and thereby improved patient prognosis.
Materials & Methods

Routine tumor imaging was performed in 11 postchemoradiation GBM patients at 1.5 T and 3 T, following informed consent. Additional VSI images were acquired using 3- or 5-echo SAGE-EPI acquisition with echo times of TE = 17-101 ms. Fifteen 5-mm slices with in-plane resolution of 84x84 (96x96 in 3-echo cases) were acquired with 24 cm FOV. A 90° spectral-spatial RF excitation pulse was followed by a 180° spin-echo pulse. Perfusion-weighted imaging (PWI) was based on the acquisition of 60 EPI volumes with TR = 1800 ms, using a single dose of gadolinium bolus via power injector. Perfusion parameters were obtained using the RAPID postprocessing toolbox. Relative VSI maps were determined from the ratio of $R_2^*$ and $R_2^{**}$-weighted CBV values, and were correlated with conventional MR images.

Results

Seven of 11 patient scans (63.6%) demonstrated findings on VSI to suggest tumor involvement at the time of imaging. Of these, five showed a greater small-vessel component than large vessel component. In one illustrative case, initially demonstrating no conventional MR imaging findings of tumor recurrence, subtle findings on VSI were noted anterior to a resection cavity (not identified on GE PWI images), which demonstrated marked pathologic enhancement on conventional MR sequences 6 and 9 months later. Similar findings were noted in additional cases. Of the four cases with no VSI findings of recurrent or residual tumor, none demonstrated positive findings up to 1 year, suggesting that VSI may have a strong negative predictive value.

Conclusion

Initial results demonstrate feasibility of the SAGE EPI method in imaging GBM in recurrent and/or treated tumor, and suggest that detection of both microvasculature (in recurrence, possibly as a consequence of novel therapeutic agents targeted at inhibiting neoangiogenesis) and large vessels in recurrent and treated primary neoplasm, may be a sensitive method for tumor detection. Since VSI can detect subtle tumor recurrence, in light of apparently “negative” GE-based PWI, our results suggest that SAGE may hold promise in the evaluation of brain neoplasms and specifically help to provide earlier modification in therapy.

Key Words: Glioblastoma, astrocytoma, vessel size imaging

Paper 291 Starting at 3:38 PM, Ending at 3:46 PM

Using 3 T Multiphase Pulsed Arterial Spin Labeling to Differentiate between Low-Grade and High-Grade Gliomas

Furtner, J. • Kasprian, G. • Krssak, M. • Widhalm, G. • Hainfellner, J. • Prayer, D.

Medical University Vienna

Vienna, AUSTRIA

Purpose

To determine whether there is a difference of bolus arrival time within high-grade and low-grade gliomas using multiphase pulsed arterial spin labeling (PASL).

Materials & Methods

Fifty-four patients with primary brain tumors, histologically classified as low-grade (n = 20) or high-grade (n = 34) gliomas according to the WHO brain tumor classification were included. A 3 T MR scanner was used to perform a multiphase PASL sequence at eight different inversion timepoints (TI = 364 ms, 614 ms, 864 ms, 1114 ms, 1364 ms, 1614 ms, 1864 ms, 2114 ms). The bolus arrival time reflecting the maximum of tumor perfusion at one of the defined inversion timepoints was calculated. A Mann Whitney-U test was used to reveal potential differences in the bolus arrival time between high-grade and low-grade gliomas.

Results

The mean bolus arrival time of high-grade gliomas was 864 ms (range: 614 ms-1114 ms). Low-grade gliomas showed a mean bolus arrival time of 1614 ms (range:1364 ms-1834 ms). According to the Mann Whitney-U test the differences of the bolus arrival time between high-grade and low-grade gliomas were statistically significant (p = 0.005).

Conclusion

Using multiphase ASL at 3 T, tumor vascularization can be noninvasively assessed. The bolus arrival time is a new and useful parameter to differentiate between low-grade and high-grade gliomas.

Key Words: Arterial spin labeling, gliomas, perfusion

Paper 292 Starting at 3:46 PM, Ending at 3:54 PM

Methodology for Multireader Assessment of MR Imaging Features of Gliomas in Clinical Trials

Flanders, A. E. • Huang, E. • Wintermark, M. • Hammoud, D. • Nilcolasjilwan, M. • Raghaven, P. • Holder, C. • Hwang, S. • Clifford, R. • Freymann, J. • Kirby, J. • Rubin, D. • Siegel, E. • Jaffe, C. C. • Butew, K. H.

1Thomas Jefferson University Hospital, Philadelphia, PA, 2National Cancer Institute, Bethesda, MD, 3University of Virginia, Charlottesville, VA, 4National Institute of Health, Bethesda, MD, 5Emory University, Atlanta, GA, 6SAIC-Frederick, Inc., Frederick, MD, 7Stanford University, Paolo Alto, CA, 8Boston University School of Medicine, Boston, MA

Purpose

Research trials that incorporate imaging present unique challenges due to nonstandard use of terminologies, absence of uniform data collection and validation. These obstacles traditionally limit the impact of imaging as an effective biomarker in oncology. The purpose of this project was to assess reliability of tools and terminology developed by the Cancer Bioinformatics Grid (caBIG) initiative when performing a multireader simultaneous assessments of glioblastoma MR imaging (MRI) features.

Materials & Methods

A controlled terminology for describing the MR features of human gliomas was devised based upon prior work (VASARI/Rembrant project). This comprehensive featureset consists of 24 observations familiar to neuroradiologists to describe the morphology of brain tumors on routine contrast-
enhanced MRI. The National Biomedical Imaging Archive (NBIA) was used to store the de-identified baseline MRI studies for 78 glioblastomas collected for the Cancer Genome Atlas (TCGA) initiative. Six neuroradiologists in three disparate geographic locations were recruited and trained in the use of the featureset using a visual guidebook. Training cases were employed to assess competency and to ensure agreement. A open-source PACS workstation (Clear Canvas) was customized for clinical imaging research evaluation and deployed at each of the three centers. Networking tools built into the workstation were used to securely download studies from NBIA (eaGRID). As studies were evaluated, scores were simultaneously uplinked to a single remote AIM (Annotation and Image Markup) repository for QC checks and inter-rater analysis. Case assignments were deliberately staged in a staggered fashion to ensure that a minimum of three evaluations were efficiently obtained. Administrative tools were employed by coordinators in a fourth location. Qualitative assessments included: (1) effectiveness of training, (2) ease of deployment and functionality of the informatics solutions and (3) efficiency of the process. Interobserver variation for each feature was assessed with the generalized kappa statistic of Berry&Miekle.

**RESULTS**

Training, deployment of resources and completion of three evaluations per case were accomplished in 30 days. Functionality of the IT solutions was rated superior in qualitative assessment. The results indicated strong overall average interobserver agreement among all six readers. Agreement was highest for tumor side (generalized kappa statistic $k=0.943$, 95% CI 0.915-0.982) and tumor location ($k=0.837$, 95% CI 0.807-0.902). Other features with high agreement included proportion enhancing tumor ($k=0.656$, 95% CI 0.596-0.757), presence of satellites ($k=0.663$, 95% CI 0.591-0.780), and diffusion ($k=0.730$, 95% CI 0.664-0.828). Of the remaining, only three features (12.5%) showed low agreement ($k<0.4$): presence of calvarial remodeling ($k=0.366$, 95% CI 0.124-0.626), cortical involvement ($k=0.167$, 95% CI 0.157-0.335), and definition of non-enhancing margin ($k=0.374$, 95% CI 0.347-0.514).

**CONCLUSION**

Inclusion of vetted, tested and validated controlled terminologies into imaging arms of clinical trials is essential in adding value of imaging as a biomarker in cross-cutting correlative studies. Controlled terminologies such as the one described herein for assessment of gliomas can be used effectively by domain experts following a relatively short training period. Technologies developed through the caBIG initiative provide an effective and efficient framework for federated imaging assessments that can expedite cross-correlative analysis with other data repositories (e.g., genomics/proteomics/pathology).

**KEY WORDS:** Informatics, glioma, imaging features

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**Paper 293 Starting at 3:54 PM, Ending at 4:02 PM**

**Does High b-Value Diffusion Tensor Imaging Provide Better Tissue Characterization of Peri-Tumoral Region?**

Guo, W.1 • Liu, H.2 • Lin, C.3

1Taipei Veterans General Hospital, Taipei, TAIWAN, 2School of Medicine, National Taiwan University, Taipei, TAIWAN, 3School of Medicine, National Yang-Ming University, Taipei, TAIWAN

**PURPOSE**

Brain tumors involve also their surrounding tissues. The involvement presents signal abnormalities, usually abnormal high signals on T2-weighted MR images (T2W), around the tumors. Microscopically, the peritumoral signal abnormalities (PSA) contain a variety of tissues, namely, vasogenic edema, tumor infiltration, gliosis and their mixtures. Among them, vasogenic edema is reversible while tumor infiltration and gliosis are irreversible. Clinically, differentiating the tissues is important for treatment optimization of brain tumors. The study was aimed to probe the tissue characteristics of the peri-tumoral region by diffusion tensor imaging (DTI) with different $b$-values.

**MATERIALS & METHODS**

Fifteen patients (10 male and 5 female; age 45, 34-74 years) with different tumor types (glioblastoma in four, anaplastic astrocytoma in three, metastasis in six, and meningioma in two) were recruited. All tumors were scanned by 3T MR system before and 2 months after surgery. MR imaging were performed using a 12-channel head coil. In addition to routine diagnostic pulse sequences, two sets of single-shot spin-echo echoplanar DTI sequences with TR/TE = 10000 ms / 99 ms, FOV = 230x230 mm$^2$, $b = 1000$ and 3000 s/mm$^2$, 24 directions, and Nex = 2 and 4 were performed. For each patient, the region-of-interest (ROI) was placed in both PSA and its mirror area of the contralateral hemisphere on T2W. These regions were interrogated first to obtain the lesion-to-nonlesion FA ratios of ROI.

**RESULTS**

Fractional anisotropy (FA) ratios for reversible group and irreversible group in $b$-value = 1000 s/mm$^2$ were, respectively, 0.507±0.085 and 0.369±0.114 with statistically significant differences (p=0.011). In addition, FA ratios for reversible group and irreversible group in $b$-value = 3000 s/mm$^2$ were, respectively, 0.554±0.088 and 0.333±0.111 with statistically significant differences (p=0.002). The differences were bigger in $b$-value = 3000 s/mm$^2$ than in 1000 s/mm$^2$. The reversibility of PSA was predictable by FA ratios measured on diffusion tensor imaging (DTI). The FA ratio of reversible and irreversible PSA with $b$-value= 3000 s/mm$^2$ were more significantly different than that with $b$-value= 1000 s/mm$^2$. The findings supported that higher $b$-value provide better tissue characterization of peri-tumoral region.
CONCLUSION
Based on the study, we conclude that higher $b$-valued DTI helps to explore the microstructures of peri-tumoral tissues. It may not only improve predicting postsurgical outcome of PSA but also serve as a biomarker for delineating targets for surgical intervention or radiotherapy and may, therefore, improve therapeutic effects.

KEY WORDS: MR imaging, diffusion tensor imaging, brain tumor

RESULTS
There is statistically significant difference in $T_S$ depending on the location of the primary tumor, with patients with occipital lobe disease having the poorest post-resection survival (occipital<temporal<frontal<parietal) ($p = 0.0394$). Presurgical assessment of tumor appearance based on ADC maps and enhancement has statistically significant prognostic value in predicting $T_S$. Specifically, tumors without rl-ADC areas and no enhancement (Group 1) (5 WHO III-IV/IV, and 1 WHO II/IV patients), and tumors with large rl-ADC area and large area of enhancement (Group 4) (9 WHO III-IV patients) correlate with significantly shorter $T_S$ than the other two groups with intermediate appearance (14 WHO III/IV, 2 WHO II/IV) ($p = 0.0039$). Finally, statistically significant inverse relationship between postsurgical $V_F$ and $T_R$ was found ($p<0.05$). However, no statistically significant correlation is yet seen between the other imaging-based variables (presurgical $V_F$, pre and postsurgical $V_C$, pre-op rl-ADC volume, and $ADC_{min}$) and surgical outcome variables ($T_R$ and $T_S$) in our preliminary data. Nonetheless, significant trends were observed.

CONCLUSION
Qualitative and quantitative MR characterization of pre and postsurgical tumor volumes and mean diffusivity in glioma patients can be helpful in predicting surgical outcomes (recurrence and survival) and individualizing neuro-oncology treatment strategies.

KEY WORDS: Apparent diffusivity, FLAIR volume, postsurgical recurrence
Corpus Callosum Wallerian Degeneration in Unilateral Brain Tumors: Evaluation with Diffusion Tensor Imaging

Narang, J. • Sakena, S. • Nazem-Zadeh, M. • Jain, R.
Henry Ford Health System
Detroit, MI

**PURPOSE**
Corpus callosum (CC) is the largest commissural fiber that connects the homologous regions of both cerebral hemispheres and callosal axons exhibit a topographic distribution with different CC regions serving different cortical regions. Corpus callosum white matter tracts are significantly influenced by cortical damage; a previous study demonstrated wallerain degeneration (WD) changes in CC in large middle cerebral artery stroke patients using diffusion tensor imaging (DTI). The purpose of this retrospective study was to evaluate whether DTI can demonstrate water diffusivity changes in CC not visible on morphologic imaging in patients with grade IV gliomas and brain metastases with no midline CC infiltration.

**MATERIALS & METHODS**
Twenty-seven patients with treatment naïve unilateral glioblastoma (WHO grade IV, GBM) and 11 patients with a solitary brain metastasis with no midline CC infiltration underwent DTI at 3.0T scanner. Ten age- and sex-matched controls also were included. Based on tensors, principal diffusion directions, anisotropy values of neighboring voxels, and prior information about the diffusivity pattern in CC, a similarity measure was proposed and used as a speed function in the level-set based algorithm. Subsequently, the CC was automatically divided into the Witelson subdivisions. Two sample t-tests were done for the pairwise comparisons of controls, patients with GBM and metastases.

**RESULTS**
We observed significantly decreased FA values in all regions of CC in patients with GBM and metastases compared to controls (Table 1). MD values showed a significant increase in all regions of CC except splenium in patients with GBM and isthmus in metastases compared to controls respectively (Table 2). However, no significant difference in FA and MD values for all the seven regions of CC was found in patients with GBM compared to metastases.

**CONCLUSION**
In our study, most of patients had involvement of frontal, parietal, parieto-occipital and temporal region secondary to a GBM and metastases. This suggests that interhemispheric fibers from the frontal, parietal, occipital and temporal lobes that course through rostrum, genu, rostral body, anterior midbody, posterior midbody, and splenium are most affected fibers secondary to the tumor-related WD changes in these regions of CC. Our results indicate that DTI is more sensitive than morphologic MR imaging in the evaluation of changes within CC in brain tumors not infiltrating or directly involving the CC. However, these changes of DTI metrics in CC are due to WD rather than tumor infiltration as proved by our results showing similar changes in GBM as well as noninfiltrating metastases.

**KEY WORDS:** Corpus callosum, diffusion tensor imaging, Wallerian degeneration

### Table 1

<table>
<thead>
<tr>
<th>Region</th>
<th>Controls</th>
<th>GBM</th>
<th>Metastases</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>CC2</td>
<td>0.55 ± 0.05</td>
<td>0.25 ± 0.11</td>
<td>0.42 ± 0.16</td>
<td>0.001</td>
</tr>
<tr>
<td>CC3</td>
<td>0.55 ± 0.07</td>
<td>0.50 ± 0.05</td>
<td>0.56 ± 0.05</td>
<td>0.004</td>
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<tr>
<td>CC4</td>
<td>0.50 ± 0.00</td>
<td>0.50 ± 0.00</td>
<td>0.51 ± 0.03</td>
<td>0.001</td>
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<tr>
<td>CC5</td>
<td>0.49 ± 0.07</td>
<td>0.50 ± 0.00</td>
<td>0.35 ± 0.08</td>
<td>0.001</td>
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<tr>
<td>CC6</td>
<td>0.47 ± 0.10</td>
<td>0.39 ± 0.07</td>
<td>0.35 ± 0.08</td>
<td>0.003</td>
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<tr>
<td>CC7</td>
<td>0.50 ± 0.00</td>
<td>0.50 ± 0.00</td>
<td>0.50 ± 0.00</td>
<td>0.004</td>
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</tbody>
</table>

### Table 2

<table>
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<tr>
<th>Region</th>
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<th>Metastases</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>CC2</td>
<td>0.56 ± 0.05</td>
<td>0.85 ± 0.22</td>
<td>0.85 ± 0.33</td>
<td>0.006</td>
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<tr>
<td>CC3</td>
<td>0.61 ± 0.01</td>
<td>0.84 ± 0.04</td>
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<td>CC7</td>
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</table>

Dynamic contrast-enhanced (DCE) MR imaging (MRI) has shown potential for predicting the biologic aggressiveness of cerebral gliomas. The perfusion parameters Ktrans (volume transfer constant) and cerebral blood volume (CBV) have been found to provide particularly valuable prognostic information. For these measurements, it is a common practice to estimate the arterial input function (AIF) from the magnitude images. However, absolute quantification of these parameters using this technique can be biased by signal saturation or nonlinearity in the artery. We have developed an alternative...
approach which uses the AIF from the phase images during dynamic acquisition. The purpose of this study is to evaluate the diagnostic accuracy of DCE-MRI using phase-derived AIF in grading gliomas.

**MATERIALS & METHODS**

Thirty-one cerebral glioma patients (6 grade II, 3 grade III, 22 grade IV) were studied at 1.5 T. Dynamic contrast-enhanced MRI was performed with double-echo 2D FLASH (TR/TE/flip 50ms/2.1 & 5.5 ms/90 deg), with one slice prescribed on the ICA. Bookend T1 measurements and MR signal phase were used to obtain Gd concentration-vs-time in the vessels and tissue. Tracer kinetic modeling then was used to obtain parametric maps of Ktrans and CBV, using regions of interest (ROIs) drawn over the superior sagittal sinus (SSS) to obtain the AIF. Four 5 mm diameter circular ROIs were drawn on each tumor (on the enhanced solid part for enhancing tumor), and perfusion parameters for these ROIs were averaged.

**RESULTS**

The mean Ktrans was 0.012 ± 0.013 seconds⁻¹ for low-grade gliomas and 0.13 ± 0.15 seconds⁻¹ for high-grade gliomas (P<0.05, Wilcoxon Rank-Sum test). The mean CBV was 2.2 ± 1.60 ml/100g for low-grade gliomas and 4.1 ml/100g ± 3.3 ml/100g for high-grade gliomas (P = 0.18).

**CONCLUSION**

Dynamic contrast-enhanced MRI using phase-derived AIFs may have a role in the preoperative assessment of patients with glioma. The measurement of Ktrans can be used to distinguish low-grade from high-grade gliomas.

**KEY WORDS:** Dynamic contrast enhancement, perfusion, glioma

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**Paper 297 Starting at 4:26 PM, Ending at 4:34 PM**

**Dynamic Contrast-Enhanced and Dynamic Susceptibility Contrast MR Imaging Evaluation of True Early Progression versus Pseudoprogression in Patients with High-Grade Gliomas**

Shiroishi, M. S. • Jones, J. G. A. • Ozhand, A. • Muradyan, N. • Chen, B. T. • Pagnini, P. G. • Chen, T. C. • Go, J. L. • Boyko, O. B. • Lerner, A. • Patil, T. • Law, M.

Keck School of Medicine, University of Southern California, Los Angeles, CA; iCAD Inc, Nashua, NH; City of Hope, Duarte, CA

**PURPOSE**

To describe the utility of MR perfusion and permeability in distinguishing pseudoprogression from recurrent disease in high-grade glioma patients. Since adoption of the Stupp protocol of temozolomide plus radiation therapy following maximal total resection in newly diagnosed glioblastoma multiforme, there has been an increased awareness of pseudoprogression. Increasing contrast-enhancement noted on surveillance MR imaging, usually within 12 weeks of radiation, poses a diagnostic dilemma to clinicians: either switch the patient to a different therapy or continue the existing regimen with close observation. MR perfusion and permeability metrics may predict which patients will go on to develop progressive disease versus those who will stabilize or improve. This information would prove vital to physicians in charge of patient care.

**MATERIALS & METHODS**

MR perfusion and permeability metrics of 20 high-grade glioma patients with MR imaging findings of increased enhanced enhancement after the completion of radiation therapy were evaluated. Relative cerebral blood volume (rCBV) and vascular permeability (Ktrans) were determined in the abnormally enhancing regions. Patients were classified as having pseudoprogression (PsP) or true early progression (TEP) based on subsequent imaging and pathology data at reoperation (if available).

**RESULTS**

Relative CBV and Ktrans of those with TEP was significantly increased compared with those classified as having PsP. In patients for whom pretreatment perfusion and permeability metrics were available, there appeared to be a trend toward increasing rCBV and Ktrans relative to baseline in those with TEP while in those with PsP, they appeared to decrease.

**CONCLUSION**

MR perfusion and permeability appear to show promise in distinguishing PsP from TEP. An ongoing prospective trial is underway to enroll more patients to further validate these preliminary findings.

**KEY WORDS:** Perfusion, permeability, glioma

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**Paper 298 Starting at 4:34 PM, Ending at 4:42 PM**

**Proton MR Spectroscopy: Assessing the Metabolic Effects of Super-Selective Intra-Arterial Cerebral Infusion of Bevacizumab in Treatment of Glioblastoma**

Jeon, J. • Kovanlikaya, I. • Boockvar, J. • Mao, X. • Shin, B. • Burkhardt, J. • Kesavarhotla, K. • Christos, P. • Shungu, D. • Riina, H. • Tsiouris, J.

Weill Cornell Medical Center New York, NY

**PURPOSE**

Bevacizumab has emerged to the forefront as standard therapy for recurrent glioblastoma multiforme (GBM). While treatment with this drug produces dramatic decreases in MR imaging (MRI) contrast enhancement, the degree to which this radiographic finding reflects an actual tumoricidal effect remains unclear. Although believed to function as an inhibitor of vascular endothelial growth factor (VEGF), its concurrent reduction of vessel permeability contributes to changes in enhancement features, confounding the relationship between enhancement and tumor burden. This interplay of dynamics and inherent ability of conventional MRI to differentiate tumor response, progression, and post-treatment effects limits utility of this technique. We propose that proton MR spectroscopy (1H MRS) may serve to elucidate the dynamics of neoplastic evolution post bevacizumab treatment at the cellular level. Neurochemical analysis may reveal the degree to which enhancement changes are related to or independent of tumor volume, with a decrease in choline (Cho) suggesting a tumoricidal mechanism in part.
The need for more advanced techniques is supported by recent literature focusing upon Cho/NAA (Choline/N-acetylaspartate), Cho/Cr (Choline/Creatine), and NAA/Cr (N-acetylaspartate/Creatine) ratios as useful discriminators. The aims of this study were to (a) use 1H MRS to assess the effects of bevacizumab on the metabolic composition of GBM, with emphasis on enhancing and nonenhancing components, and (b) assess how metabolic profiles of GBM are altered after super selective intra-arterial cerebral infusion (SIACI) of bevacizumab, a relatively new and promising dose-intensification technique.

MATERIALS & METHODS
Thirty-eight patients with recurrent GBM will be studied prospectively with IRB approval from an ongoing serial study. Inclusion criteria required SIACI of bevacizumab with both pre- and post- treatment gadolinium-enhanced MRI and 1H MRS within the time frame of a few days prior to and 3-5 weeks after therapy respectively. Six morphologic categories or regions of interest (ROI) were selected for 1H MRS analysis: contrast-enhancing, nonenhancing T2 signal abnormality, matched contralateral parenchyma (corresponding to the total area of enhancing and nonenhancing T2 signal abnormality), normal contralateral white matter, normal cortex, and highest choline peak measure. Matched contralateral parenchymal was designated as the control ROI. 1H MRS then was utilized to assess for changes of Cho, Cr, and NAA levels as objective markers of therapeutic response.

RESULTS
Preliminary results of Cho/NAA in a subset of eight patients have been promising. In areas of enhancement, the median percent change was -20.6% (range: -47.7% to 123.9%; p = 0.20). In areas of nonenhancing signal abnormality, the median percent change was -6.5% (range: -23.7% to 4.1%; p = 0.02). Comparison of median percent change in Cho/NAA between the nonenhancing versus control ROI group was significant (p = 0.012), and demonstrated a trend towards significance (p = 0.16) between the enhancing versus the control ROI group.

CONCLUSION
Preliminary results of 1H MRS suggest that SIACI of bevacizumab may result in a direct tumoricidal effect; a significant reduction of Cho/NAA ratios was observed within the nonenhancing T2 hyperintense components of glioblastomas.

KEY WORDS: Avastin, Bevacizumab, glioblastoma
**KEY WORDS:** Oligodendroglioma, MR imaging

**Paper 300 Starting at 4:50 PM, Ending at 4:58 PM**

Correlation of MR Imaging Contrast Enhancement in Gliomas with Immuno-Histological Vascular Parameters Using Image-Guided Biopsy Specimens

Narang, J. • Jain, R. • Rock, J. P. • Rosenblum, M. • Scarpace, L. • Schultz, L. • Gutierrez, J. • Mikkelsen, T.

Henry Ford Health System
Detroit, MI

**PURPOSE**

The purpose of this study was to correlate the status of MR imaging (MRI) contrast enhancement with immuno-histological vascular parameters such as microvascular cellular proliferation (MVCP), microvascular density (MVD), VEGFR-2 (vascular endothelial growth factor receptor-2) expression and WHO grade obtained from image-guided biopsy specimens. We also compared perfusion CT (PCT) parameters such as cerebral blood volume (CBV), cerebral blood flow (CBF) and permeability surface area product (PS) with presence or absence of contrast enhancement.

**MATERIALS & METHODS**

Twenty-six image-guided biopsy specimens in 16 patients with treatment naive gliomas were obtained from contrast enhancing (CE) and nonenhancing (NE) regions of the glioma and contrast enhancement status was correlated with MVD, MVCP, VEGFR-2 expression and WHO grade as well as with the PCT parameters and statistical analysis performed.

**RESULTS**

Six patients were diagnosed with low grade gliomas (I=1, II=5) and 10 patients with high grade gliomas (III=4, IV=6) as their final tumor grade. There were 16 CE specimens and 10 NE specimens. Out of 16 CE specimens, 10 (62.5%) were high grade (III=3, IV=7) whereas 6 (37.5%) were low grade (II=6). Out of the 11 NE specimens, 10 (91%) were low grade (I=1, II=9) and 1 specimen could not be graded. VEGFR-2 staining was done in 26 specimens. Out of 16 CE specimens, 12 (75%) showed positive VEGFR-2 immunoreactivity, whereas 4 (25%) CE specimens were VEGFR-2 negative. Sixteen CE specimens showed much higher number of blood vessels (138.1± 40.1/20x hpf) as compared to 11 NE specimens (81.6 ± 9.0/20x hpf). Contrast enhancing specimens did show higher CBV (p value 0.157), CBF (p value 0.497) and PS (p value 0.007) as compared to NE specimens though only PS values showed a statistically significant correlation.

**CONCLUSION**

Different regions within a glioma may show different grade, aggressiveness and treatment response based on heterogeneity of tumor angiogenesis. Recent literature has stressed the role of functional imaging techniques like perfusion studies in glioma grading and biopsy guidance so as to obtain the highest grade of the tumor and to predict tumor angiogenesis. However availability and expertise in interpretation are important limiting factors in widespread use of some of the advanced neuroimaging techniques. In this study we assessed the utility of contrast enhancement as a measure of tumor angiogenesis and aggressiveness. The results show that MRI contrast enhancement correlates well with various immune-histological markers as well as CT perfusion parameters and can help assess regional heterogeneity of tumor angiogenesis.

**KEY WORDS:** MRI contrast enhancement, angiogenesis, CT perfusion

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**Tuesday Afternoon**

3:30 PM - 5:00 PM

Ballroom 6A

(23b) New Devices & Arteriovenous Malformations/Fistulae

(Scientific Papers 301 - 311)

*See also Parallel Session*

(23a) Adult Brain: Neoplasms II: Gliomas
(23c) Pediatrics: Brain Ischemia and Its Consequences
(23d) Spine: Intervention and Other
(23e) Socioeconomics & Anatomy

**Moderators:** Jack M. Farinhas, MD
David F. Kallmes, MD
Paper 301 Starting at 3:30 PM, Ending at 3:38 PM

Hemorrhagic Complications following the Neuroendovascular Treatment of Brain Arteriovenous Malformations

Baharvahdat, H. • Blanc, R. • Teremehchi, G. • Varavipour, B. • Pistocchi, S. • Bartolini, B. • Piotin, M.
Fondation Adolphe De Rothschild
Paris, FRANCE

PURPOSE
The intracranial hemorrhage is the most important complication during or after embolization of brain arteriovenous malformations (AVMs). This study was designed to identify the possible risk factors related to intracranial bleeding during and after embolization of brain AVMs.

MATERIALS & METHODS
We retrospectively studied 474 consecutive embolization procedures of AVMs, using ONYX 18 or NBCA. The demographic and angiographic characteristics were reviewed and analyzed.

RESULTS
The mean age of patients was 32.2 years ± 13.8 (SD). The AVMs were located cortically in 70%, deep in 20%, and infratentorial in 10%. The most common clinical presentations were hemorrhage in 46% of cases and seizure in 23%. The procedural complications were intracranial bleeding (12%), catheter-related problems (10%), and ischemia (3.7%). Out of 57 cases complicated with intracranial hemorrhage, 39 (68.4%) demonstrated good recovery or moderate disability, 14 (24.3%) severe disability or vegetative, and four (7%) death. The Onyx volume injected was higher in procedures with hemorrhagic complications than the ones without hemorrhagic complications (p = 0.020). The intracranial bleeding was not related to the patients’ age (p = 0.20), nidus size (p = 0.59), hemorrhagic presentation of AVM (p = 0.54), the spetzler-Martin grade of AVM (p = 0.75), and location of AVM (deep-infratentorial versus cortical, p = 0.28). The hemorrhagic complication was different between the procedures using detachable microcatheter and one using nondetachable microcatheter (p = 0.61).

CONCLUSION
Intracranial hemorrhage is the major complication of embolization of brain AVMs. It could be associated with poor outcome, including severe disability and death. According to results of this study, the onyx volume injected during the procedure was the only factor correlated to the development of intracranial bleeding.

KEY WORDS: Arteriovenous malformation, intracranial hemorrhage, embolization

Paper 302 Starting at 3:38 PM, Ending at 3:46 PM

Long-Term Follow Up of Intracranial Dural Arteriovenous Fistulas with Cortical Venous Drainage Treated with Onyx Embolization of a Single Pedicle

Tejada, J. G.1 • Escobar, W.2 • Pedroza, A.2 • Shah, N.1 • Usecche, N.1
1Indiana University, Indianapolis, IN, 2Imbanaco Medical Center, Cali, COLOMBIA

PURPOSE
The therapeutic strategy for intracranial dural arteriovenous fistulas (DAVFs) is not yet well established. We now report on the treatment of intracranial DAVFs using Onyx-18, a nonadhesive liquid embolic agent.

MATERIALS & METHODS
We retrospectively identified all patients with intracranial DAVFs who were treated with Onyx as the single treatment technique at our institutions between April 2006 and December 2010. We documented age, gender, presenting symptoms, DAVF site, number of feeders per DAVF, whether cortical venous reflux was present, post-treatment angiography results, and follow-up angiography results when available.

RESULTS
Thirteen male patients were identified, who underwent 13 procedures for DAVF repair using Onyx-18. The mean age was 56 ± 12 years. Thirteen patients presented with symptoms related to the fistula. There was an average of five feeders per DAVF (range 1-9). Cortical venous reflux was present in all patients. All patients underwent transarterial super-selective catheterization of the pedicle arising from the branch of the middle meningeal artery, and Onyx-18 was injected under continuous road map guidance. Complete resolution of the DAVF on immediate post-treatment angiography was achieved in 12 patients. One patient had residual flow after the embolization and was taken to surgery the next day and complete cure of the fistula was achieved. In 12 patients complete cure of the fistula was achieved by Onyx injection on a single feeder arising from the middle meningeal artery. These 11 patients all had cortical venous drainage (Borden type III). There were no reported complications related to the procedure. Follow-up angiography was available for eleven patients (mean, 6.4 months); one patient was lost to follow up. None of the patients who returned for follow up had any signs of angiographic recurrence.

CONCLUSION
In our experience, the endovascular treatment of intracranial DAVFs with Onyx-18 is feasible, safe, durable and highly effective. No recurrence of the DAVF was demonstrated on follow-up catheter angiography. If a feeder from the middle meningeal artery is identified, it is highly probable to achieve a cure with the Onyx injection of this single pedicle with treatment in one session.
Paper 303 Starting at 3:46 PM, Ending at 3:54 PM

Brain Arteriovenous Malformation Embolization with Onyx: Clinical and Anatomical Results in BRAVO Series

Pierot, L. • on behalf of BRAVO investigators
Hôpital Maison-Blanche
Reims, FRANCE

PURPOSE
To evaluate the clinical and anatomical results of brain arteriovenous malformation (AVM) embolization with Onyx.

MATERIALS & METHODS
BRAVO is a multicentric, prospective, consecutive, European study conducted in 11 neurointerventional centers in Europe. One hundred and seventeen patients harboring brain AVMs embolized with Onyx were included in BRAVO series. Clinical presentation was epilepsy or hemorrhage in most cases. Hemorrhage during or in the month following the treatment was observed in 14 patients with clinical worsening (death or neurologic deficit) in six cases (5.1%). Nonhemorrhagic postoperative neurologic deficit was observed in 22 patients with residual deficit at hospital discharge in eight cases (6.8%).

RESULTS
Anatomical results were evaluated by an independent core lab. Nidal occlusion was total in 23%, 75-99% in 34%, 50-75% in 28%, and <50% in 15% of the cases.

CONCLUSION
Embolization of brain AVMs with Onyx is associated with a high rate of total or subtotal occlusion.

KEY WORDS: Brain AVM, embolization, Onyx

Paper 304 Starting at 3:54 PM, Ending at 4:02 PM

Perisylvian Arteriovenous Malformation: Angioarchitecture and Multimodal Imaging Characterization

Naidu, P. K. • Marin, H. • Kole, M. • Sanders, W. • Ellika, S. • Y. S., M. • Malik, G.
Henry Ford Hospital
Detroit, MI

PURPOSE
Perisylvian arteriovenous malformations (AVMs) are uniquely challenging lesions to manage surgically. The nidus is located in eloquent brain and is related closely to the middle cerebral artery (MCA). Arterial feeders are often en passageway branches, precluding embolization and complicating surgical excision. Furthermore, arterialized veins can overlie the nidus in the sylvian fossa (SF), making dissection even more difficult. The purpose of this study is to classify perisylvian AVMs based on nidus location and analyze each lesion’s angioarchitecture with specific attention to arterial feeders and venous drainage in order to improve the decision-making process regarding optimal treatment modality and also to determine clinical outcomes.

MATERIALS & METHODS
We reviewed 200 consecutive patients with intracranial AVMs referred to our hospital from March 2003 to date to identify those in a perisylvian location (21 patients). Data regarding patient demographics and clinical presentation were collected. Digital subtraction angiograms were reviewed and categorized based on nidus location, arterial supply and venous drainage. Nidus location was characterized as: a) anterior versus posterior relative to the central sulcus, b) insular, opercular, within the SF proper, or a combination thereof. Arterial supply was analyzed for origin, number of feeders, presence of perforating vessels and terminal versus en passage vessels. Spetzler Martin (SM) classification was applied. Treatment modality and outcome data were collected.

RESULTS
61.9% of perisylvian AVMs presented with seizures and 14.3% with intracranial hemorrhage. An insular nidal component (7/21) was associated with basal ganglionic extension and feeders from lateral lenticulostriate (3/7) vessels in addition to en passage branches from the M2 MCA branches (7/7). Subpial opercular nidus location (13/21) had at least one end-on MCA M3 or M4 branch supplying the AVM, amenable to endovascular embolization (11/13). In 2/13 patients with subpial opercular location, the nidus was supplied by en passage branches and nidus size was less than 2 cm. Nidus extension into the SF proper (4/21) or pial surface was associated with the presence of en passage branches (14/21), which were not amenable to preoperative embolization without jeopardizing more distal MCA cortical territory. Arteriovenous malformation location within the anterior (12/21) versus posterior SF did not correlate with presence of en passage MCA branches. Superficial venous drainage towards the superior sagittal sinus and transverse sigmoid junction was identified in 20/21 patients. Nine of 21 had deep venous drainage via basilar vein of Rosenthal (7/9) or subependymal veins towards the internal cerebral vein (2/9).

For treatment, 5/21 patients with SM grade ranging between 1 and 4 underwent radiosurgery. Four of 21 with SM grades of 3 or less had surgical resection (one after failed radiosurgery). 4/Four of 21 patients with SM grade 3-4 underwent embolization followed by surgery, and 8/21 with SM grade 2-5 were observed. Modified Rankin scale in all treated patients was 0-1 except for a single patient with mRS of 4 due to a post-surgical stroke.

CONCLUSION
Detailed multimodal imaging analysis of perisylvian AVMs with regards to specific nidus location, presence of perforating and en passage vessels, and venous drainage is imperative in planning treatment to improve outcome.

KEY WORDS: Arteriovenous malformation, perisylvian, sylvian
Paper 305 Starting at 4:02 PM, Ending at 4:10 PM

**Ear Arteriovenous Malformation Management**

Yakes, W. F.
Vascular Malformation Center
Englewood, CO

**Purpose**
To determine the efficacy of ethanol endovascular repair of ear arteriovenous malformation (AVMs).

**Materials & Methods**
Six patients (5 female, 1 male; age range 6-39 years; mean age: 22 years) with ear AVMs presented for therapy. Two patients had failed prior embolizations (PVA/coils/nBCA/steroids) and two patients had other therapies (laser/excisions/grafting). All presented with grossly enlarged painful ear with intermittent bleeding. All patients underwent transcatheter and direct puncture ethanol Rx (77 procedures).

**Results**
All six patients were cured of the AVM at long-term follow up (mean follow up: 65 months). One patient had transient partial VII nerve palsy. Two patients had minor blisters and ear injuries.

**Conclusion**
Ethanol endovascular repair of ear AVMs can effect cures in this vexing lesion that previously was treated with resection of the ear and high recurrence rates.

**Key Words:** Arteriovenous malformation, ethanol, ear.

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Paper 306 Starting at 4:10 PM, Ending at 4:18 PM

**Intracranial Dural Arteriovenous Fistula with Cortical Drainage, Curative Transarterial Treatment with Onyx: A Series of 16 Patients**

Maimon, S. • Nossek, E. • Frolov, V. • Ram, Z.
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Tel Aviv, ISRAEL

**Purpose**
Intracranial dural arteriovenous fistulas (DAVF), with cortical venous drainage have a grave natural history with high tendency to bleed or to cause neurologic deficit. Early and complete closure of the lesion is needed. Endovascular embolization with Onyx has evolved in the last few years as a tool used for curative treatment of intracranial DAVFs. In the last years, as we adopted Onyx for arteriovenous malformations (AVMs) we also shifted from glue to Onyx, in the treatment of the dangerous DAVFs, with a curative intent. The purpose of this study is to describe our results of using the arterial approach, in the last 4 years, with special emphasis on the safety, feasibility and efficacy of that technique. Some technical detail on the way we used Onyx also will be given.

**Materials & Methods**
Transarterial embolization was performed in 16 consecutive patients with cranial DAVF having cortical venous drainage between October 2006 and August 2010, using Onyx and mainly microcatheter with detachable tip. Fifteen patients were treated for Borden type III DAVFs, and one patient was treated for type II DAVFs.

**Results**
Most patients (14/16 - 87%) underwent one procedure to cure the lesion. One underwent two procedures for two separate nearby fistula; the first with Onyx transarterially, the second transvenous (not included in the presentation) and one patient underwent three procedures. Complete obliteration using embolization with Onyx was achieved in 15 patients, resulting in a 94% cure rate. The mean amount of onyx injected was 2.3 cc (ranged 0.4- 4.8). There was one technical complication, emboli to MCA branch that resolved by intra-arterial TPA injection. It did not have any clinical impact. There was one minor clinical complication of trochlear nerve palsy, in complex petrosal sinus fistula, that resolved in 3 months. The technical and transient clinical complication was in the same patient, the one that has been left with fistula remnant. He was sent to open surgery for definitive treatment. There were no mortality cases in that cohort.

**Conclusion**
Intra-arterial embolization of cranial DAVFs with cortical venous drainage, using Onyx results in a high complete obliteration rate with low morbidity. Achieving a good cast of Onyx in the fistula and mainly in the proximal venous side, will cure the lesion and prevent reopening.

**Key Words:** Dural arteriovenous fistula, Onyx.

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Paper 307 Starting at 4:18 PM, Ending at 4:26 PM

**Safety and Efficacy of Ethylene Vinyl Alcohol Copolymer Used in Pediatric Neurointervention**

Shaibani, A.1 • Schoeneman, S.1 • Dipatri, A.2 • Ansari, S.1 • Alden, T.2 • Aghaei-Lasboo, A.1 • Hurley, M. C.1
1Northwestern Memorial Hospital, Chicago, IL, 2Childrens Memorial Hospital, Chicago, IL

**Purpose**
Onyx (ethylene vinyl alcohol dissolved in dimethylsulfoxide and mixed with micronized tantalum powder) now is used extensively in adult cerebrospinal arteriovenous malformation (AVM) and fistula embolization due to its more predictable properties and better lesion penetration compared to cyanoacrylic glue. However, there remains a paucity of its reported use in the pediatric population. We report a very large single center experience.

**Materials & Methods**
All patients at a major Childrens Hospital in the United States treated with embolization using Onyx from August 2005 to July 2010 by a single operator were reviewed retrospectively. The following datapoints were recorded: Patient age and sex, lesion type, pre-embolization neurologic and functional status, estimated angiographic efficacy/outcome...
of the embolization procedure, technical complications, neurologic/functional outcome at follow up. Technical complications were defined as unintended consequences of the treatment whether or not associated with clinically apparent deterioration in the patient’s condition. Patient functional status was obtained from clinic follow-up notes and a modified Rankin scale score (mRS) was calculated on the basis of follow-up information or using a previously described telephone-based method.

RESULTS
A total of 40 patients ranging in age from 4 weeks to 17 years of age were treated with a total of 82 embolizations (mean of 2.16 embolizations per patient). The breakdown of diagnoses is as follows: brain pial AVM (n = 21), dural arteriovenous shunts (n = 2), spinal vascular malformations (n = 3), extracranial head and neck arteriovenous malformations (n = 3), vein of Galen malformation (n = 3), intracranial neoplasm (n = 1), mycotic intracranial aneurysms (n = 2). Of the pial AVMs there was an average nidal obliteration per injection of 55% and an average final nidal reduction of 74%. The respective sessional and final obliteration rates for the remaining lesion types was: spinal malformations (100%, 100%), extracranial AVMs (43%, 80%), vein of Galen malformations (24%, 80%). The overall technical complication rate per embolization was 13% and comprised vessel perforations (n = 3), embolization of nontarget vessels (n = 3), hemorrhage into surrounding tissues (n = 3), embolization of nontarget organ (n = 2). There were no cases of catheter retention. The overall rate of symptomatic complications (all neurologic) was 7.5% with a permanent procedural morbidity of 2.5%. There were no deaths. The average mRS preprocedurally was 1.18, with a median of 1. The average mRS post-treatment was 1.14 with a median of 1.

CONCLUSION
Ethylene vinyl alcohol copolymer can be used in pediatric neurovascular procedures in a wide range of patient ages and conditions with very good efficacy and an excellent safety profile.

KEY WORDS: Onyx, cerebrovascular, pediatric

Paper 308 Starting at 4:26 PM, Ending at 4:34 PM

Deployment Technique Has Major Impact on Flow Diverter Morphology

Kallmes, D. F. • Lane, J.
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Rochester, MN

PURPOSE
To quantify the changes in measured porosity, pore density, and pore area for the pipeline embolic device (PED) as a function of deployment technique.

MATERIALS & METHODS
We constructed straight and curved glass tubes, to simulate the carotid siphon, of 4.0 and 3.2 mm diameter. We implanted PEDs with diameters of 3.3, 3.9, 4.6, and 5.4 mm into the
CONCLUSION
Deployment techniques for flow diverter devices may have profound influence on the morphology of the metallic struts across an aneurysm neck. Ideally, iso-sized devices deployed with forward pressure, to “pack” struts tightly, should be preferentially employed.

KEY WORDS: Flow diverter, aneurysm

Paper 309 Starting at 4:34 PM, Ending at 4:42 PM
Small, Branch Arteries Remain Patent even after Coverage with Multiple Flow Diverseters: An in vivo Study in Rabbits
Dai, D. • Ding, Y. • Kadirvel, R. • Ehteshami Rad, A. • Lewis, D. • Kallmes, D.
Mayo Clinic Rochester, MN

PURPOSE
The safety of placing multiple, telescoped endoluminal flow diverters remains unclear, since small, eloquent branch arteries theoretically could become occluded by the devices. In this study we placed single and multiple flow diverters over small, branch arteries in rabbit aortas in order to determine the incidence of branch artery occlusion.

MATERIALS & METHODS
Twenty-two female New Zealand white rabbits were included in the current study. Flow diverters [Pipeline Embolic Device (PED), eV3] were placed into the abdominal aorta to cover one or more lumbar arteries. Subjects were divided into three groups (single flow diverter, n=9; double flow diverter, with 2 telescoped/overlapped devices, n=7; and triple flow diverter, with 3 telescoped/overlapped devices, n=6) and followed for 6 or 12 months. At follow up, digital subtraction angiography was performed. Subsequently, the tissue was processed and sectioned at 5 μm and stained with hematoxylin and eosin (H&E) for histologic evaluation, histomorphometry and analysis. A single PED stented sample at 12 months was processed for scanning electron microscopy (SEM) and whole tissue mount immunostaining for CD31.

RESULTS
On angiography, all lumbar arteries in all groups were patent at follow up. Mean diameter of branch arteries in the single, double, and triple device groups were 0.66, 0.54 and 0.69 mm, respectively. As a point of reference, the human anterior choroidal is typically 0.5-0.6 mm diameter. Histologic evaluation in most samples showed partial covering of the ostia of the branch vessels, but demonstrable, patent lumens at the ostia in all cases were present (Figure 1a-b). Degrees of neointimal hyperplasia were mild (8%, 13%, and 15% mean area stenosis in the single, double, and triple groups, respectively). The cells’ covering on the lumen side of the device were positive for endothelial cells marker CD31 staining (Figure 1c). There was no significant inflammatory response noted in any group.

CONCLUSION
Small, branch arteries remain patent even when covered by multiple, overlapped flow diverter devices.

KEY WORDS: Flow diverter, branch artery, rabbit

Paper 310 Starting at 4:42 PM, Ending at 4:50 PM
Initial Experience with the Pipeline Embolization Device in the Treatment of Intracranial Aneurysms
Lamin, S. • Chavda, S. • Thomas, A. • Senthil, L.
University Hospital Birmingham Birmingham, UNITED KINGDOM.

PURPOSE
Aneurysm coiling has been associated with a relatively high rate of recurrence. The pipeline endovascular reconstruction device is a novel technique in the management of complex cerebral aneurysms. We present our prospective analysis of our experience with the device.

MATERIALS & METHODS
A total of 27 aneurysms were treated by implantation of the pipeline stent device. Angiographic and clinical results were recorded immediately and at 6 months following treatment.

RESULTS
Angiography at 6 months demonstrated complete occlusion in 22 and partial filling in four patients. One failed procedure and the same patient suffered stroke from carotid dissection. No delayed ruptures or mortality. One subclinical side branch occlusion.

Conclusion
Intracranial aneurysm treatment with the pipeline flow diversion device is technically feasible and with safety profile comparable to endovascular treatment with coils.

KEY WORDS: Flow diversion, aneurysm, pipeline
MR-Guided Sclerotherapy for Pediatric Vascular Malformations: A Radiation Dose Reduction Strategy

Green, D. A. • Imbesi, S. G. • Cho, A. • Pakbaz, R. S.
University of California San Diego
San Diego, CA

PURPOSE
We hypothesize that MR imaging (MRI)-guided sclerotherapy with time-resolved imaging of contrast kinetics (TRICKS) can substitute for fluoroscopy in the treatment of vascular malformations, resulting in significant radiation dose reduction for patients.

MATERIALS & METHODS
Under general anesthesia in the MRI suite, the patient is prepped and draped in the usual sterile manner. Using a 1.5 T MRI unit, initial multiplanar multisequence images are obtained to assess the lesion. Surface markers are placed to identify the treatment sites. The lesion is accessed percutaneously with titanium needles (22G). Appropriate intraleisional position usually is suspected clinically by vigorous blood return; however, MRI acquisition via TRICKS then is obtained to confirm accurate needle placement. The TRICKS parameters have been optimized to provide acquisition times of less than 2 seconds for each frame. Initially, precontrast mask images are obtained. Contrast (1:100 dilution of Multihance and normal saline solution) and saline flush then is injected into the lesion during subsequent image acquisition. Mask images are subtracted to provide MRI digital subtraction images. The slices from each digital subtraction sequence are compressed into a single maximum intensity projection (MIP) image. Maximum intensity projection images then are stacked into a cinematic clip for visualization of flow through the lesion over time. Sclerotherapy using absolute alcohol then is performed. After 10 minutes of dwell time, a new mask is obtained and the imaging process is repeated. Angiographic success is determined by diminished runoff and pruning of the vessels.

RESULTS
We have used MR guidance for the sclerotherapy of vascular malformations in four patients: three venous malformations of the head and neck, and a peripheral venous malformation involving the knee. All cases previously had undergone fluoroscopic angiography to define the microvascular anatomy of the lesion and for therapy. Prior procedures using fluoroscopy in these patients resulted in fluoroscopy times ranging from 0.1 to 5.1 minutes, with a dose range of 46 to 533 mGy per treatment. In all cases using MRI, we achieved a temporal resolution of less than 2 seconds which was adequate for evaluation of vascular flow and runoff, with the obvious benefit of no additional radiation exposure. Good response to therapy was obtained in every case, evidenced by diminished flow within the lesions and pruning of the lesion vasculature. No procedural complications were encountered, and all patients had an uneventful postprocedural recovery.

CONCLUSION
MR imaging with TRICKS for guidance during sclerotherapy allows for adequate lesion visualization, and sufficient temporal resolution to assess vascular flow and evaluate treatment results. The obvious benefit of this technique is that no additional radiation is required to treat these lesions which typically occur in a pediatric population and require multiple treatments. Limitations of this technique include a low temporal resolution compared to conventional digital subtraction angiography, and high utilization of the MRI during relatively long procedural times. In the future, continued optimization of the technique and implementation of 3T MRI will improve temporal resolution and increase patient throughput.

KEY WORDS: Sclerotherapy, MR imaging, TRICKS

Tuesday Afternoon
3:30 PM - 5:00 PM
Room 606-609

(23c) Pediatrics: Brain Ischemia and Its Consequences
(Scientific Papers 312 - 322)

See also Parallel Session
(23a) Adult Brain: Neoplasms II: Gliomas
(23b) New Devices & Arteriovenous Malformations/Fistulae
(23d) Spine: Intervention and Other
(23e) Socioeconomics & Anatomy

Moderators: Arabinda K. Choudhary, MD, MRCP
Tina Young Poussaint, MD

Paper 312 Starting at 3:30 PM, Ending at 3:38 PM
Reperfusion in Neonates with Hypoxic Ischemic Injury

Madan, N.1 • Pienaar, R.2 • Paldino, M. J.2 • Grant, P. E.2
1Tufts Medical Center, Boston, MA, 2Children's Hospital Boston, Boston, MA

PURPOSE
Hypoxic ischemic injury (HII) remains a common cause of neonatal brain injury and neurodevelopmental disability. Current theories for injury mechanisms suggest a central role for reperfusion and excitotoxicity, with associated increased neuronal metabolism. To minimize these consequences, therapeutic hypothermia has become the standard treatment. We hypothesized that in neonates who did not undergo therapeutic hypothermia, areas of decreased diffusion on apparent diffusion coefficient (ADC) maps would be associated with increased perfusion on arterial spin labeled (ASL) cerebral blood flow (CBF) maps.
**Materials & Methods**

Eight neonates with clinical and imaging evidence of HII and nine neonates without abnormality on MR imaging (MRI) were evaluated retrospectively. All subjects underwent MR imaging including diffusion-weighted imaging (DWI) and ASL CBF imaging. Utilizing a novel algorithm previously described (Pienaar, et al, 2009), the ADC and ASL data were coregistered, mask filters were generated, and an automated statistical analysis was performed to automatically select regions of interest (ROIs) with abnormal ADC or CBF, and generate a correlation vector integral reflecting a voxel-by-voxel correlation between the ADC and ASL-CBF maps. Mean ADC and ASL intensity values in ROIs and non-ROI regions also was determined in neonates with HII. Two-sample equal variance Student t-test then was used to compare correlation vector integrals in the neonates with HII and the comparison group as well as ADC and ASL values in ROI and non-ROI regions in the patients with HII.

**Results**

Evaluation of correlation vector integrals in the neonates with HII (mean 5.85) compared to the control patients (mean 0.007) demonstrated a significant difference (p = 0.002). No correlation of ADC and ASL was present in control subjects. In HII subjects decreased ADC was correlated with increased ASL CBF (correlation coefficient of -0.33). Additionally, comparison of automatically selected ROIs and non-ROI regions in patients with HII, demonstrated significant decreased ADC in ROIs (732 vs. 1150 x 10⁻⁶ mm²/sec, p < 0.001) confirming the algorithm correctly identified regions of decreased diffusion and elevated ASL CBF in ROIs (103 vs 39 mL/100 g/min, p = 0.001).

**Conclusion**

In neonates with hypoxic ischemic injury decreased diffusion is associated with increased cerebral blood flow indicating hyperperfusion of ischemic lesions. While it is not clear if hyperperfusion/reperfusion represents a contributory or secondary phenomenon to the development of injury in these patients, it may prove as an important early biomarker in predicting outcome as well as assessing the efficacy of hypothermic or other novel treatments.

**Key Words:** Hypoxic ischemic injury, reperfusion, cerebral blood flow

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**Paper 313 Starting at 3:38 PM, Ending at 3:46 PM**

**MR Imaging Diffusion Changes in Neonatal Encephalopathy Treated with Hypothermia**

Bednarek, N. • Wilkinson, J. • Mathur, A. • Srinivasakumar, P. • Neil, J. J. • Inder, T. E. • Shimony, J. S.

Washington University School of Medicine
St. Louis, MO

**Purpose**

Hypoxic ischemic encephalopathy (HIE) is a common cause of death and severe lifelong sequela in term newborns. A recent development in the treatment of such infants is the use of systemic hypothermia begun within 6 hours of injury, which has been shown to improve neurologic outcomes. Given the ischemic nature of the injuries, diffusion-weighted imaging (DWI) is critical not only for the diagnosis of the extent and severity of the hypoxic insult but also for the timing of the injury. The changes in diffusion imaging following injury are dynamic, with diffusion imaging showing the strongest contrast 2 days after injury and “pseudo-normalizing” after that. The purpose of this study was to assess the impact of hypothermic therapy on the chronology of DWI changes in HIE.

**Materials & Methods**

Retrospective review was performed on 66 neonates that underwent hypothermia treatment at our institute during the years 2007 to 2010. Eleven were excluded due to death, prematurity, and congenital anomalies. Average gestational age at birth was 38.7±1.6 wks and there were 29 males. Clinical MR imaging (MRI) scans were performed on both 1.5 T and 3 T Siemens scanners (Erlangen, Germany) included anatomical imaging and DWI with calculated mean diffusivity (MD) values (b=1000 s/mm²). There were 23 infants with two MRIs and three infants with three MRIs. Forty-eight of the MRIs were performed between day 0 and 5; 40 were performed between day 6 and 15; 15 were performed after day 15. Two complementary analyses of the MD were performed. In the first, 12 infants were identified with focal MD abnormalities on their first MRI scan (obtained at mean 2.3±1.5 days), and these areas were measured further on follow-up scans (obtained at mean 9.0±1.5 days). The second analysis followed the methods in (3). Sixteen neonates were identified with focal injury present after day 5, identified on either anatomical imaging or on DWI. The MD in these areas then was measured longitudinally across all the scans available for that infant. Two infants with global injury that subsequently died were excluded from both groups.

**Results**

The time course of focal diffusion abnormalities in our cohort was compared with the MD time course in infants not treated with hypothermia presented in (3). Although there was some overlap, as a group, neonates treated with hypothermia demonstrated a slower recovery of the MD to the point of pseudo-normalization, 10-12 days, as compared to 5-7 days reported in studies of HIE without hypothermia treatment.
CONCLUSION
There are differences in the recovery time of DWI lesions in HIE neonates treated with hypothermia as compared to those not treated with hypothermia. These changes appear to extend the window in which HIE lesions are visible on DWI sequences and have implications for the radiologic interpretation of these studies.

KEY WORDS: Hypothermia, encephalopathy, diffusion

Paper 314 Starting at 3:46 PM, Ending at 3:54 PM
Effect of Whole-Body Cooling Therapy on Brain Metabolism and Pattern of Brain Injury following Perinatal Hypoxic Ischemic Injury

Machado, S. G. A. • Corbo, E. • Merritt, T. A. • Wycliffe, N. • Ashwal, S. • Bartink-Olson, B.
Loma Linda University Medical Center
Loma Linda, CA

PURPOSE
Determine if whole-body hypothermia (WBH) therapy improved brain metabolism and pattern of injury following hypoxic-ischemic injury (HII) seen by MR spectroscopy (MRS) and imaging (MRI), respectively.

MATERIALS & METHODS
Retrospective review of medical and radiology records of 40 neonates with HII with brain MRI and MRS acquired within 21 days postinjury. Twenty neonates received 72 hours of WBH and matched to 20 non-cooled neonates using their 5 minute APGAR scores. An additional nine neonates who had MRI/MRS studies within the first 21 days of life, with no neurologic deficits at 3 months of age, were included as controls. MR imaging/MRS studies were performed using a circularly polarized head coil in a conventional 1.5 T whole-body imaging system. Quantitative N-acetylaspartate (NAA), creatine(Cr), choline (Cho), myo-inositol (Ins), and lactate (Lac) metabolite levels and ratios were obtained in the occipital gray matter (OGM) using an LC model. Semiquantitative mean metabolite ratios were calculated from the average metabolite ratios for the bilateral basal ganglia (BG) and thalami (Th). Bilateral basal ganglia and sub-cortical and watershed (W) cortical injury were evaluated on T2, T1, proton density and diffusion-weighted images and scored according to the Barkovich scale. Group differences in MRS ratios and MRI severity scores were analyzed using Kruskal-Wallis one-way analysis of variance. Group differences in demographic and clinical measures were measured using independent samples t-tests. Differences were considered significant at $p = 0.05$.

RESULTS
Compared to controls, MRI scores of the cooled neonates were not significantly different in the BG, W and combined basal ganglia and watershed regions (BGW) on T1, T2, proton density (PD) and diffusion-weighted images (DWI), except in the BG on T1. In contrast, MRI scores of the non-cooled neonates were significantly different in all evaluated regions and sequences, except in the watershed region on DWI. In the Th and OGM, NAA/Cr was significantly decreased in noncooled neonates vs controls ($p< 0.05$), but was not significantly different between cooled neonates and controls. The presence of lactate in the OGM and Th was noted in 10% (2/20) of the cooled neonates and 25% (5/20) of the noncooled neonates. In the BG lactate was present in 20% (4/20) of the cooled neonates and in 30% (6/20) non-cooled neonates.

CONCLUSION
MR imaging scores of the treated neonates were not significantly different than healthy neonates, suggesting structural preservation. Moreover, the absence of difference in the BG and Th NAA/Cr between treated neonates and controls and the reduced number of neonates with detectable lactate suggests the preservation of metabolism following 72 hours of WBH after HII.

KEY WORDS: Hypoxic-ischemic injury, whole body cooling therapy, metabolism

Paper 315 Starting at 3:54 PM, Ending at 4:02 PM
Intracranial Hemorrhage and Ischemia in Preterm Infants: Comparison of Detectability on Head Ultrasound and Susceptibility-Weighted Imaging

Intrapioromkul, J. • Huisman, T. A. G. • Northington, F. • Izbudak, I. • Meoded, A. • Tekes, A.
The Johns Hopkins University
Baltimore, MD

PURPOSE
Susceptibility-weighted imaging (SWI) is an advanced MR technique that is highly sensitive for detection of hemorrhage and calcium. Immature/developing brain predisposes to intracranial hemorrhages as well as ischemic white matter injury. The purpose of this study was to evaluate the sensitivity of head ultrasound (HUS) in the detection of the intracranial hemorrhage and white matter injuries compared to SWI in premature infants. Imaging findings were correlated with the management plan.

MATERIALS & METHODS
Premature neonates who had HUS through the anterior fontanel in the standard coronal and sagittal planes and MRI of the brain with SWI sequences were included. Susceptibility-weighted imaging consisted of low-bandwidth (80Hz/pixel) 3-D, fast, low-angle shot sequence with TE/TR: 40/48 ms; flip angle: 15; section thickness: 1.2 mm; FOV: 200x162; matrix: 256x217. Germlinal matrix hemorrhage (GMH) - grade 1, intraventricular hemorrhage (IVH) - grade 2, hydrocephalus - grade 3, cerebral parenchymal hemorrhage secondary to venous infarction (previously known as grade 4), other intraxial hemorrhage, extraaxial hemorrhage, white matter ischemia and cerebellar hemorrhage were evaluated in HUS and SWI in each cerebral hemisphere and cerebellum by an experienced pediatric neuroradiologist and a trained radiologist.

RESULTS
Twelve infants (mean age, 9.8 days; range, 3-23 days) with mean gestational age of 32.8 weeks (range: 29.6-35.4 weeks) were studied. The interval between the US and the MRI was 2.75 days (range: 1-13 days). Susceptibility-weighted imag-
ing was considered the gold standard and sensitivity and specificity of HUS were demonstrated in the table. There was a good sensitivity and specificity of HUS in detection of the GMH, hydrocephalus, and parenchymal hemorrhage secondary to venous infarction, and white matter ischemia. Small amount of blood that covers the choroid plexus was difficult to diagnose in HUS, resulting in decreased sensitivity in detection of IVH. Cerebellar hemorrhages were small in size and solely detected on SWI. In one case with perinatal depression, HUS detected hypoxic injury whereas SWI was negative.

Table 1. Sensitivity and specificity of the HUS compared to SWI

<table>
<thead>
<tr>
<th>Findings</th>
<th>Sensitivity</th>
<th>Specificity</th>
</tr>
</thead>
<tbody>
<tr>
<td>GMH</td>
<td>77.78%</td>
<td>100%</td>
</tr>
<tr>
<td>IVH</td>
<td>38.1%</td>
<td>100%</td>
</tr>
<tr>
<td>Grade III IVH</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>Acute hemorrhagic infarction</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>Other intraxial hemorrhage</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>Cerebellar hemorrhage</td>
<td>0%</td>
<td>100%</td>
</tr>
<tr>
<td>Extraaxial hemorrhage</td>
<td>11.11%</td>
<td>100%</td>
</tr>
<tr>
<td>Hypoxic Ischemic Injury</td>
<td>0%</td>
<td>91.67%</td>
</tr>
<tr>
<td>Periventricular leukomalacia</td>
<td>100%</td>
<td>95.24%</td>
</tr>
</tbody>
</table>

**CONCLUSION**

Head ultrasound is sensitive and specific in the evaluation of intraaxial hemorrhage and ischemia related with prematurity. Susceptibility-weighted imaging is superior to HUS in detecting small intraaxial, or extraaxial hemorrhages that are related to birth trauma; however this information did not have any impact on their management. Given the feasibility and bed-side evaluation advantages, HUS should remain as the first line of imaging, and often times can be conclusive of brain injury in premature infants.

**KEY WORDS:** Head ultrasound, prematurity, susceptibility-weighted imaging

**MATERIALS & METHODS**

Fifty-two preterm and term neonates of a high risk NICU were enrolled in this study (GA 32-41, mean=37 weeks). A neonatal head-coil and incubator was used. Functional MR was performed with blood oxygen level dependent (BOLD) single-shot gradient-echo echo-planar imaging (GR-EPI). Functional imaging consisted of three alternating epochs of control (darkness) and activation (flicker light at 1Hz). Statistical parametric mapping software was used for spatial preprocessing and t-test statistics. Areas of activation/deactivation were identified (p<0.01) and mapped onto high-resolution T2 imaging used to calculate thalamic volumes. Four neonatal groups were analyzed: (1) full term control, (2) term with PVL, (3) preterm with PVL and (4) preterm with intraventricular hemorrhage (IVH). Brain metric measurements and clinical variables were recorded.

**RESULTS**

The term control neonates showed reliable and well defined activation of the visual cortex for the 1Hz task (Top Figure - A). The percent of visual cortex activation relative to the control group was variable in the PVL group compared to the IVH group, which exhibited the lowest relative percent visual activation. There was a strong correlation between thalamic volume and percent visual cortex activation in neonates with PVL compared to the term controls and IVH cases (r2=0.8) (bottom Figure).

**Correlation of Thalamic Volume and Visual Functional MR Imaging in Neonates with Perinatal White Matter Injury**

Panigrahy, A.1,2 • Chen, V.2 • Paquette, L.3 • Ceschin, R.4 • Tavare, C. J.3 • Gilles, F. H.1 • Bluml, S.2,3 • Nelson, M. D.3

1Children’s Hospital of Pittsburgh of the University of Pittsburgh Medical College, Pittsburgh, PA, 2Children’s Hospital Los Angeles, Los Angeles, CA, 3Rudi Schulte Research Institute, Santa Barbara, CA

**PURPOSE**

The underlying neural substrate of cognitive visual impairment in preterm children is poorly understood. Thalamo-cortical connections via the subplate play a critical role in the early development of the visual system. We hypothesize that there is a correlation between thalamic volume and visual function in neonates with perinatal white matter injury (PVL).
CONCLUSION
There is a strong correlation between thalamic volume and degree of activation of visual cortex in neonates with PVL. This study emphasizes the role of thalamo-cortical connections in the long-term pathogenesis of cognitive visual impairment in neonates with PVL.

Paper 317 Starting at 4:10 PM, Ending at 4:18 PM
Neonatal Hypoxic-Ischemic Encephalopathy: Tractography Confirms Selective Vulnerability of Projection Fiber System and Predicts Motor Outcome

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1Brigham and Women's Hospital, Boston, MA, 2Children's Hospital Boston, Boston, MA

PURPOSE
Demonstrate selective vulnerability of the projection fiber system (PFS) passing through the PLIC compared to corpus callosum (CC) in neonates with neonatal hypoxic-ischemic encephalopathy (HIE). Determine if mean ADC within PFS-PLIC in HIE neonates differs from controls and if mean ADC predicts outcomes at 1-2 years.

MATERIALS & METHODS
Nineteen neonates with clinical diagnoses of HIE who underwent 3 T MR imaging (MRI) including diffusion tensor imaging (DTI) < 1 week of age between 2007-2009 were identified. Neurologic outcomes at 1-2 years were classified using the Gross Motor Function Classification System. Nine infants with normal MRIs < 1 week of age without HIE were selected as normative controls. Diffusion Toolkit was used for track reconstruction using FACT and 35° threshold. Using an ROI approach in TrackVis, the PFS-PLIC and CC tracts were selected (Figure 1) and mean ADC and FA values of each tract were obtained. Statistical analyses were performed using unpaired T-tests.

RESULTS
Nineteen HIE neonates and nine controls were identified. Mean birth GA was 38 6/7 and 36 5/6 weeks and mean age at initial MRI was 2.5 and 3.5 days respectively. Eleven of 19 HIE neonates were imaged < 3 days. Two neonates with HIE died and one was lost to followup. At followup (mean 14.7 months) six subjects had GMFCS > four (severe) and 10 had GMFCS = 1 (normal). Mean ADC of the PFS-PLIC was significantly lower in HIE neonates compared to controls (Left: P = 0.02, Right: P = 0.02). Mean ADC of the CC was not significantly different between these two groups (P = 0.07). Subgroup analysis showed HIE neonates with GMFCS > four had significantly lower ADC in the PFS-PLIC and CC than neonates with HIE and normal outcomes (Left PFS: P = .001, Right PFS: P = .001, CC: P = 0.01). No threshold ADC value in any tract predicted death or poor outcome or separated normal from HIE. No statistical difference was identified between eight patients on hypothermia protocol versus 10 who were not in this small cohort.

CONCLUSION
To our knowledge, this is the first study using tractography in HIE to quantify mean ADC values of PFS-PLIC and CC. We found significant ADC decreases in the PFS-PLIC compared to controls < 7 days of life with mean ADC predicting motor outcomes at 14 months. In HIE patients, lower mean ADC in CC as well as PFS-PLIC was associated with worse outcomes.

KEY WORDS: Tractography, hypoxic ischemic encephalopathy, neonatal MR imaging

Paper 318 Starting at 4:18 PM, Ending at 4:26 PM
Preservation of White Matter Integrity on Fractional Anisotropy Maps in Encephalopathic Neonates with Normal-Appearing MR Imaging

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Children's National Medical Center
Washington, DC

PURPOSE
Neonatal encephalopathy (NE) carries a high mortality and morbidity rate. We evaluated the underlying white matter changes using diffusion tensor imaging (DTI) and correlated DTI findings with short-term clinical outcome, with the purpose to evaluate prognostic factors.

MATERIALS & METHODS
Fifty-one term encephalopathic neonates who had undergone hypothermia therapy were imaged during 2008-2010. Each had an MRI study of the brain with conventional T1-weighted, T2-weighted brain imaging and a 25 direction diffusion tensor imaging study. Forty-five studies were evaluated with six excluded due to motion artifacts. Studies from 14 healthy term equivalent neonates who were born premature were used as controls. Study was approved by our institutional IRB. Short-term clinical outcome was evaluated through the hospital medical records system. The mean fractional anisotropy (FA) and apparent diffusion coefficient (ADC) were categorized into three groups: neonatal encephalopathy with no conventional MRI and ADC map changes (NE-ve), neonatal encephalopathy with abnormal conventional MRI or ADC map changes (NE+ve) and controls. Diffusion tensor imaging was performed on a 1.5 T magnet, (TR 10000, TE 94.2, b = 800, Nex = 1, slice thickness 4 mm). Diffusion tensor imaging postprocessing was done on Advantage GE workstation (Milwaukee, WI). Regions of interests were drawn in frontal white matter, parietal white matter, occipital white matter, temporal white matter, genu and splenium of the corpus callosum, as well as in the posterior limb of the internal capsule.
RESULTS
There were no statistical differences in FA between control and (NE-ve) group. Short-term clinical outcomes of the (NE-ve) group were also within normal except for one neonate who had respiratory issues which resulted in some neurologic deficits; and another neonate who was diagnosed with a congenital neuromuscular disorder with neurologic deficits. On the other hand, there was significant reduction in FA in all white matter regions in the (NE+ve) neonates compared to (NE-ve). For (NE+ve) neonates, majority showed neurologic deficits ranging from seizures, developmental delay to cerebral palsy. No significant differences in ADC were detected between (NE-ve) and (NE+ve). Significant reduction of ADC was noted in the NE group compared to controls only in frontal and parietal white matter.

CONCLUSION
Encephalopathic neonates with normal conventional MRI findings do not have detectable white matter changes on FA, which correlated with good short-term clinical outcome. Significant reduction in ADC in frontal and parietal white matter of the NE group raises possible underlying injuries in the actively myelinating white matter regions, not adversely affecting short-term clinical outcomes in NE-ve group. Injuries in term neonatal encephalopathy predominate in the gray matter. Diffusion tensor imaging demonstrates extensive underlying white matter changes in the NE subgroup with abnormal conventional MRI studies, which correlated with poor neurologic outcome.

KEY WORDS: Neonatal encephalopathy, fractional anisotropy, diffusion tensor imaging

Paper 319 Starting at 4:26 PM, Ending at 4:34 PM
Evaluation of Ischemic Injury in Infants Using Super Resolution Tract Density Imaging
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University of California San Francisco Medical Center San Francisco, CA

PURPOSE
The supratentorial and brainstem white matter tracts can be affected by hypoxic-ischemic injury amongst other disease processes. However, the small size of these structures often limits anatomical localization of these abnormalities in infants. The goal of this work was to determine whether a recently proposed method for using whole-brain fiber tractography to obtain super resolution tract density imaging (TDI) would identify tract-specific differences between infants with severe ischemic injuries and normal controls.

MATERIALS & METHODS
Patient selection: Three infants with severe watershed ischemic infarcts and three normal controls were imaged at an age of 12-19 months. Data acquisition: Diffusion data were acquired on either 1.5 or 3 T General Electric Healthcare (Waukesha, WI) MR imaging scanners using 8-channel receive head coils. Subjects were scanned with a 55 direction diffusion (b=3000 s/mm2, voxel size 1.8 x 1.8 x 2 mm3) high angular resolution diffusion imaging (HARDI) protocol. Fiber-tracking: Fiber-tracking was performed utilizing constrained spherical deconvolution using MRtrix (Brain Research Institute, Melbourne, Australia, http://www.brain.org.au/software/). Tractography was performed by randomly seeding 2,000,000 points throughout the brain. Track-density imaging: Track density maps were constructed using the approach proposed by Calamante, et al. by counting the fraction of the total number of tracts passing through each voxel on grid with subvoxel resolution (250 micron isotropic). Image analysis: Regions of interest (ROI) were drawn over the white matter tracts of genu and splenium of corpus callosum, anterior and posterior limbs of internal capsule, cerebral peduncles, corticospinal tracts and medial lemniscus.

RESULTS
Super resolution tract density maps reconstructed from the comparatively lower resolution raw diffusion data yielded a dramatic improvement in both spatial resolution and white matter contrast. There were significant differences between infants with watershed ischemic injuries compared to the normal controls: 48% and 39% average decrease in tract density in the genu and splenium of the corpus callosum respectively, 20% and 27% decrease in anterior and posterior limbs of internal capsule respectively, 21% decrease in cerebral peduncles, 29% decrease in corticospinal tracts and 9% decrease in medial lemniscus.

CONCLUSION
Tract density maps provided exquisite visualization of supratentorial and brainstem white matter tracts. Despite the small sample size, there was a significant difference in the tract density between the ischemic and normal groups. Tract density imaging promises to be a useful tool for studying a number of developmental and acquired disorders in the infant brain.

Acknowledgement: Project is supported by National Institute of Health grants R01EB009756, R01NS046432 and P50NS035902.

KEY WORDS: Tract density imaging, ischemic injury, diffusion tensor imaging
Comparison of Susceptibility-Weighted MR Imaging and Head Echograms in Evaluation of Germinal Matrix Hemorrhages

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PURPOSE
The primary goal of this research was to compare head echograms (HE) and susceptibility-weighted MR imaging (SWI) in the evaluation of germinal matrix hemorrhages in preterm infants. Secondarily, we compared the correlations between HE and SWI grades with outcomes.

MATERIALS & METHODS
We included preterm infants (less than 37 weeks gestational age) who were evaluated with both HE and MRI which included susceptibility-weighted sequences. A total of 98 patients were found to meet these criteria from 2002-2008. The germinal matrix hemorrhages detected on HE were classified by a pediatric radiologist using the grading system developed by Papile, et al. A modified grading system was used by a neuroradiologist for interpretation of the SWI sequence. Chart review of the patients was performed to assess clinical outcomes based on the Pediatric Cerebral Performance Category Scale (PCPCS) developed by Fiser, et al. The data were analyzed for differences in location and grade of hemorrhages utilizing the Wilcoxin Sigfried Ranks test, and correlation between SWI grade and HE grade and outcomes utilizing the Kruskall-Wallis test.

RESULTS
The mean gestational age was 27 weeks, and the mean birth weight was 1.09 kg. There was a relatively even distribution of males and females. Susceptibility-weighted MR imaging detected significantly more high-grade hemorrhages than ultrasound (US) (p<0.001). Susceptibility-weighted MR imaging detected many more cerebellar hemorrhages than US (51% compared to 5%) although this did not correlate with outcomes. Using both techniques, significant but low correlations between the grade of germinal matrix hemorrhage and outcome were detected (SWI, Spearman’s rho = 0.249 and HE, Spearman’s rho = 0.283).

CONCLUSION
As expected, susceptibility-weighted MR imaging was more sensitive in detection of hemorrhage (p<0.001). Moreover, the use of SWI improved the detection of cerebellar hemorrhage in these patients as compared to previous reports in the literature, but this did not correlate with outcomes. Despite the increased sensitivity of SWI, US grade remains a better predictor of clinical outcome.

KEY WORDS: Germinal matrix hemorrhage, susceptibility-weighted imaging, head echogram
CONCLUSION
Conventional MRI and DWI are able to detect acute cerebral ischemic lesions during fetal life even in the absence of sonographic findings. Thus, in patients with ongoing pregnancies, MRI with DWI should be performed soon after an insult to one twin.

KEY WORDS: Twins pregnancy, intrauterine fetal death

Paper 322 Starting at 4:50 PM, Ending at 4:58 PM

Pediatric Posterior Reversible Encephalopathy Syndrome: Risk Factors, Typical and Atypical Neuroimaging Findings and Predictors of Severity

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Pittsburgh, PA

PURPOSE
Reversible posterior encephalopathy syndrome (PRES) usually is a reversible clinicoradiologic entity that affects individuals at any age. Its pathophysiology remains not well defined and there is a paucity of studies in children with PRES. Objective: To systematically review the magnetic resonance images of children with PRES in order to better understand its pathophysiology and to identify predictors of nonreversible lesions.

MATERIALS & METHODS
Twenty-five children with PRES diagnosed by imaging and clinical follow up were reviewed. The underlying conditions were obtained from medical records. Two neuroradiologists retrospectively evaluated the MR images for patterns of distribution, enhancement, cortical/juxtacortical involvement, and the presence of hemorrhage on unenhanced FLAIR, T2-weighted, and gradient-echo, T1-weighted and postcontrast T1-weighted imaging. The apparent diffusion coefficient (ADC) values of the largest lesions in each affected lobe were calculated. Eighteen patients had follow-up imaging at our facility (range from 35 to 222 days) and residual lesions were assessed using unenhanced FLAIR and susceptibility effect using gradient-eco.

RESULTS
Sixteen boys (64%) and nine girls (36%), average age of 10 years old (range from 3 to 19 years) were studied. The most common underlying condition was immunosuppressant therapy for organ transplant (56%), followed by autoimmune disorder (20%), acute or chronic renal failure (12%) and chemotherapy (12%). Twenty-three of 25 (92%) had lesions predominantly in the medial parietal lobe, followed by the occipital 20/25 (80%), frontal 12/25 (48%) and temporal lobes 8/25 (32%). Predominant involvement of the watershed zones was observed in 21/25 (84%). The abnormal FLAIR signal in the parietal lobe was predominantly subcortical in 12/23 (52%), cortical 7/23 (30%), and cortical and subcortical 4/23 (17%). In the occipital, frontal and temporal lobes the cortical involvement was more prevalent with 10/20 (50%), 7/1 (58%), and 5/8 (63%) followed by subcortical 5/20 (25%), 4/12 (33%), and 3/8 (37%), cortical and subcortical 1/12 (8%), 5/20 (25%), and none (0%), respectively. Cerebellar lesions were seen in 4/25 (16%), brainstem lesions in 1/25 (4%) and another 1/25 (4%) in the splenium of the corpus callosum. Five of 25 (20%) had enhancing lesion, 2/25 (8%) had parenchymal hemorrhages and 2/25 (8%) had restricted diffusion. All the remaining 23/25 (92%) had facilitated diffusion. Seven of the 25 (28%) patients had lesions on the follow-up imaging and of those, 6/7 (85%) were in the medial parietal lobe. Four of 7 (57%) of the patients with residual lesion had markedly increased juxtacortical FLAIR signal and 3/7 (42%) had enhancement. One of the two patients with reduced diffusion had hemorrhage
on follow up and the patient lesion resolved. All of the lesions with parenchymal hemorrhage on baseline images persisted on follow up.

CONCLUSION
1) This study demonstrates that the underlying conditions associated with pediatric PRES differ consistently from the known causes in adults. 2) The predominant involvement of the watershed zones and its relation with the different patterns of cortical/subcortical involvement allows insights on new hypothesis to better understand the pathophysiology of PRES. 3) The presence of hemorrhage, the degree of juxta-cortical increased FLAIR signal and the enhancement were predictors of nonreversible lesions. 4) Lesions with reduced diffusion were uncommon in children.

KEY WORDS: Posterior reversal encephalopathy, pediatric neuroimaging, brain

Tuesday Afternoon
3:30 PM - 5:00 PM
Room 611/612

(23d) Spine: Intervention & Other
(Scientific Papers 323 - 332)

See also Parallel Session
(23a) Adult Brain: Neoplasms II: Gliomas
(23b) New Devices & Arteriovenous Malformations/Fistulae
(23c) Pediatrics: Brain Ischemia and Its Consequences
(23e) Socioeconomics & Anatomy

Moderators: Benjamin P. Liu, MD
Steven M. Weindling, MD

Paper 324 Starting at 3:38 PM, Ending at 3:46 PM
Detection of Cerebrospinal Fluid Leak in Spontaneous Intracranial Hypotension

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PURPOSE
Spontaneous intracranial hypotension (SIH) is an uncommon cause of headache resulting from spontaneous loss of CSF volume, typically due to rupture of a perineural spinal nerve cyst or spinal disk osteophyte. Confirming the presence and site of cerebrospinal fluid leak often is difficult and may require multiple imaging modalities. We review our experience of detecting a cerebrospinal fluid leak in patients with SIH.

MATERIALS & METHODS
A retrospective review of medical and radiologic records of patients with the term “SIH” was undertaken from our report archives over the time period of 1995-2010. Thirty-three patients with SIH who were evaluated with spine imaging [CT or MR myelography, or noncontrast MR imaging (MRI) of the spine] for the source of the CSF leak. A review of their records and scans was performed.

RESULTS
Among all patients with SIH who were evaluated with spinal imaging, 17 of 33 (52%) patients had a cerebrospinal fluid leak demonstrated. CT myelography detected a spinal leak in 12 of 17 patients (71%). MR imaging of the spine detected a
spinal fluid leak in nine of 18 patients (50%). MR myelography detected a spinal leak in four of 10 patients (40%). Among 16 patients with perineural spinal pathology as the definite or presumed cause of SIH, a spinal leak was detected in six of 16 patients (38%). CT myelography detected a spinal leak in four of 16 patients (25%). MR imaging of the spine detected a spinal fluid leak in one of eight patients (13%). MR myelography detected a spinal leak in two of eight patients (25%), both of which had no identifiable leak with CT myelography. Among 14 patients with disk osteophyte spinal pathology as the definite or presumed cause of SIH, a spinal leak was detected in 10 of 14 patients (71%). CT myelography detected a spinal leak in eight of 10 patients (80%). MR imaging of the spine detected a spinal leak in eight of nine patients (89%). MR myelography detected a spinal leak in two of two patients (100%), both of which had a leak demonstrated with CT myelography. Despite the detection of a cerebrospinal fluid leak with noncontrast MRI or MR myelography, the disk osteophyte was visualized better with CT imaging in all cases. Among the remaining three patients, two patients had both perineural cysts and thoracic disk osteophytes without a cerebrospinal fluid leak on CT myelography, noncontrast MRI of the spine, or MR myelography; one patient had a cerebrospinal leak identified on CT myelography without an identifiable etiology.

**CONCLUSION**

Patients with spontaneous intracranial hypotension present a formidable diagnostic challenge that often requires multiple imaging modalities. Confirming the presence and site of a spinal fluid leak is important for guiding therapeutic intervention. A significant percentage of patients with SIH do not have a spinal fluid leak demonstrated with imaging despite the presence of pathology; however, patients with SIH secondary to disk osteophytes more frequently have a spinal fluid leak demonstrated compared with patients with perineural cysts.

**KEY WORDS:** Spontaneous intracranial hypotension, CT, MR imaging

**Paper 325 Starting at 3:46 PM, Ending at 3:54 PM**

**Imaging Features of Surfer’s Myelopathy**

Patel, N. D. 1 • Neal, C. A. 2 • Rogers, T. 3 • Farid, H. 4 • Chin, C. T. 1 • Halbach, V. V. 1

1University of California San Francisco, San Francisco, CA, 2Maui Radiology Consultants, Kahului, HI, 3Maui Memorial Medical Center, Wailuku, HI

**PURPOSE**

Nontraumatic spinal cord injury includes etiologies such as spinal stenosis, vascular ischemia, tumor compression or congenital disease. Surfer’s myelopathy is a rare nontraumatic spinal cord injury to the lower thoracic spine that has been described to affect first time surfer’s. The pathogenesis of injury has been postulated to be related to the prolonged hyperextension while lying prone on the surfboard. We present 17 patients with surfer’s myelopathy and describe their clinical presentation, imaging findings, and clinical outcome.

**MATERIALS & METHODS**

We retrospectively reviewed the imaging and clinical findings in 17 patients (teenagers to mid thirties) with surfer’s myelopathy between January 1996 and July 2010. Most patients presented with acute paraplegic symptoms. All patients previously had been healthy with no associated medical conditions.

**RESULTS**

Seventeen patients were detected with surfer’s myelopathy between January 1996 and July 2010. All patients had MRI imaging of the thoracic spine which demonstrates abnormal increased T2 signal in the anterior 2/3 of the lower thoracic spinal cord.

**CONCLUSION**

While the prognosis in the patients reported in the few case reports in the literature has been favorable, often the clinical presentation has been predictive of eventual outcome, with long duration of symptoms or severe symptoms portending a poorer outcome. Recent cases of surfer’s myelopathy have been treated with phenylephrine-induced mild hypertension often with immediate improvement in symptoms. Thus, treatment efficacy may be improved if this rare entity is considered in the differential diagnosis of patient’s presenting with nontraumatic spinal cord injury after surfing.

**KEY WORDS:** Surfer’s myelopathy, nontraumatic spinal cord injury

**Paper 326 Starting at 3:54 PM, Ending at 4:02 PM**

**Emergent Lumbar Spine Imaging for Cauda Equina Syndrome: What Is Appropriate?**

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University of Utah
Salt Lake City, UT

**PURPOSE**

Poor understanding of cauda equina syndrome (CES) has lead to overzealous emergent MR spine imaging. This study will review the clinical definition of CES and the various causative pathologies in order to suggest an algorithm for the evaluation of these patients. Our aim is to help clarify appropriate indications for emergent MR imaging (MRI) of the lumbar spine.

**MATERIALS & METHODS**

A retrospective review of the radiology information system was completed for MRI lumbar spine studies performed emergently over a 12-month period for the indication of “cauda equina syndrome,” “lower extremity motor weakness,” and/or “bowel and bladder symptoms.” The study population was limited to those patients referred from the emergency department (ED). The electronic medical record then was examined for each patient’s clinical history and neurologic assessment.

**RESULTS**

The search found 232 patients with the indications stated previously. One patient was excluded because of chronic confounding neurologic symptoms and noncontributory clinical and imaging findings. Four patients in our series (1.7%) had true CES. Of these cases, two were due to disk herniation, one was secondary to a fracture, and one resulted from lep-
tomeningeal carcinomatosis. All four had neurologic deficits with significant attributable imaging findings. Seventy MRI studies (30.3%) showed clinically important findings; however, these were not associated with CES. Trauma-related fracture was the etiology in 29/70 cases (41%). Furthermore, 10/70 cases (14%) with clinically significant MRI findings were secondary to neoplastic involvement, and these 10 patients had known primary malignancies. Only 13.4% of cases (31/231) had clinically significant disease with relevant MRI findings, not related to known trauma or malignancy. Seventy-eight (33.7%) imaging exams had minor findings not attributable to any neurologic deficit. Lastly, 79 (34.2%) studies were within normal limits for age.

**CONCLUSION**

We have observed discordance between the indication on the ED request and the medical record, as MRI of the lumbar spine often is requested as part of the evaluation of low back pain. There are inconsistencies surrounding the etiology and clinical presentation of CES. A review of the literature proposes that for a diagnosis of CES, one or more of the following should be present: (1) bladder and/or bowel dysfunction, (2) reduced saddle sensation, (3) sexual dysfunction, with possible neurologic deficit in the lower limb (motor/sensory loss, reflex change). In our experience, thorough history and neurologic exam are fundamental to diagnose CES accurately, which only then should prompt emergent MRI evaluation of the lumbar spine.

**KEY WORDS:** Cauda equina syndrome, MR imaging

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**Paper 327 Starting at 4:02 PM, Ending at 4:10 PM**

**Radiofrequency Kyphoplasty for Targeted Vertebral Augmentation in the Treatment of Upper Thoracic (T2 - T6) Vertebral Compression Fractures as a Result of Multiple Myeloma**

Erdem, E. • Akdol, S. • Amole, A. • Fryar, K. • Eberle, R. W.: “The University of Arkansas for Medical Sciences, Little Rock, AR, Clinical Information Consultants, Inc., Apex, NC

**PURPOSE**

The purpose of this study was to assess the use, safety and efficacy of radiofrequency kyphoplasty (RFK) in the treatment of patients with upper thoracic vertebral compression fractures (VCFs) as a result of the osteolytic process associated with multiple myeloma (MM).

**MATERIALS & METHODS**

Between December 2008 and May 2009, a consecutive series of 66 RFK procedures were performed for VCF secondary to MM. A subset of these patients was identified with VCFs which occurred between T2 to T6 inclusive were identified for further analysis. Patients were included for study if they had a preoperative VAS equal to or greater than four on a ten-point scale. The RFK procedure was performed using proprietary navigational instruments permitting controlled, site specific intravertebral cavity creation (MidLine Osteotome, DFine, Inc, San Jose, CA), ultrahigh viscosity (UHV) PMMA (StabiliT™ ER2 Bone Cement, DFine, Inc, San Jose, CA), and a radiofrequency-based cement delivery system (StabiliT™ Vertebral Augmentation System, DFine, Inc, San Jose, CA). All cases were performed through a unilateral extrapedicular approach to the vertebral body. Pre and postoperatively, a standard 10-point visual analog scale (VAS) was utilized to assess back pain. Pain medication use and activity categories were defined and monitored for changes before and after RFK. All patients were followed for 6 months postoperatively.

**RESULTS**

Forty-one of 66 patients met the inclusion criteria. A subset of 15 patients had VCFs in the upper thoracic region of interest with a total of 22 VCFs treated with RFK. The preoperative VAS was 7.4 ± 2.2 (range: 4 to 10), and improved to 3.4 ± 2.6 (range: 0 to 8) at 6 months. There was also a reduction of narcotic use and an improvement in overall ambulation at the 6-month follow up. At six months postoperatively, there was no evidence of neurologic or clinical complications related to the RFK procedure. There was no evidence of PMMA leakage in this patient subset.

**CONCLUSION**

Spinal augmentation for vertebral compression fractures of any etiology, osteoporotic or malignant, has been widely accepted and performed with predictable results in the relief of pain and creation of a stable PMMA-host bone composite with minimal complications. However, there are few reports published specific to the use of vertebroplasty (VP) or balloon kyphoplasty (BKP) in the upper thoracic spine. The morphometry of the compromised vertebral body and pedicle in the upper thoracic region may limit the use of standard VP or BKP techniques, thus increasing the risk of complica-
tion to the surrounding neurovascular structures over those reported in the treatment of VCFs in the lower thoracic and lumbar spine. We report optimum safety and efficacy results in the treatment of malignant VCFs with a novel targeted vertebral augmentation technique in which accurate, yet remotely controlled delivery of an ultrahigh viscosity PMMA is utilized for fracture stabilization. Following use of a navigational osteotome for site specific cavity creation and predictable delivery of UHV-PMMA with RFK can be performed without the standard PMMA handling constraints and concerns, or operator radiation exposure encountered with VP and BKP.

**Key Words:** Radiofrequency kyphoplasty, ultrahigh viscosity PMMA, upper thoracic VCFs

**Paper 328 Starting at 4:10 PM, Ending at 4:18 PM**

*Use of Percutaneous Vertebroplasty to Augment Anterior Column Support Following Multilevel Spinal Oncologic Reconstructive Surgery*

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Columbus, OH

**Purpose**

Delayed hardware complications such as loss of reduction due to failure of anterior column support and adjacent level compression fractures may occur following multilevel spinal oncologic reconstructive surgery. Percutaneous vertebroplasty can be performed in spinal oncologic patients with instrumentation, for pain relief in the setting of compression fractures and to augment and stabilize the anterior column, despite the instrumentation necessitating an adjustment to the approach of the vertebroplasty. We report our experience with vertebroplasty in this setting.

**Materials & Methods**

A retrospective review identified eight patients who required percutaneous vertebroplasty following spinal oncologic reconstructive surgery. Vertebroplasty was performed with polymethylmethacrylate using the transpedicular or the lateral extrapedicular route if instrumentation was present at the level of the affected vertebral body. Patients were followed with CT and MRI to determine the status of the spinal construct.

**Results**

Eights patients with a mean age of 67.6 ± 8 years had PVP performed at 10 levels (Thoracic n = 3; Lumbar n = 7) with an average time of 8 ± 11 (Range: 1 - 28.4) months following surgery. Vertebroplasty was performed for adjacent compression fractures below the construct (n = 4) and within the construct for failing anterior column support (n = 5). All vertebroplasty complications were asymptomatic and included cement extravasation in the epidural space (n = 2) and into the titanium cage (n = 1). A single patient had repeat vertebroplasty at the same level for further stabilization. Follow-up neuroimaging with an average follow up of 16.3 (Range: 2 - 35.3) months revealed no further compression, progression or failure of the spinal constructs.

**Conclusion**

In the presence of hardware for multilevel spinal oncologic reconstructive surgery, the use of percutaneous vertebroplasty to augment anterior column support when needed is a feasible option to prevent ongoing and delayed hardware failure as well as for the treatment of pain related to compression fractures. The presence of hardware does complicate the performance of the vertebroplasty but it remains feasible and safe with minor adjustments in the technique/approach.

**Key Words:** Vertebroplasty, spinal instrumentation

**Paper 329 Starting at 4:18 PM, Ending at 4:26 PM**

*Percutaneous Plasma-Mediated Radiofrequency Ablation of Spinal Osteoid Osteomas*

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**Purpose**

The optimal treatment of spinal osteoid osteomas is controversial. Surgical excision may be difficult as the lesion is not visible grossly; the resection of the posterior spinal elements may necessitate a fusion operation. Percutaneous thermal ablation risks thermal injury to nearby neural and other normal structures. Plasma-mediated radiofrequency ablation (pmRFA) may allow for percutaneous treatment with reduced risk of thermal injury. This is the first report of the usage of this technique not only for an osteoid osteoma, but also for a primary bone tumor.

**Materials & Methods**

After informed consent was obtained, three patients, a mean age of 16 years, underwent percutaneous ablation of their spinal osteoid osteoma with pmRFA. The procedure was performed under CT guidance using the 11-gauge Coblation SpineWand (ArthroCare, Austin, Texas).

**Results**

Two lesions were located in the inferior articular process (right T11 and left C4), in proximity to the spinal canal and the facet joint, respectively. The third was in the transverse process of L3. There were no procedural or postprocedural complications. With an average follow up of 11.7 months, none of the patients have had a recurrence of the tumor; pain was quantified using the visual analogue scale, which decreased from a mean score of 8.67 to 0.67 at final follow up.
CONCLUSION

PmRFA of spinal osteoid osteomas is safe, feasible and efficacious, even when the tumor is in proximity to or abutting the spinal canal, the facet joint, or the exiting nerve root. Larger studies with a longer follow up are needed to determine the response and recurrence rates.

KEY WORDS: Osteoid osteoma, plasma ablation, coblation

Paper 330 Starting at 4:26 PM, Ending at 4:34 PM

Patient-Reported Outcomes of CT-Guided Targeted Blood Patching for Spontaneous Intracranial Hypotension: A Pilot Study

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PURPOSE

One potentially promising treatment option for headaches caused by spontaneous intracranial hypotension (SIH) is computed tomography (CT)-guided targeted epidural blood patching. In general, CT-guided targeted blood patching is not widely offered and outcome data has not been reported. Although lumbar epidural blood patching is used more widely, it may not be effective in many cases of SIH. The lumbar epidural blood patch places approximately 10-20 mL of blood in the lumbar spine, with the assumption it will diffuse to sites of CSF leakage. Although effective for post-LP headache, this approach has limitations for SIH, where the leaking spinal nerve roots in SIH are located most commonly in the thoracic spine. In CT-guided targeted blood patching, a smaller amount of blood (1-3 mL) is placed adjacent to a leaking nerve root, which provides a higher concentration of blood to patch the CSF leak. Thus, there is reason to believe that CT-guided targeted blood patches would be a superior method of treatment. In anticipation of designing a randomized controlled trial, there is need to collect proof of principle data on the degree and timing of headache relief, if any, following CT-guided targeted blood patching. In doing so, we plan to test the hypothesis that targeted blood patching provides a patient-reported relief from headaches caused by SIH.

MATERIALS & METHODS

Institutional IRB approval was obtained. All patients referred for CT-guided targeted blood patch for SIH were asked to complete a questionnaire pretreatment, and at 1, 3, and 12 months following the procedure. The primary efficacy variable is the Headache Impact Test 6 (HIT-6), a six-question survey that was developed to measure a wider spectrum of the burden of headache (minimum score 36, maximum 78). Among the general population, the HIT-6 has good reliability and validity for measuring patients’ subjective experience of the impact of headache on health-related quality of life, and has been used in the context of published clinical trials and observational headache studies.

RESULTS

A sample size of 36 for adequate power was calculated during the initial design of this study. From 6/23/2010 through 10/23/2010, 18 patients were enrolled in the study. Five patients have completed the follow-up questionnaire at the 1 month interval, of which three have completed the 3-month follow up. The primary efficacy variable of HIT-6 score, is lower (improved) in all five patients in the 1-month followup interval with average decrease in HIT-6 score of 6.5 +/- 4.6 (range 1-12). HIT-6 score is decreased in all 3 patients in the 3 month follow-up interval with a decrease in score of 5.3 +/- 1.5 (range 4-7).

CONCLUSION

CT-guided targeted blood patching may provide a benefit to patients with SIH. Additional data with longer follow-up intervals is needed to see if there is a sustained benefit. Preliminary results of this pilot study may provide the groundwork to substantiate a more extensive trial with control groups, which will be needed to demonstrate that this is indeed a true benefit.

KEY WORDS: Intracranial hypotension, blood patch, headache

Paper 331 Starting at 4:34 PM, Ending at 4:42 PM

A Comparison of Lumbar Puncture Opening Pressure Measurements Obtained in the Lateral Decubitus and Prone Positions

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PURPOSE

Lumbar puncture (LP) is a common diagnostic tool used to measure the pressure of the cerebrospinal fluid (CSF) and to obtain CSF for laboratory analysis. An accurate measure of the opening pressure is important as it has important ramifications for diagnosis and treatment. Because our referring neurologists believed there was a discrepancy between the opening pressures measured at the bedside with the patient in a lateral decubitus or sitting position and those obtained in the fluoroscopic suite where the patient was supine, they requested for the LP to be done in a lateral decubitus position. These patients then were repositioned into a supine position, a repeat measurement of the pressure was made,
and fluid was obtained. The current study is a retrospective review of the patients who had opening pressures measured in such a manner to determine if any difference exists.

**Materials & Methods**

Nine patients who were referred to the department of interventional neuroradiology for a lumbar puncture for various clinical indications and who were requested to have the opening pressure measured in a lateral decubitus and supine position were included in this study. The opening pressure was measured initially in the lateral decubitus position and then subsequently measured in a supine position (taking into account the distance of the spinal needle and the manometer). The Pearson product-moment correlation coefficient was determined.

**Results**

The opening pressure in this population ranged from 11 to 44 mm H2O, with a Pearson correlation coefficient of 0.987, p < 0.001. Evaluation of the data in each patient showed that the pressure measurements were within 1 mm H2O for all patients except one, who had an opening pressure measured in the lateral decubitus position of 44 mm H2O compared with 37 mm H2O in the supine position.

**Conclusion**

There is a strong correlation in the opening pressures measured in a lateral decubitus position and supine position. In our patient population, it was only in the one patient with a very high opening pressure that a discrepancy was observed. This may be related to the fact that the supine measurement was obtained after the lateral decubitus measurement, could potentially represent a change in pressure with time, may be a spurious measurement, or could imply that measurements in the supine position are less reliable when pressures are very elevated. However, for the purposes of diagnosis and therapy, measurements of the opening pressure obtained in a supine position are reliable.

**Key Words:** Lumbar puncture, opening pressure, cerebrospinal fluid

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**Paper 332 Starting at 4:42 PM, Ending at 4:50 PM**

**1H-MR Spectroscopy in the Evaluation of Osteoporotic and Neoplastic Vertebral Fractures Prior to Percutaneous Vertebroplasty**

Massari, F. • Masala, S. • Assako Ondo, P. • Simonetti, G.

University of Rome
Rome, ITALY

**Purpose**

The detection of spongious vertebral molecular variations can be utilized to distinguish the different sources of bone pathology. The relative water intensity correlates with hematopoietic elements dominating in youth. Instead fat cells proportion increases with age resulting in a conversion of red/yellow marrow.
**Diagnostic Yield of Head CT in the Dizzy Patient**

Saha, A.1 • Prezziia, C. F.1,2 • Seo, S.1 • Goldberg, M. F.1

1West Penn Allegheny Health System, Pittsburgh, PA,
2Temple University School of Medicine, Philadelphia, PA

**PURPOSE**
Dizziness is a common patient complaint, accounting for 4% of emergency department (ED) visits in the United States. With approximately 23% of these patients receiving a head CT, it is the sixth most common indication for CT in the ED. Excessive imaging has come under scrutiny in recent years due to mounting concern about the risks of radiation exposure and increasing health care costs. In light of these concerns, the purpose of our study was to assess the diagnostic value of head CT in the ED setting during the work up of dizzy patients. This has not been described previously in the radiology literature.

**MATERIALS & METHODS**
The study group was composed of ED patients presenting to a metropolitan tertiary care center between January 2010 and November 2010. All patients presenting with a chief complaint of “dizziness” or “vertigo” who subsequently received an unenhanced head CT were included in the study. Patients were identified through a search of the radiology information system (RIS). Subjects were excluded for history of head/neck trauma, altered mental status, headache, recent head/neck surgery, or clinical diagnosis of stroke. Findings were categorized as “normal” (no abnormalities), “incidental” (findings do not explain patient’s symptoms), or “abnormal” (findings explain patient’s symptoms). The RIS search accrued 294 head CTs. After exclusion criteria were applied, a total of 212 patients were included in the study. Calculations were performed using Microsoft Excel.

**RESULTS**
Males comprised 47.6% of subjects (n = 101). Age range was 19-91 years (mean, 70 years). Only one scan (0.5%) was considered "abnormal" and demonstrated findings that explained the patient's symptoms: a case of acute pontine infarct confirmed by MRI. Nearly half of the studies were normal (48.2%, n = 102). Incidental findings were present in 51.4% of patients (n = 109). Findings included chronic small vessel disease (34.9%), chronic lacunar infarction (6.1%), sinus disease (4.2%), chronic postoperative/radiation changes (1.9%), and other (13%). Subgroup analysis of subjects age 40 and below (n = 23) showed that 78.1% of studies were completely normal and zero were diagnostic of the patient’s symptoms.

**CONCLUSION**
This study demonstrates the low diagnostic value of unenhanced head CT for ED patients presenting with dizziness, especially in younger patients. The amount of unnecessary radiation is significant, averaging 75 mGy (CTDIvol) per scan based on ACR/ASNR reference standards. Medicare Part B reimbursement for an unenhanced head CT in our practice setting is $190.59. Based on an estimate of approximately 592,800 head CTs performed every year in American EDs for dizziness, this results in an annual cost of $113,000,000 to our health care system. Given the findings in this study, patients may be better served by a careful clinical history, appropriate neurologic exam, and, if indicated, MRI of the brain.

**KEY WORDS:** Dizziness, vertigo, head CT
compared the rate of withdrawals, defined as "procedure not performed by consensus", or "procedure changed by consensus" with the ordering physician among the five neuroradiologists. Studies were not denied by the neuroradiologists.

RESULTS
A total of 5,256 studies were reviewed by the five neuroradiologists (mean, 1051 cases; median, 1043). There were 573 procedures (10.9%) "not performed by consensus", and 298 studies (5.7%) "changed by consensus" with the ordering physician. Hence, a total of 871 withdrawals (16.6%) were identified. Among the five neuroradiologists, the withdrawal rates varied by approximately a factor of two (mean, 16.5%; median, 15.2%; range, 12.8%-23.5%). Further analysis showed that the rate of "procedure not performed by consensus" varied by approximately a factor of two (mean, 10.8%; median, 8.1%; range, 7.6%-18.0%), whereas the rate of "procedure changed by consensus" showed little variation (mean, 5.7%; median, 5.5%; range, 4.8%-6.6%).

CONCLUSION
The principal source of variability in the performance of the neuroradiologists participating in this RBM program was related to cases in which the ordering physician was asked not to perform the study. Conversely, there was little variation in cases where the ordering physician was asked simply to change the study to a (presumably) more appropriate one. These data imply agreement among the neuroradiologists regarding the appropriateness of the evidence-based rule sets, but suggest that certain personal attributes (e.g., persuasiveness, desire for conflict avoidance) play an important role in each radiologist's performance.

KEY WORDS: Utilization management, performance

Paper 336 Starting at 3:46 PM, Ending at 3:54 PM

Quality Control in Neuroradiology: Discrepancies in Image Interpretation among Academic Neuroradiologists

Babiarz, L. S. • Yousem, D. M.
The Johns Hopkins Hospital
Baltimore, MD

PURPOSE
Prior studies have looked at interpretation variability between readers of different training levels. We set out to compare imaging reports between equally trained practitioners through an internal quality control study among neuroradiologists on staff at a university hospital.

MATERIALS & METHODS
Over 17 months (01/09-05/10), staff neuroradiologists randomly reviewed studies and reports of previously read examinations. The discrepancies between the original and "second opinion" reports were scored according to a 5-point scale: 1) no change, 2) clinically insignificant detection discrepancy, 3) clinically insignificant interpretation discrepancy, 4) clinically significant detection discrepancy, and 5) clinically significant interpretation discrepancy. Studies graded 4 or 5 were assessed by a third independent reviewer with 22 years of experience and familiarity with the scoring system for accuracy. Department-wide, individual, and study type-specific discrepancy rates were calculated.

RESULTS
One thousand neuroradiology studies (400 CTs, 586 MRs) read by 18 neuroradiologists were reviewed by 11 neuroradiologists currently on staff. In 87.6% (876/1000) there were no changes to the original report. There were 20 scores of 4 or 5; 8 CTs (7 CT brain, 1 CT angiogram) and 12 MRs (9 MR brain, 1 MR neck, 1 MR spine, and 1 MR venogram). Discrepancies were classified as vascular (7), neoplasms (9), congenital (2), and artifacts (2). The entire neuroradiology service had a 2.0% (20 in 1000; 95% CI: 1.1% - 2.9%) rate of clinically significant discrepancies. Individual neuroradiologists ranged 0% to 7.7% (SD = 2.3%, n = 18). Both CT and MR studies had a discrepancy rate of 2.0% (8/400 and 12/586). There was no statistically significant difference between the average years of experience or the number of studies read and the discrepancy rates when the neuroradiologists with the scores of 4 or 5 were compared to those without scores of 4 and 5.

CONCLUSION
We found a 2.0% rate of detection or interpretation discrepancy between neuroradiologists on staff at a university hospital. Our quality assessment study could serve as a blueprint for initial data collection prior to intervention as part of a practice quality improvement (PQI) project.

KEY WORDS: Quality improvement

Paper 337 Starting at 3:54 PM, Ending at 4:02 PM

Impact of the Sentinel Effect in a Radiology Benefit Management Program

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Philadelphia, PA

PURPOSE
The sentinel effect can be defined as a decrease in services given by providers as a result of a utilization management program. In this project, we evaluated the sentinel effect caused by a prior authorization (PA) process in a radiology benefit management (RBM) company.

MATERIALS & METHODS
Using evidence-based guidelines, an RBM company (HealthHelp, LLC) provides real time, peer to peer decision support for physicians ordering high cost, outpatient imaging studies (CT, MRI, PET, nuclear medicine) on patients enrolled in national and local health plans. After initial consultation between RBM personnel (level I, customer service representative; level II, nurse) and the provider’s staff, studies not meeting appropriateness criteria are referred to an academic radiologist (level III) for further review. The radiologist can approve the study based upon the electronic chart evaluation, or call the provider’s office for further information; the determination of appropriateness then is made. If a suitable individual is not available to take the radiologist’s call, and there is subsequently “no callback” from the
provider’s office with 48 hours, the study is administratively withdrawn. Studies are not denied by the radiologist. We analyzed the rate of “procedure withdrawn by consensus with the provider” and the rate of “no callback” for a 3-year interval (January 2007 - December 2009). We also assessed how often a study was reordered after being withdrawn simply due to “no callback”.

**RESULTS**

A total of 28,120 studies were reviewed during the 3-year interval. There were 3,906 procedures “withdrawn by consensus” (13.9%). There were “no callbacks” for 4,216 (15.0%). Dividing each year into quarters, the percentage of “no callbacks” did not significantly change over the study period (mean, 14.9%; median, 15.1%; range, 11.5% - 18.3%). Of 4,216 studies withdrawn due to “no callback”, 1,557 (36.9%) subsequently were reordered within the next 30 days. Hence, 2,659/28,120 (9.5%) of all studies were not performed simply due to “no callback”.

**CONCLUSION**

The PA process acts as a “sentinel” by imposing a minor barrier to ordering high cost, outpatient imaging studies. In our project, at Level III, almost one out of four studies was not performed due to this barrier. Moreover, this study does not address the sentinel effect at the point of entry into the PA process (Level I). Our data suggest that RBMs can slow the rapid growth in high cost, outpatient imaging.

**KEY WORDS:** Utilization management, sentinel effect

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**Paper 338 Starting at 4:02 PM, Ending at 4:10 PM**

**Interpretation Rates of Neuroradiology: Analysis across Neuroscience Specialties**

Babiarz, L. S. · Yousem, D. M. · Parker, L. · Levin, D. C. · Rao, V.

1The Johns Hopkins Hospital, Baltimore, MD, 2Thomas Jefferson University Hospital, Philadelphia, PA

**PURPOSE**

Recent literature suggests that nonradiologists are interpreting an increasing portion of imaging studies. We looked at the trends in neuroradiology interpretation focusing on radiologists, neurologists, neurosurgeons, and other specialists within the Medicare patient population.

**MATERIALS & METHODS**

The number of neuroradiology studies interpreted by radiologists, neurologists, neurosurgeons, and other subspecialists in the inpatient, hospital outpatient, and private office settings was determined from the Centers for Medicare & Medicaid Services Physician/Supplier Procedure Summary Master Files for 1996-2008. Neuroradiology studies included computed tomography (CT) and magnetic resonance (MR) of brain/head & neck, and spine. Market shares, utilization rates, and utilization rate compound annual growth rates (CAGRs) were computed for specialties and service locations.

**RESULTS**

In 1996, of all 5,124,050 neuroradiology studies performed, 4,802,490 (93.7%) were interpreted by radiologists, 77,312 (1.5%) by neurologists, 9,825 (0.19%) by neurosurgeons, and 234,423 (4.6%) by other subspecialists. In 2008, of all 11,993,833 studies, 11,048,727 (92.1%) were interpreted by radiologists, 114,159 (1.0%) by neurologists, 21,166 (0.18%) by neurosurgeons, and 809,803 (6.8%) by other subspecialists. Neurology and neurosurgery lost market share at all service sites. Radiology gained market share in inpatient (94.8% to 98.2%) and hospital outpatient facilities (95% to 98.4%), but saw a decline in private office setting share (88.2% to 70.3%). Radiology, nonetheless, accrued 991,886 additional private office cases compared with 31,390 cases for neurology, 10,287 for neurosurgery, and 593,354 for other subspecialists. Lost market share was captured by the “other specialists” category which included independent diagnostic facilities (IDTFs) and multidisciplinary groups, many of whom include radiologists.

**CONCLUSION**

There has been tremendous growth (134%) in neuroradiology studies between 1996-2008 in the Medicare patient population. Radiology still interprets the vast majority of all neuroradiology studies. Radiology’s market share has shown growth in the inpatient and hospital outpatient sectors, but not the private office service where IDTFs, multidisciplinary groups, and other specialists have seen increases.

**KEY WORDS:** Utilization rates

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**Paper 339 Starting at 4:10 PM, Ending at 4:18 PM**

**Utilization Rates of Neuroradiology across Neuroscience Specialties in the Private Office Setting: Who Owns or Leases the Scanners on Which Studies Are Performed?**

Babiarz, L. S. · Yousem, D. M. · Parker, L. · Levin, D. C. · Rao, V.

1The Johns Hopkins Hospital, Baltimore, MD, 2Thomas Jefferson University Hospital, Philadelphia, PA

**PURPOSE**

We looked at the trends in the Medicare global and technical fee submission rates for neuroradiology studies submitted by radiologists, neurologists, neurosurgeons, and other physician subspecialists in private offices. We sought to identify shifting trends in performance of neuroradiology studies on private office MR imaging (MRI) and CT scanners over the last decade.

**MATERIALS & METHODS**

The number of neuroradiology studies performed on MR and CT machines owned or leased by radiologists, neurologists, neurosurgeons and other specialties in the private office were determined from the Centers for Medicare & Medicaid Services Physician/Supplier Procedure Summary Master Files for 1998-2008. Independent diagnostic testing facilities were excluded. Studies billed through technical and global charges were aggregated. Neuroradiology examinations were categorized as 1) CT brain/head and neck, 2) CT spine, 3) MR brain/head and neck, and 4) MR spine. Utilization
rates and utilization rate compound annual growth rates (CAGRs) were computed for each specialty and imaging study type.

**RESULTS**

Between 1998 and 2008, MR studies grew 2.5x and CT studies grew 2.1x; MR brain/head and neck increased 2.9x and MR spine 2.1x. In 2008, radiologists, neurologists, neurosurgeons, and other specialists performed 1,386,669, 82,360, 29,218 and 324,626 neuroradiology cases, respectively. Radiologists’ 1998 base rate of 24.1 per 1,000 Medicare beneficiaries increased to 39.7 in 2008, compared to neurologists’ 1.03 1998 to 2.4 in 2008, neurosurgeons’ 0.15 in 1998 to 0.84 in 2008, and other specialists’ 1.3 in 1998 to 9.6 in 2008. All specialties increased MR utilization greater than CT; however neurology, neurosurgery, and other specialists’ MR growth was greater than that of radiology (CAGR of 5.3%, 10.6%, 22.1%, and 21.7% respectively), especially in MR brain/head and neck (CAGR of 4.2%, 11.1%, 25.2% and 18.5% respectively).

**CONCLUSION**

Neurologists, neurosurgeons, and other specialists that own or lease scanners have increased their utilization rates of private office CT and MR neuroradiology studies at a greater rate than radiologists. However, radiology still performs 3.5x more neuroradiology studies than all provider specialties combined.

**KEY WORDS:** Utilization rates

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**Paper 340 Starting at 4:18 PM, Ending at 4:26 PM**

**Evaluation of Volumes of Second Opinion Consultations**

Chokshi, F. H. • Savery, S. • Lewin, J. S. • Yousem, D. M.
The Johns Hopkins Hospital
Baltimore, MD

**PURPOSE**

To analyze the growth in volume of the second opinion consultation (SOC) studies compared with internal work growth rate, division by division, within the department of radiology at our hospital. Our hypothesis was that the rate of growth of the SOC service was greater than non-SOC studies, across all divisions, between years 2008 and 2010.

**MATERIALS & METHODS**

The IDX system was queried for all studies performed at our hospital between academic year (AY) 2008-2010, which were assigned the CPT-4 code 76140 (“Consultation on x-ray exam made elsewhere, written report”). Four sets of study volumes were tabulated for absolute number and percent change: Total growth of SOC procedure volume, AY 2008-2010; total growth of non-SOC procedure volume, AY 2008-2010; Growth of SOC procedure volume, per imaging section, AY 2008-2010; Growth of non-SOC procedure volume, per imaging section, AY 2008-2010.

**RESULTS**

In AY 2008, 12,697 SOC studies were read and by end of AY 2010, the volume was 22,961, corresponding to overall growth of 81% between 2008 and 2010. In AY 2008, 431,140 non-SOC studies were read, increasing to 442,688 by end of AY 2010, representing 2% overall growth between 2008 and 2010. Between AY 2008 to 2010, all divisions saw an increase in SOC volume, with greatest increase in CT Body (79.2%), followed by MRI Neuro (76.9%). The only section with less than 50% growth in SOC volume was MRI Body (48.3%). Between 2008 and 2010, non-SOC volumes per division showed varied rates of change. The three leading divisions with volume growth were MRI Neuro (18.2%), Body Interventional (17.1%) and Neuro-Interventional (13.1%). The nuclear medicine, pediatric radiology, and MSK divisions saw a varied range of decreasing volume.

**CONCLUSION**

Departmental and divisional SOC volumes have increased to a greater extent than non-SOC volumes over the lifetime of the SOC service (academic years 2008-2010).

**KEY WORDS:** Second opinion consultation, MR imaging, CT

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**Paper 341 Starting at 4:26 PM, Ending at 4:34 PM**

**Aorto-CT by Intra-Aortic Injection, in Hybrid Operating Room, for the Presurgical Location of Adamkiewicz Artery: Feasibility and Sensitivity**

Clarencon, F. • Cormier, E. • Di Maria, F. • Sourour, N. • Szatmary, Z. • Iosif, C. • Chiras, J.
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Paris, FRANCE

**PURPOSE**

To study the feasibility of the aorto-CT by intra-aortic injection (ACTIA) performed in hybrid OR (Miyabi Emotion 16, Siemens, Erlangen, Germany) for the presurgical location of Adamkiewicz artery (AA). To evaluate the sensitivity of this new technique.
MATERIALS & METHODS
Twelve patients (7 females, 5 males) aged from 57 to 83 years (n = 71 years) had an ACTIA for the location of AA before surgery of aneurysm or dissection of the thoraco-abdominal aorta (n = 10) or before spine surgery (n = 2). After femoral artery puncture, a pigtail catheter was positioned at the origin of the descending aorta. CT acquisition was performed in the same OR, by simple translation of the table, with an intra-aortic contrast media injection (15 cc/s; 120 cc). For each patient, the visualization of the AA and the location of the intercostal artery(ies) that fed the AA were evaluated. The duration of the exam and the x-ray dose were assessed. Selective catheterism was performed systematically to confirm the result of the ACTIA.

RESULTS
In 11/12 cases, AA and its arterial feeders were visualized by the ACTIA. In three cases, two intercostal arteries were supplying the AA. In one case of thoraco-abdominal dissection in an obese patient, the AA was not depicted. Mean x-ray dose was 565 mGy.cm. Mean duration time for ACTIA was 40 min. In all the cases for which the AA was visualized, the selective catheterism confirmed the results of the ACTIA.

CONCLUSION
ACTIA is a feasible technique in a daily practice that has a good sensitivity (92%) for the location of the Adamkiewicz artery and its feeders.

KEY WORDS: Adamkiewicz artery

Paper 342 Starting at 4:34 PM, Ending at 4:42 PM
Superior Cervical Ganglion: Hiding in Plain Sight

Ravi, V. • McNulty, N. J. • Belden, C. J.
Dartmouth-Hitchcock Medical Center
Lebanon, NH

PURPOSE
The superior cervical ganglion is a well described anatomical structure, but has received little attention in the radiology literature. Knowledge of the imaging appearance of the superior cervical ganglion is important to avoid mistaking it for an abnormal lymph node. The purpose of this study was to demonstrate how commonly this normal anatomical structure is identifiable on routine computed tomography(CT) imaging and define the features that help to distinguish it as the superior cervical ganglion.

MATERIALS & METHODS
This study was approved by our institutional review board. Fifty consecutive contrast-enhanced CTA examinations of the neck with axial and coronal images were reviewed. These examinations were performed on a 64 slice MDCT. CT angiography examinations were deliberately chosen to create a study population which did not include patients with head and neck malignancy or ongoing infection. The patient population consisted of 21 women and 29 men, with ages...
ranging from 23 to 84 years and a mean age of 58.5 years. Axial and coronal images were reviewed on a PACS workstation. The presence or absence of the superior cervical ganglion was documented on the right and left sides, and if present its three-dimensional size was recorded.

RESULTS
On the right, the superior cervical ganglion was identified in 42 out of 50 cases (84%). The average size of this structure on the right was 4.5 mm x 3.9 mm x 11.6 mm. On the left, the superior cervical ganglion was identified in 38 out of 50 cases (78%); its average size was 4.3 mm x 3.9 mm x 12.3 mm. The superior cervical ganglion typically was found at the C2/C3 level and was fusiform or spindle shaped on coronal images. A characteristic central dot of low density was seen on axial images in most cases.

CONCLUSION
The superior cervical ganglion is a normal anatomical structure which is routinely visible on CT examinations of the neck. Knowledge of this structure and the ability to confidently identify it are important particularly in the imaging of patients with head and neck cancer. Case reports of mistaking this for an abnormal lymph node, as there is potential for it to enlarge following radiation therapy, and unnecessary biopsy of this structure has been reported in this setting. We found the location (at the C2/C3 level), shape (fusiform or spindle shaped) and a central focus of low attenuation to be reliable characteristics to identify the superior cervical ganglion.

KEY WORDS: Superior cervical ganglion, sympathetic nervous system, lymph node

Paper 343 Starting at 4:42 PM, Ending at 4:50 PM

Normal Carotid Body: A Frequent Finding on CT Angiography

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1Hospital of Sion, Sion, SWITZERLAND, 2The Johns Hopkins Hospital, Baltimore, MD

PURPOSE
To report the nearly constant demonstration of an enhancing nodule above the common carotid artery (CCA) bifurcation thought to correspond to the normal carotid body (NCB) during CT angiography (CTA) of the neck.

MATERIALS & METHODS
IRB approval was obtained for the study. All patients were consented for the imaging studies, which were performed routinely in the clinical setting of stroke or stroke-like symptoms. Neck CTA were studied prospectively in 33 consecutive patients. CT angiography was performed after bolus test and injection contrast medium (70 ml, 370 mg Iodine/mL, 4.5 ml/sec). An enhancing nodule was sought for in both sides above the CCA bifurcation. Size and relation of the nodule to the distal CCA and proximal internal carotid (ICA) and external carotid (ECA) arteries was noted. Maximum size in three planes was measured on axial source images and MPR reconstructions. Atheromatous disease and presence of CCA/ICA/ECA stenosis were noted. A vascular blush at the CCA bifurcation also was sought whenever digital subtraction angiography (DSA) was performed in this group of patients. In five additional patients not included in the CTA group, DSA and dyna-CT obtained during routine diagnostic work up also were studied and a nodule was sought for as a vascular blush in the former and an enhancing nodule in the latter.

RESULTS
Three CTA studies were excluded from the study due to poor quality (movement in two patients, bad timing of the contrast medium administration in one patient). Mean age was 50.3 years (19-88 years old); 60% were female. A nodule was observed in 28/30 studies (93%) and, when present, always was found bilaterally. Mean maximum sizes were 2mm, 1.8mm, and 3.5 mm, and on the right and were 1.7mm, 2.2mm and 3.2 on the left. The nodule was found most commonly between the ICA and ECA immediately above the CCA bifurcation (87%), though it rarely was observed to be abutting the medial surface of the proximal ECA in 13% of cases. It always appeared less dense than the contrast medium within the carotid arteries. In two cases of severe atherosclerosis of the CCA bifurcation and proximal ICA, no nodule could be visualized. A blush at the CCA bifurcation never was observed on DSA studies. However, an enhancing nodule identical to those demonstrated by CTA was found in all dyna-CT cases.

CONCLUSION
A small enhancing nodule above the CCA bifurcation is a near constant finding on CTA. The location and small size of the nodule, the absence of splaying of the surrounding ICA and ECA, the absence of blush on DSA and its demonstration on dyna-CT support the hypothesis that it corresponds to the NCB. It should not be mistaken for pathologic conditions such as a carotid body tumor.

KEY WORDS: Normal carotid body, CT angiography, dyna-CT
Structured Reporting Versus Conventional Dictation for Complex Head and Neck Neoplasms: Which Do Clinicians Prefer?

Shah, V. • Hess, C. • Wang, S. • El-Sayed, I. • Quivey, J. • Shih, R. • Kim, W. • Glastonbury, C.

University of California San Francisco
San Francisco, CA

PURPOSE
To determine whether using structured templates for reporting complex head and neck cases results in higher quality reports than using conventional free-text dictation.

MATERIALS & METHODS
Study was approved by an institutional review board and was HIPPA compliant. Using AJCC 2010 guidelines we created individualized templates for reporting of various head and neck neoplasms. For part 1, two clinical instructors in neuroradiology reviewed the same set of 11 pretreatment head and neck tumor MR and CT cases and reported them using free-text dictation. For part 2, 4 months later, the two instructors reread the same cases, this time using the structured reporting templates. A total of 176 reports subsequently were graded by a CAQ-certified neuroradiologist, an experienced head and neck radiation oncologist, and two head and neck surgeons using a report survey form that included a 5-point grading scale (ranging from poor to excellent) for 10 different report attributes (Table 1). Scores assigned to each attribute were averaged to produce a composite report score. Reviewers were blinded to which report used a structured template and which report was generated via free-text dictation.

RESULTS
The 88 structured reports (average score 4.6) received significantly higher scores than 88 unstructured reports (average score 3.8; p-value = 0.000001). Average scores for structured vs unstructured reports were significantly higher across each reviewer: neuroradiologist (4.8 vs 4.3), radiation oncologist (4.4 vs 3.8), head and neck surgeon 1 (4.7 vs 4.0), and head and neck surgeon 2 (4.4 vs 3.0). Average scores for author 1 were: 3.7 for unstructured reports (average report length 409 words) versus 4.7 for structured reports (255 words). Average scores for author 2: 3.8 for unstructured reports (177 words) versus 4.5 for structured reports (197 words). The authors felt that the templates were “easy to use” and “forced (them) to address staging criteria.” The reviewers judged 60% of the structured reports to be better than the average quality of reports they have received from the same institution in the past (35% judged to be of similar quality, 5% worse). In comparison 63% of unstructured reports were judged to be of similar quality (17% better, 20% worse).

Table 1
PHYSICIAN SURVEY FORM FOR HEAD & NECK REPORTS
Please evaluate each report for completeness of reporting, accuracy, consistent terminology, and clinical relevance using the following scale:

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>NA</th>
</tr>
</thead>
<tbody>
<tr>
<td>poor</td>
<td>fair</td>
<td>good</td>
<td>very good</td>
<td>excellent</td>
<td>not applicable</td>
</tr>
</tbody>
</table>

Please identify yourself as Head & Neck Surgeon / Radiation Oncologist / Neuroradiologist

The Report:
1. Provides consistent descriptions to help you understand
   a) the location of the pathology
      1 2 3 4 5 NA
   b) the severity of the pathology
      1 2 3 4 5 NA

2. Uses consistent terminology to describe relevant pathology
      1 2 3 4 5 NA

3. Provides pertinent negatives and positives regarding local extent and invasion of adjacent structures
      1 2 3 4 5 NA

4. Appropriately comments on lymph node involvement
      1 2 3 4 5 NA

5. Provides a confidence level for reported findings
      1 2 3 4 5 NA

6. Provides a radiological TNM Staging
      1 2 3 4 5 NA

7. Provides a clinically relevant imaging report
      1 2 3 4 5 NA

8. I can make treatment decisions based on the report
      1 2 3 4 5 NA

9. This report meets my expectations as a referring physician
      1 2 3 4 5 NA

This report is better / worse / about the same quality as reports I have received from this institution in the past.
CONCLUSION
The written report is a critical means for radiologists to communicate with referring physicians. Use of structured templates, particularly when reading complex head and neck cases, may enable radiologists to produce higher quality reports. In our study, a neuroradiologist, head and neck radiation oncologist, and two head and neck surgeons judged structured reports to be of a higher quality than reports generated via free-text dictation. Template reporting may reduce variability in reporting, help reduce errors or omissions within radiology reports that may adversely impact patient care, and may increase referring physician satisfaction.

KEY WORDS: Structured report, quality control, head and neck neoplasm

Tuesday Afternoon

5:00 PM - 6:30 PM
Ballroom 6 B/C

(25) Comparative Effectiveness Research, Evaluation of Common Neuroradiologic Studies

(345) Comparative Effective Reserch (CER) and Low Back Pain: A Spine Interventionalist Perspective of Where We’ve Been
— Ray M. Baker, MD

(346) CER and Low Back Pain: Gathering Practical Data Now. The Back Pain Outcomes Using Longitudinal Data (BOLD) Initiative
— Jeffrey G. Jarvik, MD, MPH

(347) Comparative Effective Research and Back Pain: Cautionary Tales and Where We Need to Go
— Richard A. Deyo, MD, MPH

Moderator: David J. Seidenwurm, MD

CER and Low Back Pain: Gathering Practical Data Now. The Back Pain Outcomes Using Longitudinal Data (BOLD) Initiative

Jeffrey G. Jarvik, MD, MPH

PRESENTATION SUMMARY
Randomized controlled trials have high rigor but generally limited relevance due to multiple factors such as stringent selection criteria, strict control over intervention quality, limited sample size, and other factors. Comparative effectiveness research tries to address these shortcomings by examining the relative effectiveness of interventions in real-world settings. The Back pain Outcomes using Longitudinal Data (BOLD) project, is an AHRQ funded effort to gather practical, real-world data about older patients with low back pain. We are recruiting 5,000 patients 65 and older from health systems that are part of the HMO Research Network into a prospectively assembled registry. We are collecting data about pain, function, health-related quality of life and resource utilization. The project includes an observational cohort investigating early imaging for low back pain as well as a practical, randomized controlled trial of epidural steroids vs. local anesthetic for spinal stenosis. I will discuss the advantages as the challenges of assembling this type of data.

Comparative Effective Research and Back Pain: Cautionary Tales and Where We Need to Go

Richard A. Deyo, MD, MPH

Dr. Richard Deyo is the Kaiser Permanente Professor of Evidence-Based Family Medicine and Professor of Medicine at Oregon Health and Science University. He is Director of...
Tuesday Afternoon

5:00 PM - 6:30 PM
Room 606/609

(26) ASPNR Programming: Metabolic Diseases of Childhood

(349) Clinical Features and Neurological Presentation of the Inborn Errors of Metabolism
— Russell P. Saneto, DO, PhD

(350) Imaging of Inborn Errors of Metabolism in the Neonate
— Susan I. Blaser, MD, FRCPC

(351) Genetic Approach to Metabolic Conditions
— Sihoun Hahn, MD, PhD

Moderator: L. Santiago Medina, MD, MPH

Clinical Features and Neurological Presentation of the Inborn Errors of Metabolism

Russell P. Saneto, DO, PhD

Dr. Russell Saneto received his PhD from the University of Texas Medical Branch in Human Biological Chemistry and Genetics, and completed a postdoctoral fellowship in developmental neurobiology at the University of California, Los Angeles. He received his medical degree from Des Moines University and completed his pediatric and pediatric neurology residencies as well as his pediatric neurophysiology fellowship, at the Cleveland Clinic. Dr. Saneto is currently an Associate Professor in the Division of Pediatric Neurology, department of neurology at Seattle Children’s Hospital and University of Washington. He is Head of the Program for Mitochondrial Medicine and Metabolism at Seattle Children’s Hospital. Dr. Saneto’s clinical and research interests are in the treatment of intractable epilepsy and the relationship with epilepsy and neurogenetic disorders, in particular mitochondrial disease.

Presentation Summary
Clinically, diseases of inborn errors of metabolism (IEM) can be divided into two major categories. The first involves only one functional system or organ. Presenting symptoms usually are uniform, such as bleeding in coagulation defects. The second category arises from defects affecting one metabolic pathway common to a large number of cells or organs such as lysosomal storage disease. The age of onset and range of organ involvement can give clues to a given inborn error of metabolism. One exception to the rule of presentation is mitochondrial disease. Mitochondrial diseases are a group of heterogenous disorders that can involve any organ, with any symptom at any age. In the pediatric age group,
there are two peaks of disease onset, neonatal and later infancy/childhood. Most mitochondrial diseases presenting during the neonatal period are severe, with mortality >60% by age 3 years. The predominant disease etiologies are nuclear gene mutations. Boys and girls are equal affected. Neurologic symptoms including unexplained encephalopathy, nystagmoid eye movements, seizures, muscle hypotonia, basal ganglia disease, ataxia, and microcephaly. As time progresses, up to 97% have neurologic involvement. Nonspecific features of failure to thrive and persistent vomiting are common initial findings. Most have multiorgan involvement including cardiac, respiratory and gastrointestinal systems. The median age of onset in the infant/child age is about 2 years. Males are more affected (1.5:1). Mitochondrial disease syndromes due to mitochondrial DNA(mtDNA) mutations begin to present during this period. Additional neurologic presentations appear; status epilepticus and myoclonic seizures, myopathy (or exercise intolerance), neuropathy, hearing loss, and migraine headache. Most (> 90%) have neurologic involvement. The range of other involved organ systems increases, with renal, endocrine, and gastrointestinal (especially liver failure) becoming more prominent. Approximately 65% of mitochondrial disease has onset before age 20, but disease onset can occur until late maturity. Prevalence (1.5:1) in males continues. Most adult presentations are due to mtDNA mutations. The exception are diseases caused by the mtDNA replicate, polymerase gamma 1 (POLG). Mutations in POLG produce diseases at all ages and are common in adult diseases. The most notable additional neurologic findings in adults are psychiatric and neurodegenerative disorders. Multisystem involvement remains high in the older population. In summary, mitochondrial diseases can present at any time with multiple organ involvement. The most prevalent organ system involved is the central nervous system. Males tend to have more disease than females. The range of presentation varies and may relate to genetic etiology.

**Imaging of Inborn Errors of Metabolism in the Neonate**

*Susan I. Blaser, MD, FRCPC*

**Genetic Approach to Metabolic Conditions**

*Sihoun Hahn, MD, PhD*

Dr. Sihoun Hahn is a Professor of Pediatrics and Medicine at University of Washington and Seattle Children’s Hospital serving as the director of clinical biochemical genetics program and the director of biochemical and molecular genetics laboratory. He is board certified in Clinical Genetics and Clinical Biochemical Genetics. After finishing pediatric residency at Korea University Medical Center, Dr. Hahn enrolled in medical genetics fellowship at the National Institutes of Health, Bethesda, MD, where he was the recipient of a National Research Service Award Fellowship. He was an Associate Professor of Pediatrics, Medical Genetics and Laboratory Medicine at Mayo Clinic in Rochester, MN before he joined the faculty at the University of Washington. His work focuses on developing clinical tests using tandem mass spectrometry and high-throughput next-generation sequencing technology. He is an author of over 70 peer-reviewed articles, several book chapters and many review articles. Dr. Hahn serves as a member of the medical advisory committee for WA State Newborn Screening. Dr. Hahn hopes to improve clinical practice through integrated laboratory testing

**Presentation Summary**

Inborn errors of metabolism (IEM) are individually rare, but collectively numerous. Newborn screening (NBS) has opened new perspective in preventive medicine. Since the first application to the detection of phenylketonuria in 1961 using dried blood spot sample, NBS has expanded rapidly in the past decade to allow the detection of many disorders of amino acid, organic acid and fatty acid metabolism enabling early diagnosis and preemptive treatment before permanent complications develop. However, it is important to remind that there are over 1,000 metabolic conditions that cannot be detected by this approach. Clinical suspicion of IEM relies on the recognition of key symptoms but they often are nonspecific and overlap with other conditions such as seizure or infectious disease. Initial approach to metabolic conditions therefore requires several exclusion analyses. If you suspect mitochondrial disease, you may need to exclude the possibility of congenital disorders of glycosylation or fatty acid oxidation defect as they can develop secondary mitochondrial dysfunction. Functional investigations are followed based on the measurement of intermediary metabolites in body fluids. The classic example is the enzyme assay for glycogen storage disorders which requires fresh or frozen liver tissue for the confirmation. As many of functional tests require specific tissue such as muscle or liver, simple direct DNA analysis on the sample obtained from peripheral blood is becoming a standard alternative to many functional assays. Nevertheless, diagnosis of IEM cannot always be achieved by metabolic screening or genetic testing. Additional investigations also do not lead to the diagnosis while there is a strong suspicion of a metabolic disorder. One good example is again mitochondrial disease as you will hear more from Dr. Saneto in this panel discussion. It is indeed difficult to prioritize the genes to be sequenced, as there is no predominantly mutated gene, while sequencing all candidate genes is not feasible with traditional method. While some patients have mtDNA mutations, the majority of cases are thought to be due to mutations in the nuclear genes which encode the largest part of the organelles components. Advances in genome sequencing technology offer a new opportunity to solve the genetic basis of many unknown metabolic cases. Recently, we developed and validated the next generation sequencing technology to selectively enrich and sequence targeted exons from 800 genes simultaneously. Next generation sequencing for targeted genes may be readily applicable to patients, in particular, for selected cohort of patients with similar clinical symptoms.


**Tuesday Afternoon**

**5:00 PM - 6:30 PM**

**Ballroom 6A**

(27) Advanced Imaging Seminar: Imaging Brain Hemodynamics

(353) PWI: Quantitation and Validation
   — Timothy J. Carroll, PhD

(354) CSF Flow Imaging
   — William G. Bradley, Jr., MD, PhD, FACR

(355) Imaging Brain Oxygen Metabolism
   — Weili Lin, PhD

Moderator: Peter B. Barker, D.Phil

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**Perfusion-Weighted Imaging: Quantitation and Validation**

*Timothy J. Carroll, PhD*

**Presentation Summary**

The development of a means to quantify physiologically related to cerebral perfusion using magnetic resonance imaging (MRI) has been identified as a priority by the American Heart and Stroke Association. A wide approach to the measurement of cerebral blood flow (CBF) with MRI is to inject a gadolinium-based contrast agent and to calculate parametric images of CBF, cerebral blood volume (CBV) and mean transit time (MTT). Quantification of CBF (in ml/100g min) and CBV (in ml/100g) is very difficult due to nonlinearities in the MRI signal as well as delay and dispersion effects. We will discuss recent progress in the quantification of cerebral perfusion. Special emphasis will be placed on the “bookend technique” which has shown early success in this regard. We will give a very basic review of the MRI imaging protocols used to create perfusion imaging discussing both noncontrast [Arterial Spin Labelling, (ASL)] and contrast-enhanced [dynamic susceptibility contrast (DSC)] approaches. The difficulties and pitfalls associated with cerebral perfusion imaging will be discussed. Recent results on validation, test-retest reliability and technical improvement will be presented. Special emphasis will be placed on use of these new approaches in the patient studies. Recent results in the intended patient populations will be shown.

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**Cerebrospinal Fluid Flow Imaging**

*William G. Bradley, MD, PhD, FACR*

**Presentation Summary**

Cerebrospinal fluid (CSF) flow imaging is a phase-contrast, cardiac-gated cine technique which is used most commonly to measure the volumetric flow of CSF through the aqueduct in patients with clinical normal pressure hydrocephalus (NPH). Like phase-contrast MRA, the encoding velocity (Venc) is set prospectively; we use Vencs of 10cm/sec, 20 cm/sec and 30 cm/sec for patients being considered for shunting for NPH. We use a 512x512 matrix over a 16 cm FOV positioned perpendicular to the aqueduct with flow-encoding in the slice direction. When the velocities in each 0.312 mm voxel are multiplied by the area of the voxel, the volumetric flowrate is determined. By integrating over the area of the aqueduct, the volumetric flow (ml/sec) through the aqueduct is determined. By integrating over all systolic phases of the cardiac cycle, we determine the volume of CSF flowing down during systole. The average of the volume down during systole and up during diastole is called the “aqueductal CSF stroke volume (1)”. In normals, this is about 40 microliters, although this measurement is highly machine-dependent. We like to see twice normal (stroke volume > 80ul) to call “hyperdynamic CSF flow”. In patients with clinical symptoms of NPH and imaging findings of communicating hydrocephalus, the finding of hyperdynamic CSF flow correlates nicely with shunt-responsiveness (2). By using CSF flow imaging and other measures of hyperdynamic flow over the past three decades, we have begun to piece together a possible etiology for idiopathic NPH. We now feel that NPH begins as benign external hydrocephalus in infancy with CSF drainage via the extracerebral space of the brain as well as the fourth ventricle. With deep white matter ischemia in late adulthood, flow through the extracerebral space is impeded, leading to hydrocephalus and symptoms of NPH (3).

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**REFERENCES**

3. Bradley, WG, Bahl, G, Alksne, JF. Idiopathic normal pressure hydrocephalus may be a “two hit” disease: Benign external hydrocephalus in infancy followed by deep white matter ischemia in late adulthood. *JMRI* 2006 (Oct);24:747-755

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**Imaging Brain Oxygen Metabolism**

*Weili Lin, PhD*

**Presentation Summary**

While blood oxygen level dependent (BOLD) contrast has been employed widely to shed light on our understanding of how the brain works, quantitative measurements of BOLD effects (or susceptibility effects) are less popular. Specifically, it has been demonstrated that quantitative measures of BOLD may enable the estimates of cerebral oxygen metabolism. To this end, this presentation focuses on reviewing current approaches for obtaining quantitative measurements of cerebral oxygen metabolism using BOLD (susceptibility) effects, including the underlying biophysical mechanisms, the imaging sequences, and the potential clinical applications. Susceptibility effects at three different spatial scales with respect to imaging resolution will be
addressed, including microvasculature (<< imaging resolution), venules (<= imaging resolution), and large vessels (>> imaging resolution). For the microvascular level, imaging approaches to obtain quantitative measures of cerebral oxygen extraction fraction (OEF) have been demonstrated in both animal and human studies. Combining OEF with cerebral blood flow, quantitative measures of cerebral metabolic rate of oxygen utilization, an important physiologic parameter discerning the balance between oxygen demands and utilization, can be obtained. Clinical applications in cerebrovascular diseases utilizing this approach will be discussed. For the venule level, the susceptibility-weighted imaging approach is a great example for this scale level and has been utilized widely in revealing detailed cerebral venous vasculature. Finally, for the large vessel level, quantitative measures of T2 (T2*) have been utilized as a means to delineate blood oxygenation. In summary, this presentation will offer a comprehensive overview of current approaches for obtaining quantitative measurements of cerebral oxygen metabolism using MR imaging.
Purpose
To describe a rare case of necrotizing granulomatous angiitis of the central nervous system (CNS) associated with Hodgkin lymphoma.

Case Report
A 37-year-old man with a history of hypertension presented with 1 year of memory loss and a week of progressive gait instability and truncal ataxia. He also had noted a mass in his right neck for the last 2 weeks. Head imaging was performed, which showed an extensive enhancing abnormality in the brain of unknown etiology. CT of the body depicted right lower cervical and mediastinal lymphadenopathy, which was FDG-avid on PET. A cervical lymph node FNA revealed classical Hodgkin lymphoma, nodular sclerosis subtype (stage IIA). At 3 weeks after presentation, repeat head MR imaging (MRI) showed clear progression of the brain abnormality. A right frontal stereotactic brain biopsy then was performed, which disclosed a necrotizing granulomatous angiitis. In situ hybridization for varicella zoster virus (VZV) was negative. The patient was begun on corticosteroids and ABVD chemotherapy (Adriamycin, bleomycin, vinblastine, and dacarbazine). Granulomatous angiitis of the CNS is a rare and frequently fatal condition. It has been associated with herpes zoster virus, VZV, HIV, sarcoidosis, non-Hodgkin lymphoma, and Hodgkin lymphoma. Treatment is with corticosteroids and immunomodulating chemotherapy. When associated with Hodgkin lymphoma, it can present before or after the Hodgkin lymphoma itself presents, and it has been speculated that the angiitis in this setting represents a paraneoplastic syndrome.

Imaging Findings
Head MRI depicted a diffuse abnormality of the deep centrum semiovale and corpus callosum which was hyperintense on T2-weighted images and enhanced in a patchy and linear fashion, suggestive of a perivascular component. There was no restricted water diffusion in these abnormalities, but there were a few small foci of paramagnetic effect, also hyperintense on CT, likely small foci of hemorrhage.

Summary
We present a rare case of necrotizing granulomatous angiitis of the CNS associated with Hodgkin lymphoma. Because Hodgkin lymphoma involvement of the brain is exceedingly rare, an enhancing brain abnormality in a patient with known Hodgkin lymphoma should first raise the possibility of associated granulomatous angiitis or infectious encephalitis. Brain biopsy is needed to confirm the diagnosis. Awareness of the entity and a high level of suspicion by the neurosurgeon and neuropathologist are pivotal in obtaining a representative diagnostic sample, thereby minimizing the likelihood of a “nonspecific” or “false-negative” biopsy result. The neuroradiologist can help in this regard by preoperatively suggesting the possibility of this diagnosis.

Key Words: Granulomatous angiitis, Hodgkin lymphoma, brain.
Paper 357 Starting at 6:50 AM, Ending at 6:55 AM
Kikuchi-Fujimoto Disease: Brain Involvement with Malignant Features on MR Spectroscopy and MR Perfusion

Sarkodie, B. D.1 • Mourelatos, Z.2 • Mamourian, A.2
1Korlebu Teaching Hospital, Accra, GHANA, 2University of Pennsylvania, Philadelphia, PA

PURPOSE
Advanced MR imaging has been reported to be valuable for differentiating malignant from infectious or inflammatory disease in the brain. We report the imaging findings of a discrete enhancing brain lesion that proved to be an extranodal manifestation, Kikuchi disease. There are very few reports of central nervous system (CNS) involvement with this disease. Furthermore, this benign brain lesion demonstrated malignant features on advanced MR imaging (MRI).

CASE REPORT
This 44-year-old female presented with recent headaches and worsening symptoms of imbalance. Her past medical history of remarkable for a 15-year history of lymphadenopathy and during that time had several lymph node biopsies, all reported as showing reactive changes. In 2007 she developed night sweats and PET imaging demonstrated multiple hypermetabolic nodes in the retroperitoneum and mesentery. Nodal biopsy was again negative for lymphoma.

IMAGING FINDINGS
On the basis of her CNS symptoms an MR scan was obtained. Using a 3T MR unit (Siemens, Erlangen, Germany) scans demonstrated a right occipital mass with central enhancement and surrounding T2 prolongation. Advanced imaging also was available and the enhancing portion of the lesion demonstrated on MR perfusion examination an elevated rCBV that was six times that of the contralateral brain. Multivoxel MR spectroscopy (MRS) also was obtained which showed an elevated choline/creatinine ratio and a reversed choline/NAA ratio which also may occur with acute demyelination, but the perfusion scan demonstrated marked elevation of rCBV compatible with malignancy.

Because of these aggressive imaging features a biopsy of the brain lesion was performed. This demonstrated a nodular, necrotizing inflammatory lesion without acute inflammatory findings. All stains and cultures for micro-organisms were negative. At this time, based on her history and findings on repeated biopsies, the diagnosis of Kikuchi-Fujimoto disease was established.

SUMMARY
While unusual, in a patient with known or suspected Kikuchi disease and neurologic symptoms encephalitis should be considered in the differential diagnosis. Advanced MR imaging, while helpful in many cases for discriminating benign from malignant CNS disease, was misleading in this case of Kikuchi disease. Not only did the MRS have malignant features, which also may occur with acute demyelination, but the perfusion scan demonstrated marked elevation of rCBV compatible with malignancy.

KEY WORDS: MR spectroscopy, MR perfusion

Paper 358 Starting at 6:55 AM, Ending at 7:00 AM
Pseudo Hyperdense Middle Carotid Artery Sign in a Patient with Acute Herpes Simplex Virus Encephalitis

Thacker, P. • Miller, G. • Campeau, N. • Wijdicks, E.
Mayo Clinic Rochester, MN

PURPOSE
To illustrate a case of herpes simplex virus (HSV) encephalitis which presented with confounding clinical and imaging findings, including false hyperdense middle cerebral artery (MCA) sign on CT, leading to the erroneous initial diagnosis of acute MCA infarction.

CASE REPORT
A 57-year-old woman with no significant past medical history presented to the emergency department with a 3-hour history of confusion. On the day of presentation, the patient’s husband received a phone call from a neighbor several blocks away stating that his wife was found stumbling in the neighbor’s back yard confused and thinking that she was walking her dog. The patient was brought to the emergency department by her husband. On initial examination by the emergency neurology service, she was noted to be somewhat confused, but alert. She had difficulty following one-step commands and was unable to name the current President. Physical examination revealed a dense homonymous hemianopsia. Remainder of the examination was otherwise negative. An initial noncontrast head computed tomography (CT) study revealed a hyperdense MCA sign. The acute stroke team was mobilized. A CT angiogram/CT perfusion study then was obtained, but did not support ischemic stroke, therefore thrombolytic therapy was not administered. Subsequent brain MR imaging (MRI) and lumbar puncture with PCR of the cerebrospinal fluid confirmed the final diagnosis.

IMAGING FINDINGS
Initial noncontrast head CT demonstrated hypodensity of the right temporal lobe, inferior frontal, and parietal lobes in the vicinity of the MCA, leading to appearance of asymmetric
right MCA hyperintensity and mimicking a hyperdense MCA sign. CT angiogram and CT perfusion demonstrated a widely patent right MCA and diffusely increased perfusion of the right temporal lobe. Subsequent MRI of the brain demonstrated heterogeneously enhancing signal involving the right greater than left posterior inferior frontal lobes and limbic formations, compatible with HSV encephalitis.

**SUMMARY**
The hyperdense MCA sign refers to the CT appearance of increased attenuation of the proximal MCA resulting from the presence of acute intraluminal thrombus, typically present in 35-50% of acute MCA territory infarctions. This case illustrates that a pseudo positive hyperdense MCA sign on CT imaging can occur with HSV encephalitis. Unlike other previously reported mimics of hyperdense MCA such as increased hematocrit and arterial wall calcification, the clinical presentation of HSV encephalitis can overlap that of infarction, and knowledge of this pseudo hyperdense MCA sign is essential in preventing catastrophic misadministration of thrombolytic therapy.

**KEY WORDS:** Hyperdense MCA, herpes encephalitis, stroke mimicker

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**Paper 359 Starting at 7:00 AM, Ending at 7:05 AM**

**Ependymal Enhancement as a Manifestation of Neuromyelitis Optica**

Lui, Y. W.¹ • Sonni, S.²

¹New York University Medical Center, New York, NY, ²Albert Einstein College of Medicine/Montefiore Medical Center, Bronx, NY

**PURPOSE**
To describe a manifestation of neuromyelitis optica (NMO) which has not been reported previously and to review the pathophysiology of the disease that may contribute to ependymal enhancement.

**CASE REPORT**
Thirty-nine-year-old female with a prior clinical history of optic neuritis and a previous diagnosis of systemic lupus erythematosus (SLE) presents with acute right hemiparesis. Lumbar puncture is notable for the lack of oligoclonal bands and the patient is serum NMO antibody positive. Neuromyelitis optica is a demyelinating disorder characterized clinically by extensive longitudinal transverse myelitis and optic neuritis. While previously thought to be a variant of multiple sclerosis, the discovery of the autoantibody NMO IgG has distinguished NMO as a separate and unique entity. Similar to multiple sclerosis, NMO has a propensity to occur in young and middle-aged women, and has been associated with other autoimmune disorders, particularly, SLE. Neuromyelitis optica IgG autoantibody selectively binds to the aquaporin-4 water channel (AQP4) which has high expression in the central nervous system, particularly at the blood-brain barrier, the glia-limitans, and the ependyma. Aquaporin-4 water channel plays a key role in water content of the central nervous system and has been implicated in the pathophysiology of brain and spinal cord edema.

**IMAGING FINDINGS**
MR imaging of the spine demonstrates long-segment T2 hyperintensity and enhancement within cervical and upper thoracic cord, characteristic of NMO. Brain MR imaging demonstrates smooth and thin enhancement along the ependymal surface of the frontal horns of the lateral ventricles. To our best knowledge, this finding has not been reported previously in NMO and may be related to the relative high expression of AQP4 in ependymal cells.

**SUMMARY**
Neuromyelitis optica is a unique immune-mediated demyelinating disorder. Imaging findings include optic nerve edema and/or atrophy and long-segment spinal cord signal abnormality. We describe smooth ependymal enhancement in a patient with antibody-positive NMO which may be due to high expression of AQP4 in the ependyma.

**KEY WORDS:** Demyelination
Paper 360 Starting at 7:05 AM, Ending at 7:10 AM

Steroid Responsive Encephalopathy Associated with Autoimmune Thyroiditis (Previously Known as Hashimoto’s Encephalopathy) Mimicking Creutzfeldt-Jakob Disease

Sarwar, A. • Moonis, G
Beth Israel Deaconess Medical Center
Boston, MA

PURPOSE
Highlight atypical imaging features of steroid responsive encephalopathy associated with autoimmune thyroiditis (SREAT) (previously known as Hashimoto’s encephalopathy) mimicking Creutzfeldt-Jakob disease clinically and on imaging.

CASE REPORT
A 48-year-old right-handed woman with a history of hypothyroidism, was healthy and an active social mother and housewife until 2 years prior to admission when she started developing extremity tremors, speech difficulty, abnormal gait, anxiety, and behavioral changes. She came as an outpatient to our institution and had an EEG that showed slowing and disorganization of background rhythm suggestive of encephalopathy. In addition brief bursts of slowing in right frontocentral region were noted. No epileptiform discharges or electrographic seizures or abnormal photic driving was present.

IMAGING FINDINGS
MR imaging (MRI) showed symmetric nonenhancing T2 and FLAIR signal abnormalities within caudate nuclei and putamen, in concert with a classic cortical ribbon sign on the diffusion-weighted images (Figures 1 and 2). A diagnosis of Creutzfeldt-Jakobs disease was suggested and a cerebrospinal fluid (CSF) exam was ordered. Her CSF exam came back normal and was negative for prions or protein 14-3-3. Review of her history revealed a history of Hashimoto’s thyroid disease since 1995. She has been poorly compliant to medications and most recently her thyroid panel was as follows: T3: 122 FT4 (Free T4): 1.6 Anti-TPO (antithyroid peroxidase antibodies): 505 Anti-Tg (antithyroglobulin antibodies): >3000. A presumptive diagnosis of Hashimoto’s encephalopathy was made and the patient started on high dose steroids, with resulting improvement in the clinical symptoms.

SUMMARY
Hashimoto’s encephalopathy better known as steroid responsive encephalopathy associated with autoimmune thyroiditis (SREAT), first described by Lord Brain in 1966, is a rare disorder that is seen in patients with elevated antithyroid antibody titers. Symptoms that have been attributed to SREAT include stroke-like episodes, transient aphasia, tremor, ataxia, sleep disturbance, headache, psychosis as well as visual hallucinations. The disease is reported to mimic Creutzfeldt-Jakob disease clinically. Most cases reported in the literature have MRI showing diffuse white matter FLAIR and T2 signal hyperintensities and/or dural enhancement. Our’s is the first case to report the basal ganglia and cortical findings on MRI in SREAT which mimic Creutzfeldt-Jakob disease. It is important to be aware of this appearance so that a correct diagnosis may be suggested in the appropriate clinical setting.

KEY WORDS: SREAT, Hashimoto's encephalopathy, Creutzfeldt Jakob disease

Paper 361 Starting at 7:10 AM, Ending at 7:15 AM

Cryptococcal Meningitis as a Cause of Vascular Narrowing

Kang, A. • Haynor, D.
University of Washington
Seattle, WA

PURPOSE
Demonstrate a case of cryptococcal meningoencephalitis producing narrowing of both MCA’s, shown on MR imaging (MRI)/MR angiography (MRA).

CASE REPORT
A 56-year-old man receiving prednisone for Wegener’s granulomatosis presented with confusion and progressive weakness. Initial cerebrospinal fluid (CSF) and serum studies were positive for cryptococcus neoformans with normal opening pressures. Cytology and flow cytometry were negative for B cells, plasma or malignant cells. He was treated with ambisone/flucytosine initially. The prednisone was tapered and MRI obtained. He subsequently was changed to fluconazole and then to amphotericin. The final diagnosis was cryptococcal meningoencephalitis.

IMAGING FINDINGS
MR imaging with contrast (Figure 1) demonstrates a nodular area of meningeal enhancement and parenchymal edema adjacent to the right MCA trifurcation with associated high-grade vessel narrowing seen on MRA (Figure 2). Moderate irregularity of the left A1 and proximal M1 segments, which also were involved with disease, also is noted on the MRA. Abnormal enhancement of the ependyma and choroid plexi was present. No infarct was seen on diffusion-weighted imaging (DWI). Imaging findings previously described in central nervous system (CNS) cryptococcosis range from no abnormality to meningeal enhancement, ventriculomegaly, and meningoencephalitis with pseudocysts in the basal ganglia, thalamus, midbrain, cerebellum and the periventricular regions. These pseudocysts may demonstrate diffusion restriction. Granulomatous lesions also have been described.
The differential diagnoses include neoplasm, granulomatous disease, brain abscess and arteriovenous malformation. Vascular narrowing has been described in the context of other angioinvasive microorganisms such as aspergillus. To the best of our knowledge, it has not been demonstrated previously in association with cryptococcal infection.

**SUMMARY**
A case of cryptococcal meningitis associated with vascular narrowing and multifocal enhancement. Although vascular narrowing is not commonly associated with cryptococcal infection, we conclude that this may occur, either as a result of direct vascular invasion or more likely secondary to associated inflammation.

**KEY WORDS:** Cryptococcal, vascular, narrowing

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**Paper 362 Starting at 7:15 AM, Ending at 7:20 AM**

**Case of Repeated “Clinically Mild Encephalitis/Encephalopathy with a Reversible Splenial Lesion”**

Nakatsuka, T. • Inaoka, T. • Morita, H. • Watanabe, Y. • Hasebe, T. • Nakano, K. • Terada, H.

'Toho University Sakura Medical Center, Sakura, JAPAN, 'Kyosai Tachikawa Hospital, Tachikawa, JAPAN

**PURPOSE**
We first report a case of repeated “clinically mild encephalitis/encephalopathy with a reversible splenial lesion (MERS)”.

**CASE REPORT**
A 34-year-old man presented with 1-week history of fever, sore throat and diarrhea, followed by dysarthria, disorientation and delirium. He had no medical or drug history of note. On admission, the patient was febrile with a maximum temperature of 38 degrees Celsius. Physical and neurologic examinations were otherwise unremarkable. Blood investigations revealed elevated neutrophil count, elevated CRP, and low levels of sodium. The patient was started on intravenous antibiotics.

**IMAGING FINDINGS**
Magnetic resonance (MR) imaging of the brain on admission showed a well defined ovoid lesion with mild T2 signal prolongation in the center of the splenium of corpus callosum (SCC). The lesion was hyperintense on isotropic diffusion-weighted imaging. The rest of the brain was normal. One week after admission, the patient became afebrile and a follow-up MR imaging showed complete resolution of the central splenial lesion. Based on the clinical picture and imaging findings, a diagnosis of MERS was made. Three years later, he came back to our hospital with 2-day history of fever up and headache with no neurologic abnormality. Blood investigations revealed elevated neutrophil count, elevated CRP, and normal levels of sodium. MR imaging of the brain on admission showed SCC lesion and follow-up MR imaging showed complete resolution of the central splenial lesion.

**SUMMARY**
While the pathophysiology of reversible SCC lesions is still unclear, this case highlights that some patients have vulnerability to reversible splenial lesion of SCC.

**KEY WORDS:** MERS, reversible splenial lesion

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**Paper 363 Starting at 7:20 AM, Ending at 7:25 AM**

**CT Perfusion of Deep Venous Thrombosis with Infarction**

Nguyen, V. N. • Quigley, E. P.

University of Utah
Salt Lake City, UT

**PURPOSE**
Demonstrate critical role of CT perfusion in the rapid diagnosis and treatment of cerebral deep venous occlusion.
**CASE REPORT**

A 79-year-old male presented to our tertiary stroke center 4 hours after acute onset of dysarthria and aphasia. Upon arrival at our institution, patient evaluation by stroke service yielded NIH Stroke Scale Score of 11. At this time patient was aphasic, with difficulty following commands and worsening bilateral lower extremity weakness. After admission, the patient continued to have rapid neurologic decline and became comatose with upper and lower extremity rigidity. Patient was intubated for airway protection. Despite rapid treatment intravenous anticoagulation therapy, patient was unable to recover from his initial injury. After a prolonged hospital course, the patient was eventually transferred to a long-term acute care facility.

**IMAGING FINDINGS**

Nonenhanced and contrast-enhanced CT brain demonstrated subtle but symmetric decreased attenuation of the deep gray nuclei and deep gray matter. Per our stroke protocol, a concurrent CTA/V neck and brain was performed with findings of nonopacification of the deep cerebral veins, basal veins of Rosenthal vein of Galen and the straight sinus. Concurrently performed CT perfusion showed profound and symmetric decreased cerebral blood flow, increased cerebral blood volume, and increased mean transit time in the basal ganglia, thalami and deep white matter. A follow-up MR imaging (MRI) performed within 2 hours of presentation demonstrates bilaterally symmetric FLAIR and T2 hyperintensity of thalami, deep gray nuclei and periventricular white matter. Of note, no areas of true restricted diffusion were present on diffusion tensor images. However, susceptibility artifact on GRE images of deep venous structures helped confirmed the diagnosis of deep venous thrombosis of the straight sinus, vein of Galen, internal cerebral veins and basal veins of Rosenthal.

**SUMMARY**

This case demonstrates rapid diagnosis of deep venous thrombosis by CT perfusion. To our knowledge, this is the first reported case of CT perfusion diagnosis of cerebral deep venous thrombosis. The additional CT perfusion parameters of cerebral blood flow, cerebral blood volume, and transit time can provide valuable information for rapid diagnosis and treatment guidance of this neurologically devastating, but potentially reversible injury.

**KEY WORDS:** Deep venous thrombosis, CT perfusion, ischemia

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**Paper 364 Starting at 7:25 AM, Ending at 7:30 AM**

Thromboembolic Posterior Circulation Infarction with Persistent Trigeminal Artery

Fitzgerald, R. T. • Samant, R. S. • Angtuaco, E. J. • Amole, A. O.

University of Arkansas for Medical Sciences

Little Rock, AR

**PURPOSE**

The persistent trigeminal artery (PTA) is the most common of several fetal remnant carotid-vertebrobasilar anastomoses with a reported prevalence of 0.1-0.6% in adults. Only a small number of posterior circulation infarctions attributed to PTAs have been reported in the literature. We report a case of acute left thalamic infarction in a patient with a right PTA (Saltzman type I) with fetal right posterior cerebral artery (PCA), absent left posterior communicating artery, and a hypoplastic vertebrobasilar system. Additional small infarcts within the right cerebral hemisphere suggest origin of embolic material from the right internal carotid artery (ICA) with transmission to the left thalamus via the PTA, as vascular supply to the left PCA territory was entirely via the PTA. This case illustrates the importance of recognizing the PTA as a potential mechanism for posterior circulation infarctions from ipsilateral ICA sources, in this case likely from nonflow-limiting atherosclerotic disease.

**CASE REPORT**

Our patient is a 51-year-old male with a past medical history of ethanol abuse, hypertension, and hyperlipidemia who presented to the ED following the abrupt onset of confusion and right upper extremity dysmetria/dysdiadochokinesia, right hemi-body paraesthesias, and ataxic gait. Due to his history of ethanol abuse, he was given thiamine with modest improvement in his confusion and ataxia. Subsequent management included aggressive pharmacologic risk factor modification.

**IMAGING FINDINGS**

The initial noncontrast CT showed low attenuation changes within the left thalamus suggestive of acute infarction. MR imaging confirmed the acute nature of the left thalamic infarction and also revealed several punctate foci of restricted diffusion within the right cerebral hemisphere consistent with additional small infarcts. Time-of-flight MR angiography demonstrated a right PTA, fetal origin of the right PCA, and hypoplastic vertebrobasilar system with high-grade stenosis or occlusion of the mid-basilar artery. Subsequent CT angiography of the head and neck revealed nonopacification of the mid-distal basilar artery. The right PTA was continuous across the midline to become the left PCA. Nonflow-limiting atherosclerotic disease was present within the proximal right internal carotid artery potentially representing the source of thromboembolic material.
SUMMARY
Our case highlights the role of the PTA in potentially devastating thromboembolic posterior circulation infarctions. In addition to cases attributed to carotid atherosclerotic disease as seen in this case, the PTA also may serve as a mechanism of posterior circulation infarcts in the setting of traumatic injury such as ICA dissection or as a complication of catheter angiography.

KEY WORDS: Persistent trigeminal artery, thalamic infarction

Paper 365 Starting at 7:30 AM, Ending at 7:35 AM

Added Diagnostic Value of Susceptibility-Weighted BOLD Images in Conjunction with Diffusion-Weighted Imaging in Diagnosing Diffuse Microvascular Occlusion Contributing to Hypoxic-Ischemic Encephalopathy in a Patient with Hemoglobin SC Disease

Zhiva, E. • Shah, R. • Goldberg, A.
Metrohealth Medical Center
Cleveland, OH

PURPOSE
Diagnostic value of susceptibility-weighted (SW) blood oxygenation level dependent (BOLD) sequence in diagnosing acute diffuse microvascular occlusion contributing to hypoxic-ischemic encephalopathy in patient with hemoglobin SC disease.

CASE REPORT
A 56-year-old female with a history of hemoglobin SC disease and diabetes presents obtunded to the emergency department. Initial head CT was unremarkable. A CT of the chest demonstrated LLL infiltrate consistent with aspiration pneumonitis. The EEG was suggestive of severe diffuse encephalopathy.

IMAGING FINDINGS
Scattered hyperintense foci are seen throughout gray and white matter on FLAIR sequence. Patchy restricted diffusion involves cortical and subcortical gray matter diffusely on diffusion-weighted imaging (DWI). The BOLD sequence demonstrates innumerable foci of increased susceptibility, predominantly involving supratentorial cortical and subcortical gray and white matter. Although no MRA was obtained, there is normal flow void in the major intracranial vessels and there are no basilar telangiectatic collaterals (moyamoya) on the FSE T2-weighted image.

SUMMARY
Hemoglobin SC disease is a genotypic variant of the sickle cell disease(SCD) umbrella that is much less common and generally milder form than the hallmark homozygous SS variant. Sickle cell disease affects almost any organ system, but cerebrovascular accidents(CVA) and chronic cerebral ischemia are some of the most disabling complications.
Cerebrovascular accidents in SCD has been linked predominantly to macrovascular disease, especially the internal carotid artery and circle of Willis. Risk of ischemic cerebrovascular events has a bimodal distribution in SCD, being highest during the first decade and after age 30. However, due to the longer life expectancy attributed to the hemoglobin SC phenotype, stupor and coma in older patients without other obvious manifestations of a sickling hemoglobinopathy is a potential clinical presentation. In conclusion, our case demonstrates acute and extensive cerebral microvascular thrombosis in a patient with hemoglobin SC disease, which has not been reported in the literature to the best of our knowledge.

**KEY WORDS:** Hemoglobin SC, microvascular, BOLD

**Paper 366 Starting at 7:35 AM, Ending at 7:40 AM**

**Glioblastoma Arising from a Cortical Tuber in Tuberous Sclerosis**

Katsura, M. • Mori, H. • Sasaki, H. • Kunimatsu, A. • Ikemura, M. • Shibahara, J. • Kawai, K. • Mizuguchi, M. • Ohtomo, K.

Graduate School of Medicine, University of Tokyo
Tokyo, JAPAN

**PURPOSE**
To review the pathophysiology and imaging findings of a cortical tuber in tuberous sclerosis transforming into glioblastoma multiforme.

**CASE REPORT**
A 34-year-old woman who had been followed up for tuberous sclerosis complex (TSC) was referred to our epilepsy clinic. After being seizure-free for more than 20 years, she started having complex partial seizures about 18 months ago, which had not been treated successfully with medication.

**IMAGING FINDINGS**
Her neurologic examination also revealed motor aphasia and right upper extremity weakness, both worsening over the past 3 months. During the follow-up years, her head MRI had been taken regularly at our hospital, and her last scan 2 years ago showed multiple cortical tubers and subependymal nodules, which had not changed significantly in appearance compared with previous studies. This time, her imaging studies revealed a 6 cm cystic and solid mass occupying the left superior frontal lobe, which appeared to be located very close to one of the pre-existing cortical tubers. The solid component of the mass contained calcification, appeared hypointense on MR T2-weighted imaging with restricted diffusion, and showed irregular peripheral enhancement. Other imaging findings included intratumoral hemorrhage detected with susceptibility-weighted imaging, increased relative cerebral blood volume on perfusion imaging, and increased choline with lactate doublet on MR spectroscopy; all highly suggestive of high-grade malignancy. The mass was surgically resected and examined. Histologically, the mass was a glioblastoma multiforme demonstrating pseudopalisading necrosis and hyperplastic blood vessels. Based on molecular and genetic analysis, the tumor was considered as a secondary glioblastoma, atypically originating from a cortical tuber in TSC.

**SUMMARY**
Tuberous sclerosis complex is an autosomal dominant disorder characterized by hamartomatous lesions in various organs such as the brain, skin, kidneys and heart. It is well known that TSC occasionally is associated with brain tumors. However, with few exceptions, these have been giant cell astrocytomas developing from subependymal nodules, and tumor formation is very rare in cortical tubers. Glioma-like proliferation within tissues excised as tubers in patients with tuberous sclerosis complex have been identified in literature. When tubers rapidly enlarge, especially when they are accompanied by findings such as increased vascularity, hemorrhage, and necrosis, the possibility of tumor formation should be considered. Although distinctive-ly uncommon, glioblastoma must remain in the differential diagnosis of tumors arising from cortical tubers.

**KEY WORDS:** Glioblastoma, tuberous sclerosis, cortical tuber

**Wednesday Morning**

**6:45 AM - 7:40 AM**

**Ballroom 6A**

(E006) Excerpta Extraordinaire: Pediatrics
(Scientific Papers 367 - 377)

See also Parallel Session
(E005) Excerpta Extraordinaire: Adult Brain III

**Moderator:** Peter Kalina, MD

**Paper 367 Starting at 6:45 AM, Ending at 6:50 AM**

**An Unusual Cause of Watershed Territory Infarcts in a Child**

Hingwala, D. R. • Thomas, B. • Chandrasekharan, K. • Kapilamoorthy, T. R. • Abraham, M.

Sree Chitra Tirunal Institute for Medical Sciences and Technology
Thiruvananthapuram, INDIA

**PURPOSE**
To study an unusual cause of water-shed territory infarcts (postoperative cerebral vasospasm).
CASE REPORT
A 6-year-old male child with intractable complex partial seizures of right hemispheric origin and a right hemispheric porencephalic cyst underwent right hemispherectomy. On day 10 of surgery, he became aphasic with depressed consciousness. Vital parameters were stable.

IMAGING FINDINGS
MR imaging (MRI) showed ACA - MCA watershed territory acute infarcts in the left cerebral hemisphere. Digital subtraction angiography showed focal stenosis of both cavernous ICAs and proximal left MCA and ACA. We performed chemical angioplasty which resulted in significant resolution of the vasospasm. Check angiogram performed on day 2 of the procedure showed restenosis. Chemical angioplasty was repeated. Patient showed significant improvement in the consciousness 10 days after the procedure.

SUMMARY
Our patient developed watershed infarcts 10 days after a major surgery (hemispherectomy) which involved opening up of the basal cisterns. Other more common causes of watershed infarcts like hypoperfusion, hypotension or basal exudates due to meningitis were excluded. Hence, vasospasm was suspected. Several mechanisms have been postulated for pathogenesis of vasospasm following intracranial surgery and especially post tumor resection of the skull base. These include accumulation of blood breakdown products in the basal cisterns and manipulation and damage to blood vessel walls in addition to others. In a postoperative patient who is otherwise stable, altered consciousness and sudden deterioration with MRI showing watershed infarcts should raise the suspicion of vasospasm. While this spasm can be visualized on CT or MR angiography, a low threshold for conventional angiogram with chemical/mechanical angioplasty is appropriate. This case serves to reinforce the point that watershed infarcts in a postoperative patient in the appropriate clinical setting should suggest vasospasm which should be detected at the earliest for appropriate management.

KEY WORDS: Watershed territory infarct, vasospasm, post-operative

Figure: Diffusion-weighted image shows an acute infarct in watershed territory in left cerebral hemisphere (low ADC values not shown). Digital subtraction angiography (left common carotid injection, lateral view) shows focal tight stenosis of left cavernous and supraclinoid ICA).

Paper 368 Starting at 6:50 AM, Ending at 6:55 AM
Distinct Cerebrovascular Imaging Features in Patients with R179H, Heterozygous Mutation of ACTA2 Gene
Mankad, K. • Munot, P. • Ganesan, V. • Saunders, D. E. Great Ormond Street Hospital London, UNITED KINGDOM.

PURPOSE
Mutations in the ACTA2 (Alpha Actin 2) gene are known to be associated with thoracic aortic aneurysm, arterial dissection, coronary artery disease and the moyamoya syndrome (defined as progressive vasculopathy characterized by slowly progressive stenosis involving the proximal aspects of the major intracranial arteries with compensatory hypertrophy of basal collateral arteries). We describe three cases with a novel mutation of the ACTA2 gene (heterozygous R179H). Critical analysis of the neuroimaging features in these patients reveals characteristic morphology of cerebrovascular disease, which is distinct from classical moyamoya syndrome.

CASE REPORTS
All three cases had persistent ductus arteriosus and unreactive dilated pupils identified at birth; Cases 1 and 3 also had aortic dilatation and respiratory difficulties (mixed obstructive and restrictive pattern). The neuroimaging findings are tabulated (Table 1). Typical imaging features also are depicted as a comparison with typical moyamoya syndrome (Image 1).

Table 1

<table>
<thead>
<tr>
<th>Demographics</th>
<th>Case 1</th>
<th>Case 2</th>
<th>Case 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age/sex</td>
<td>6 yrs/F</td>
<td>6 yrs/F</td>
<td>6 yrs/M</td>
</tr>
<tr>
<td>Neurology</td>
<td>Persistent left-to-right ductus arteriosus, hypotension</td>
<td>Persistent left-to-right ductus arteriosus, hypotension</td>
<td>Persistent left-to-right ductus arteriosus, hypotension</td>
</tr>
<tr>
<td>Infarct size</td>
<td>Large left MCA territory infarct</td>
<td>Large left MCA territory infarct</td>
<td>Large left MCA territory infarct</td>
</tr>
<tr>
<td>Vascular imaging</td>
<td>Long-segment fusiform dilation of the ICA, with sparing of the terminal ICAs and proximal ACA and multiple microaneurysms (MACAs). Abnormalities of the more distal intracranial vessels.</td>
<td>Platform dilation of the ICA with bilateral occlusive disease of the terminal segments.</td>
<td>Long-segment aneurysms of the ICAs, with aneurysms of the intracranial vessels.</td>
</tr>
</tbody>
</table>

Imaging Findings
The cerebrovascular phenotype associated with the R179H heterozygous ACTA2 mutation is characterized by long segment bilateral occlusive disease of the terminal internal carotid arteries (ICAs) with proximal fusiform dilatation and
attenuation of the distal intracranial vasculature. Other features are the absence of both hypertrophied basal collateral arteries and posterior circulation involvement. The appearances of the intracranial vasculature in this ACTA2 mutation are characteristic and distinct from those seen in moyamoya disease.

SUMMARY
The typical neurovascular imaging findings can guide clinicoradiologic diagnosis and direct specific neurogenetic testing.

KEY WORDS: ACTA 2, R179H, cerebrovascular

Paper 369 Starting at 6:55 AM, Ending at 7:00 AM
Childhood Primary Angiitis of the Central Nervous System Presenting with Panuveitis and Anisocoria

Sigley, M.¹ • Saettele, M.¹ • Nielsen, D.² • Miller, D.³ • Morelli, J.N.⁴
¹University of Missouri-Kansas City/St. Lukes Hospital, Kansas City, MO, ²Children’s Mercy Hospital and Clinics, Kansas City MO, ³University of Missouri-Kansas City, Kansas City, MO, ⁴Scott & White University, Kansas City, MO

PURPOSE
The purpose of this case is to report panuveitis and anisocoria as the initial clinical presentation of childhood primary angiitis of the central nervous system (cPACNS) and to illustrate the classical MR imaging (MRI) appearance of cPACNS. Childhood primary angiitis of the central nervous system is a rare, poorly understood vasculitis that preferentially involves the perivascular spaces. This entity must be distinguished from other disorders in order to initiate prompt treatment and avoid significant morbidity/mortality.

CASE REPORT
We report a 10-year-old female with 1 year history of bilateral panuveitis, anisocoria and increased intraocular pressure. Workup including inflammatory markers and extensive infectious disease and rheumatologic evaluation was negative. Cerebrospinal fluid (CSF) analysis revealed only elevated protein. MR imaging showed T2-hyperintense, enhancing, nodular foci with mild restricted diffusion throughout the brain, brainstem, and spinal cord in the distribution of the perivascular (Virchow-Robin) spaces. The orbits, optic nerves, and chiasm were normal by MRI. There was rapid resolution of symptoms with steroid administration. A biopsy confirmed the diagnosis. The patient is currently symptom free.

IMAGING FINDINGS
Childhood primary angiitis of the central nervous system has a typical appearance on MRI including T2-hyperintense, enhancing, nodular foci following the perivascular spaces, with a strong tendency towards involvement of the lenticulostriate vascular territory. Spinal cord involvement is seen in approximately 50% of cases and has a similar imaging pattern. The radiologist may be the first to suggest this diagnosis, allowing the clinician to limit an extensive, costly, and potentially unrevealing workup. In a review of 66 children with PACNS, Aviv et al. demonstrated that biopsies were often inconclusive or normal and are rarely performed. In addition, a 40% false negative rate occurs with catheter angiogram. Therefore, while biopsy and angiogram may be considered the gold standards in adults with PACNS, they are less helpful in children. In children, a preliminary diagnosis cPACNS may be based on clinical symptoms, CSF findings, and MRI appearance. Improvement with steroid therapy is thought to confirm the diagnosis.

SUMMARY
Childhood primary angiitis of the central nervous system is a rare disorder that primarily affects the perivascular spaces. This is the first report know to us of cPACNS presenting with panuveitis and anisocoria. This case also illustrates the imaging features of cPACNS and its presence in the distribution of the perivascular spaces. While the clinical presentation and workup of cPACNS may be confusing, the appearance on MRI is typical and may preclude further workup.

KEY WORDS: Childhood primary angiitis of the CNS, vasculitis, perivascular

Paper 370 Starting at 7:00 AM, Ending at 7:05 AM
Collision in the Inferior Olive: Hypertrophic Olivary Degeneration Complicated by Treatment Necrosis in a Child Treated for a Brainstem Primitive Neuroendocrine Tumor

Litkowski, P. • Jeon, J. • Patel, G. V. • Gilheeney, S. • Wolden, S. • Souweidane, M. • Young, R. J.
Memorial Sloan-Kettering Cancer Center New York, NY

PURPOSE
To describe a child who developed hypertrophic olivary degeneration after surgery for a brainstem primitive neuroendocrine tumor (PNET), and then developed treatment necrosis of the medulla.

CASE REPORT
A 4-year-old girl presented with new onset of falls, asymmetric gait, right gaze palsy and left eye drooping. Imaging revealed a dorsally exophytic, well circumscribed, expansile
nonenhancing mass lesion in the right pons. A stereotactic biopsy was performed using a right suboccipital approach. Pathology revealed a primitive neuroendocrine tumor with abundant neuropil and true rosettes. After subtotal resection of approximately 85% of the tumor, the patient underwent craniospinal irradiation to 2340 cGy with the tumor bed including the medulla boosted to 5760 cGy. Concurrent chemotherapy consisted of daily carboplatin and vincristine. The patient is doing well now 5 months after completion of therapy, without new complaints in particular without myoclonus or palatal tremor.

**IMAGING FINDINGS**
One month after completion of chemoradiation therapy, MRI revealed a stable surgical cavity in the dorsal right pons and stable adjacent expansile T2 hyperintense nonenhancing tumor. A new separate expansile T2 hyperintense lesion was found in the ventral right medulla, in the expected location of the inferior olive, consistent with hypertrophic olivary degeneration. Diffusion tractography seeded with the red nuclei and inferior olive showed discontinuity of the ipsilateral central tegmental tract. Three months later, MRI revealed increased T2 hyperintense changes in the pons and medulla, and new patchy enhancement in the right medulla, which were both confluent with the inferior olive. A follow-up MRI performed 1 month later showed decreased brainstem T2 hyperintense changes and medullary enhancement, consistent with improving radiation or treatment necrosis.

**SUMMARY**
Hypertrophic olivary degeneration is a unique phenomenon caused by disruption of the triangle of Guillain and Mollaret. We present a child who developed hypertrophic olivary degeneration after subtotal resection of a brainstem PNET due to disruption of the central tegmental tract, which connects the red nucleus and the inferior olive. The course was further complicated by treatment necrosis of the medulla that has spontaneously improved. Proper recognition of these coexisting pathologies is important for clinical management decisions in patients who may develop nontumoral complications of the inferior olive.

**KEY WORDS:** Radiation necrosis, brainstem glioma, olivary degeneration

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**Paper 371 Starting at 7:05 AM, Ending at 7:10 AM**

**Perivascular Pus**
Church, A. • Livingston, B. • Ralston, M.
Maine Medical Center
Portland, ME

**PURPOSE**
To showcase abnormal decreased diffusion secondary to pus traveling through the perivascular spaces in the setting of pneumococcal meningitis complicated with status epilepticus.

**CASE REPORT**
An 8-month-old female with normal prenatal and postnatal history, delivered by cesarean section, transferred to our hospital with lethargy from pneumococcal meningitis. Blood cultures obtained were positive for streptococcus pneumonia. A lumbar puncture showed low glucose (5; normal 40-70mg/dL), high protein (113; normal 15-45 mg/dL), elevated white blood cell (103; normal 0-30/cmm) and gram positive cocci in pairs. She received vancomycin and ceftriaxone therapy. Evening of the admission, she experienced a focal seizure comprising leftward eye and left head deviation. The patient received lorazepam and fosphenytoin, and her seizure did not recur. Cultures were sensitive for ceftriaxone and she received a total therapy for 14 days. Before discharge, she had minimal right-sided weakness, poor visual tracking across midline, and difficulty sitting and holding up her head. She has unilateral hearing deficit on inpatient screening exam.

**IMAGING FINDINGS**
MR imaging (MRI): Diffusion-weighted imaging (DWI) demonstrates abnormal increased intensity along perivascular spaces with corresponding decreased signal on apparent diffusion coefficient (ADC) map.

**SUMMARY**
Abnormal decreased diffusion can be seen in a multitude of scenarios: ischemic stroke, abscess, empyema, tumor. Pus is defined as a fluid, consisting of dead neutrophils, bacteria, debris, and transudate from leaky vessels. Some have proposed that it is the viscosity of this fluid, changing the tortuosity of the extracellular space, that decreases the diffusion of water in the setting of infection. Fanning, et al. have shown that clinical response to treatment of intracranial pus collections correlates with elevation of ADC values. Rose, et al. postulated that the perivascular lymphoplasmocytic infiltration seen on pathology correlates with pus formation, rep-
resented by abnormal diffusion in their case study. Our case showcases possible pus traveling along the perivascular spaces, represented by abnormal diffusion on MR.

**KEY WORDS:** Pediatrics, infection

**Paper 372 Starting at 7:10 AM, Ending at 7:15 AM**

**Infantile Hemangiopericytoma: A Distinct and Benign Clinical Entity**

Kalra, V. B. • Malhotra, A.

Yale University
New Haven, CT

**PURPOSE**
Infantile (or congenital) hemangiopericytoma is a distinct clinical entity with a more benign course than malignant hemangiopericytomas seen in older children and adults.

**CASE REPORT**
A two-month-old term baby boy undergoes a CT for evaluation of enlarging head circumference. A 3 cm lobulated mass in the left frontal extra-axial space is seen exerting mass effect and midline shift. Subsequent CTA and MR/MRA were performed to further characterize the lesion. A surgical resection was performed; upon histologic analysis, the mass was shown to be an infantile hemangiopericytoma. No tumor recurrence has been seen as of 1 year after resection.

**IMAGING FINDINGS**
Initial CT demonstrated a 2.8 x 2.2 x 3.0 cm extra-axial iso-dense mass in the left frontal lobe with faint calcifications. The mass exerted mass effect, compressing the frontal horn of the left lateral ventricle, and minimal midline shift. Minimal calvarial thinning at the base of the lesion could be appreciated. CT angiography showed the lesion to have intense heterogeneous enhancement with feeding vessels from the middle meningeal artery and ICA. MR imaging/MR angiography showed the single lesion to be heterogeneously slightly hypointense on T1 and hyperintense on T2. Large flow-voids were seen within the lesion and no restricted diffusion was seen. Follow-up imaging, up to 1 year after resection, showed no evidence of tumor recurrence.

**SUMMARY**
Infantile hemangiopericytoma is a distinct clinical entity with a more benign course than malignant hemangiopericytomas seen in older children and adults. New pathology literature suggests that infantile hemangiopericytomas exist on a spectrum of benign myofibroblastic lesions including myofibromatosis. It is important to distinguish a hemangiopericytoma from a meningoma. Awareness of the more benign course of infantile hemangiopericytomas compared to those seen in older children and adults is important when recommending follow-up imaging.

**KEY WORDS:** Hemangiopericytoma, pediatric neoplasms

**Paper 373 Starting at 7:15 AM, Ending at 7:20 AM**

**Solitary Juvenile Xanthogranulomas in Two Adolescent Girls**

Patel, R. • Deisch, J. K. • Cope-Yokoyama, S. D. • Koral, K.

1University of Texas Southwestern Medical Center at Dallas, Dallas, TX, 2Children's Medical Center, Dallas, TX

**PURPOSE**
To describe imaging findings of juvenile xanthogranuloma (JXG) in two adolescent girls.

**CASE REPORT**
Case 1: 15-year-old female presented with back pain for 6 weeks and more recent history of progressive lower extremity weakness and feet numbness. She was not able to flex her left foot on physical examination. MR imaging of the spine showed an extradural mass at the dorsal aspect of the spinal canal, centered at T9 level. There was mass effect on the spinal cord without myelomalacia. The mass measured approximately 2.5 cm craniocaudally. The greatest axial diameter was 1.3 cm. The mass was predominantly hypointense on T2-weighted images and isointense to muscle on T1 (Figure 1). There was intense homogeneous enhancement following administration of intravenous contrast material. Diagnostic considerations included lymphoma and primitive neuroectodermal tumor. The mass was resected surgically. Pathology was consistent with juvenile xanthogranuloma (JXG). The symptoms resolved following surgery. At follow-up imaging 4 months postoperatively, there was no recurrence.

Case 2: 14-year-old female presented with 2-month history of headache and left facial numbness. MR imaging of the brain showed a mass in the left Meckel’s cave involving the cisternal segment of the left trigeminal nerve (Figure 2). The mass extended to the nerve entry zone. The mass was homogeneously T2-weighted hypointense and showed restricted diffusion. There was intense and homogeneous enhancement following administration of intravenous contrast material. Diagnostic considerations included lymphoma and primitive neuroectodermal tumor. The mass was resected surgically. Pathology was consistent with juvenile xanthogranuloma (JXG). The symptoms resolved following surgery. At follow-up imaging 4 months postoperatively, there was no recurrence. Case 2: 14-year-old female presented with 2-month history of headache and left facial numbness. MR imaging of the brain showed a mass in the left Meckel’s cave involving the cisternal segment of the left trigeminal nerve (Figure 2). The mass extended to the nerve entry zone. The mass was homogeneously T2-weighted hypointense and showed restricted diffusion. There was intense and homogeneous enhancement of the lesion with intravenous contrast. Diagnostic considerations included nerve sheath tumors and meningioma. Biopsy of the lesion was consistent with JXG. At 9-month follow up the lesion was stable in size.
SUMMARY
Juvenile xanthogranuloma is a non-Langerhans cell histiocytosis. Skin is the most common site of involvement. Intracranial and spinal sites have rarely been described. Although rare, Meckel’s cave involvement is characteristic.

KEY WORDS: Xanthogranuloma

Paper 374 Starting at 7:20 AM, Ending at 7:25 AM
Hemangioma of the Cavernous Sinus: Report of a Case in a Child
Litkowski, P. • Jeon, J. • Huse, J. • Gilheeney, S. • Souweidane, M. • Haque, S. • Khakoo, Y. • Young, R. J.
Memorial Sloan-Kettering Cancer Center
New York, NY

PURPOSE
Hemangiomas are rare benign intracranial vascular tumors. Hemangiomas of the cavernous sinus are even more rare in children, with only a few cases reported in the literature. Because of their likelihood for bleeding during surgery, preoperative diagnosis is important for safe treatment planning. Here we report a pathologically proved case of a hemangioma located in the cavernous sinus to highlight the characteristic radiologic findings.

CASE REPORT
An 11-year-old boy presented with a 2-month history of diplopia and paresis of the right sixth cranial nerve. Magnetic resonance (MR) images demonstrated a well circumscribed extra-axial mass located in the right cavernous sinus. Over the next 5 months, growth of the mass prompted surgery for diagnosis and relief of mass effect. Several biopsies were obtained using an endoscopic trans-sphenoidal approach. Upon histologic examination, the tumor was determined to be a benign vascular tumor with little mitotic activity. There were no architectural features characterizing vascular malformations. These findings were consistent with a congenital nonprogressive hemangioma.

IMAGING FINDINGS
MR images demonstrated a 3.5 x 2.6 cm well circumscribed extra-axial mass lesion in the cavernous sinus with T1 hypointense signal (relative to gray matter) and marked T2 hyperintense signal. The lesion showed early heterogeneous enhancement that progressed on subsequent contrast sequences to late homogenous enhancement. Punctate foci of T1 hyperintense and T2 hypointense signal were consistent with calcifications. The cavernous internal carotid artery was completely encased, but not narrowed.

Figure. Cavernous hemangioma in 11-year-old male. Coronal T2-weighted image (A) shows expansile tumor centered in right cavernous sinus with hyperintense signal and punctate hypointense calcifications. Coronal contrast T1-weighted image (B) shows early heterogeneous enhancement that became homogenous on subsequent contrast sequences (not shown).
SUMMARY
Hemangiomas in the cavernous sinus are rare, but can be properly diagnosed based on their characteristic T2 hyperintense signal and progressive enhancement pattern. The most common incorrect diagnosis in patients with hemangiomas of the cavernous sinus is meningioma. Unlike hemangiomas, however, meningiomas typically display T1 and T2 isointense signal with homogeneous enhancement, enhancing dural tails and narrowing of the internal carotid artery.

KEY WORDS: Cavernous sinus, MR imaging, contrast

Paper 375 Starting at 7:25 AM, Ending at 7:30 AM
Sacrococcygeal Teratoma with Intramedullary Involvement: Extra-Axial Intracranial and Intraspinal Metastases

Patton, A.1 • Schettino, C. J.2 • Merinbaum, D. J.2 • Dokler, M. J.2 • Heger, I. M.1
1Mayo Clinic, Rochester, MN, 2Nemours Children's Clinic, Jacksonville, FL, 3Shands Jacksonville Medical Center, Jacksonville, FL

PURPOSE
To present the clinical, radiologic and pathologic findings of an unusual case of sacrococcygeal teratoma, first diagnosed on antenatal sonography, and determined to have direct intrapelvic, intraspinal with intramedullary spread, as well as extra-axial intracranial and intraspinal metastases.

CASE REPORT
A 32-week-gestation infant was delivered by cesarean section due to fetal distress. Sacrococcygeal teratoma had been diagnosed at 20 weeks gestation and the "tumor" demonstrated marked rapid growth and progressive hydronephrosis in the week prior to delivery. She required intubation, pressure ventilator support, fluids and packed cells during the immediate postnatal period. On examination, she had a very large sacrococcygeal mass, a distorted anus, and there was no spontaneous movement of her lower extremities.

IMAGING FINDINGS
CT and MR imaging after delivery revealed a large complex sacrococcygeal mass with presacral and intraspi nal extension. There were multilevel segmentation anomalies including partial sacral agenesis and diastematomyelia. The large sacral neoplasm was widely excised. The intraspinal components were removed via multilevel laminotomy and myelotomy. "Routine" head sonography at 3 months of age demonstrated an extraaxial right frontal mass which avidly enhanced on MR imaging. The serum alpha-fetoprotein was elevated markedly. The surgical pathology revealed metastatic teratoma. Subsequent MR of the brain and spine demonstrated extraaxial mass lesions in the basal cisterns and spinal canal. She subsequently has been treated with chemotherapy and her response monitored by serum alpha-fetoprotein levels.

SUMMARY
We present radiologic-pathologic correlation of an unusual case of sacrococcygeal teratoma with intramedullary extension, multifocal extraaxial, intracranial metastases, but without osseous or lung lesions.

KEY WORDS: Sacrococcygeal teratoma, intramedullary neoplasm, intracranial metastases

Paper 377 Starting at 7:35 AM, Ending at 7:40 AM
Pediatric Hemiplegic Migraine: MR Susceptibility-Weighted and Perfusion Imaging Findings

Agarwal, A.1 • Altinok, D.2
1Detroit Medical Center, Troy, MI, 2Children Hospital of Michigan, Troy, MI

PURPOSE
1. To review the MR imaging findings including susceptibility-weighted imaging (SWI) and perfusion abnormalities in a case of hemiplegic migraine. 2. Discussion on role of imaging in hemiplegic migraine.

CASE REPORT
An 11-year-old right-handed female presented to the emergency services with right-sided weakness, numbness, tingling, diffuse headache associated with vomiting and confusion. The patient had similar episodes 1 year earlier, which resolved within 24 hours. She had a history of occasional bifrontotemporal headaches without photosensitivity or phonosensitivity but with occasional vomiting. Family history was significant for olivopontocerebellar atrophy (OPCA). Her father also had history of epilepsy. On neurologic examination, she had global aphasia, right-sided upper motor neuron facial weakness and right-sided hemiparesis with motor strength of 4/5. The deep tendon reflexes were symetric in both upper and lower extremities. A lumbar puncture was performed and the opening pressure was 38 cm H20. An EEG showed focal delta slowing in the left hemisphere but no epileptiform activity was noted. MR imaging brain including susceptibility-weighted sequence and MR perfusion was performed. Diffusion-weighted images showed a small area of restricted diffusion in the left parietal lobe. Perfusion MR imaging showed a large area of diminished perfusion in the left parieto-temporal lobes. On susceptibility-weighted MR imaging, there were prominent vessels in the left cerebral hemisphere likely due to venous stasis. A possibility of stroke versus vasculitis was given based on the imaging findings. All other studies regarding hypercoagulation as well as autoimmune disorders were negative except mildly elevated CRP and ESR. Cerebrospinal fluid (CSF) and plasma lactate as well as serum homocysteine levels were normal. The symptoms of the patient resolved after 2 days. A follow-up MRI done after 3 days was normal with bilateral symmetric flow. The follow-up MRI was done on the same magnet and using exactly the same sequences and techniques. A clinical diagnosis of hemiplegic migraine finally was made.

IMAGING FINDINGS
In our present case, perfusion MR imaging was performed during the aura phase with evidence of unilateral cerebral hypoperfusion contralateral to the side of aura. Susceptibility-weighted MR imaging demonstrated prominent hypointense cortical veins in the left middle cerebral territory suggesting relatively increased deoxyhemoglobin in the draining veins within the acutely ischemic region. There was a small area of restricted diffusion in the left parietal lobe. So, the SWI findings correlated very well with the diffusion and MR perfusion
in the aura phase. The MR perfusion performed after the attack was normal. The focal area of restricted diffusion seen in the prior study also resolved. The SWI demonstrated symmetric cortical veins in both the cerebral hemispheres.

**SUMMARY**

We conclude that in cases of suspected hemiplegic migraine, it will be cost-beneficial to add the SWI sequence to the conventional MRI imaging protocol. Susceptibility-weighted imaging is a noninvasive sequence which may provide some ancillary information in cases of hemiplegic migraine. We also believe that SWI will play a role in better future understanding of the vascular events in migraine headache.

**KEY WORDS:** Hemiplegic, migraine, susceptibility

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**Wednesday Morning**

**7:45 AM - 8:45 AM**

**Ballroom 6 B/C**

(28) Maintenance of Certification (MOC)-Review Session (AR) T-Bone/Skull Base and Paranasal Sinus

(378) T-Bone/Skull Base

— Nancy J. Fischbein, MD

(379) Paranasal Sinus

— Deborah R. Shatzkes, MD

Moderator: Suresh K. Mukherji, MD, FACR

An Educational grant was received by Bayer Healthcare Pharmaceuticals, Inc., in support of the audience response (AR) technology in the Maintenance of Certification (MOC) Review Sessions.

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**Presurgical Mapping and Intraoperative Imaging: A Neurosurgeon’s Perspective**

*Sujit S. Prabhu, MD, FRCS*

Dr. Sujit S. Prabhu is presently the Associate Professor, Department of Neurosurgery, Division of Surgery at The University of Texas M. D. Anderson Cancer Center and Adjunct Associate Professor, Department of Neurosurgery, Division of Surgery at Baylor College of Medicine, Houston, Texas. Dr. Prabhu received his MD degree in medicine and surgery in 1984 from Government Medical College Bellary, in Karnataka, India. His postgraduate training was at the FR Muller’s Hospital in Mangalore, India from 1984 - 1986. Dr. Prabhu has had numerous fellowships from 1987 in Mangalore, India to Plymouth, England, 3/1991 - 7/1991 to Preston, England 8/1991 - 1/1994, to Richmond, Virginia 2/1994 - 6/1996, 1996 - 2001, 7/2000 - 6/2001, and had a Clinical Fellowship, Neurosurgical Oncology, Department of Neurosurgery, at The University of Texas M. D. Anderson Cancer Center under Dr. Franco DeMonte from 8/2001 - 12/2002.

**LEARNING OBJECTIVES**

Upon completion of this presentation, participants will be able to:

1) Describe the various types of presurgical planning procedures prior to glioma surgery.
2) Summarize the strengths and weaknesses of each planning procedure as it relates to intraoperative orientation.
3) Identify the “team approach” to surgical planning and the role of the surgeon in the process.
PRESENTATION SUMMARY
The surgical resection of gliomas adjacent to eloquent cortex and subcortical white matter carries a higher morbidity. Gliomas, as a result of being a heterogeneous group of tumors and infiltrative in nature are a surgical challenge. A number of retrospective and prospective studies for the resection of gliomas have identified maximal safe resection as playing a pivotal role to extend both overall survival (OS) and progression free survival (PFS). The role of fMRI and neuropsychologic evaluations as presurgical planning tools are well established. However the use of fMRI data as it compares to direct electrical stimulation (DES) techniques during surgery is controversial. Functional navigation using DTI (diffusion tensor imaging) and DES is used widely and beneficial during tumor resection. The role of ADC (apparent diffusion coefficient) maps with other quantitative imaging modalities including dynamic susceptibility contrast imaging (DSC-MRI), dynamic contrast-enhanced imaging (DCE-MRI) and magnetic resonance spectroscopy (MRS) have further enhanced our abilities as surgeons to understand the biology of gliomas and plan safe and optimal surgical trajectories to these tumors. This presentation will discuss the role of the surgeon to critically identify and evaluate the existing presurgical and surgical technologies that have evolved over the last few years to benefit the patient during surgery.

REFERENCES

Presurgical Mapping: A Neuroradiologist’s Perspective
John L. Ulmer, MD

Challenges for Memory and Cognitive Mapping in Clinical Populations
David S. Sabsevitz, PhD

Wednesday Morning
10:45 AM - 11:00 AM
Ballroom 6 B/C

(30) ASNR Presidential Address
— Carolyn Cidis Meltzer, MD, FACR

Wednesday Morning
11:00 AM - 11:10 AM
Ballroom 6 B/C

(31) ASNR Award Announcements
- 2011 Gold Medal Award
- 2011 Honorary Medal Award
- 2010 Outstanding Presentation Awards
- The Foundation of the ASNR Scholar Award in Neuroradiology Research
- The Foundation of the ASNR Fellowship in Basic Science Research Awards
- The Foundation of the ASNR Research Scientist Award
Wednesday Morning

11:10 AM - 11:45 AM
Ballroom 6 B/C

(32) Keynote Speaker: This Is Your Brain on Conflict of Interest (COI)

This Is Your Brain on Conflict of Interest (Economic and Psychologic Insights on Human Behavior in Response to COIs)
— George Loewenstein, PhD

Wednesday Afternoon

1:15 PM - 2:45 PM
Room 606-609

(34) ASHNR Programming: Head and Neck Cancer: Pre-Treatment Evaluation and Initial Staging: What You Need to Know

— Wendy R.K. Smoker, MD, FACR

— Hemant A. Parmar, MBBS, MD

— Yoshimi Anzai, MD, MPH

Moderator: Christine M. Glastonbury, MBBS

Pre-Treatment Evaluation of the Primary Site: What You Should Mention in Your Report

Wendy R.K. Smoker, MD, FACR

Presentation Summary
Due to time constraints, this presentation will be limited to discussion of upper aerodigestive tract and oral cavity malignancies (nasopharynx, oropharynx subsites, and oral cavity subsites). The goal of any imaging is to assist in staging as accurate staging is critical for optimal treatment planning and in overall prognosis. This involves assessment of pri-
mary tumor extent as well as an assessment of the lymph nodes. It is useful to be familiar with the criteria used in the TNM classification for the various stages of malignancies in these regions (i.e., what increases the “T” status). Areas that should be assessed and mentioned in the report are listed below for each primary site: Nasopharynx: (MR is preferred imaging modality). T1 - tumor is confined to the nasopharyngeal mucosal space; Evidence of eustachian tube dysfunction (levator muscle involved)?...look for fluid in mastoid air cells. T2 - does tumor extend down to lateral oropharynx (tonsil) or to paranasal sinuses (sphenoid frequently involved)? T2a-N0 involvement of parapharyngeal space. T2b- involvement of parapharyngeal space. T3- Retropharyngeal, prevertebral space or osseous invasion (basisphenoid and basiocciput). T4-Perineural tumor extension (V2 and V3 primarily) or perivascular spread via foramen lacerum? Evidence of intracranial extension (via foramen of Morgagni), orbital involvement, or infratemporal fossa extension? Nodal disease: 90% at presentation. First affected are retropharyngeal, levels II-V nodes. Oropharynx (base of tongue and tonsil): T1-lesion is 2cm or less in greatest dimension. T2-lesion is >2cm and <4cm in size. T3-lesion is >4cm in size. T4 - Involvement of deep muscles of the oral tongue? Pterygoid muscles? Floor of mouth? Mandible? Hard palate? Hypopharynx? Nasopharynx? Base of Tongue: Extension across the midline? Invades oral tongue? Reach tonsil via glossotonsillar sulcus? Extension to soft palate? Hypopharynx? 50%-80% nodal disease at presentation, levels II-V (30% bilateral). Tonsil: Extension to base of oral tongue? Parapharyngeal space? Floor of mouth? Soft/hard palate? Nasopharynx? 75% nodal disease at presentation, levels I-V. PNT uncommon. Oral Cavity (oral tongue, floor of mouth, retromolar trigone, gingiva, lip): T1, T2, and T3 same as for oropharynx above. T4 - Is there involvement of deep muscles of the tongue? Floor of mouth? Mandible? Inferior alveolar nerve with PNT extension? Oral Tongue: Does tumor encroach upon or cross the midline (usually mandates nonsurgical organ preservation as treatment)? Extension to floor of mouth and sublingual space (evidence of Wharton duct obstruction; Involvement of neurovascular pedicle)? Mandible? Extension to tongue base? 34-60% nodal disease at presentation, levels I-III.

Common Pathways of Perineural Spread

Hemant A. Parmar, MBBS, MD

LEARNING OBJECTIVES

Upon completion of this presentation, participants will be able to:
1) Know the concept of perineural spread of head and neck cancers and its importance.
2) Recognize the reasons why this entity remains under diagnosed and learn ways to improve its detection.
3) Review critical neuroanatomy of the affected nerves, especially of the fifth and seventh cranial nerves.
4) Understand the imaging features of the perineural spread of head and neck cancer.

Lymph Node Metastasis: What Nodes Are Most at Risk and What Study Should I Order?
Yoshimi Anzai, MD, MPH

PRESENTATION SUMMARY

The presentation will address the roles of imaging studies in the assessment of lymph node metastasis in patients with head and neck cancer. The current literature review on diagnostic accuracy of various imaging studies for detection of nodal metastasis will be provided. Imaging findings of nodal metastasis, extracapsular spread, and carotid invasion will be addressed. Emphasis will be on the CT and MR protocols, anatomical classification, and high-risk lymph node station from various head and neck cancer. The added value of PET-CT in the treatment response evaluation for head and neck cancer will be discussed. In addition, the use of ultrasound imaging for thyroid cancer staging will be addressed.

REFERENCES


Wednesday Afternoon

1:15 PM - 2:45 PM
Ballroom 6A

(35) ASFNR Programming: Arterial Spin Label Perfusion Imaging

(391) Principles and Techniques
— Jeffrey M. Pollock, MD

(392) Clinical Applications
— Joseph A. Maldjian, MD

(393) State-of-Art and Future Directions
— Thomas T. Liu, PhD

Moderator: Joseph A. Maldjian, MD
Dr. Thomas Liu is an Associate Professor of Radiology and Bioengineering at the University of California San Diego (USCD), where he is also the Director of the UCSD Center for functional MRI. His research focuses on the development of novel acquisition, analysis, and modeling methods for neuroimaging, with a focus on functional MRI. His formal training is in the field of Electrical Engineering with a B.S. degree from the Massachusetts Institute of Technology and M.S. and Ph.D. degrees from Stanford University. He is currently the principal investigator of two NIH-funded R01 projects, including a project to establish and disseminate standard protocols for arterial spin labeling MRI. He has published over 40 peer-reviewed journal papers and 100 scientific abstracts.

**Presentation Summary**
Arterial spin labeling (ASL) MRI is a noninvasive method for measuring perfusion. Although it has been used to measure perfusion in a variety of organs, ASL has been used most commonly for the measurement of brain perfusion, also known as cerebral blood flow (CBF). Most ASL methods measure CBF by taking the difference of two sets of images: tag images, in which the magnetization of arterial blood is inverted or saturated, and control images in which the magnetization of arterial blood is fully relaxed. The ASL difference signal is proportional to CBF but also exhibits a complex dependence on a number of other physiologic parameters. Proper sequence design and parameter selection are necessary to obtain quantitative CBF measures that are robust to variations in physiology. There are currently three main classes of ASL methods: pulsed ASL, continuous ASL, and velocity-selective ASL. In this talk, I will review the current state-of-the-art for each of the different methods, and discuss the pros and cons of each method. I also will discuss how these methods can be adapted to image the vascular territories of selected feeding arteries. Finally, I will discuss ongoing developments that are designed to improve the robustness and usability of ASL for clinical applications.

**Welcome to the Real World**
*John E. Jordan, MD*

**Making the Transition**
*Donald F. Schomer, MD*

**The HMO Environment**
*Sung LoGerfo, MD*

**The Corporate Environment**
*Stephen T. Sweriduk, MD*

**Understanding the Food Chain**
*Robert M. Barr, MD*
Wednesday Afternoon

1:15 PM - 2:45 PM
Ballroom 6 B/C

(37) ASPNR Programming: 2011 ASPNR Interesting Case Team Competition: Blue Stars vs Red Stars vs Audience (AR)

— Ashok Panigrahy, MD
— Andrea Rossi, MD
— Erin Simon Schwartz, MD
— Marvin D. Nelson, MD

Moderators: Charles M. Glasier, MD
Tina Young Poussaint, MD

Wednesday Afternoon

1:15 PM - 2:45 PM
Room 602-603-604

(38) Managing Conflict of Interest in Radiology

— George Loewenstein, PhD
— Eric J. Russell, MD, FACR
— Gretchen A. Brodnicki, JD

Moderators: Carolyn C. Meltzer, MD
Burton P. Drayer, MD

Wednesday Afternoon

1:15 PM - 4:45 PM
Ballroom 6 B/C

(39a) Cerebrovascular Occlusive Disease II
(Scientific Papers 407 - 417)

See also Parallel Session
(39b) Interventional: Aneurysms II
(39c) Head & Neck: Paranasal Sinuses, Temporal Bones and Cervical Carotid Disease
(39d) Pediatrics: Congenital Malformations and Disorders

Moderators: R. Gilberto Gonzalez, MD, PhD
Max Wintermark, MD

Paper 407 Starting at 3:15 PM, Ending at 3:23 PM

Angiographic Reconstructions of Volumetric Perfusion CT for the Detection of Large Vessel Occlusion in Acute Stroke: Comparison with CT Angiography

Frölich, A. M. J. • Psychogios, M. N. • Schramm, R. • Klotz, E. • Knauth, M. • Schramm, P.

1University of Medicine Göttingen, Göttingen, GERMANY
2Siemens Medical Healthcare, Forchheim, GERMANY

Purpose
Multimodal CT imaging consisting of nonenhanced CT (NECT), CT angiography (CTA) and volume perfusion CT (VPCT) is an increasingly applied option for acute stroke imaging. In these patients, presence of large vessel occlusion is an important factor governing treatment decisions and possible endovascular therapy. The goal of this study was to compare the diagnostic sensitivity of angiographic VPCT reconstructions with conventional CTA for the detection of intracranial large vessel occlusion and stenosis.

Materials & Methods
Fifty-nine patients presenting for the evaluation of acute stroke received NECT, CTA and VPCT. All images were obtained on a 128-slice multidetector CT scanner. CT angiographic maximum-intensity projections of the head in the axial and coronal plane were reconstructed from CTA and from the peak arterial scan of the VPCT dataset. Two experienced neuroradiologists evaluated all images for presence of vessel occlusion and stenosis.
Results
Twenty patients (34%) had an occlusion of an intracranial artery segment. In 18 of these cases (90%), vessel occlusion was detected on both VPCT and CTA images. Arterial stenosis was present in 14 cases as detected by CTA (24%), most of these lesions also were seen on VPCT. Seven patients (12%) had a relevant pathology of the extracranial arteries, which were not included in the VPCT scan volume.

Conclusion
For the evaluation of acute stroke, obtaining angiographic VPCT reconstructions may be a time-efficient approach to detect acute intracranial vessel occlusion and evaluate patients for endovascular therapy. CT angiography will remain necessary in the subacute phase, especially to detect coexisting extracranial pathology.

Key Words: Volumetric perfusion CT, acute stroke, vessel occlusion

Paper 408 Starting at 3:23 PM, Ending at 3:31 PM
Longitudinal Tracking of Intracerebral Implanted Stem Cells by R2* Relaxivity in Chronic Stroke Patients

Lin, C.1•2•3 • Shen, W.1 • Lo, Y.1 • Ho, Y.1 • Peng, H.1 • Lin, C.1 • Chang, H.2•3 • Chen, J.1 • Chung, H.2 • Shyu, W.1 • Lin, S.1•4
1China Medical University Hospital, Taichung, TAIWAN, 2National Taiwan University, Taipei, TAIWAN, 3China Medical University, Taichung, TAIWAN, 4GE Healthcare Taiwan, Taipei, TAIWAN, 5China Medical University Beigang Hospital, Taichung, TAIWAN

Purpose
A growing number of studies highlight the potential of stem cell transplantation as a novel therapeutic approach for stroke in animal model. The purpose of our study is to track intracerebral implanted peripheral blood stem cell(CD34+) in chronic stroke patients. This is the first large clinical trial with longitudinal tracking of the magnetic nanoparticle-labeled intracerebral stem cell in patients with chronic stroke.

Materials & Methods
Stem cells were collected from the patients (autograft) and were labeled with superparamagnetic nanoparticles. Fifteen patients received intracranial stem cell implantation in operating room. Multiecho gradient sequence was performed on a 3T GE scanner with serial MRI scans for each patient: before the stem cell implantation, 1 day, 1 week, 1 month, 3 months, 6 months after stem cell implantation. The implanted stem cells labeled with superparamagnetic nanoparticles appeared as hypointensity on T2-weighted gradient images. We segmented the hypointense area from the brain using Fuzzy c-means clustering technique in Matlab. Then the T2* values of each hypointense voxel were calculated by performing fits of the 16 echo images to a monoexponential decay as a function of echo time: S = S0 exp(-TEi/T2*). The mean R2 relaxivity of hypointense area at each time point was calculated (Figure 1).

Results
Three patterns of superparamagnetic nanoparticle clearance are classified: 1) Pattern 1: Clearance quickly in 1 week. 2) Pattern 2: Much residue until one half year without much clearance. 3) Pattern 3: Clearance slowly with little residue until one half year (Figure 2).

Conclusion
We found some of the injected magnetic nanoparticles which labeled on the stem cell can be detected on the T2-weighted gradient images in the 6-month follow up. The clearance patterns are associated with the relative injected location to the infarcted lesion. This finding emphasizes the need to control for implanted stem cell location in relation to the stroke lesion.

Key Words: R2* relaxivity, stem cell, stroke
Crossed Cerebellar Diaschisis: Lessons from Whole Brain CT Perfusion

Eckart, D. • Rassner, U. • Shah, L. • Osborn, A. • Quigley, E.  
University of Utah  
Salt Lake City, UT

**Purpose**  
Crossed cerebellar diaschisis (CCD) is the phenomenon of disruption of blood flow to the contralateral cerebellar hemisphere in the setting of supratentorial ischemia. Interruption of the cerebropontocerebellar pathway, travelling in the middle cerebellar peduncles, is thought to be the most likely mechanism of this metabolic depression. Previously described on MR perfusion and nuclear medicine brain imaging, our study establishes the presence of CCD on CT perfusion in the setting of ischemia. This study establishes a statistically significant correlation between CCD and supratentorial ischemia. This study also compares the incidence of CCD in anterior cerebral artery (ACA), middle cerebral artery (MCA), and posterior cerebral artery (PCA) distribution infarcts.

**Materials & Methods**  
We performed a retrospective review of all whole brain CT perfusion exams during the period of 1 year (326 cases). Perfusion studies were performed on a Siemens Definition or Definition AS with a 4D-Spiral technique. Postprocessing was performed on a Syngo workstation, utilizing a deconvolution method. Cases with significant motion artifact or patient malpositioning were excluded (296 cases remaining). On cerebral blood volume, cerebral blood flow, and time to peak maps, a region of interest was drawn in the middle cerebellar peduncle and cerebellar hemispheres. A difference of greater than 10% between the right and left side was established to determine the presence or absence of CCD. When available, corresponding MR images were reviewed.

**Results**  
We found the incidence of CCD in the control group (no CT perfusion or MR evidence of ischemia or infarct) to be rare (2/225). The presence of CCD was detected in approximately 50% of cases of MCA distribution ischemia and 39% of cases with ACA, MCA, or PCA distribution ischemia. Three strategically located areas of ischemia (thalamic and basal ganglia lesions) identified on MRI were detected only as CCD on CT perfusion but were not visible on supratentorial CT perfusion maps, slightly increasing the sensitivity of ischemia detection on CT perfusion.

**Conclusion**  
When a supratentorial area of ischemia disrupts the cerebrocerebellopontine motor pathway, the finding of crossed cerebellar diaschisis can be seen on imaging. Our study demonstrates the finding of crossed cerebellar diaschisis on whole brain CT perfusion, supporting previously published nuclear medicine and MRI studies. Evaluation for CCD using region of interest calculations in the middle cerebellar peduncles or cerebellar hemispheres also may increase the sensitivity of CT perfusion in the detection of acute supratentorial ischemia.

**Key Words:** Crossed cerebellar diaschisis, CT perfusion, stroke

Clinical Evaluation of Standard and GRAPPA Parallel Diffusion Imaging: Effects of Reduction Factor and Spatial Resolution

Andre, J. B. • Zaharchuk, G. • Fischbein, N. • Augustin, M. • Skare, S. • Rosenberg, J. • Lansberg, M. • Kemp, S. • Wijman, C. • Albers, G. W. • Bammer, R.  
1Stanford University School of Medicine, Stanford, CA, 2University of Graz, Graz, AUSTRIA

**Purpose**  
Standard single-shot EPI-based diffusion-weighted imaging (DWI) is commonplace in neurologic imaging, particularly in evaluating for acute stroke, but suffers from poor spatial resolution and geometric distortion, compromising interpretation of small DWI lesions. Parallel imaging offers advantages for DWI in reducing readout time (via incomplete sampling of k-space), resulting in less distortion for given spatial resolution, and shortening echo time for a given b-value (with some preserved SNR). This technique yields reduced susceptibility artifacts, increased spatial resolution, and reduced eddy current distortions. This prospective NIH-funded study independently examined the effects of higher in-plane spatial resolution (192 vs 128 square matrix) and acceleration factor (R=1 and R=3) upon diagnostic confidence and image quality. Here we report the data of this trial.
RESULTS
Mixed-effects logistic regression with fixed factors of matrix size and reduction factor demonstrated that R=3 vs R=1 had the greatest effect on susceptibility artifact and quality with odds-ratios of 47±15.5, and 26±7.3. Lesion conspicuity was not decreased on the R=3 images despite reductions in echo time (and therefore reduced T2 shine through effect). Reduction factor had the greatest effect on overall image quality and geometric distortion. A higher matrix size also was preferred, regardless of whether or not parallel imaging was used.

CONCLUSION
Earlier studies have indicated that parallel imaging might improve diagnostic quality of DWI. However, whether higher matrix size or parallel imaging reduction factors individually or conjointly impact the diagnosis had not been investigated thus far. In this prospective study, readers found that accelerated scans (R=3) had improved image quality and decreased susceptibility artifact compared with unaccelerated standard DWI, without adverse effects on lesion conspicuity, subjective noise assessment, or motion artifact. Of the imaging conditions studied, we believe R=3 accelerated 192x192 matrix scans offer the best imaging conditions for clinical DWI at 1.5 T, and are preferred over either independently adjusted higher resolution or higher reduction factor.

KEY WORDS: Diffusion, parallel imaging, reduction factor

Paper 411 Starting at 3:47 PM, Ending at 3:55 PM
Structural Plasticity in Stroke Inferred by Probabilistic Tractography and Magnetoecephalography

Bucci, M.1 • Westlake, K.1 • Nguyen, C.1 • Amirbekian, B.1 • Parati, E.1 • Nagarajan, S.1 • Henry, R. G.1
1University of California San Francisco, San Francisco, CA, 1Istituto Neurologico C. Besta, Milano, ITALY

PURPOSE
To investigate neural plasticity as a result of structural connectivity changes of the hand motor network in stroke subjects assessed before and after a novel rehabilitation intervention, using q-ball fiber tracking algorithm (1) with connectivity metric. To apply a multimodal approach using time frequency reconstructions of magnetoecephalography data (tMEG) and High-angular resolution diffusion imaging (HARDI) diffusion MR.

MATERIALS & METHODS
We studied four stroke subjects in subacute phase after a stroke in the sensorimotor cortex of the right hemisphere and four controls. The stroke subjects received sensorimotor neurorehabilitation training of the upper extremity, delivered by a robotic device. The patient function was assessed with Fugl-Meyer (66). High-angular resolution diffusion imaging datasets were acquired before and after the intervention for stroke subjects and in single session for the four controls. For fiber tracking we used probabilistic QBall fiber tracking algorithm developed in our laboratory. Additionally bootstrap methods have been developed to estimate the probability of connectivity.

RESULTS
Seeding in MEG-based hand motor region with q-ball probabilistic fiber tracking in four controls, we successfully mapped the structural connectivity of the motor network yielding the known motor pathways (Figure1a). When seeding in MEG-based hand motor region of the ipsilesional and contralateral hemispheres in stroke patients with different degrees of recovery we observed improved structural connectivity for the ipsilesional M1 connections to contralateral M1 and to the ipsilesional ventral PMC in the patient with the best recovery score after the intervention and different degrees of structural changes that correlate with the functional outcome in other three patients. While our connectivity metric was already at 100% for the CST we observed an almost doubling of the visitation number (Figure1b). The spatial probability maps of the best improved stroke patient show reliable connections from M1 to CST and from M1 to PMv in which >50% of bootstrap connections were found in voxels between the seed and target regions (red). However, for M1 to M1c there is less reliable connections with <<50% of bootstrap connections (blue) (Figure 1c).
**CONCLUSION**

Our preliminary results are consistent with evidence from animal tracing studies showing plasticity over time of the structural connectivity of the regions involved in the hand motor network and demonstrate the ability of probabilistic q-ball fiber tracking to delineate the hand motor network and, when combined with the functional data from tMEG, to enable a better interpretation of the underlying plastic of the motor network in stroke.

**KEY WORDS:** Stroke, plasticity, tractography

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**Paper 412 Starting at 3:55 PM, Ending at 4:03 PM**

**Evaluation of the Impact of Transplanted Feridex-Labeled Neural Stem Cells, in the Presence and Absence of Erythropoietin, on the Evolution of Acute Infarct in a Rodent Model, Using Sequential MR Imaging**

Taheri, M. R. 1 • Wolfsheimer, K. M. 2 • Nutt, S. E. 2 • Maravilla, K. R. 2 • Horner, P. J. 3 • Minoshima, S. 3 • Murphy, S. P. 3

1 George Washington University, Washington DC, WA, 2 University of Washington Medical Center, Seattle, WA

**PURPOSE**

Stroke-related morbidity and mortality is rising and accounts for a significant portion of our annual medical-related expenses. Identification of therapies that can improve outcome is highly desirable.

**MATERIALS & METHODS**

Erythropoietin (EPO) has been shown to exert a neuroprotective effect in animal stroke models through multiple mechanisms, one of which is related to improved migration of neural progenitors to the peri-infarct region. We tested the null hypothesis that erythropoietin would exert a similar effect on transplanted neural stem cells and that the rodent with acute infarct receiving these therapies would have a better outcome than those in the control group. Four groups of rats (n=10) were subjected to a 45 min middle cerebral artery (MCA) occlusion and subsequently were evaluated using a behavioral (grid) test and MR imagings (MRIs) on postoperative days (POD) 2, 7 and 14. Subjects in the first group received intraperitoneal injections of erythropoietin on POD 0, 1, 2 and 3. Feridex-labeled embryonic neural stem cells (eNSC) were transplanted (intracerebral) into the noninfarcted hemispheres of the rats in the second group at the time of reperfusion. The subjects in the third group received both EPO and NSC. The subjects in the last group received saline. Tabulation of the recorded parameters before and during surgery confirmed that the initial weight, and duration of MCA occlusion are similar in all groups. Duration of anesthesia and blood loss in the EPO group were different, though pose no confounding issue in the analysis of the data. The mean rate of motor/movement error on POD 2 was highest in the group receiving NSC and EPO, followed by the group receiving EPO. The size of area of T2 signal hyperintensity on POD 2 was largest in the group receiving NSC and EPO, followed by the EPO group. The volume of the area of restricted diffusion on POD 2 was highest in the NSC+EPO group. The percent residual MRI abnormalities and motor deficits of the animals in the four groups were similar by the end of the 2 weeks. However, the mean deficit and MRI abnormalities were generally more pronounced in NSC+ EPO and EPO groups.

**RESULTS**

The data suggest that administration of NSC and EPO to a rodent with an acute infarct results in no beneficial effect and may be deleterious.

**CONCLUSION**

These findings are consistent with the recently released human clinical trials that evaluated the relationship of EPO and stroke.

**KEY WORDS:** Stroke, molecular imaging, neural stem cells

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**Paper 413 Starting at 4:03 PM, Ending at 4:11 PM**

**Predicting Poor Outcome following Direct Extracranial-to-Intracranial Bypass Using Xenon CT Cerebral Blood Flow and Reserve in Moyamoya Disease: A Case-Control Study**

Pulling, T. M. • Burns, T. • Marks, M. P. • Steinberg, G. K. • Zaharchuk, G.

Stanford University
Stanford, CA

**PURPOSE**

Moyamoya disease is characterized by progressive stenosis of intracerebral arteries, and has an unrelenting course in the absence of surgical intervention with external carotid artery to internal carotid artery (EC-IC) bypass. Stable xenon-enhanced CT (XeCT) can be used to obtain quantitative measurements of cerebral blood flow (CBF) and CBF augmentation following a vasodilator, such as acetazolamide (ACZ) (“cerebrovascular reserve”). In this case-control study, we analyzed the baseline CBF and post-ACZ CBF augmentation in patients suffering large postsurgical cerebral infarcts and compared them with measurements in similar patients with benign clinical course.

**MATERIALS & METHODS**

Postoperative MRI examinations of adult moyamoya disease patients treated with EC-IC bypass at our institution from 2003 to present were reviewed (n=270 patients). Five patients (cases) were identified with the largest postoperative cerebral infarction and technically successful preoperative baseline and post-ACZ (1 g IV) XeCT CBF imaging. Five patients (controls) were selected based on the absence of MRI findings of postoperative cerebral infarct, absence of new permanent or temporary neurologic deficits following surgery, and technically successful pre-operative baseline and post-ACZ XeCT CBF studies within 1 month of the index case. Patients in both groups with unilateral moyamoya disease based on preoperative catheter angiography were included; the XeCT data from both sides were included in the analysis. Baseline CBF and CBF augmentation (post-ACZ CBF - baseline CBF) was calculated for the combined anterior (MCA + ACA) and posterior (PCA) territories from both hemispheres. All CBF values are reported in ml/100 g/min and shown as mean±SD. The differences between the means were evaluated with two-factor ANOVA (group, region) at a p value of 0.05.
RESULTS
There were no demographic differences between the patient groups (age: cases 45 years (range: 27-67) vs controls 49 years (range: 39-58); three females and three unilateral disease in each group, p=NS). Baseline CBF was not different between the two groups for combined anterior and posterior territories [cases vs controls: anterior 38.7±5.7 vs 41.4±7.2; posterior 40.3±4.6 vs 33.3±2.3; group F(1,4)=0.62; p=0.48]. However, the poor outcome case patients had significantly lower CBF augmentation compared with control patients in both regions (cases vs controls: anterior -3.6±9.6 vs 17.3±7.5; posterior 6.3±12.8 vs 22.9±11.4; group F(1,4)=11.5; p=0.028).

CONCLUSION
Reduced preoperative cerebrovascular reserve, as evidenced by a markedly blunted increase or paradoxical decrease ("steal") in CBF, particularly in the anterior circulation, was more common in moyamoya patients with extensive postoperative cerebral infarcts compared with controls. This is a small study, mainly because serious complications from EC-IC bypass are rare. However, it suggests that preoperative XeCT CBF analysis may help identify patients who are more likely to suffer this uncommon, but potentially devastating postoperative course.

KEY WORDS: CBF, moyamoya disease, cerebrovascular reserve

Paper 414 Starting at 4:11 PM, Ending at 4:19 PM
High-Resolution MR Imaging in Patients with Middle Cerebral Artery Atherosclerotic Stenosis

Kwik, H. • Chung, G.
Chonbuk National University Hospital and Medical School
Jeonju, KOREA, REPUBLIC OF

PURPOSE
The technique of high-resolution magnetic resonance imaging (HRMRI) has been developed to depict intracranial artery wall. The aim of this study was to compare the vessel wall between symptomatic and asymptomatic atherosclerotic plaque of middle cerebral artery (MCA) using HRMRI.

MATERIALS & METHODS
From September 2009 to August 2010, we prospectively screened consecutive patients for MCA stenosis as documented by time-of-flight (TOF) MR angiography. We studied 14 patients with symptomatic and 16 patients with asymptomatic MCA stenosis. The MR protocol was included in four different scans; three-dimensional (3D) TOF MRA, T1-, T2-, and proton density (PD)-weighted black blood MRI. The cross-sectional images of MCA wall on HRMRI were compared between the two groups such as plaque signal intensity, plaque irregularity, plaque volume, stenosis, and wall remodeling.

RESULTS
The degree of MCA stenosis and ratio of plaque thickening and patent lumen in the symptomatic group was significantly higher than that seen in the asymptomatic group. Outward remodeling of stenotic area in symptomatic group was significantly higher than that seen in the asymptomatic group, but inward remodeling of stenotic area in asymptomatic group was significantly higher that seen in symptomatic group.

CONCLUSION
HRMRI has the potential to characterize atherosclerotic plaque between symptomatic and asymptomatic MCA stenosis.

KEY WORDS: Stroke, MR imaging, intracranial artery

Paper 415 Starting at 4:19 PM, Ending at 4:27 PM
Efficacy of EC-IC Bypass in Improving BOLD MR Imaging Measured Cerebrovascular Reserve and Clinical Outcome in Symptomatic Patients with Carotid or Middle Carotid Artery Steno-Occlusive Disease

Han, J. S. • Mandell, D. M. • Abou-Hamden, A. • Poublanc, J. • Crawley, A. • Farb, R. I. • Silver, F. L. • Fisher, J. • Tymianski, M. • Mikulis, D. J.
University Health Network
Toronto, ON, CANADA

PURPOSE
The International EC-IC bypass trial demonstrated no reduction in the risk of stroke with EC-IC bypass in patients with intracranial atherosclerotic disease. A major criticism of the trial was that patients were selected for treatment based on angiography without the assessment of cerebral hemodynamics. An impairment in cerebrovascular reserve (CVR) is an indicator of compromised cerebral hemodynamics and is associated with an increased risk of stroke. The purpose of this current study was to determine if the use of ECIC bypass in patients with symptomatic carotid or MCA steno-occlusive disease and preoperative impairment in CVR would 1) improve CVR postoperatively, 2) reduce the risk of new infarcts and 3) result in improved or stabilized clinical outcomes.

MATERIALS & METHODS
Sixteen patients with either an occluded or stenosed ICA or MCA (7 ICA occlusion, 4 ICA stenosis, 1 MCA occlusion, 2 MCA stenosis) and exhausted CVR in the ipsilateral hemisphere measured using BOLD MRI were enrolled. Patients subsequently underwent an EC-IC bypass and follow up CVR and T2 FLAIR imaging. Two patients were excluded from the study due to the lack of follow-up imaging. Bypass patency was evaluated using either CT or conventional angiography. Clinical outcome was assessed by comparing the preoperative and follow-up Modified Rankin Scale (MRS) scores.

RESULTS
The mean clinical follow-up period was 20.1 ± 19.3 months and the mean imaging follow-up period was 9 ± 6.9 months. Postoperative angiography demonstrated bypass patency in all 14 procedures. Postoperative CVR in all patients improved, except in one case. None of the 14 patients developed new ischemic changes on follow up as demonstrated with T2 FLAIR imaging and clinically no
patients deteriorated on follow up (four patients demonstrated improvement and 10 patients had unchanged MRS scores).

**Conclusion**
The use of EC-IC bypass in patients with preoperatively identified hemispheric impairment in CVR appears to result in improved cerebral hemodynamics and stabilized or improved clinical outcomes. This indicates that ECIC bypass is an effective treatment in patients with cervical cerebral steno-occlusive disease once appropriately screened via assessment of cerebrovascular reserve.

**Key Words:** Cerebral hemodynamics, EC-IC bypass, intracranial steno-occlusive disease

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**Paper 416 Starting at 4:27 PM, Ending at 4:35 PM**

**Replacement of Proton Density by FLAIR for White Matter Disease Grading in Large Cohort Studies**

LiMarzi, G. M. • Beauchamp, N. • Shibata, D.
University of Washington
Seattle, WA

**Purpose**
Large multicenter longitudinal cohort studies of cerebrovascular disease and aging such as the Cardiovascular Health Study (CHS) or the Atherosclerotic Risk in Communities Study (ARIC) have used a well established grading system using proton density-weighted (PD) images to score the relative severity of white matter hyperintensities (WMH). Although follow-up imaging in these studies have continued to use PD images for grading continuity, thinner section FLAIR images are now favored and it has been questioned if the FLAIR images may substitute on further follow-up scans. New cohort studies have switched to FLAIR but there is no published data to allow conversion of FLAIR to PD scoring so that the results of these studies can be directly compared. The purpose of this study was to compare the grading of WMH on the PD versus FLAIR images acquired from the same subjects with the hypothesis that when using the same set of standards, the WMH will be scored higher on the FLAIR images, but that a conversion factor can be derived.

**Materials & Methods**
A total of 113 1.5 T MR scans (part of the ARIC study) with mean age 72 years were graded for WMH severity by two neuroradiology readers each having undergone training in the WMH grading protocol first used in the CHS study. Contiguous axial 5 mm PD (TR/TE: 3000/30) and 3 mm FLAIR (TR/TI/TE: 16000/2600/142) spin-echo images were scored independently on a ten-point scale against the original PD “standards” used in the CHS study. Results were analyzed for statistical significance using a paired t-test and linear regression analysis was performed.

**Results**
When combining the data from both scorers, 92 of 226 cases (40.7%) had a difference of at least one grade between the severity of WMH on the PD and FLAIR scoring. Of those 92 cases, 88 (95.6%) showed greater severity on FLAIR. The mean scores were 2.32 for PD and 2.73 for FLAIR and the difference was found to be statistically significant (P < 0.0001). Linear regression analysis of the PD and FLAIR scores yielded the equation: FLAIR = 0.942 (PD) + 0.536 (r² = 0.89).

**Conclusion**
Scoring of the FLAIR instead of the PD images resulted in a significant overestimation of the WMH severity by approximately half a grade, supporting our hypothesis that the increased conspicuity of WMH on FLAIR might lead to higher grade scoring and thus the results of FLAIR scoring may not be directly comparable with prior studies based on PD grading. However using linear regression analysis we derived a relatively robust (r² = 0.89) conversion formula allowing the scores from the FLAIR images to be converted to their PD equivalent. The equation also demonstrates that the difference in grading is greatest at the mild end of the WMH spectrum (y intercept of 0.53 and slope of 0.94), which is also where most subjects lie and differentiation best correlates with risk factors and neurologic status.

**Key Words:** White matter hyperintensities, FLAIR, cerebrovascular disease

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**Paper 417 Starting at 4:35 PM, Ending at 4:43 PM**

**Interpretation Errors in CT Angiography of the Head and Neck**

Bharatha, A. • Lian, K. • Aviv, R. I. • Symons, S. P.
1University of Western Ontario, London, ON, CANADA, 2University of Toronto, Toronto, ON, CANADA

**Purpose**
CT angiography provides high-resolution imaging of not only head and neck vasculature, but also soft tissues and osseous structures. This results in a large volume of information which must be interpreted by the radiologist. The purpose of this study was to examine the errors associated with the interpretation of head and neck CTA studies.

**Materials & Methods**
Consecutive CTA studies of the neck and intracranial circulation were identified retrospectively and reviewed for vascular and nonvascular findings by a consensus of two neuroradiologists. The results were compared with the official report. Significant discrepancies were considered as those which would have influenced follow up or management.

**Results**
Five hundred four studies were reviewed. Twenty-six significant discrepancies were discovered in 20 studies. This corresponds to 4.0% of studies with at least one error, and an overall error rate per study of 5.2%. There was no significant difference between the relative percentage of discrepancies between studies performed on 4-slice and 64-slice scanners (6.0% versus 4.5%). The most common errors were unreported small aneurysms (50% of missed findings). Other discrepancies included other vascular pathologies such as significant stenoses, sino-venous thrombosis, dissections, and masses.
<table>
<thead>
<tr>
<th>Lesion</th>
<th>Number</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arterial aneurysm (1-4 mm)</td>
<td>13</td>
<td>50%</td>
</tr>
<tr>
<td>Arterial occlusion or severe stenosis</td>
<td>5</td>
<td>19%</td>
</tr>
<tr>
<td>Dural venous sinus thrombosis</td>
<td>1</td>
<td>4%</td>
</tr>
<tr>
<td>Arterial dissection</td>
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<td>4%</td>
</tr>
<tr>
<td>Mass</td>
<td>3</td>
<td>11.5%</td>
</tr>
<tr>
<td>Other</td>
<td>3</td>
<td>11.5%</td>
</tr>
</tbody>
</table>

**CONCLUSION**

CT angiography neck and head datasets are large and there is a potential for missed findings. Significant discrepancies can occur with a low but not insignificant rate. Arterial pathology accounted for the majority of discrepancies. This study emphasizes the need for careful and systematic scrutiny for both vascular and nonvascular pathology in all patients regardless of indication. Strategies to reduce errors include double reading.

**KEY WORDS:** CT angiography, interpretation error, misdiagnosis

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**Wednesday Afternoon**

**3:15 PM - 4:45 PM**

**Ballroom 6A**

(39b) Interventional: Aneurysms II

(Scientific Papers 418 - 428)

*See also Parallel Session*

(39a) Cerebrovascular Occlusive Disease II

(39c) Head & Neck: Paranasal Sinuses, Temporal Bones and Cervical Carotid Disease

(39d) Pediatrics: Congenital Malformations and Disorders

Moderators: Michael Marks, MD

Ajay K. Wakhloo, MD, PhD

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**Paper 418 Starting at 3:15 PM, Ending at 3:23 PM**

**Hemodynamic Force Dyssynchrony Found in Cerebral Aneurysms: A Quantitative Patient-Specific Aneurysm Flow Analysis at Single Location**

Chien, A. • Loo, S. • Tateshima, S. • Vinuela, F.

David Geffen School of Medicine at the University of California Los Angeles Los Angeles, CA

**PURPOSE**

Brain aneurysm rupture is one of the causes of subarachnoid hemorrhage, and the morbidity rate due to aneurysm rupture remains high in the United States. Studies have suggested that aneurysm growth and rupture may be related to the hemodynamic force and unstable blood flow inside an aneurysm. This study investigates the hemodynamic force changes in a group of aneurysms over a cardiac cycle. Our hypothesis is that the unstable blood flow inside an aneurysm may alter both the magnitude and the timing of the peak hemodynamic force over the cardiac cycle.

**MATERIALS & METHODS**

To minimize hemodynamic variation due to aneurysm location, aneurysms from the same anatomical location were selected. Twenty-seven internal carotid artery-ophthalmic artery aneurysms (5 ruptured and 22 unruptured which were consecutively treated in the Division of Interventional Neuroradiology at UCLA Medical Center) were included in this study. Images acquired by three-dimensional rotational angiography prior to embolization were used for the quantitative patient-specific hemodynamic analysis. To measure the hemodynamic force changes in an aneurysm over a complete cardiac cycle, pulsatile flow profiles obtained from a normal subject were applied to simulate the blood flow. Results of aneurysmal flow properties at different cardiac phases were carefully examined, and the magnitude of the hemodynamic forces at the aneurysm neck, body and dome were recorded and compared with the hemodynamic force at the parent artery.

**RESULTS**

We observed general agreement between the changes in hemodynamic force within an aneurysm and the changes of the blood pressure profile. Detailed comparison using quantitative flow parameters (wall shear stress and flow velocity) revealed that some aneurysms had the peak hemodynamic force shifted to the later cardiac phases. Among the 27 aneurysms, 21 cases had the peak hemodynamic force occurring at the end of systole, and six cases had the peak force occurring at the early diastolic phase. The magnitude of the hemodynamic force ranged from 15.1 Pa to 0.19 Pa within aneurysms and from 33.6 Pa to 0.32 Pa at the parent arteries.

**CONCLUSION**

The shift of the peak of hemodynamic force was observed in 20% of the cases. This suggests that to understand the influence of hemodynamics on brain aneurysms, studies may need to consider the results of blood flow analysis at both the end of the systolic and the early diastolic phases. Continued studies focusing on these peak shifts may shed more light on hemodynamic force effects on aneurysm growth and rupture.
Endovascular Coiling of Small Aneurysms Is Not Associated with Increased Morbidity

Lum, C. • Babu, S. • Shankar, J. • Deus-Silva, L. • Lesiuk, H. • Bussiere, M. • Santos, M.

University of Ottawa-The Ottawa Hospital, Ottawa, ON, CANADA, Dalhousie University, Halifax, NS, CANADA

Purpose

Coiling of small aneurysms can be technically challenging. Factors encountered when coiling small aneurysms are microcatheter stability, aneurysm location and vessel tortuosity, especially in older patients. Medium to large aneurysms are typically more accommodating of microcatheters and coils. The purpose of our study was to investigate the feasibility, intraprocedural rupture rates and long-term durability of endovascular coiling for small (≤ 4 mm) aneurysms compared to an age and location-matched control group of nonsmall (>4) aneurysms.

Materials & Methods

We performed a retrospective review of 360 intracranial aneurysms coiled at our institution between 2003-2008. Aneurysms which measured less than or equal to 4 mm in greatest dimension were classified as small. To control for factors such as vessel tortuosity and aneurysm location, we chose a control group which matched the study group both in age and aneurysm location with the following assumptions: equivalence limit = 6%, α = 0.05 (1-sided), procedural rupture test group 3%, standard group 8%, power = 80% resulting in a sample size of 68. The rupture status, location, size, sex, age, follow-up period, rupture status, incidence of perforation, good clinical outcome after perforation defined as modified Rankin scale ≤ 2, degree of obliteration at end of coiling and recurrence according to Raymond & Roy was determined for each group. Recurrences were defined as an increase in Raymond & Roy scale at follow-up from initial postcoiling results. The perforation rate in our study was compared to the overall rate of intraoperative perforation during aneurysm coiling extracted from our aneurysm coiling database. A p-value of 0.05 was considered significant.

Results

Between January 2003-December 2008, there were 34 small aneurysms coiled in our institution. For the control group, 68 aneurysms matched to sex, age and location were reviewed. There was no significant difference between the two groups for sex, age, initial degree of obliteration and mean follow-up period. The mean size of small vs nonsmall aneurysms was 3.25 mm (1.5-4) and 8.47 mm (4-25) mm. The frequency of intraprocedural perforations was 4/34 (0.11) and 3/68 (0.04), for the small and nonsmall cohort, respectively (p = 0.22). In comparison, during a similar time period, a total of 360 sacculae aneurysms were coiled resulting in an overall perforation rate occurring in 13 (0.036). All patients who had a perforation in the small aneurysm groups had a good clinical outcome compared to 1/3 in the nonsmall group (2 mortalities). The frequency of recanalization for the small and nonsmall groups was 3/34 (0.08) and 23/68 (0.33), respectively (p = 0.006). There was no retreatments in the small aneurysm group and five (0.07) in the nonsmall group (p = 0.116).

Conclusion

Coiling of small, ≤ 4 mm aneurysms is feasible. There is an increase in frequency of intraprocedural rupture with coiling of small aneurysms which is not associated with increased morbidity. Coiling of small aneurysms leads to durable results at long-term follow up.

Key Words: Aneurysm, coiling

Lack of Aneurysm Formation after Carotid Artery Ligation in Rabbits: A Polymer MicroFil Study

Dai, D. • Ding, Y. • Kadirvel, R. • Ehteshami Rad, A. • Lewis, D. • Kallmes, D.

Mayo Clinic Rochester, MN

Purpose

Previous studies have noted formation of saccular aneurysms along the distal basilar artery/P1 segments after carotid ligation in rabbits; this model is being used to study the coupling between hemodynamics and aneurysm formation. We performed a MicroFil study, in which a polymer is used to fill the entire arterial tree, to study the incidence of microaneurysm formation following carotid ligation in rabbits.

Materials & Methods

Right carotid artery ligation was performed in 18 New Zealand White rabbits. The basilar artery and its bifurcation were harvested at 3 weeks (n = 7), 16 weeks (n = 10), 36 weeks (n = 1). At the time of sacrifice, 5ml Microfil MV-122 Yellow was injected into the left CCA to fill the cerebral vasculature. After gross photographs were taken, all the specimen were embedded in paraffin and sectioned at 4μm in a coronal orientation; all sections were harvested and stained with hematoxylin and eosin (H&E) and VVG to show the basilar terminus and its branches. The relative diameters of the posterior communicating arteries (Pcomms) were compared using t-test. Gross and microscopic images were carefully evaluated for microaneurysm formation, defined as a localized, pathologic dilatation of vessel wall, associated with IEL fragment or disappear or and media layer degeneration.

Results

The right posterior communicating artery was markedly enlarged compared to the left (mean diameters 0.80 v.s. 0.49 mm, p=.000001). Gross examination demonstrated no evidence for saccular aneurysm, but prominent perforating vessels were present in all 18 cases at BT or and near BT area. In all subjects the internal elastic lamina (IEL) and media were intact and continuous along the distal basilar artery/P1 segments. Small branches noted from gross examination corresponded on histology to small, saccular contour defects, which also demonstrated apparent loss of the IEL and presence of medial thinning. These observations, however, were a consequence of sectioning through the bases of perforating arteries, which simulated microaneurysm formation due to

Key Words: Aneurysm, hemodynamics, aneurysm rupture

Endovascular Coiling of Small Aneurysms is not Associated with Increased Morbidity

Lum, C. • Babu, S. • Shankar, J. • Deus-Silva, L. • Lesiuk, H. • Bussiere, M. • Santos, M.

University of Ottawa-The Ottawa Hospital, Ottawa, ON, CANADA, Dalhousie University, Halifax, NS, CANADA

Purpose

Coiling of small aneurysms can be technically challenging. Factors encountered when coiling small aneurysms are microcatheter stability, aneurysm location and vessel tortuosity, especially in older patients. Medium to large aneurysms are typically more accommodating of microcatheters and coils. The purpose of our study was to investigate the feasibility, intraprocedural rupture rates and long-term durability of endovascular coiling for small (≤ 4 mm) aneurysms compared to an age and location-matched control group of nonsmall (>4) aneurysms.

Materials & Methods

We performed a retrospective review of 360 intracranial aneurysms coiled at our institution between 2003-2008. Aneurysms which measured less than or equal to 4 mm in greatest dimension were classified as small. To control for factors such as vessel tortuosity and aneurysm location, we chose a control group which matched the study group both in age and aneurysm location with the following assumptions: equivalence limit = 6%, α = 0.05 (1-sided), procedural rupture test group 3%, standard group 8%, power = 80% resulting in a sample size of 68. The rupture status, location, size, sex, age, follow-up period, rupture status, incidence of perforation, good clinical outcome after perforation defined as modified Rankin scale ≤ 2, degree of obliteration at end of coiling and recurrence according to Raymond & Roy was determined for each group. Recurrences were defined as an increase in Raymond & Roy scale at follow-up from initial postcoiling results. The perforation rate in our study was compared to the overall rate of intraoperative perforation during aneurysm coiling extracted from our aneurysm coiling database. A p-value of 0.05 was considered significant.

Results

Between January 2003-December 2008, there were 34 small aneurysms coiled in our institution. For the control group, 68 aneurysms matched to sex, age and location were reviewed. There was no significant difference between the two groups for sex, age, initial degree of obliteration and mean follow-up period. The mean size of small vs nonsmall aneurysms was 3.25 mm (1.5-4) and 8.47 mm (4-25) mm. The frequency of intraprocedural perforations was 4/34 (0.11) and 3/68 (0.04), for the small and nonsmall cohort, respectively (p = 0.22). In comparison, during a similar time period, a total of 360 sacculae aneurysms were coiled resulting in an overall perforation rate occurring in 13 (0.036). All patients who had a perforation in the small aneurysm groups had a good clinical outcome compared to 1/3 in the nonsmall group (2 mortalities). The frequency of recanalization for the small and nonsmall groups was 3/34 (0.08) and 23/68 (0.33), respectively (p = 0.006). There was no retreatments in the small aneurysm group and five (0.07) in the nonsmall group (p = 0.116).

Conclusion

Coiling of small, ≤ 4 mm aneurysms is feasible. There is an increase in frequency of intraprocedural rupture with coiling of small aneurysms which is not associated with increased morbidity. Coiling of small aneurysms leads to durable results at long-term follow up.

Key Words: Aneurysm, coiling
artifact during the histological processing. Apart from these artifacts at the origins of perforating arteries, there were no bulge-like, local dilations to suggest microaneurysm or nascent aneurysm formation in any subject.

CONCLUSION
Unilateral RCCA ligation does not induce microaneurysm formation at the BT in rabbits. Prominent perforating arteries may simulate “aneurysms” histologically.

KEY WORDS: Basilar tip, aneurysm, rabbit

Paper 421 Starting at 3:39 PM, Ending at 3:47 PM

Prospective Randomized Comparison of Total Neck Healing of Intracranial Aneurysms with Bioactive Coils: Matrix versus Cerecyte

Sigmund, G. A. • Jacobson, P. • Lam, T. • Luh, G.
Loma Linda University Medical Center
Loma Linda, CA

PURPOSE
Recanalization remains a significant drawback in the endovascular treatment of intracranial aneurysms using platinum coils. Bioactive coils (Polyglycolic lactic acid/polyglycolic acid) have been proposed to theoretically reduce the rates of recanalization by promoting endothelial healing over the aneurysmal neck. In this study, we report our comparative experience between the Cerecyte (Endovascular, San Jose, CA) and Matrix (MDC; Boston Scientific/Target, Fremont, CA) bioactive coils.

MATERIALS & METHODS
In an IRB-approved prospective trial, patients undergoing endovascular embolization of intracranial aneurysms, ruptured or unruptured, were assigned randomly between Cerecyte-only and Matrix-only treatment arms. Thirty-four aneurysms were treated in 32 patients. Follow-up examinations were obtained in 22 of 32 patients with four patients lost to follow up and six deaths unrelated to endovascular coiling. Patients were followed mostly by conventional angiography, or in three cases, by MR angiography (MRA). Outcome of aneurysm treatment at first follow up was scored, blinded to treatment, using the Raymond Classification.

RESULTS
Demographic characteristics and covariates of interest (e.g., subarachnoid hemorrhage, hypertension, diabetes) were similar between the treatment groups except for history of smoking, which was significantly more frequent in the Cerecyte group. Complete occlusion (grade 1) was observed in nine of 11 patients (82%) with Cerecyte coils and nine of 13 patients (69%) with Matrix coils. One Cerecyte patient and three Matrix patients displayed residual neck remnant (grade 2). One Cerecyte patient showed partial recanalization and one Matrix patient showed dome filling with both of these patients requiring retreatment. Patients in the Matrix treatment arm were more likely to have residual (Raymond Class 2 or 3) than patients in the Cerecyte arm (OR = 2.0, 95 CI: 0.29-13.8).

Table 1: Patient Demographics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Matrix</th>
<th>Cerecyte</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>18</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Age (Median, IQR)</td>
<td>52.5 (20.5)</td>
<td>52 (16.5)</td>
<td>1.0</td>
</tr>
<tr>
<td>Size (Median, IQR)</td>
<td>45 (224)</td>
<td>85 (116)</td>
<td>0.49</td>
</tr>
<tr>
<td>% Filled (Median, IQR)</td>
<td>27 (13)</td>
<td>29 (13)</td>
<td>1.0</td>
</tr>
<tr>
<td>Sex (Female)</td>
<td>17/18</td>
<td>10/15</td>
<td>0.07</td>
</tr>
<tr>
<td>Subarachnoid Hemorrhage (+)</td>
<td>13/18</td>
<td>11/15</td>
<td>0.95</td>
</tr>
<tr>
<td>Hypertension (+)</td>
<td>16/18</td>
<td>10/15</td>
<td>0.12</td>
</tr>
<tr>
<td>High Cholesterol (+)</td>
<td>6/18</td>
<td>4/15</td>
<td>0.72</td>
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<tr>
<td>Cerebrovascular Disease (+)</td>
<td>4/18</td>
<td>1/15</td>
<td>0.34</td>
</tr>
<tr>
<td>Diabetes Mellitus (+)</td>
<td>5/18</td>
<td>1/15</td>
<td>0.19</td>
</tr>
<tr>
<td>Smoking (+)</td>
<td>8/18</td>
<td>14/15</td>
<td>0.004</td>
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</tbody>
</table>

CONCLUSION
In a small randomized trial, a higher rate of complete aneurysm occlusion was observed with Cerecyte coils relative to Matrix, not statistically significant. These results may be useful in conjunction with the results of other studies/meta-analysis in ascertaining the efficacy of the various bioactive coils.

KEY WORDS: Aneurysm, Cerecyte, matrix

Paper 422 Starting at 3:47 PM, Ending at 3:55 PM

Creation of Larger Elastase-Induced Aneurysms with Predilation of Right Common Carotid Artery before Elastase Incubation

Ding, Y. • Kadirval, R. • Ehteshami Rad, A. • Lewis, D. A. • Dai, D. • Kallmes, D. F.
Mayo Clinic
Rochester, MN

PURPOSE
To determine whether predilation of the right common carotid artery (RCCA) with an angioplasty balloon before elastase incubation can result in larger elastase-induced aneurysms in rabbits as compared to the standard technique.

MATERIALS & METHODS
Elastase-induced aneurysm sizes were analyzed retropective-ly in 76 New Zealand White rabbits. Two groups were classified: A. Group 1, in which predilation of RCCA with an angioplasty balloon (balloon diameter/length: 3.5 mm/2 cm; inflation pressure: 8 atm; inflation duration: 60 seconds; inflations...
times: 3) was performed before elastase incubation. Thirty-eight rabbits were selected randomly in this group. B. Group 2 included 38 rabbits that underwent aneurysm creation without predilation. Follow-up digital subtractive angiography (DSA) was performed 3 weeks after aneurysm creation. Aneurysm sizes (neck diameter, width, height, and volume) in the two groups were measured and calculated. Comparison of aneurysm sizes between the two groups was compared using the Student’s t test.

**RESULTS**
The mean aneurysm neck for Group 1 was not different from Group 2 (3.6 ± .9 mm and 3.3 ± .8 mm, respectively, p > .05). Differences of aneurysm width between the two groups were not significant (4.7 ± .9 mm and 4.4 ± .9 mm, respectively, p > .05). Mean aneurysm height for Group 1 was larger than Group 2 (11.2 ± 1.7 mm and 9.2 ± 2.2 mm, respectively, p < .001). Aneurysm volume for Group 1 was significantly larger than that of Group 2 (207.1 ± 98.5 and 154.2 ± 94.2 mm³, p < .05) (Figures).

**CONCLUSION**
Predilation of RCCA before elastase incubation can induce experimental aneurysms of greater height and volume than those created with standard techniques.

**KEY WORDS:** Aneurysm volume, elastase-induced model, predilation

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**MATERIALS & METHODS**
We performed a retrospective review of our aneurysm database from 1991 to 2009. All patients with saccular aneurysms measuring 25 mm or greater were identified. The demographic, angiographic, and clinical outcome data were analyzed.

**RESULTS**
Forty-one patients with giant saccular intracranial aneurysms were identified. There were 31 females and 10 males. The average age was 55.5 years old with a range from 4 months to 83 years old. There were 27 aneurysms in the anterior circulation and 14 in the posterior circulation. Intracavernous and basilar tip were the top two locations. Twenty patients presented with mass effect, 13 patients presented with history of SAH, and eight were found incidentally. No patient presented with TIA. Thirty-two patients underwent coiling alone, six underwent parent artery occlusion, and three underwent stent-assisted coil embolization. After the initial coiling only procedure, complete occlusion was achieved in only four patients. There was filling of the aneurysm body in four patients and a neck remnant in 24 patients. In patients that underwent parent artery occlusion, complete occlusion was seen in five patients and persistent body filling in one patient. In the stent-assisted coil embolization, complete occlusion was seen in two patients and dome filling in one patient. There were two technical complications: aneurysm rupture and coil misplacement. Neither resulted in any permanent neurologic sequela. There was one ischemic complication which required an urgent EC-IC bypass. One case also was complicated by a retroperitoneal hematoma. There was no immediate morbidity. Retreatment was needed in 16 patients (39%). In ten (24.3%) patients, a second embolization was performed. In four patients (9.7%) three embolizations were performed. In two patients eventual parent artery occlusion was performed. Delayed rupture was seen in five patients (12%) occurring 7 months to 8 years post-treatment.

**CONCLUSION**
Giant sacular intracranial aneurysms represent a small but very challenging subgroup of intracranial aneurysms. Although endovascular management has made a significant improvement in the natural history of these patients, many challenges still remain.

**KEY WORDS:** Giant intracranial aneurysm, endovascular, coiling
Hemodynamics of Cerebral Aneurysm Initiation: The Role of Wall Shear Stress and Spatial Wall Shear Stress Gradient

Kulcsar, Z.1 • Ugron, A.2 • Marosfoi, M.1 • Berentei, Z.3 • Paal, G.2 • Szikora, I.3
1Hirslanden Clinic Zurich, Zurich, SWITZERLAND, 2Budapest University of Technology and Economics, Budapest, HUNGARY, 3National Neuroscience Institute, Budapest, HUNGARY

PURPOSE
Cerebral aneurysms are preferentially located at arterial curvatures and bifurcations that are exposed to major hemodynamic forces, increasingly implicated in the life cycle of aneurysms. By observing the natural history of aneurysm formation from its preaneurysm state, our purpose was to examine the hemodynamic microenvironment related to aneurysm initiation at certain arterial segments later developing an aneurysm.

MATERIALS & METHODS
The three patients included in the study underwent cerebral angiography with 3D reconstruction before a true aneurysm had developed. The arterial geometries obtained from the 3D-DSA models were used for flow simulation using finite volume modeling. The WSS and SWSSG at the site of the future aneurysm, as well as the flow characteristics of the developed aneurysms were analyzed.

RESULTS
The analyzed regions of interest demonstrated significantly increased WSS, accompanied by an increased positive SWSSG in the adjacent proximal region. The WSS has reached values of more than five times the temporal average values of the parent vessel, whereas the SWSSG approximated or exceeded peaks of 40 Pa/mm in all three cases. All patients developed an aneurysm in a period of 2 years, one of which had ruptured.

Conclusion
The results of this hemodynamic study, in accordance with the clinical follow up suggests that the combination of high WSS and high positive SWSSG focused on a small segment of the arterial wall may have a role in the initiation process of aneurysm formation.

Key Words: Cerebral aneurysm, hemodynamics, aneurysm initiation

Long-Term Anatomical Results after Endovascular Treatment of Ruptured Intracranial Aneurysms with GDC™ and Matrix™ Coils: Analysis of the CLARITY Series

Pierot, L.1 • Cognard, C.2 • Ricolfi, F.3 • Anxionnat, R.4 • on behalf of CLARITY investigators
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PURPOSE
CLARITY is a prospective, multicenter, consecutive series including patients treated with GDC™ or Matrix™ coils for ruptured aneurysms. Long-term anatomical results are presented.

MATERIALS & METHODS
Postoperative and long-term anatomical results were evaluated anonymously and independently by two experienced neuroradiologists using the 3-point Modified Montreal scale.

RESULTS
Postoperative and long-term anatomical results were evaluated in 517/649 patients (79.7%). In the long-term follow up, complete occlusion was reported in 95/276 aneurysms (34.4%) in the GDC group and 80/241 aneurysms (33.2%) in the Matrix group, neck remnant in 127/276 aneurysms (46.0%) in the GDC group and 118/241 aneurysms (49.0%) in the Matrix group, and aneurysm remnant in 54/276 aneurysms (19.6%) in the GDC group and 43/241 aneurysms (17.8%) in the Matrix group (p = 0.780). Direct comparison of long-term versus immediate postoperative aneurysm occlusion showed improvement in 35/272 aneurysms (12.9%) in the GDC group and 27/239 aneurysms (11.3%) in the Matrix group, stable situation in 98/272 aneurysms (36.0%) in the GDC group and 97/239 aneurysms (40.6%) in the Matrix group, and worsening in 139/272 aneurysms (51.1%) in the GDC group and 115/241 aneurysms (48.1%) in the Matrix group (p = 0.555). Direct comparison of long-term versus immediate postoperative aneurysm occlusion showed improvement in 15/272 aneurysms (5.5%) in the GDC group and 13/239 aneurysms (5.4%) in the Matrix group (p = 0.780). Direct comparison of long-term versus immediate postoperative aneurysm occlusion showed improvement in 35/272 aneurysms (12.9%) in the GDC group and 27/239 aneurysms (11.3%) in the Matrix group, stable situation in 98/272 aneurysms (36.0%) in the GDC group and 97/239 aneurysms (40.6%) in the Matrix group, and worsening in 139/272 aneurysms (51.1%) in the GDC group and 115/241 aneurysms (48.1%) in the Matrix group (p = 0.555). During the follow-up period, a total of 32/517 patients were retreated: 9/276 (3.3%) in the GDC group and 23/241 (9.5%) in the Matrix group (p = 0.003).

Conclusion
One-year anatomical results are not different in patients with ruptured aneurysms treated with GDC™ or Matrix™ coils. Similarly, the evolution of aneurysm occlusion is not different in patients treated with GDC™ or Matrix™ coils.
Intracranial Aneurysms Coiling with Matrix versus Guglielmi Detachable Coils: Long-Term Anatomical Follow Up

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Paris, FRANCE

PURPOSE
Recanalization remains a limitation of aneurysm coiling. Bioactive coils as Matrix (Boston Scientific, Fremont, CA) were designed to reduce recanalization. However, controversy still exists about its efficacy. Our objective was to evaluate the long-term anatomical results in 90 intracranial aneurysms treated with Matrix coils.

MATERIALS & METHODS
From 2002 to 2010, 587 aneurysms were treated selectively with either bare platinum Guglielmi detachable coils (GDC) (Boston Scientific, Fremont, CA) or Matrix coils exclusively. All patients were referred to us from other institutions for endovascular treatment. Only aneurysms with long-term angiographic follow up (≥ 12 months) were considered for the purpose of this study. Aneurysm status (ruptured versus unruptured), patient’s gender, use of balloon remodeling technique, use of stent-assisted coiling technique, initial total angiographic occlusion, angiographic recurrence were noted and evaluated for statistical significance using a 2-tailed Fisher Exact Test. Patient ages, size of aneurysms, packing densities (the ratio between the volume of the inserted coils and the volume of the aneurysm), duration of follow up, time to recurrence were compared by using the Mann-Whitney U and Unpaired-t Tests. A stepwise multivariate logistic regression analysis was performed to control for potential confounders in aneurysms characteristics and in the occurrence of angiographic recurrence. A P value of <0.05 was considered statistically significant. Statistical tests were performed with SAS Release 8.2 (SAS Institute Inc., Cary, NC).

RESULTS
Overall, 397 (67.6%) aneurysms were followed, 248 having been followed at least 12 months. Recurrence rates were similar for both groups. A hemorrhagic presentation was the lone factor affecting angiographic recurrence in the multivariate analysis.

CONCLUSION
The use of Matrix coils did not influence the long-term recanalization rate of aneurysms. Consequently, there is definitely no evidence to recommend the use of Matrix over GDC bare platinum coils.

KEY WORDS: Cerebral aneurysm, embolization, recurrence

Differences in Stability of Helicity Flow Patterns Quantified with Image-Based Correlation Analysis in Ruptured and Unruptured Saccular Cerebral Aneurysms

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Houston, TX

PURPOSE
To explore the potential of intra-aneurysmal helicity patterns for discriminating rupture status of saccular cerebral aneurysms. Helicity measures energy transferred into rotational flow patterns while reducing forward flow. Previously, complexity of intra-aneurysmal recirculation patterns was associated with rupture risk (1).

MATERIALS & METHODS
Three-dimensional digital subtraction angiographic (DSA) image data acquired on angiographic biplane systems (Siemens Medical Solutions) was obtained from eight patients diagnosed with a cerebral aneurysm (six internal carotid artery (ICA) aneurysms (five unruptured, one ruptured), two posterior communicating artery aneurysms (ruptured)). Transient computational fluid dynamics (CFD) simulations were performed (Fluent, Ansys Inc.) based on patient-derived boundary conditions. Helicity values (defined as the vector product of vorticity and blood velocity) available on the mathematical grid used for the simulations were converted into image data. Stability of helicity patterns within the cardiac cycle was quantified with image correlation analysis employing the Pearson correlation coefficient (CC, Figure 1). Correlation coefficient was correlated with aneurysm size (largest diameter).

RESULTS
Mean CC value was significantly (p=0.01) elevated in the ruptured group (0.97±0.02, size: 9.9±2.6 mm) compared to the unruptured group (0.86±0.09, 14.5 ± 11 mm). Analysis restricted to unruptured aneurysms with comparable size as in the ruptured group (n=3, size: 8.4±2.4 mm) still yielded elevated mean CC for ruptured group (0.91±0.06, p<0.01). Aneurysm size correlated negatively with CC (R=-0.68, Figure 1) in agreement with previously reported measurements utilizing phase-contrast MR imaging (MRI) (2).

Figure 1: (left) On top, helicity patterns for selected time points during the cardiac cycle for ICA aneurysms #4 in cross section intersecting aneurysm dome. Two separate main features of opposite sign (black and white) can be appreciated. Below, CC for all time points. Right: CC averaged over the cardiac cycle for all aneurysms (open symbols: ruptured; closed symbols: unruptured). Straight line visualizes inverse relationship of CC with aneurysm size.
CONCLUSION
Elevated temporal stability of helicity patterns in ruptured saccular cerebral aneurysms indicates differences in intraaneurysmal energy losses compared to unruptured aneurysms. These findings are in concordance with reports associating pressures losses with rupture status (3) and encourage further investigation of helicity as a potential parameter for discriminating rupture status.

REFERENCES

KEY WORDS: Cerebral aneurysm, hemodynamics, computational fluid dynamics

Wednesday Afternoon
3:15 PM - 4:45 PM
Room 606-609

(39c) Head and Neck: Paranasal Sinuses, Temporal Bones, and Cervical Carotid Disease
(Scientific Papers 429 - 439)

See also Parallel Session
(39a) Cerebrovascular Occlusive Disease II
(39b) Interventional: Aneurysms II
(39d) Pediatrics: Congenital Malformations and Disorders

Moderators: Christine M. Glastonbury, MBBS
Gul Moonis, MB, BS
Paper 429 Starting at 3:15 PM, Ending at 3:23 PM

Peripheral Nerve Tractography in Brachial Plexus Lesions
Kasprian, G. J. • Breitenseher, J. • Mallouhi, A. • Czerny, C. • Prayer, D.
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Vienna, AUSTRIA

PURPOSE
The noninvasive MR imaging technique of diffusion tensor imaging (DTI), has been used predominantly to 3D visualize the structural white matter (WM) connectivity of the human brain. Recently this technique has shown to provide structural and functional data on the integrity of peripheral nerves. Clinical DTI has been used to image the brachial plexus in mainly normal subjects. This study aims to evaluate the clinical feasibility of 3 T peripheral nerve DTI in the assessment of brachial plexus pathologies at 3 T.

MATERIALS & METHODS
Nine patients (3 obstetric and 2 posttraumatic plexus lesions, 1 postamputation neuroma, 2 peripheral nerve sheet tumors (PNST), 1 pancoast tumor, underwent 3 T MR scanning using an optimized and dedicated plexus imaging protocol including multiplanar T2-weighted sequences and paracoronal STIR sequences. A sagittal echo-planar DTI sequence (b-values of 0 and 750s/mm², fat saturation, 16 gradient encoding directions, slice thickness: 2.5 mm) covering the supra and partly the infraclavicular portion of the brachial plexus was acquired and 3D tractography performed using a multi ROI approach.

RESULTS
Diffusion tensor imaging allowed for the 3D visualization of the proximal nerve roots (C5-Th1) in all of the examined cases. In case of a traumatic lateral nerve avulsion, tractography readily indicated the site of neurotmesis. In a case of a post amputation neuroma, complete neurotmesis resulted in complete discontinuity and deranged organization of trajectories in proximity of the neurinoma (Figure). In a case of obstetric plexus lesions, nerve roots affected by a neurinoma in continuitatem did not display intact tracts. In two cases of PNST and one case of a Pancoast tumor, the anatomical relationship between the lesion and the affected nerve roots/truncks could be 3D clarified.

CONCLUSION
According to the improved signal-to-noise ratio at 3 T, the detailed 3D visualization of the proximal/supravclavicular segment of the brachial plexus is possible. Despite the common presence of motion artifacts (breathing, pulsation of vessels), the imaging data is valid and provides valuable information on peripheral nerve structure and 3D anatomy in traumatic and neoplastic plexus lesions.

KEY WORDS: Brachial plexus, diffusion tensor imaging, 3 T MR imaging

Paper 430 Starting at 3:23 PM, Ending at 3:31 PM

Transfacial Dental Ultrasonography: A New Technique for the Assessment of Jaw Cysts
Gad, K. • Abd El-Hamid, A.
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Ismailia, EGYPT

PURPOSE
To describe the role of ultrasonography in the assessment of jaw cysts.

MATERIALS & METHODS
Thirty patients with cystic jaw lesions either developmental or inflammatory were examined using a transfacial approach, in which a high-frequency transducer was applied over the face at the region of a suspected lesion. The normal film of oral saliva and sometimes a bolus of water kept in mouth, acted as aquistic media to enhance sound transmission. Oral pantomograms were performed on all patients as a reference.

RESULTS
Jaw cysts could be clearly visualized. Their size, outline, content, and extension were identified easily. Anatomical relationship with adjacent teeth also was recongnized. Cortical bone erosion as well as related soft tissue abnormalities were reported. Doppler was applied on all lesions to describe the pattern of flow.

CONCLUSION
Transfacial dental ultrasonography proved to be a useful and safe imaging modality in the assessment of jaw cysts specially when x-ray or CT are impractical or contraindicated.

KEY WORDS: Transfacial dental ultrasonography, jaw cysts

Paper 431 Starting at 3:31 PM, Ending at 3:39 PM

Adult Cystic Fibrosis Sinonasal CT Findings
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PURPOSE
The purpose of this study is to evaluate the CT imaging features of the paranasal sinuses in adult patients with cystic fibrosis.
**Materials & Methods**

Sinus CT imaging studies of adult cystic fibrosis (CF) patients were reviewed retrospectively at an academic medical center over a 10-year period. The paranasal sinuses were evaluated for development, extent of inflammatory change, presence and location of bone sclerosis, possible mucocele formation and possible prior surgery.

**Results**

Eighty-three adult CF patients were identified and included in this study. Sphenoid sinus aplasia or hypoplasia in this cohort is prevalent (65.9%). Maxillary sinus hypoplasia was less common (22%). Sclerosis was seen frequently (>84.4%), and less than 10% of patients had a mucocele present. Paranasal sinus inflammation was common in these cases.

**Conclusion**

Sinonasal underdevelopment and inflammatory change in adult cystic fibrosis patients are akin to findings in pediatric patients. High prevalence of bone sclerosis suggests osteoneogenesis secondary to chronic sinonasal inflammation.

**Keywords**: Cystic fibrosis, sinonasal disease, CT

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**Paper 432 Starting at 3:39 PM, Ending at 3:47 PM**

**Sinonasal Tumors: Olfactory Neuroblastomas vs Sinonasal Undifferentiated Carcinomas: Revisiting Marginal Cysts**

Ahmed, M. • Chute, D. • Smith, A.

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**Purpose**

To study the presence of and also characterize marginal or intratumor cysts in sinonasal tumors with intracranial extension. To revisit marginal cysts and immune histochemical markers in sinonasal tumors. The sinonasal tumors with neuroendocrine markers can pose a challenge to pathologist and MR imaging may be helpful.

**Materials & Methods**

Retrospective database search. Sinonasal tumors with intracranial extension included. Only sinonasal undifferentiated carcinomas (SNUCs), olfactory neuroblastomas (ONBs) and sinonasal tumors with neuroendocrine differentiation. The tumor cysts characterized as follows: (A) Rounded or ovoid exophytic marginal cysts at the tumor interface with the brain (typical cysts described in the literature for ONBs), (B) Nonexophytic cysts abutting the intracranial tumor margin (2 mm or less lateral rim enhancement), (C) Intratumor cysts, not abutting the intracranial tumor margin and, (D) No margin or tumor cysts. Immune histochemical markers reviewed.

**Results**

The distribution of cases from the database which met the criteria of the study were as follows: SNUC (4), Small cell undifferentiated cancer (1), Sinonasal malignant tumor with neuroendocrine differentiation (1) and ONB (5). The different type of cysts seen in these tumors were: SNUC (type A-0, type B-3, type C-2, type D-0), ONB (type A-2, type B-2, type C-1, type D-1), Sinonasal malignant tumor with neuroendocrine differentiation (both type B and C) and small cell undifferentiated cancer (type D). The intratumor and nonexophytic marginal cysts in tumors other than ONB had irregular nonrounded appearance. The ONB consistently showed positivity for at least one neuroendocrine marker (Synaptophysin, Chromogranin and Neuron specific enolase) plus characteristic S-100 staining of sustentacular cells. The non-ONB tumors consistently showed cytokeratin positivity and variable positivity for neuroendocrine markers.

**Conclusion**

The exophytic marginal rim enhancing cysts is a characteristic feature of ONBs. Marginal or intratumor cysts can be seen in SNUC and other sinonasal tumors.

**Keywords**: Sinonasal undifferentiated carcinomas, olfactory neuroblastomas, cysts
**Paper 434 Starting at 3:47 PM, Ending at 3:55 PM**

CT and MR Imaging of Invasive Fungal Disease

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**PURPOSE**

Invasive fungal sinusitis is an important cause of morbidity/mortality in hospitalized patients, with its incidence increasing in recent years. In contrast to fungal mycetomas and allergic disease, invasive sinusitis disseminates rapidly via vascular, perineural, and direct mechanisms. The time course may be fulminant, acute, or chronic, depending on the level of immunocompromise. Without prompt aggressive treatment, severe infectious and vascular complications can develop in adjacent soft tissue, bone, orbits, and brain. In practice, the distinction between invasive and allergic fungal sinusitis is often difficult. Few scientific studies have been performed, due to low case volumes and challenges in clinical/imaging workup. Definitive diagnosis requires biopsy and culture, which is highly invasive and technically challenging. In order to better characterize the radiologic manifestations of invasive fungal sinusitis, we performed a retrospective imaging review of all biopsy-proved cases at our institution over the past 5 years.

**MATERIALS & METHODS**

Following approval by the institutional review board, the hospital information system was queried for discharge diagnoses of mycotic infection over a 5-year time period from January 2005 - December 2010. This included ICD-9-CM codes 112.5: candidiasis, 117.3: aspergillosis, 117.5: cryptococcosis, 117.7: zygomycosis, and 118: opportunistic mycoses. Pathology records and clinical notes were used to verify cases of invasive rhinocerebral disease. Available cross-sectional (CT, MR) neuroimaging examinations were retrieved from the radiology information system. Prospective interpretation of studies was provided by five head/neck radiologists at the time of examination. Retrospective review of images was performed by an experienced head/neck radiologist and a radiology resident (PGY-3) with attention to anatomical site and extent of disease, CT/MR signal characteristics, presence of contrast enhancement, and associated imaging findings.

**RESULTS**

Fifteen patients were identified with biopsy-proved invasive fungal infection, including nine acute, two acute-on-chronic, and four chronic subtypes. Predisposing factors included diabetes mellitus in six patients, chronic allergic sinusitis in four patients, malignancy in two patients, organ transplantation in two patients, and congenital immunodeficiency in one patient. Fungal cultures yielded diagnoses of aspergillus in eight, mucormycosis in six, and candida in one patient. Fourteen CT and 11 MR studies were reviewed. Imaging findings were similar for acute and chronic subtypes, differing primarily in the time course and extent of disease at presentation. CT findings included unilateral mucosal thickening, iso- to hyperattenuating soft tissue mass lesions, aggressive bony destruction, and soft tissue inflammatory changes. MR imaging demonstrated corresponding mucosal edema/enhancement, with T1 isointense and T2 iso-to-hypointense soft tissue masses. More specific findings included vascular involvement, perineural enhancement, cellulitis, osteomyelitis, and orbital/intracranial invasion. Late complications included abscess, granuloma, thrombosis, and hemorrhage.

**CONCLUSION**

The imaging findings of invasive fungal rhinosinusitis have not been well described in the American/European literature. As an international head and neck referral center, we have access to a large patient population and expert clinico-radiologic consultation. Based on our review of 15 biopsy-proved cases over the last 5 years, we describe key morphologic/signal abnormalities and patterns of disease spread that can indicate the presence of invasive fungal infection, prompting early intervention to minimize patient morbidity and mortality.

**KEY WORDS:** Invasive fungal, sinusitis, rhinocerebral

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**Paper 434 Starting at 3:55 PM, Ending at 4:03 PM**

Prevalence of Mastoid Effusion Associated with Adjacent Dural Venous Sinus Thrombosis

Bykowski, J.1 • Chen, J.1,2 • Chalian, A. A.3 • Mamourian, A. C.3

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**PURPOSE**

Previous reports have suggested that mastoid effusions can occur in the setting of dural venous sinus thrombosis. This is presumed secondary to abnormal or reversed flow within lymphatic pathways or the mastoid venous system of emissary veins, posterior auricular veins, and the occipital venous plexus. This may result in lymphatic and venous congestion with sterile fluid accumulation in the mastoid air cells. This is an important observation since this fluid may lead the imager to mistake this combination of findings for septic thrombophlebitis. In this retrospective study, we attempted to determine the prevalence of bland mastoid opacification in cases with adjacent sinus thrombosis.

**MATERIALS & METHODS**

IRB approved a retrospective review of the radiology imaging databases at two university hospitals and a Veteran's Administration Medical Center in order to identify all cases of dural venous sinus thrombosis over 3 years confirmed with MR imaging using search expansion with MeSH and Radlex terminologies. Cases were reviewed to confirm presence and location of thrombus as well as timing of appearance of any mastoid fluid. Cases were excluded if thrombus was remote from the expected lymphatic or venous drainage of the mastoid air cells - the distal transverse and sigmoid sinuses- or for a history of recent or prior mastoid region surgery, radiation, embolization, or nasopharyngeal mass. Accessible medical records also were reviewed for signs or symptoms of mastoid infection.
CONCLUSION

Adult patients with thrombosis of the distal transverse or sigmoid sinus may have bland mastoid effusions, believed to be associated with impaired lymphatic and venous drainage. By recognizing this association, it may be possible to avoid unnecessary antibiotic therapy in the setting of bland mastoid opacification with dural venous sinus thrombosis. Alternatively, in patients with new and unexplained headaches, the presence of unilateral mastoid effusion should prompt a search for an underlying dural venous sinus thrombosis, with bilateral mastoid effusions. None of these patients had signs or symptoms of mastoid infection. Serial imaging was available in three of the patients with thrombus and ipsilateral mastoid effusion. One patient demonstrated resolution of mastoid fluid coinciding with resolution of thrombus. The one patient showed no change in the extent of sinus thrombus or mastoid effusion. The remaining patient demonstrated resolution of mastoid fluid, but persistent sinus thrombus.

KEY WORDS: Mastoid opacification, sinus thrombosis

RESULTS

Search criteria identified 376 unique adult patients of which 22 patients were found to have evidence of dural venous thrombosis on MR imaging. Of these patients, eight were excluded since their venous sinus thrombosis did not involve the distal transverse or sigmoid sinuses. Three other patients with sinus thrombus and mastoid effusion were excluded due to recent surgical intervention in the area, and another due to endovascular embolization of an adjacent arteriovenous malformation (AVM). Of the 11 patients with thrombus in the distal transverse and/or sigmoid sinuses, six (54%) had significant mastoid effusion ipsilateral to the thrombosed transverse or sigmoid dural venous sinus. One of these patients had bilateral transverse sinus thrombosis, with bilateral mastoid effusions. None of these patients had signs or symptoms of mastoid infection. Serial imaging was available in three of the patients with thrombus and ipsilateral mastoid effusion. One patient demonstrated resolution of mastoid fluid coinciding with resolution of thrombus. The one patient showed no change in the extent of sinus thrombus or mastoid effusion. The remaining patient demonstrated resolution of mastoid fluid, but persistent sinus thrombus.

CONCLUSION

Adult patients with thrombosis of the distal transverse or sigmoid sinus may have bland mastoid effusions, believed to be associated with impaired lymphatic and venous drainage. By recognizing this association, it may be possible to avoid unnecessary antibiotic therapy in the setting of bland mastoid opacification with dural venous sinus thrombosis. Alternatively, in patients with new and unexplained headaches, the presence of unilateral mastoid effusion should prompt a search for an underlying dural venous sinus thrombosis in addition to obstruction of the eustachian tube due to a nasopharyngeal mass.

KEY WORDS: Mastoid opacification, sinus thrombosis

RESULTS

Search criteria included “third window,” “dehiscence/erosion/fistula,” “seemicircular canal,” “perilymphatic/labyrinth,” “jugular bulb,” “carotid canal,” and “superior petrosal sinus.” Nonfocal lesions of the cochlea/vestibule and diffuse etiologies were excluded, due to mixed hearing loss and associated malformations complicating definitive diagnosis. Prospective interpretation of studies was provided by five head/neck radiologists at the time of examination. Retrospective review of images was performed by an experienced head/neck radiologist and a radiology resident (PGY-3) to determine etiology, anatomical location, and extent of disease. Findings were correlated with available clinical information, including history and physical examination, audiometry data, and operative findings.

CONCLUSION

This is the largest and most comprehensive study of third window anomalies to date. As an international adult head and neck referral center, we have accumulated a diverse repository of pathologic lesions, revealing novel clinicoradiologic findings and associations. From a clinical standpoint, vestibulo-auditory symptoms should raise the possibility of third window pathology. However, imaging is crucial for identifying the underlying etiology, location/extent of disease, and associated findings, thereby enabling appropriate management and surgical planning.

KEY WORDS: Third window, semicircular canal dehiscence, perilymphatic fistula
Long-Term Alterations in the Procerus Muscle after Single-Dose Botulinum Toxin Injection

Koert, I. K.1 • Schroeder, S.1 • Borggraefe, I.1 • Fietzek, U.1 • Steffinger, D.1 • Timpert, K.1 • Reiser, M.3 • Kerscher, M.3 • Heinen, F.4 • Ertl-Wagner, B.1
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PURPOSE
The use of botulinum toxin type A (BoNT/A) in facial aesthetics for the treatment of wrinkles is very popular. Recently it also has been discussed as a potential treatment of chronic migraine. However, its true efficacy and potential adverse effects are still unclear. Despite numerous clinical and experimental studies on BoNT/A, long-term alterations of muscle morphology following BoNT/A treatment have not been studied thus far in normal human skeletal muscle.

MATERIALS & METHODS
After obtaining institutional review board approval, we performed a prospective, placebo-controlled, double-blinded follow-up study on four healthy male adults using 3 T MR imaging (MRI) and clinical examination to visualize long-term alterations after a single BoNT/A injection into the procerus muscle. One control subject underwent a saline-injection (control A) another control received no intervention (control B).

RESULTS
MR imaging disclosed a significant reduction of the muscle volume in the BoNT/A injected (at 1, 4, 6, 10 and 12 months in volunteer A: 54%, 38%, 52%, 44%, 46%; and B: 52%, 58%, 56%, 47%, 38%), but not in the saline-injected control and in the control without any intervention. Clinical examination including photo documentation confirmed reduced glabellar lines at 1, 4 and 6 months after BoNT/A injection, while at 10 months the clinical effect had ceased.

CONCLUSION
The data confirm that MRI is a suitable tool to monitor the long-term effect of BoNT/A in facial aesthetics. Significant muscle atrophy following a single BoNT/A injection lasting beyond the clinical effect should be taken into consideration when repeated BoNT/A injections into the same muscles are proposed.

KEY WORDS: Botulinum toxin, mimic muscles, migraine
CONCLUSION
The 3-point Dixon MRI method provides direct and immediate information about the lipid and hemorrhage content in carotid artery plaques in a shorter examination time without the need for a complex analysis involving multiple contrast-weighted images. Identification of lipid, hemorrhagic and calcified regions can be made immediately and are not dependent on differences in T1 between lipid and hemorrhage. The use of the 3-point Dixon MRI method may provide a more robust biomarker of plaque stability and have an important impact on patient management.

KEY WORDS: Carotid, plaque, MR imaging

Paper 438 Starting at 4:27 PM, Ending at 4:35 PM
Three-Dimensional Transaxial Measurement of Carotid Stenosis Using the Curved Multiplanar Reformating Function of Vitrea: Is the Cross-Sectional Area a Better Estimate of the Degree of Stenosis than Conventional Unidirectional Measurement by ECST Criteria?

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Long Branch, NJ

PURPOSE
Traditionally, the degree of carotid stenosis can be calculated by using either the NASCET or ECST criteria. However, the true degree of carotid stenosis maybe over- or under-estimated by the conventional single-dimensional measurement. In this study, we are comparing the percent stenosis, as measured by the cross-sectional area of the stenotic lumen as calculated by 3-D curved multiplanar reformating (Vitrea) of a carotid CT angiogram (CTA), to the conventional unidirectional measurement using the ECST criteria.

MATERIALS & METHODS
Patients who have undergone CTA of the carotids from January 2008 to December 2010 at the Monmouth Medical Center are selected in this study. A total of 92 patients are eligible. Patients without stenosis were excluded from this study. A fellowship-trained neuroradiologist retrospectively measured the cross-sectional area of the stenotic and expected lumen of the carotid bulbs in the studied population, orthogonal to the longitudinal axis, using the curved multiplanar reformating and fly-through function of the 3-D reconstruction of the CTA. The conventional unidirectional degree of carotid stenosis was calculated using the ECST methodology with the formula: \[1 - \min(\text{diameters of the stenotic lumen})/\text{diameter of the normal lumen}\]. The cross-sectional area of carotid stenosis was calculated using the formula: \(1 - \text{cross-sectional area of stenotic lumen}/\text{cross-sectional area of expected normal lumen}\). Statistical analysis was performed using Microsoft Excel.

RESULTS
A total of 144 diseased carotid vessels were evaluated. A scatter plot was generated using the two sets of data (unidirectional vs cross-sectional). Linear-squared regression lines were obtained, which were \(y = 0.0048x + 0.11\) and \(y = 0.0067x - 0.043\) (graph). The average stenoses were 44% and 46%, respectively. The \(p\)-value was statistically significant, measuring 0.012. The two regression lines intersected at the 51.4% stenosis point.

CONCLUSION
Our data suggest that, above the 51.4% stenosis threshold, the unidirectional measurement underestimates the degree of stenosis, as compared to the cross-sectional measurement. However, below the 51.4% stenosis threshold, the unidirectional measurement overestimates the degree of stenosis. This has significant clinical implications since the current cutoff for surgical treatment (i.e., carotid endarterectomy) for the asymptomatic patient is at 70%. Therefore, the current method of stenosis calculation may be leading to undertreatment of potential surgical candidates.

KEY WORDS: Carotid stenosis, cross-sectional measurement, ECST criteria

Paper 439 Starting at 4:35 PM, Ending at 4:43 PM
Sensory Neural Hearing Loss Due to SLC26A4 Mutations: Imaging Analysis

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PURPOSE
Mutations in SLC26A4 are the most frequent cause of autosomal recessive enlarged vestibular aqueduct (EVA) and congenital vestibulocochlear anomalies. The purpose of this study is to investigate phenotypic variation of inner ear anomalies by imaging in a large group of pediatric patients proved to have SLC26A4 mutations.

MATERIALS & METHODS
Eighty-two cross-sectional images of the temporal bones (70 high-resolution CT and 12 MRI) from 75 hearing-impaired children (mean age, 2 years) with SLC26A4 mutations were reviewed. Images were analyzed for malformations of bony
otic capsule including; cochlear, vestibular, semicircular canal, internal auditory canal (IAC) and vestibular aqueduct malformations.

**RESULTS**
Twenty-one patients had normal bony otic capsule, 10 patients had unilateral pathology and 44 patients had bilateral otic capsule pathology. The variety of anomalies included: 21 isolated EV As; 1 isolated vestibular dysplasia; 5 isolated cochlear dysplasia; 3 combined vestibular dysplasia and cochlear dysplasia; 5 combined vestibular dysplasia and EVA; 2 EVA and cochlear dysplasia; and 17 EVA, vestibular and cochlear dysplasia.

**CONCLUSION**
The presence, the laterality and the severity of the imaging findings of the inner ear anomalies in patients with SNHL with proved SLC26A4 are variable and may reflect genetic variability and environmental factors. Correlation of the severity of the imaging findings and the variable allele mutations is underway and also will be presented.

**KEY WORDS:** Enlarged vestibular aqueduct, SLC26A4, sensory neural hearing loss

**Wednesday Afternoon**
3:15 PM - 4:45 PM
Room 611-612

(39d) Pediatrics: Congenital Malformations and Disorders
(Scientific Papers 440-450)

See also Parallel Session
(39a) Cerebrovascular Occlusive Disease II
(39b) Interventional: Aneurysms II
(39c) Head & Neck: Paranasal Sinuses: Temporal Bones and Cervical Carotid Disease

Moderators: Arabinda K. Choudhary, MD, MRCP, FRCR
Bernadette L. Koch, MD

**Paper 440 Starting at 3:15 PM, Ending at 3:23 PM**

Evaluation of Focal Cerebellar Lesions in Pediatric and Young Adult Patients with Tuberous Sclerosis: Characterization of Lesions and Longitudinal Study in a Large Cohort

Vaughn, J. • Katz, J. • Weiner, H. • Roth, J. • Milla, S. S.
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**PURPOSE**
There are few papers characterizing cerebellar lesions in patients with tuberous sclerosis (TS) and no published papers documenting longitudinal evaluation of cerebellar lesions. There has been recent suggestion of a possible correlation between autism and cerebellar lesions in TS patients, heightening the importance for understanding and evaluating these lesions. Our purpose was to characterize cerebellar lesions in a large cohort of pediatric and young adult TS patients with specific interest in assessing longitudinal changes.

**MATERIALS & METHODS**
We retrospectively reviewed MR imaging (MRI) scans from 148 pediatric and young adult patients with tuberous sclerosis (initial MRI at age 0-25; mean 8.4). Imaging characteristics recorded: number/location of focal lesions, T1, T2 and FLAIR signal, presence of enhancement, calcification, associated retraction deformity, and cerebellar atrophy. Review of patients also included evaluation for subependymal giant cell astrocytomas (SGAs). Patients with cerebellar lesions and follow-up scans ≥3 months from the original scan were further analyzed for longitudinal characterization (range from 3 months to 10 years follow-up scans).
RESULTS
Thirty of 148 patients had focal cerebellar lesions (20.3%). The total number of cerebellar lesions in the 30 patients totaled 43 (21 right sided, 22 left sided) with 11 patients having more than one cerebellar lesion. Of these 30 patients, 18 patients had follow-up MRIs >3 months from the original MRI. Seven of these 18 patients (38.9%) demonstrated changes in characteristics of a cerebellar lesion (change in size and number of lesions, enhancement, retraction deformity, and calcification) while 11 patients did not show change in lesion appearance. Eighteen of the 43 lesions demonstrated enhancement (41.9%). Six of the 30 patients with cerebellar lesions had pathologically confirmed supratentorial SGAs (20%), as compared to the overall total incidence of 15 SGAs in the 148 TS patients reviewed (10.1%).

CONCLUSION
In our large cohort of young TS patients, 20.3% had at least one focal cerebellar lesion. In patients with cerebellar lesions, longitudinal review of their MRI scans demonstrates 38.9% of patients had change in signal characteristics of a cerebellar lesion. This may explain the slight variance in previous reports of incidence of cerebellar lesions and their MRI appearance. Additionally, a higher percentage of patients with cerebellar lesions developed SGAs than patients without cerebellar lesions. As this is the first report-ed longitudinal study of cerebellar lesions in TS, further investigation of cerebellar lesions may provide additional insight into TS pathology and associated clinical manifestations, such as autism, developmental delay, and seizures.

KEY WORDS: Tuberous sclerosis, cerebellum, longitudinal

Paper 441 Starting at 3:23 PM, Ending at 3:31 PM
MR Diffusion Tensor Imaging of the Optic Nerve and Optic Radiations at 3.0 T in Children with Neurofibromatosis Type I
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PURPOSE
Optic pathway glioma (OPG) is a characteristic hallmark of neurofibromatosis Type I (NF-I). The purpose of this study was to evaluate the optic nerves and radiations in children with NF-I using MR diffusion tensor imaging (MRDTI) at 3.0 T to determine if MRDTI can serve as a noninvasive measure of OPG and disease progression.

MATERIALS & METHODS
MR diffusion tensor imaging and tractography was performed prospectively at 3.0 T in nine children with NF-I (7 boys, 2 girls, average age 7.8 years, range 2-17 years) and 44 normal controls (25 boys, 19 girls, average age 8.1 years, range from 3-17 years). Fractional anisotropy (FA) and mean diffusivity were determined by manual region-of-interest analysis for the optic nerves and optic radiations. Statistical analysis was used to compare normal controls to the patients with NF-I.

RESULTS
Three NF-I patients had bilateral optic nerve gliomas, two had chiasmatic gliomas, and four had unidentified neurofibromatosis objects (UNOs) along the optic nerve pathways without focal mass. In all NF-I patients, there were statistically significant decreases in FA and elevations in Dav in both optic nerves and optic radiations compared to age-matched controls. In normals, average FA was 0.549 +/- .069 in optic nerves and 0.624 +/- .070 in optic radiations, and in children with NF-I, the average FA in optic nerve was lower at 0.391 +/- .079 and lower in optic radiations at 0.565 +/- .065. Mean diffusivity was elevated in children with NF-I to 1.227 +/- .015 (10^-3 mm^2/sec) in optic nerve and 0.938 +/- .094 (10^-3 mm^2/sec) in optic radiations. Normals had mean diffusivity in optic nerves of 1.064 +/- .12 (10^-3 mm^2/sec) and 0.888 +/- .87 (10^-3 mm^2/sec) in optic radiations.

CONCLUSION
MR diffusion tensor imaging can evaluate the optic pathways in pediatric patients with NF-I. Statistically significant abnormalities were detected in the diffusion tensor metrics of the optic nerves and radiations compared to age-matched controls. MR diffusion tensor imaging may serve as a non-invasive and quantitative biomaging marker of optic pathway disease and disease progression in NF-I.

KEY WORDS: NF I, DTI, optic nerve and radiations
Serial Study of Arteriopathy in PHACE Syndrome

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**Purposes**

Our goal is to evaluate the frequency with which dynamic changes occur in the head and neck arteries of children with PHACE syndrome. MR angiography (MRA) examinations of the head and neck frequently are performed in patients with PHACE syndrome, sometimes every 3 months, for fear of possible development of arterial stenosis, aneurysms, moyamoya-like vasculopathy and infarctions.

**Materials & Methods**

After IRB approval was obtained, serial MRA examinations of the head and neck of 19 patients ranging in age from 2 days to 11 months at presentation (14 females and 5 males), diagnosed with probable or definite PHACE syndrome, from three institutions were reviewed retrospectively. Serial MRA examinations were performed at mean time intervals of approximately 6 months (with only one time interval greater than 15 months). MR angiography findings were reviewed independently by two fellowship-trained pediatric neuroradiologists and one fellowship-trained pediatric interventional radiologist. Imaging findings were categorized according to the Hess classification and agreed upon by consensus.

**Results**

Four of the 19 patients (21%) had unanticipated changes: two of the children developed arterial narrowing and two demonstrated interval enlargement of a narrowed artery. The two children who developed arterial narrowing were: (1) a 6-month-old girl with a left IAC hemangioma and a large right orbital hemangioma, who developed long segment narrowing of the distal cervical right ICA 8 months after her initial MRA examination, and (2) a 6-month-old girl with a right orbital and right malar hemangioma who developed focal right MCA M1 segment narrowing 7 months after the initial MRA. The two children who demonstrated enlargement of a narrow vessel included the following: (A) a 4-month-old boy with a small left cheek hemangioma who developed an acute left MCA infarction due to focal narrowing of the left MCA M1 segment, that resolved 5 months later and (B) a 10-week-old girl with a right temporal hemangioma and bilateral orbital hemangiomas with long segment left MCA M1 segment narrowing, that resolved 7 months later. None of the children had an aneurysm and none developed moyamoya-type vasculopathy during the study time period.

**Conclusion**

Our retrospective study of 19 children with PHACE syndrome revealed that 21% (4/19) developed unanticipated narrowing or enlargement of a single artery that occurred over an approximately 6-month interval. This finding suggests that arteriopathy in PHACE syndrome is most likely dynamic. None of the children developed an aneurysm and none of the children developed moyamoya-like changes over the study time period. There were no distinguishing morphologic features that separated the children who developed arterial narrowing from those that did not. The timing of the changes that occurred over approximately 6-month intervals suggests that two time points may be sufficient for initial MRA evaluation, with possible further follow up in children who show changes in vessel caliber or have new symptoms.

**Key Words:** PHACES, vasculopathy, infarction
cases. Hypogenesis or diffuse hypoplasia of the corpus callosum was present in 42% of the cases, whereas focal enlargement or uniform thickness was present in 7.5%. Orbital abnormalities were present in 7% of cases, including septo-optic dysplasia and hypoplastic optic nerves and chiasm. Dysmorphic basal ganglia were present in 3.8% of the cases, the most distinctive pattern being globular appearance with apparent fusion of caudate and lentiform nuclei, present in three cases of bilateral perisylvian polymicrogyria and in four other different patterns. Cerebellar hemispheric dysgenesis was present in 10% of the cases, whereas vermic dysgenesis was present in 17%. Abnormal brainstem morphology was present in 30% of the cases, mostly reflecting wallerian degeneration rather than true dysplasia. Assessment of white matter volume revealed regional or diffuse decrease in the vast majority of the cases, usually commensurate with the extent of abnormal cortex.

**CONCLUSION**

This study expands our understanding of the spectrum of associated cortical and noncortical abnormalities in patients with polymicrogyria syndromes. Several of these associated findings are nonspecific, reflecting atrophy or wallerian degeneration. However, specific abnormalities associated with polymicrogyria may suggest the diagnosis or underlying genetic mutation. Systematic assessment and characterization of these associated abnormalities by dedicated MR imaging may help improve diagnostic, prognostic and genetic counseling.

**KEY WORDS:** Polymicrogyria, malformations of cortical development, MR imaging

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**Materials & Methods**

Five patients with *gpr56* mutations underwent MRI examination including DTI for quantitative measurements. Polymicrogyria topographic pattern, supra- and infra-tentorial WM abnormalities, corpus callosum, cerebellum and brainstem morphology were studied. The advanced imaging protocol was followed by the estimation of parametric maps by using tools from the FMRIB software library. Apparent diffusion coefficient (ADC), fractional anisotropy (FA) and mean diffusivity values were measured and compared to age-matched healthy children.

**RESULTS**

Three patients were diagnosed with missense *gpr56* mutations; the remaining two were affected of two newly reported nonsense *gpr56* mutations. We observed a characteristic morphologic pattern including bilateral fronto-parieto-occipital PMG according to an antero-posterior gradient with a relative sparing of the temporal lobes, enlarged perivascular spaces, cerebellar cysts located at the posterior periphery of the hemispheres and patchy subcortical and peri-ventricular WM abnormalities, in two cases affecting the cerebellum. The corpus callosum in all cases showed a uniform mild increased thickness. The only patient with significant supratentorial ventriculomegaly, presented an arch-shaped corpus callosum. A dysmorphic brainstem was seen in all patients with flattening of the ventral portion of the pons and a flat to concave aspect of its posterior surface. The WM areas with increased signal on FLAIR T2-weighted images showed increase of ADC values. Significant alterations of the myelination and WM pathways were documented by means of FA values and fiber probabilistic tractography both at the supra and infratentorial level.

**CONCLUSION**

We describe a conventional MRI pattern of cerebral and cerebellar malformations characterizing the patients with *gpr56* mutations, useful to guide genetic counseling. Diffusion tensor imaging allows to better depict the associated WM abnormalities regarding both fiber integrity and fiber pathways that contribute to the clinical features of these patients.

**KEY WORDS:** Polymicrogyria, diffusion tensor imaging

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**Purpose**

*GPR56*-related bilateral frontoparietal polymicrogyria (BFPP; MIM606854) is a rare recessively inherited disorder with a overall brain appearance similar to that of the so-called cobblestone lissencephaly, resulting from abnormalities of the pial basement membrane overlying the developing cortex. We report five patients with bilateral polymicrogyria (PMG) diagnosed by *gpr56* (G protein coupled receptor 56) gene mutations. The purpose of this study is to contribute to the definition of the gray and white matter (WM) abnormalities that define the *gpr56* brain mutations pattern by means of conventional MR imaging (MRI), diffusion weighted (DWI) and diffusion tensor (DTI) imaging.

**Materials & Methods**

Five patients with *gpr56* mutations underwent MRI examination including DTI for quantitative measurements. Polymicrogyria topographic pattern, supra- and infra-tentorial WM abnormalities, corpus callosum, cerebellum and brainstem morphology were studied. The advanced imaging protocol was followed by the estimation of parametric maps by using tools from the FMRIB software library. Apparent diffusion coefficient (ADC), fractional anisotropy (FA) and mean diffusivity values were measured and compared to age-matched healthy children.

**RESULTS**

Three patients were diagnosed with missense *gpr56* mutations; the remaining two were affected of two newly reported nonsense *gpr56* mutations. We observed a characteristic morphologic pattern including bilateral fronto-parieto-occipital PMG according to an antero-posterior gradient with a relative sparing of the temporal lobes, enlarged perivascular spaces, cerebellar cysts located at the posterior periphery of the hemispheres and patchy subcortical and peri-ventricular WM abnormalities, in two cases affecting the cerebellum. The corpus callosum in all cases showed a uniform mild increased thickness. The only patient with significant supratentorial ventriculomegaly, presented an arch-shaped corpus callosum. A dysmorphic brainstem was seen in all patients with flattening of the ventral portion of the pons and a flat to concave aspect of its posterior surface. The WM areas with increased signal on FLAIR T2-weighted images showed increase of ADC values. Significant alterations of the myelination and WM pathways were documented by means of FA values and fiber probabilistic tractography both at the supra and infratentorial level.

**CONCLUSION**

We describe a conventional MRI pattern of cerebral and cerebellar malformations characterizing the patients with *gpr56* mutations, useful to guide genetic counseling. Diffusion tensor imaging allows to better depict the associated WM abnormalities regarding both fiber integrity and fiber pathways that contribute to the clinical features of these patients.

**KEY WORDS:** Polymicrogyria, diffusion tensor imaging

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**Purpose**

Predominant involvement of cortical layer 5 in polymicrogyria (PMG) predicts abnormalities in subcortical projection pathways. In many instances, this fails to explain deficits in higher-order functions (e.g., language) mediated by cortico-cortical connections [e.g., arcuate fasciculus(AF)] which arise from and terminate in layers 2 and 3. Our purpose was to identify: 1. presence/absence of the left AF and 2. dys-
plastic involvement of language cortices and to determine their relationship to language development in pediatric patients with PMG.

**Materials & Methods**
Patients were identified retrospectively with the following inclusion criteria: 1. Polymicrogyria (PMG). 2. 30-direction DTI data set performed at 3 T. 3. Language characterized by a pediatric-neurologist. Eleven patients presenting with headache without neurologic deficit, language impairment, or MRI abnormality served as a comparative cohort; these subjects underwent identical sequences. The AF in each patient was categorized as present on the left-only, on the right-only, or bilaterally. Patients were divided into three groups of language development: 1. Intact: age-appropriate. 2. Mild-to-moderate impairment: delayed. 3. Profound impairment: absent verbal language. Based on anatomical MRI, the presence of dysplastic cortex in the left inferior frontal (IFG) and/or superior temporal (STG) gyri was evaluated by a pediatric neuroradiologist blinded to the DTI and language data.

**Results**
One hundred percent of PMG patients with intact language had an identifiable left AF. One hundred percent of patients without a left AF had some degree of language impairment; 20% of patients with a left AF were impaired. All normatives had an identifiable left AF; 73% had an identifiable right AF. The following differences were significant: 1. Frequency of language impairment in PMG patients without a left AF versus normatives (p<0.0001). 2. Frequency of language impairment in PMG patients with versus without a left AF (p<0.015). 3. Frequency of absence of the left AF in PMG patients versus normatives (p<0.008). Absence of the left AF had 100% specificity, 86% sensitivity, and 100% positive predictive value for some degree of language impairment. Five of six PMG patients with dysplastic cortex within the left IFG and/or STG had no left AF; four of five patients with no involvement of these gyri had a left AF. One patient had dysplastic involvement of both language cortices and an identifiable left AF; this patient had normal language. There was no significant difference between the frequency of language impairment in patients with dysplastic cortex versus those with identifiable dysplasia in these locations(p<0.2). Involvement of one or both of these regions had 67% specificity, 71% sensitivity, and 83% positive predictive value for language impairment.

**Conclusion**
These preliminary findings suggest that absence of the left AF may be a specific biomarker of language impairment in patients with PMG. Presence/absence of the left AF predicted language function better than presence/absence of dysplasia within the expected anatomical locations of language cortices. Therefore, the ability to form connections may be a more important determinant of cortical function than whether it is dysplastic. Correlation with language cortex locale by fMRI will be an important next step.

**Key Words:** Brain, arcuate fasciculus, language

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**Paper 446 Starting at 4:03 PM, Ending at 4:11 PM**

**Corroboration of Normal and Abnormal Fetal Cerebral Lamination on Postmortem MR Imaging with Autopsy**

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**Purpose**
The presence of normal fetal cerebral laminar germinal matrix, intermediate zone, subplate layer and cortex, can be used as a marker of normal fetal cerebral development. Our primary aim was to compare postmortem MRI imaging (MRI) assessment of normal and abnormal fetal cerebral laminar pattern on T1- and T2-weighted images with histopathology. The secondary aims were to compare postmortem MRI assessment of the sulcation and gyration with autopsy and also to determine if there was an association between fetal cerebral laminar pattern with sulcation and gyration on autopsy.

**Materials & Methods**
Fifty-five formalin-fixed brain from postmortem fetuses, ranging from 16-30 weeks gestational age, mean of 23 weeks, underwent T1- and T2-weighted MRI and subsequently sectioning and histologic examination. The cerebral laminar pattern was graded as normal or abnormal on T1- and T2-weighted imaging and compared with autopsy findings. The sulcation and gyration pattern also was defined as normal or abnormal. The sensitivity, specificity, positive and negative predictive values of T1 and T2 assessment of cerebral laminar pattern and MR assessment of cerebral laminar were calculated.

**Results**
Twenty-six fetuses had abnormal and 29 had normal cerebral laminar pattern on histology. On T1, the overall sensitivity, specificity, positive and negative predictive value of evaluating cerebral laminar pattern were 96.15% (CI:78.42% - 99.80%), 89.66% (CI:71.50% - 97.29%), 89.29% (CI:70.63% - 97.19%) and 96.29% (CI:79.11% - 99.80%) respectively. On T2, the overall sensitivity, specificity, positive and negative predictive value of evaluating cerebral laminar pattern were 73.08% (CI:51.95% - 87.65%), 96.55% (CI:80.37% - 99.82%), 95.00% (CI:73.06% - 99.74%) and 80.00% (CI:62.54% - 90.94%) respectively. Twenty-five fetuses had abnormal sulcation pattern and 30 had normal sulcation and gyration on histology. The sensitivity, specificity, positive and negative predictive value of MRI evaluation of the sulcation and gyration pattern were 100.00% (CI: 83.68% - 100.00%), 96.67% (CI: 80.95% - 99.83%), 96.15% (CI: 78.42% - 99.80%) and 100% (CI: 85.44% - 100.00%) respectively. There was significant association between fetal cerebral laminar pattern and sulcation and gyration (χ²=0.891, p<0.0001).

**Conclusion**
Postmortem MRI has high sensitivity, specificity, positive and negative predictive values in assessing the fetal cerebral laminar pattern compared to histology. T1-weighted imaging has higher sensitivity and negative predictive value whilst T2-weighted imaging has higher specificity and positive predictive value. Assessment of fetal cerebral laminar pattern is subop-
timal on current antenatal MRI, particularly on T1-weighted images, due to poorer resolution and motion degradation of antenatal MRI. However, with further technical developments of antenatal MRI, assessment of fetal cerebral lamination potentially can be applied antenatally as an additional neuroimaging marker of normal and abnormal cerebral development.

**KEY WORDS:** Fetal, MR imaging, postmortem

**Paper 447 Starting at 4:11 PM, Ending at 4:19 PM**

Prenatal Tractography of Abnormal White Matter Connectivity in Callosal Agenesis

Kasprian, G. J. • Mitter, C. • Brugger, P. • Perju-Dumbrava, L. • Prayer, D.

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**PURPOSE**

The most striking feature in the condition of callosal agenesis is the presence of abnormally oriented callosal axons, forming the aberrant bundle of Probst. So far, the intrauterine growth and maturation of this pathway have not been studied. This study aims to apply the technique of diffusion tensor imaging (DTI) and tractography in utero to visualize the abnormal 3D white matter (WM) connectivity in cases of complete (CCA) and partial (PCA) callosal agenesis.

**MATERIALS & METHODS**

In utero MR imaging (MRI) of 13 fetuses with CCA and three fetuses with PCA [age: 20-37 gestational weeks (GW), mean: 26.7±5.5 GW] was performed at 1.5 T without the use of sedation. An axial DTI sequence (16 diffusion encoding directions, reconstructed voxel size 0.94mmx0.94mmx3mm, b values of 0s/mm2 and 700s/mm2) was acquired and geometrically coregistered with multiplanar T2-weighted sequences of the fetal brain. The Probst bundle was a priori defined by sequential multiple regions of interest on coronal images and 3D visualized by a streamline algorithm.

**RESULTS**

Frontooccipitally oriented trajectories could be visualized successfully in 11/13 cases with CCA bilaterally corresponding to the bundles of Probst. In the remaining 2/13 cases, the Probst bundle was detected unilaterally. The 2/13 cases these WM tracts were proved by postnatal follow up and 1/13 cases by post-mortem imaging (including DTI) MRI and DTI (Figure a,b prenatal; c,d postmortem). In all 3/3 fetuses with PCA an atypical “sigmoid” bundle connecting the opposing frontal and occipital lobes, which could not be visualized by conventional (T2- and T1 weighted) fetal MR sequences, was detected.

**CONCLUSION**

To our knowledge this is the first in utero neuroimaging study to demonstrate the abnormal 3D WM architecture in cases of CCA in vivo (Figure). In addition to the visualization of the characteristic bundles of Probst, in utero DTI allowed to confirm the presence of aberrant sigmoid trajectories in cases of PCA prenatally, opening further diagnostic options for a more specific prediction of future neuropsychologic deficits in a rather heterogeneous group of developmental brain pathologies.

**KEY WORDS:** Diffusion tensor imaging, fetal MR imaging, callosal agenesis

**Paper 448 Starting at 4:19 PM, Ending at 4:27 PM**

Incidence of Rhombencephalosynapsis in Aqueductal Stenosis

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**PURPOSE**

Rhombencephalosynapsis (RES) is an uncommon cerebellar malformation defined by fusion of the cerebellar hemispheres due to primary failure of vermian differentiation. Rhombencephalosynapsis is diagnosed increasingly on neonatal imaging, particularly with careful review in recognition of cases with partial fusion. Speculation of the embryologic etiology for RES implicates factors involved in midline differentiation and association with other midline anomalies has been noted anecdotally. To further elucidate potential association with other midline brain malformation, a retrospective study of children identified with aqueductal stenosis (AS) was undertaken.

**MATERIALS & METHODS**

With IRB approval a radiology report database for a single children's hospital was searched for all occurrences of the keywords “aqueductal stenosis” from 2005-2010. Cases were excluded if inadequate imaging was available (e.g., only CT), a midbrain neoplasm was causing the AS, or
stenosis was not present. A neuroradiologist reviewed all potential imaging exams with primary dependent measure being number of cases that exhibit an RES pattern. Cases identified with RES then were read in consensus with two pediatric neuroradiologists.

RESULTS
One hundred and thirteen cases were identified with the key-words: 56 were identified with aqueductal stenosis. Five of 56 (9%) were found to have (previously unidentified) RES; 4/5 partial, 1/5 complete.

CONCLUSION
Rhombencephalosynapsis may be more common than would be suggested from the number of cases reported in the literature having been found in 9% in the cases in a consecutive series of children imaged with AS. (AS accounts for 20% of congenital hydrocephalus). Results suggest developmental defect(s) associated with RES may have commonality with defects also on the rostral side of the thalamus in the midbrain and that RES should be looked for in cases where aqueductal stenosis is identified.

KEY WORDS: Rhombencephalosynapsis, aqueductal stenosis

Paper 449 Starting at 4:27 PM, Ending at 4:35 PM
Peroxisome Biogenesis Disorders: MR Imaging Findings

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PURPOSE
Peroxisomal biogenesis disorders (PBDs) refer to a genetically heterogeneous group of autosomal recessive disorders resulting in characteristic enzymatic defects in the peroxisome assembly mechanism with elevation of the very long chain fatty acids (VLCFA). The mutations produce a wide phenotypic spectrum of increasing severity classically referred to as infantile Refsum disease (IRD), neonatal adrenoleukodystrophy (NALD), and Zellweger syndrome (ZS). In the most severe form (ZS) considerable neuronal migration abnormalities have been described, while there is variable expression white matter hypomyelination or demyelination in patients with longer survival. The purpose of this study was to analyze the MR imaging features, particularly the pattern of white matter involvement, from patients with PBDs.

MATERIALS & METHODS
Forty-one MR studies of 26 patients (12 M, 14 F, mean age 5.24 years, ranging from 9 days to 27 years) with clinically diagnosed PBD (5 IRD, 12 NALD, 7 enzyme deficiencies and 2 ZD) were reviewed retrospectively. MR studies were examined for brain volume, state of myelination, the presence or absence of white matter lesions, cortical gyration pattern, and contrast enhancement.

RESULTS
White matter abnormality is a frequent finding in patients with PBD, found in 15/26 cases (57%). Among the positive cases, three patients revealed diffuse cerebral hypomyelina-

Paper 450 Starting at 4:35 PM, Ending at 4:43 PM
How Reliable Is the Ultrasound Diagnosis of Agenesis of the Corpus Callosum In Utero?

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PURPOSE
It appears from the existing literature on fetal MR that agenesis of the corpus callosum (ACC) may be a more difficult diagnosis to make on ultrasound than previously thought. The purpose of this paper is to describe all of our cases in which "agenesis of the corpus callosum" has featured in either the referral from ultrasound or in the report of the interuterine MRI (iuMRI).

MATERIALS & METHODS
Thirteen hundred and twenty-seven iuMRI examinations performed between April 2004 and April 2010 of which over 95% included imaging of the fetal brain. Three groups were formed by reviewing the referral data and the iuMRI reports: Group 1: Ultrasound and iuMR agreed on the presence of ACC. Group 2: Ultrasound suggested ACC but the corpus callosum was normal on iuMRI. Group 3: iuMRI found ACC that was not suspected on the ultrasound referral.

RESULTS
One hundred sixty-two cases met the entrance criteria for the study. Group 1: Ultrasound and iuMR agreed on the presence of ACC, 54/162 (33%). Group 2: Ultrasound suggested ACC
but the corpus callosum was normal on iuMRI, 58/162 (36%). Group 3: iuMRI found ACC that was not suspected on the ultrasound referral, 50/162 (31%).

**Conclusion**
This study shows that the diagnosis of ACC by ultrasound is poor in terms of sensitivity and specificity. Any question of an abnormality on ultrasound warrants investigation by fetal MR.

**Key Words:** Fetal, agenesis of the corpus callosum, MR imaging

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### Setting Up a Research Program

**A. James Barkovich, MD**

**Presentation Summary**

A research program cannot be started without a research group. The group, of necessity, will start small with few members and will grow with success. The most important characteristics of group members should be variation of background. In most disciplines, students are taught to approach problems based upon a finite, well established knowledge fund. Members of that discipline, as a result of their knowledge and long established concepts, tend to approach all problems from a rather narrow perspective. This limitation of perspective by nature restricts the breadth of ideas that emanate from its disciples. Advances are made by analysis of problems from new perspectives, which entails recruiting members from different disciplines. For example, a biology project might be advanced by the perspective of a physical scientist, mathematician, or engineer. A physics project might be helped by ideas from a biologist or mathematician. A radiology project might be helped by a biologist or a geneticist. The Group Leader must not feel threatened by the knowledge of his recruits; (s)he should use it to learn and to broaden the horizon of the group’s research pursuits. In medicine, research projects should address clinical concerns. Radiologists who began as physicists or engineers may be able to forge a career based upon technical advances, but neuroradiologists will be far more successful working with neurosurgeons and neurologists, directing the study toward finding new methods to diagnose and treat clinically important conditions that are not treated adequately by current methods. Imaging helps to identify new characteristics of the disorder not yet known to the clinicians; this may involve pathophysiology, genetics, anatomy, or intrinsic physiologic aspects that can only be identified with the help of imaging methods. After a few discoveries, acquire financial support to pay for your time and that of your co-workers. Initial grants will come from your institution or imaging societies. The NIH and NSF support grants for young investigators, as well. A Project Coordinator can handle day-to-day communications with patients, scheduling of exams, organizing meetings, and updating of IRB approvals. The project coordinator allows you time to write papers based on your results; without those papers, future grants will not be forthcoming. As results accumulate and papers are written, results are used to trigger ideas and supply “Preliminary Data” for more grants. At this point, you have a research program.

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### Getting Hired

*Carolyn C. Meltzer, MD, FACR*

**Presentation Summary**

Starting your academic career in radiology may not be the easiest thing. There is no one-size-fits-all roadmap and recent changes in health care organization brought about by economic and political shifts have made advice by past colleagues somewhat less relevant. In this session, we will discuss strategies that may allow you to be best prepared for a promising academic career, negotiating for that ideal position, and what to expect in the process. We also will overview potential obstacles in this goal and approaches to face these most effectively and with the right tools.

**References**

The Post-Treatment Evaluation of the Primary Site: Pearls and Pitfalls from My Experience
Lawrence E. Ginsberg, MD

PRESENTATION SUMMARY
Following conventional forms of therapy for head and neck cancer, both clinical and radiologic evaluations are essential to ensure that therapy has been effective and to exclude recurrent tumor. For surgical therapy, immediate post-operative imaging is sometimes performed to ensure adequacy of resection prior to the development of potentially confounding surgery-related changes. Such cases include sinonasal and complex skull base surgeries. In other post-operative settings imaging is performed subsequently, at the time of restaging, both to exclude tumor recurrence, and to evaluate for post-operative complications. Imaging is indicated at any time, of course, to exclude infection or any number of complications, should symptoms arise. As with any post-treatment imaging, prior baseline imaging is of paramount importance, to facilitate comparison. In patients treated nonsurgically, it is not usual to image immediately following the conclusion of therapy, but rather to wait a variable time period, generally in the range of 8-12 weeks. This is done to permit some of the acute post-treatment (post-XRT, really) changes to evolve and resolve prior to imaging, and to allow tumor sufficient time to regress. In patients who are being treated with sequential chemotherapy followed by XRT, interim imaging is often performed to assure at least partial response to therapy, with the intent of re-imaging following radiotherapy. With respect to imaging modality, this is often disease and center specific. There is ongoing divergence of opinion as to which imaging modality is preferred for the initial staging of various malignancies, and indeed, for skull base and sinonasal cancers, MR and CT are regarded as complimentary; both are generally obtained. As to the preferred cross-sectional imaging modality for the post-treatment setting, it would be most advantageous to use the same imaging modality. Comparing pre-treatment and post-treatment studies of differing modalities should be vigorously avoided IMHO (in my humble opinion). As to the evolving role of PET/CT, this modality is increasingly being obtained at MD Anderson Cancer Center as an initial staging modality, as for its role in post-treatment care, this is currently in evolution. It will no doubt have a place at the table, but during this evolution, radiologists are warned that not every instance of hypermetabolism will represent tumor recurrence—there are many false positives, some of which will be reviewed in this presentation. With respect to assessment of imaging efficacy, this is extremely challenging. When a tumor resolves completely, or if a tumor unequivocally progresses, the assessment is easy—unfortunately, that is seldom the case. Alas, this determination entails a great deal more nuance, experience, the knowledge born of error, and the acceptance that on an individual given day, one cannot know all. While additional imaging or biopsy may be obtained in certain cases, it is often necessary to await follow-up imaging. In terms of the appearance of operated or radiated tissues, one must be familiar with the expected findings and their time course, as well as a host of treatment-related complications. This presentation will cover these appearances as well as their possible overlap with tumor recurrence.
REFERENCES

The Post-Treatment Neck
Suresh K. Mukherji, MD, F ACR

PRESENTATION SUMMARY
The intent of the presentation will be to review the post-treatment imaging findings of the neck. This presentation will review the imaging findings following surgery and radiation therapy. The surgical procedure which will be reviewed include the radical neck dissection, supraomohyoid neck dissection and selective neck dissection. The expected imaging findings following radiation therapy will be presented in detail. The presentation will also help the neuroradiologists distinguish between recurrent tumor and the expected post-treatment changes.

PET-CT for Evaluation of Treatment of Head and Neck Cancer: Current Applications and Best Practices
Laurie A. Loevner, MD

PRESENTATION SUMMARY
In patients with suspected or known recurrent or residual head and neck cancer, PET-CT plays a critical role in restaging, especially if surgical resection is being contemplated. If distant metastatic disease is identified on PET, it is unlikely that a large radical surgical procedure would be performed as such surgery often causes significant functional losses, as well as cosmetic deformity, and will not improve long-term survival. In patients without distant disease, specific findings isolated to the head and neck may alter patient management. Close evaluation of the bilateral neck for nodal recurrence is essential for surgical planning. The radiologist must diligently evaluate the primary site of recurrence to assess the extent of tumor so that the surgeon can determine operative candidacy. This presentation will review the normal distribution of FDG in the treated neck, as well as the many physiologic variations of FDG uptake in the treated neck that can result in image misinterpretation. Critical analysis of PET-CT/MR hybrid images with an emphasis on what the surgeon and radiation therapist need to know will be addressed, also emphasizing pitfalls to avoid. A rationale for when and how to use PET-CT in your practice with patient care paramount will be discussed.

REFERENCES

Wednesday Afternoon
4:45 PM - 6:15 PM
Ballroom 6A

(41) ASPNR Programming: Of Molecules and Morphology: Molecular Bases of Malformation

(459) Patterning of the Cerebral Cortex
— Thomas P. Naidich, MD

(460) The Great Forebrain Commissures: Development, Anatomy and Misunderstandings
— Charles A. Raybaud, MD

(461) Malformations of the Midbrain and Hindbrain: Embryology, Genetics and Imaging
— A. James Barkovich, MD, MPH

Moderator: Richard L. Robertson, MD

Patterning of the Cerebral Cortex
Thomas P. Naidich, MD

PRESENTATION SUMMARY
This review will address the sequence of gross anatomical and molecular biological events that lead to the establishment of the cerebral cortex. It will review the progression of the forebrain from prosencephalon to telencephalon, the patterning of the prosencephalomes, the arealization of the cerebral cortex, the development of the subependymal germinal matrix, the genesis of neurons and glia, the timing and molecular mechanisms underlying neuronal migration including the cell adhesion molecules, the lamination of the cortex, the mechanisms of axonal outgrowth and guidance that “wire” specific cortical laminae into circuits, and the
events leading to cortical folding, sulcation and gyration. It also will touch upon the derangements of molecular events that lead to familiar malformations and tumors.

REFERENCES
2. Sanes DH, Reh TA, Harris WA. Development of the Nervous System. 2006 Elsevier Academic Press, Burlington, Massachusetts, USA

The Great Forebrain Commissures: Development, Anatomy and Misunderstandings
Charles A. Raybaud, MD

PRESENTATION SUMMARY
Anatomy. In humans, anterior commissure (AC) connects olfactory structures and temporal and lateral occipital neocortices; hippocampal commissure (HC), presubicula and parahippocampal gyrri; anterior corpus callosum (anCC) (lamina rostralis, genu, body), the frontal lobes; isthmus, the sensory-motor strips; splenium (spl) the parietal and medial-occipital neocortices. Ipsilaterally, septal nuclei (SN) connect to hippocampus by fornix and to cingulate gyrus by septum pellucidum (SP). Anterior corpus callosum overlies SP and spl overlies HC. Comparative anatomy. Primitive vertebrates have olfactory bulbs and paleocortices only, with a basal telencephalic commissure (BTC). More advanced vertebrates have an archicortex (hippocampus) also, with corresponding HC. In addition mammals have a neocortex but commissuration depends on their subclass. In monotremes/marsupials neocortical fibers cross along BTC from SN and hippocampus; HC, between fornices in dor- sally. Enormous growth of frontal lobes in humans dis- places HC posteriorly, stretching fornix and SP. In weeks 12-13, a special callosal “midline glia” apparatus develops: an attractant “glial sling” fills the bottom of interhemispheric fissure to convey pioneer fibers of AC; both repellent “indusium griseum glia” at the cortico-septal boundary and “glial wedge” medial to lateral ventricles channel them toward the glial sling; temporal neocortical fibers follow BTC to form a complete AC; parieto-occipital fibers follow HC to form spl. At week 14 the commissural plate is small but structurally complete. Eventually each segment grows by addition of fibers while hemispheres expand, frontal anCC more than any other segment pushing the spl/HC dorsally. Misunderstandings. Corpus callosum doesn’t grow from front to back. It forms from two separate structures. Cavum septi pellucidi is the bottom part of frontal interhemispheric fissure left after glial sling has disappeared. Commisural ageneses result from any combination of commisural segmental defects, either with homotopic or heterotopic (sighmoid) connections, variably associated with white matter, gray matter, ocular, hypothalamo-pituitary, brainstem, cerebellar, cystic or lipomatous meningeal dysgeneses, or complex syndromes. Presumably, these specific subtypes reflect specific developmental pathways defects.

REFERENCES

Malformations of the Midbrain and Hindbrain: Embryology, Genetics and Imaging
A. James Barkovich, MD, MPH

PRESENTATION SUMMARY
I. Malformations secondary to early antero-posterior (AP) and dorso-ventral (DV) patterning defects, or to misspecifi- cation of mid-hindbrain germinal zones. A. AP Patterning defects: 1. Gain, loss or transformation of the diencephalon (DIEN) and midbrain (MIDB); 2. Gain, loss or transforma- tion of the MIDB and rhombomere1 (Rh1); 3. Gain, loss or transformation of lower hindbrain structures. B. DV Patterning defects: 1. Defects of alar and basal ventricular zones (VZ); 2. Defects of alar VZ only; 3. Defects of basal VZ only. II. Malformations associated with later generalized developmental disorders that significantly affect the brainstem and cerebellum (and have pathogenesis at least partly understood). A. Developmental encephalopathies associated with mid-hindbrain malformations. B. Mesenchymal- neuroepithelial signaling defects associated with mid-hind- brain malformations. C. Malformations of neuronal and glial proliferation that prominently affect the brainstem and cerebellum. D. Malformation of neuronal migration that prominently affect the brainstem and cerebellum: 1. Lissencephaly with cerebellar hypoplasia; 2. Neuronal heterotopia with prominent brainstem and CBL hypoplasia; 3. Polymicrogyria with cerebellar hypoplasia; 4. Malformations with basement membrane and neuronal migration deficits. E. Diffuse molar tooth type dysplasias associated with defects in ciliary proteins: 1. Syndromes affecting the brain with low frequency involvement of the retina and kidney; 2. Syndromes affecting the brain, eyes, kidneys, liver and variable other systems. III. Localized brain malformations that significantly affect the BS and CBL (pathogenesis partly or largely understood, includes local proliferation, cell specification, migration and axonal guid- ance). A. Multiple levels of mid-hindbrain. B. Midbrain malformations. C. Malformations of Rh1 including cerebellar malformations. D. Pons malformations. E. Medulla malformations. IV. Combined hypoplasia and atrophy in putative prenatal onset degenerative disorders: A. Pontocerebellar hypoplasia (PCH). B. Mid-hindbrain malformations with congenital disorders of glycosylation (CDG). C. Other meta- bolic disorders with cerebellar or brainstem hypoplasia or disruption. D. Cerebellar hemisphere hypoplasia (rare, more commonly acquired than genetic, often associated with clefts or cortical malformation). With the dissemination of modern MR scanners and the rapid increase in the use of MR imag- ing in children with developmental disability, many disor- ders of the brain stem and cerebellum have been discovered. These disorders can be difficult to understand and describe if no system is available to help in understanding them. This classification system explains these disorders based upon embryology and genetics, allowing diagnosis and an accu- rate prognosis. These different classes of malformations will be explained and imaging studies will be shown.
Neural Basis for Resting State Functional Connectivity

Jeffrey S. Anderson, MD, PhD

**Presentation Summary**
Functionally related brain regions show synchronized fluctuations in fMRI signal, termed functional connectivity (fcMRI). Functional connectivity MRI measurements are obtained by acquiring serial blood oxygen level dependent (BOLD) images, often with the subject in a resting state where no cognitive task is performed. Quantitative measurements of correlation then can be obtained between the time series of any collection of voxels, regions of interest, or even entire networks. These correlation measurements are related to the anatomical connectivity between the structures, and are abnormal in numerous neurodevelopmental, neurologic, and psychiatric disorders such as dementia, autism, multiple sclerosis, brain neoplasms, and schizophrenia, among others. Such synchronized fluctuations have emerged as a useful tool in studying brain network architecture noninvasively, corresponding precisely to known boundaries of distributed functional networks in the brain, and allowing precise measurements of the brain’s “connectome.” The fluctuations are correlated with behavior, and do not represent mere noise. Yet the signal fluctuations underlying fcMRI have characteristic features that have made it difficult to identify a neural basis for the signal. They are very slow compared to neural activity, with greatest power in frequency ranges less than 0.05 Hz. The fluctuations also exhibit features of colored noise, where the amplitude of the fluctuations decays by an inverse power law. By comparing the signal fluctuations from fMRI to power fluctuations in electrophysiologic measurements such as from EEG or MEG as well as to simulated BOLD data, it can be shown that such features likely...
represent the effects of ongoing neural activity that is observed after low-pass filtering through the microvasculature, combined with neural network interactions between brain regions, where the fractal dimension of signal fluctuations is a function of the extent of local and distributed connectivity to other brain regions. This model for the neural basis of fcMRI has important implications for acquiring functional connectivity data. Noise in functional connectivity measurements may be an unavoidable consequence of aliasing of high frequency neural information during vascular filtering that may require longer imaging times than typically are performed for very precise connectivity measurements within an individual subject. Replication data are shown between subjects and within a single subject that allow estimation of imaging time needed to obtain sufficiently accurate functional connectivity measurements for single-subject diagnosis or image guidance, such as for deep brain stimulation targets.

**HARDI & MEG: Implications for Connectivity**

*Timothy P. L. Roberts, PhD*

**MRSI and Networks in Epilepsy**

*Hoby P. Hetherington, PhD*
Thursday Morning
6:45 AM - 7:25 AM
Ballroom 6 B/C

(E007) Excerpta Extraordinaire: Head & Neck
(Scientific Papers 469 - 476)

Moderator: Yoshimi Anzai, MD, MPH

Paper 469 Starting at 6:45 AM, Ending at 6:50 AM
Clinical and Imaging Evolution of Temporal Bone Myxomas

Guha-Thakurta, N. • Deavers, M. • DeMonte, F. • Gidley, P. W.
M.D. Anderson Cancer Center
Houston, TX

PURPOSE
To describe the clinical picture, natural history, imaging features and management of an unusual case of primary myxoma of the temporal bone.

CASE REPORT
A 41-year-old man with conductive hearing loss.

IMAGING FINDINGS
Evaluation of serial CT imaging revealed an enlarging, expansile lesion within the left temporal bone. The lesion involved the mastoid air cells, the petrous apex, and extended up to the petroclival junction, with thinning of the inner and outer tables and cortical defects. Additionally present was involvement of the jugular foramen and obliteration of the left internal auditory canal with soft tissue mass in the middle ear cavity and non-visualization of the ossicles. MR imaging demonstrated a 6 cm x 2.5 cm, T2 hyperintense, homogeneously enhancing lesion. The patient underwent a transcochlear approach for excision of the mass, and removal of tumor in the jugular foramen. Histologic examination revealed a myxoid neoplasm similar in appearance to myxoma of soft tissue.

SUMMARY
The purpose of this presentation is to describe the clinical evolution, and role of diagnostic imaging in the assessment and management of primary myxoma of the temporal bone. Since 1900 a dozen cases have been described. These tumors, if misdiagnosed, can grow into locally aggressive expansile masses, producing hearing loss, facial paralysis, dural invasion, and mass effect on the adjacent brain parenchyma.

KEY WORDS: Temporal bone, primary myxoma, imaging and management

Paper 470 Starting at 6:50 AM, Ending at 6:55 AM
Invasive Rhino-Orbito-Palatal Fungal Disease in a Child with Gorlin Syndrome and ALL

Harreld, J. H. • Thompson, J. W. • Roberts, D. R. • Patay, Z. • Sandlund, J.
1St. Jude Children's Research Hospital, Memphis, TN, 2University of Tennessee Health Science Center, Memphis, TN, 3Medical University of South Carolina, Charleston, SC

PURPOSE
To describe early MR imaging (MRI) findings of invasive fungal disease in an immunocompromised patient with Gorlin syndrome, and to reiterate the necessity of imaging gently in children with genetically susceptible cancers.

CASE REPORT
An 8-year-old child with Gorlin (basal cell nevus) syndrome, multiple basal cell carcinomas and ALL with prolonged neutropenia presented with rhinorrhea, facial and jaw pain and somnolence. Initial examination demonstrated a gray spot on the palate; evidence of fungal disease along the nasal septum, turbinates and midline palate also were present. Biopsy revealed invasive fungal infection with GMS+ fungus with wide septated hyphae, and focal necrosis. The child subsequently developed fulminant fungemia and obstruction of the upper airway and expired 2 months later.

IMAGING FINDINGS
MR imaging demonstrated sharply delineated hypointense enhancement of the nasal septum and bilateral medial inferior turbinates extending inferiorly to the hard palate and superiorly to the inferior aspect of the sphenoid, with no definite evidence of intracranial extension. STIR signal was essentially normal, and there was no significant mucosal swelling or sinus T2 hypointense material. A large left maxillary odontogenic cyst expanded the left maxillary sinus. There was a right convexity subdural hemorrhage. CT 1 month later demonstrated extension of sinonasal disease, new orbital invasion, and a small focus of nasal septal destruction.
SUMMARY
Invasive fungal disease, seen in immunocompromised patients, may be rapidly fatal. The heightened sensitivity and specificity of contrasted MRI as compared to CT may make a crucial difference in patient care. A nasal cavity, orbital, ethmoid and maxillary sinus pattern is highly suggestive. Because patients with Gorlin syndrome and other genetic or syndromic cancers are at high risk of developing additional, radiation-induced cancers, they should be imaged particularly gently and radiation avoided whenever possible.

KEY WORDS: Pediatric, fungal, Gorlin

Paper 471 Starting at 6:55 AM, Ending at 7:00 AM
Reparative Giant Cell Granuloma of the Clivus

Nekhline, M. L. • Patel, S. C.
Henry Ford Hospital
Detroit, MI

PURPOSE
Imaging findings in reparative giant cell granuloma of the clivus.

CASE REPORT
A 24-year-old previously healthy female presented with headaches for several weeks with double vision and left lateral rectus palsy. The imaging demonstrated an expansile enhancing clival lesion without pituitary or adjacent vascular involvement. Transsphenoidal biopsy was performed with pathologic diagnosis of a reparative giant cell granuloma. Surgical tumor debulking was performed, and the residual tumor was treated with chemo and radiation therapy demonstrating considerable tumor shrinkage, resolution of symptoms, and stability over the last 5 years.

IMAGING FINDINGS
CT demonstrated an expansile aggressive enhancing soft tissue mass of the clivus with erosion of the cortex. MR imaging demonstrates a T1, T2, T2-FLAIR, and diffusion-weighted isointense expansile avidly enhancing clival mass without involvement of the pituitary gland. Angiography demonstrates a diffuse tumor blush of the clival region supplied by small branches of bilateral internal carotid arteries (ICAs).

SUMMARY
Reparative giant cell granuloma is an uncommon non-neoplastic osseous lesion originally described in 1953 by Jaffe. Such lesions were observed initially in mandibular or maxillary regions and thought to represent a reparative process induced by local intraosseous hemorrhages related to trauma. Later such lesions also were found in the skull and small bones of the hands and feet many of which were lacking reparative elements and had no clear association to trauma. Thus, the term “reparative” became commonly omitted. Although regarded as a benign process, such lesions can be locally aggressive eroding bone and extending into surrounding soft tissues. The histologic features of giant cell granuloma include granulomatous reaction with plump fibroblasts and giant cells surrounding foci of hemorrhage as well as osteoid production which is highly unusual in giant cell tumor but may resemble brown tumor of hyperparathyroidism. Readily distinguished from giant cell tumor histologically, giant cell granulomas have nonspecific features on traditional imaging. These lesions predominantly affect females in the second and third decades of life. They may bleed internally resulting in rapid expansion. With lack of distinctive imaging features, differential diagnosis of clival giant cell granuloma should include chordoma, sarcoma, osteolytic metastasis, brown tumor, and fibrous dysplasia commonly occurring in the same region. The presented case demonstrates an unusual clival occurrence of the reparative giant cell granuloma, the rather uncommon osseous lesion. With lack of specific radiographic findings such lesion should be included in the differential, particularly in the younger patients for appropriate treatment and prognostic implications.

KEY WORDS: Reparative, granuloma, giant
CT-Guided Hookwire Localization for Guiding Surgical Excision of Laryngocele

Gafton, A. R. • Cohen, S. M. • Eastwood, J. D. • Dang, M. K. • Hoang, J. K.
Duke University Hospital
Durham, NC

PURPOSE
1. To present a case of recurrent pyolaryngocele in which CT-guided hookwire localization was used to guide surgical excision. 2. To illustrate the CT findings of laryngocele and pyolaryngocele. 3. To describe the technique of CT-guided hookwire localization in the neck.

CASE REPORT
A 38-year-old male presented to the emergency department with 1-week history of sore throat, productive cough and 3-day history of fever, dysphagia, odynophagia, and inability to tolerate liquids and solids. CT scan of the neck demonstrated a large right pyolaryngocele. The patient underwent endoscopic drainage of this fluid collection and was placed on a course of broad spectrum antibiotics with resolution of his infectious symptoms. A follow-up CT scan 2 months later showed a large right laryngocele bulging through the thyrohyoid ligament. Surgical resection of the laryngocele was performed. Four months after surgery, the patient returned with similar symptoms. A CT scan of the neck demonstrated a recurrent right pyolaryngocele. After treatment of the acute phase of the infection, resection was again contemplated. It was felt that the external wall of laryngocele had been resected incompletely due to scarring. Preoperative localization of the lateral wall of the lesion with hookwire placement was requested. On the morning of surgery, a Kopan hookwire (commonly used for breast lesion localization) was placed under CT fluoroscopy guidance at the level of the lateral wall of the laryngocele. The laryngocele was resected successfully based on the location of the hookwire.

IMAGING FINDINGS
A. Coronal contrast-enhanced CT image demonstrates a peripherally enhancing collection in the right paraglottic space bulging through the thyrohyoid membrane, in keeping with a pyolaryngocele. There is surrounding mucosal edema of the supraglottic larynx. B. Axial CT image through the right laryngocele with hookwire tip at the level of the lateral laryngocele wall.

Summary
CT fluoroscopy-guided hookwire placement at the level of the lateral laryngocele wall was useful in guiding excision surgery. Hookwire placement for nodal resection also has proved a helpful technique to assist surgery. Pyolaryngoceles are rare complications of laryngoceles. They can present with rapid and alarming airway obstruction. While aggressive antibiotic therapy and aspiration of the purulent content are required acutely, surgical excision is the definitive management and is performed when the infectious symptoms have resolved.

Key Words: Pyolaryngocele, laryngocele, hookwire

Pseudothrombus at the Carotid Bifurcation on CT Angiography

MacLean, D. B. • del Campo, M. • Mikulis, D. J.
University Health Network
Toronto, ON, CANADA

PURPOSE
The purpose of this report is to demonstrate a diagnostic pitfall during CT angiography (CTA) of the carotid bifurcation, consisting of a filling defect that mimics intraluminal thrombus following contrast administration. This artifact, termed pseudothrombus, is well characterized in venous circulation, but has not been reported previously in carotid arteries. Due to higher incidence of flow-related artifact on 64- compared to 16-section CT and ever-increasing prevalence of 64-section scanners, heightened awareness of pseudothrombus detection is required to avoid unindicated antithrombotic therapy.

CASE REPORT
A 62-year-old woman with irradiated non-Hodgkin's lymphoma presented for a CT staging exam of the neck, head, and abdomen. There was no history of smoking, diabetes, hypertension, hyperlipidemia, hypercholesterolemia, or family history of atherosclerosis.

IMAGING FINDINGS
CT angiography revealed a filling defect of the right internal carotid artery, accounting for >70% stenosis (Figure A, *). However, ultrasonography detected only mild stenosis (<29%), consistent with smooth, stable atherosclerotic plaque. To resolve conflicting findings, the patient was referred for additional MR and CT imaging. High-resolution MR imaging (MRI) was performed 6 weeks after initial CT. T2 black-blood MRI revealed a small plaque and a region of high luminal signal secondary to artifact caused by recirculating flow at the carotid bulb (Figure B, **). Luminal signal loss, caused by carotid bulb recirculation, appeared on 3D bright-blood MRI (Figure C), while luminal signal on 2D bright-blood MRI appeared homogeneous (Figure D). The MR luminal signal changes were congruent in size, shape, and location with the CT filling defect. These similarities strongly suggest delayed entry of contrast into the carotid bulb due to flow recirculation as the source of the unusual intraluminal signal abnormalities. Seven weeks after initial CT, follow-up CTA was performed using an increased con-
trast dose and slower injection rate to ensure proper mixing of contrast with blood. Follow-up CTA images showed only mild luminal stenosis consistent in size and location with plaque observed on MRI, with no luminal filling defect (Figure E). All CT scans were performed on 64-section scanners.

**SUMMARY**

We report a case of pseudo-thrombus of the carotid arteries on contrast-enhanced CT, likely due to contrast bolus exclusion from the recirculating flow domain of the carotid bulb during rapid anatomical coverage afforded by 64-section CT scanners. In patients undergoing CTA or contrast-enhanced CT of the carotid arteries on 64-section scanners or greater, the risk of pseudo-thrombus detection should be minimized by ensuring sufficient contrast mixing time.

**KEY WORDS:** CT artifacts, contrast-enhanced CT

**Paper 474 Starting at 7:10 AM, Ending at 7:15 AM**

**Hyperparathyroidism-Jaw Tumor Syndrome**

Akle, N.1 • Ginsberg, L. E.2
1Baylor College of Medicine, Houston, TX, 2University of Texas M. D. Anderson Cancer Center, Houston, TX

**PURPOSE**

We report a case of an uncommon disease entity, hyperparathyroidism-jaw tumor syndrome.

**CASE REPORT**

An 11-year-old boy presented with a complicated medical history including stage V bilateral Wilm’s tumor diagnosed at age 3. He was later diagnosed with "jaw tumors", and more recently he was diagnosed with primary hyperparathyroidism, for this a neck ultrasound and a chest CT scan were performed and demonstrated no evidence of parathyroid adenoma. The patient's past surgical and medical history includes right partial and left radical nephrectomy, chemotherapy, and radiation for Wilm’s tumor. His past family history is negative. A left mandibulectomy was performed, and the pathology demonstrated a juvenile active ossifying fibroma.

**IMAGING FINDINGS**

A head CT scan was compared to the previous study and demonstrated a continual growth of bone lesions of the bilateral maxilla and mandible. Those lesions are large, expansile that contain soft tissue and bone density with “ground glass” appearance material consisting with multiple benign fibroosseous tumors.

**SUMMARY**

This is a case of a very rare hyperparathyroidism-jaw tumor syndrome; this is an autosomal dominant syndrome with a highly penetrant phenotypic spectrum. The hyperparathyroidism is related to parathyroid adenomas and is present in 95%. The jaw tumors are juvenile active ossifying fibromas and consist of trabeculae of woven bone set in a cytologically bland fibrocellular stroma. Fifty percent of the patients develop fibro-osseous tumors of the maxilla or mandible, which may recur. Also those patients have a risk of developing kidney cysts and tumors (nephroblastomas, hamartomas or Wilm’s tumors). The treatment consists mainly of surgical removal of the neoplastic tissues. Juvenile active ossifying fibroma is complex and often difficult to diagnose from both clinical and histopathologic points of view. The main parameters for the diagnosis are as follows: age under 15 years, localization of the tumor involving the maxilla and mandible, and radiologic features including an expansile diffusely lesion that could frequently recur compared to the usual ossifying fibroma.

**KEY WORDS:** Jaw tumor, hyperparathyroidism-jaw tumor syndrome, hyperparathyroidism
The Angry Torus: Osteoradionecrosis and Inflammation Resulting in a Potential PET/CT Pitfall

Mayo, R. • Ginsberg, L. E.
M. D. Anderson Cancer Center
Houston, TX

**Purpose**
While PET/CT is an important, evolving tool in the staging and restaging of head and neck cancer, there are numerous cases in which false-positive findings may confuse the radiologist. The purpose of this presentation is to present a case of an inflamed postradiation torus palatini that mimicked metastatic tumor on PET/CT.

**Case Report**
A 59-year-old female was treated with surgery and chemoradiation for a high-grade nasoethmoid neuroendocrine carcinoma. Eight months following completion of therapy, the patient experienced discomfort in the roof of her mouth. Physical exam revealed an ulceration of the hard palate.

**Imaging Findings**
A restaging PET/CT revealed abnormal FDG activity in the left coracoid process and in the hard palate, both thought possibly to represent metastases. These were new findings relative to prior PET/CT performed 4 months after conclusion of therapy. Review of the CT portion of the exam revealed a probable sequestrum of dead bone anteriorly in the torus palatini that also had not been present on the prior PET/CT. Biopsies confirmed metastatic tumor in the scapula, but only acute-on-chronic inflammation in the palate. The combined results of imaging, physical exam of the palate and biopsy suggested the most likely diagnosis was palatal osteoradionecrosis.

**Summary**
The mandible is the most common site of osteoradionecrosis. High radiation doses from overlapping external beam radiation portals combined with a relatively limited blood supply to the mandible predispose it to injury. In 1% of the population the hard palate may develop with an area of bony overgrowth at the palatine suture. This protuberance is termed a *torus palatinus*. Because it protrudes directly into the oral cavity it is vulnerable, and since the blood supply is limited by the extremely thin mucosal covering, this anatomical variant does not heal as easily as a normal hard palate. The torus palatinus shares two of the most important factors predisposing the mandible to osteoradionecrosis - high radiation doses as a result of its proximity to certain neoplastic targets and relatively reduced blood flow. The torus has one additional factor that further increases its vulnerability, its proclivity for injury resulting from a combination of oral trauma and radiation may predispose the torus palatini to become inflamed, with resultant increased FDG uptake on PET/CT, perhaps even without overt osteoradionecrosis. Given that unnecessary biopsy may result in or accelerate osteoradionecrosis, radiologists are reminded of this potential imaging pitfall.

**Key Words:** Torus palatinus, inflammation, PET/CT

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Ossified Mucoepidermoid Carcinoma of the Hard Palate

White, M. L. • Matsuo, K. • Kazmi, S. A. • Zhang, Y. • Militsakh, O. • Omojola, M.
University of Nebraska
Omaha, NE

**Purpose**
To report a case of hard palate mass that appeared as a chondrosarcoma on CT, but was diagnosed as mucoepidermoid carcinoma with extensive ossifications by pathology.

**Case Report**
A 46-year-old female presented with a submucosal mass involving the entire hard palate and the left alveolus. Maxillofacial CTs were performed without and with contrast to assess the mass. The patient underwent a bilateral palatetectomy and left maxillectomy through an intraoral approach.

**Imaging Findings**
CT showed the mass of the left hard palate remodeled the inferior aspect of the nasal septum and the left maxillary alveolar ridge, while extending anteriorly to near the left first premolar. Speckled high densities with a ring and arc appearance suggested that the mass had the appearance of a calcified chondroid matrix and a diagnosis of chondrosarcoma was suggested (Figure 1). On the final pathology, there were both epidermoid and mucous cells present. The tumor demonstrated extensive ossification; however, no calcification was present (Figure 2). Histologic findings confirmed the diagnosis of mucoepidermoid carcinoma with ossification.
SUMMARY
Mucoepidermoid carcinomas are the most common type of salivary gland malignancies. Ossifications in mucoepidermoid carcinoma are extremely rare. The ring and arc appearance of the ossifications in our case is unique compared to the other reported case of ossification in a mucoepidermoid carcinoma. This case underscores the fact that although rare, mucoepidermoid carcinoma should be considered in the differential diagnosis of a hard palate mass with ossification.

KEY WORDS: Mucoepidermoid carcinoma

Thursday Morning
7:30 AM - 8:30 AM
Ballroom 6 B/C

(44) Maintenance of Certification (MOC) - Review Session (AR)
Pediatric Brain and Pediatric Head and Neck

(477) Pediatric Head and Neck
— Caroline D. Robson, MB, ChB
(478) Pediatric Brain
— Thierry A.G.M. Huisman, MD, EQNR, FICIS

Moderator: Robert A. Zimmerman, MD

An Educational grant was received by Bayer Healthcare Pharmaceuticals, Inc. in support of the Audience Response (AR) technology in the Maintenance of Certification (MOC) Review sessions.

Pediatric Head and Neck
Caroline D. Robson, MB, ChB

PRESENTATION SUMMARY
This will be a case-based presentation covering a wide variety of head and neck topics including the following: • Non-neoplastic developmental masses; • Tumors; • Inflammatory/infectious disorders; • Congenital malformations. Cases will highlight abnormalities in various regions as follows: • Neck; • Sinuses; • Orbits; • Temporal bone/skull base. A relevant differential diagnosis will be presented for each case shown.

Pediatric Brain
Thierry A.G.M. Huisman, MD, EQNR, FICIS

PRESENTATION SUMMARY
The pediatric brain is unique because of the multiple, well programmed maturational and developmental processes which extend from the prenatal period well into the first and even second decade of life. Familiarity with the normal and abnormal anatomy is of essential importance to correctly identify and characterize pediatric brain diseases. In addition, the spectrum of diseases and pathologies that may be encountered varies for the various age groups and include the wide spectrum of malformations, tumors, infectious diseases, metabolic and neurodegenerative diseases and trauma. Brain malformations typically are diagnosed in the first days
or years of life and may have a life-long impact on the quality of life. Brain neoplasm of various histology may be encountered which differ from adult neoplasms for their location and age of presentation. Infectious diseases are common in children but the impact on the brain and clinical presentation is determined by the age at which the infection occurred and the maturity of the pediatric immune system. Metabolic and neurodegenerative diseases may present prenatally, perinatally or later during life and are at risk to be diagnosed with significant delay. Finally, traumatic brain injury and its sequelae depend heavily on the age of the child. Neonates are at risk for shaken baby injury, toddlers for fall-related traumatic brain injury, while adolescents are more at risk for motor vehicle accidents. The (pediatric) neuroradiologist should be familiar with all aspects of the specific pediatric brain pathologies and optimize the imaging protocols in order to diagnose pediatric pathology with high specificity and sensitivity. In the current session, typical pediatric brain pathologies of the various categories of pathology will be presented including their differential diagnosis. In addition, the appropriate imaging protocols will be discussed.

CER and the Impact on Payer Policies: The National Scene

Brian W. Bresnahan, PhD

Presentation Summary
Several United States initiatives are systematically assessing comparative evidence for medical technologies, condition-specific intervention strategies, and health systems. Recent decades have led to an increase in public and private health technology assessments, accompanied by attention to evidence-based medicine, including evidence-based radiology. Dramatically expanded information access for patients, physicians, and researchers has influenced behavior and decision-making. Rapid innovation in premium-priced diagnostic testing modalities has contributed to consistently increasing medical costs which have been deemed by many to be unsustainable. The Institute of Medicine’s 2009 Comparative Effectiveness Research (CER) Top 100 National Research Priorities identified advanced imaging as a target for studies improving the base of comparative evidence. Public and private payers are using and developing CER initiatives and demonstration projects, creating partnerships with multiple stakeholders to develop evidence, and observing recent CER funding efforts and technology assessments. Payers may have different evidentiary standards for establishing coverage/reimbursement policies.

The Problem from a Payer Perspective: Medicaid in Washington State

Jeffery Thompson, MD, MPH

Leah Hole-Curry, JD

Presentation Summary
This presentation is part of a plenary session on research and impact on payer policies. The Washington State Technology Assessment (HTA) program will be described. The HTA is a state program that uses systematic reviews of clinical evidence and an 11-member panel of practicing clinicians, in public meetings to decide on whether state programs should cover certain tests, treatments, and procedures. An overview of the program and examples of decisions will be provided. Additionally, a new research funding organization, the Patient Centered Outcomes Research Institute (PCORI) will be described, and potential impacts discussed.
**Thursday Morning**

**10:30 AM - 12:15 PM**

**Ballroom 6 B/C**

(46a) Chiari, Tumor, and Other
(Scientific Papers 483-495)

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**Assessment of Tonsillar Pulsatility in Patients with and without Tonsillar Ectopia Using Cardiac-Gated Balanced Steady-State Precession MR Imaging**

Sharma, A. • Moran, K. • Smyth, M. • Limbrick, D. • Pilgram, T. • Parsons, M.

Washington University School of Medicine
St. Louis, MO

**Purpose**

Chiari 1 malformation is associated with altered dynamics of the cerebrospinal fluid (CSF) flow at the foramen magnum, which may influence the pulsatility of cerebellar tonsils. Cardiac-gated balanced steady-state precession MR imaging recently has been applied to show pulsatile motion of the brain structures. It provides a means to directly visualize and measure the extent of cranio-caudal translation of the cerebellar tonsils during the cardiac cycle. In this retrospective study, we present our experience with this technique to assess the tonsillar motion in patients with and without tonsillar ectopia.

**Materials & Methods**

We identified 82 patients (age 8 months-38 years; 47 males, 35 females) in whom cardiac-gated cine True-FISP imaging had been performed as a part of CSF flow study. This sequence generated 25 5mm thick sagittal images obtained at different time points during the cardiac cycle, at the same location. The study population included 16 subjects without tonsillar ectopia, 51 patients with tonsillar ectopia, and 15 patients of Chiari malformation in whom occipital decompression was performed previously. The studies were evaluated by two neuroradiologists in a consensus read. The images were viewed initially as a cine loop to assess the perceived degree of tonsillar motion in a cranio-caudal axis. This subjective perception of tonsillar motion was graded on a scale of 0-2, signifying absent, minimal, and marked pulsatility respectively. In addition, the extent of cranio-caudal translation of the cerebellar tonsils was measured directly after selecting the images showing the most cranial and most caudal position of the cerebellar tonsils. Mean tonsillar pulsatility grade and maximal tonsillar translation were calculated for the three groups, and compared for statistical significance.

**Results**

Most (14/16, 87.5%) controls without tonsillar ectopia did not demonstrate any appreciable motion of the cerebellar tonsils on cine TrueFISP images. On direct measurement, mean tonsillar translation for this group was 0.06mm, with a range of 0-0.6mm. As compared to this control group, patients with tonsillar ectopia demonstrated significantly higher tonsillar pulsatility grade, with minimal pulsatility in 15 (29.4%) patients, and marked pulsatility in 12 (23.5%) patients (p=0.0036). This also was reflected in a significantly higher extent of tonsillar translation, with a mean value of 0.58mm, and a range of 0-2.7mm (p<0.001). Within the group with tonsillar ectopia, there was a moderately strong positive correlation between the extent of the tonsillar ectopia and the motion grade as well as the distance moved by the tonsils. The tonsillar pulsatility grades and cerebellar translation in patients who were status post-occipital decompression were not significantly different from the corresponding values for patients with tonsillar ectopia. However, the values were significantly lower when compared to the subset of patients with tonsillar ectopia who subsequently underwent occipital decompression.

**Conclusion**

Majority of patients without tonsillar ectopia demonstrate no perceptible tonsillar pulsatility. Patients with tonsillar ectopia demonstrate significantly increased tonsillar pulsatility. As a group, patients with prior occipital decompression show decreased cerebellar motion compared to the patients with tonsillar ectopia who need surgery, suggesting that the tonsillar pulsatility may normalize after occipital decompression.

**Key Words:** Chiari malformation, CSF flow, MR imaging

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**Cerebellar Tonsillar Ectopia Mimicking Chiari I Malformation in Idiopathic Intracranial Hypertension**

Hoots, J. • Aiken, A. H. • Saindane, A. • Hudgins, P.

Emory University Hospital
Atlanta, GA

**Purpose**

Idiopathic intracranial hypertension (IIH), also known as pseudotumor cerebri, is defined as increased intracranial pressure with normal cerebrospinal fluid (CSF) composition...
and no other identifiable cause. Although IIH is a clinical diagnosis, suggestive imaging findings have been described in the radiology literature. These include flattening of the posterior sclera, tortuosity of the optic nerve sheath, partially empty sella, and stenosis of the transverse venous sinuses. Previous reports in clinical literature describe a subset of IIH patients with tonsillar ectopia that meets criteria for and mimics Chiari I malformation. These IIH patients with an associated “Chiari I” do not respond well to surgical decompression. The purpose of this study was to determine the incidence and morphology of cerebellar tonsillar ectopia (CTE) in patients with a clinical diagnosis of IIH.

MATERIALS & METHODS
After IRB approval, MR imaging reports from 2008-2010 were searched for the terms “idiopathic intracranial hypertension” or “pseudotumor cerebri”. This search resulted in 90 patients. After a review of clinical records, only 46 of these patients (mean age 36 years +/- 12 years, 1 male: 43 female) had a clinically confirmed diagnosis of IIH. Two additional patients were excluded for a nondiagnostic study and lack of sagittal imaging respectively. Two CAQ neuroradiologists blindly reviewed selected sagittal MR images in these 44 IIH patients and 44 age-matched normal controls (mean age 40 years +/- 12 years, 17 male: 27 female). The following measurements were obtained: cerebellar tonsil and obex position relative to the plane of the foramen magnum and the prepontine cistern width at the level of the mid pons. A line drawn from the basion to the opisthion on a sagittal spin-echo T1-weighted or volumetric gradient-echo T1-weighted image identified the plane of the foramen magnum. Cerebellar tonsillar ectopia was defined as tonsillar position > 5 mm below this reference line at the foramen magnum.

RESULTS
Nine of 44 patients with IIH and 1/44 normal patients had CTE (tonsillar position >5mm below the foramen magnum). Five of nine IIH patients with CTE also had a “peg-like” configuration of their cerebellar tonsils, closely mimicking Chiari I malformation. Idiopathic intracranial hypertension patients had a significantly lower tonsillar position (2.1mm ±2.8) than age-matched controls (0.7mm ±1.9, P < 0.05). The prepontine cistern width was not significantly different between the two groups. The obex position was significantly lower in IIH versus normal controls (7.9mm above the plane of foramen magnum versus 9.4mm, p<.05), but the obex to tonsillar tip length was not significantly different.

CONCLUSION
Cerebellar tonsillar position in patients with IIH is significantly lower than in age-matched controls. A significant proportion of our IIH patients had CTE, which was often “peg-like” mimicking Chiari I malformation. Obex position was significantly lower in IIH patients, suggesting that the brainstem and cerebellum are both shifted inferiorly. A future study of obex position in IIH versus Chiari I would be helpful to determine the significance of this finding to distinguish among cases of CTE. When CTE is identified, careful radiographic and clinical consideration of IIH is warranted to avoid misdiagnosis as Chiari I malformation.

KEY WORDS: Idiopathic intracranial hypertension, pseudotumor cerebri, cerebellar tonsillar ectopia

Paper 485 Starting at 10:46 AM, Ending at 10:54 AM
Clinical Correlation and Significance of MR Imaging Findings in Chiari I Malformation
Bllstein, M. B. K. • Rogg, J. M. • Boxerman, J. L. • Jayaraman, M. V. • Klinge, P. • Sampath, P. • Mandelbaum, D.
Rhode Island Hospital/Brown University Providence, RI

PURPOSE
Chiari I malformation (CM1) is diagnosed and treated with increasing frequency, paralleling the expanded use of MR imaging (MRI). Despite the use of advanced MRI techniques to assess these patients there remains no well described objective imaging correlates to the clinical severity of CM1 that may be used to corroborate clinical examination and assist in the treatment stratification of these patients. The aim of this study was to assess the diagnostic integrity of several classic and novel MRI criteria for their correlation with clinically significant CM1 (CS-CM1).

MATERIALS & METHODS
Following institutional review board (IRB) approval, patients having MRI between January 2006 and March 2010, with the term “Chiari I” in the radiology information system (RIS) were identified. Inclusion criteria were: 1) no prior surgery or other central nervous system (CNS) disease, and 2) clinical chart access. Thirty-seven patients were enrolled. MR imaging included: sagittal SE T1-weighted, sagittal PC cine flow (21 phase cine, VENC 4, retrograding set). Clinical and MRI reviewers were blinded. MR imaging review was performed via consensus reading by two neuroradiologists. Analyzed imaging features were: 1) magnitude of cerebellar tonsil descent, 2) tonsil deformity, 3) CSF flow asynchrony/aliasing, 4) absent CSF flow anterior + posterior at the foramen magnum, and 5) absent 4th ventricular CSF flow. Charts were reviewed for the following CM1 clinical criteria: 1) occipital headache, 2) exacerbation by Valsalva/exertion/cervical flexion, 3) lower cranial nerve dysfunction, and 4) graded subjective clinical impression of the examining neurologist or neurosurgeon. Clinically significant CM1 was diagnosed when two of the first three criteria were met or high clinical suspicion was noted on chart review.

RESULTS
The study group included 37 patients, 21 of whom met anatomical criteria for CM1 (tonsil descent >5 mm). Of these, 19% (7/37) had CS-CM1. All patients with CS-CM1 also had CM1 (7/21). Absent 4th ventricular CSF flow was noted in 71% (5/7) of patients with CS-CM1 and was highly correlated (Fisher exact p=0.001). Absent CSF flow anterior + posterior at the foramen magnum was also correlated with severe CS-CM1 (Fisher exact p = 0.045). There was no correlation of tonsil deformity, magnitude of tonsil descent or CSF flow asynchrony with CS-CM1.

CONCLUSION
Absent 4th ventricle CSF flow, and absent CSF flow anterior + posterior at the foramen magnum appear to be useful MR imaging criteria for the assessment of CS-CM1 and are congruent with proposed pathophysiology. In patients with
anatomical CM1, absent 4th ventricle CSF flow and absent CSF flow anterior + posterior at the foramen magnum appear to be useful ancillary MRI findings for clarifying the imaging diagnosis of CS-CM1. Their application to future randomized presurgical evaluation trial is warranted.

**Key Words:** Chiari I malformation, MR imaging

**Paper 486 Starting at 10:54 AM, Ending at 11:02 AM**

**Imaging Evaluation of Vertigo in the Emergency Room: Rate of Critical Findings on Head CT and Comparison with Findings on follow-up MR Imaging**

Buckle, C. • Christoforidis, G
University of Chicago Hospitals
Chicago, IL

**Purpose**
Vertigo is a common reason to visit the emergency department, accounting for 5-10% of visits. Often these patients will receive a head CT to exclude an acute etiology, although the ACR appropriateness criteria considers MR imaging (MRI) to be a more appropriate exam than CT in the evaluation of patients with new onset or fluctuating vertigo. In addition, MRI does expose patients to radiation. The purpose of this study was to determine the rate of critical findings on head CT in ER patients presenting with vertigo and to compare with findings on MRI, when performed as a follow-up exam.

**Materials & Methods**
Two hundred eighty-six consecutive head CTs performed on emergency room (ER) patients for the primary or secondary indication of vertigo and/or dizziness were reviewed retrospectively. Additional demographic, clinical and imaging data including associated symptoms, diagnoses and follow-up imaging was collected. Head CT findings were classified into critical (intracranial, subarachnoid or subdural hematoma, acute infarct, new ventriculomegaly, vasogenic edema with mass effect and venous sinus thrombosis confirmed on MRI), new subacute (new tumor, subacute infarct, increased ventriculomegaly), chronic (known neoplasm, microvascular disease, unchanged lacunar infarcts) and false positives (asymmetric transverse sinus, rule out venous sinus thrombosis).

**Results**
The average age of patients was 59 years and 58% of the population was female. Head CT (97% without contrast) diagnosed a critical finding in 0.3% of patients all of whom had additional focal neurologic signs. New subacute events were diagnosed on head CT 1.7% of the time; False positive results occurred 1.4% of the time. Follow-up imaging occurred in 30% of patients, most commonly with MRI (60%). When MRI was obtained, it altered the diagnosis in 16% of cases, identifying acute strokes occult on CT 6% of the time. These strokes were associated with secondary symptoms in most (2/3) but not all patients.

**Conclusion**
The diagnostic yield of head CT for emergent findings in patients presenting with vertigo without focal neurologic deficits is extremely low, zero in this study. The incidence of subacute findings is also low. However MRI altered the diagnosis in several ER vertigo patients with normal head CTs in a way that may have impacted their immediate and near-term management. These findings suggest that (A) head CT is a very low yield study in patients with vertigo without focal neurologic signs (B) head CT has a significant false-negative rate and may provide false assurance that a central cause for vertigo has been excluded and (C) concurrent with the ACR appropriateness criteria, MRI, where available, is significantly more helpful than CT for ER patients with vertigo who require imaging.

**Key Words:** Vertigo, emergency, CT

**Paper 487 Starting at 11:02 AM, Ending at 11:10 AM**

**Detection of Microhemorrhage in Posterior Reversible Encephalopathy Syndrome Using Susceptibility-Weighted Imaging**

McKinney, A. M. • Sarikaya, B. • Gustafson, C. • Truwit, C. L.
University of Minnesota & Hennepin County Medical Centers
Minneapolis, MN

**Purpose**
Posterior reversible encephalopathy syndrome (PRES) classically is reversible, where endothelial cell damage/dysfunction may lead to cortical/subcortical edema and occasionally hemorrhage. Two previous studies determined the rate of hemorrhage in PRES to range from 15.2-17.3%, based on conventional FLAIR and T2* MRI sequences. However, susceptibility-weighted imaging (SWI) has a greater ability to detect microhemorrhage (MH), so the incidence of hemorrhage could be higher. Thus, we set out to determine the incidence of MH, subarachnoid hemorrhage (SAH), and intraparenchymal hemorrhage (IPH) in PRES using SWI, and to determine if such MH is reversible.

**Materials & Methods**
After IRB approval, 30 total patients with clinically confirmed PRES and SWI MRI were included retrospectively, 15 of whom had follow-up MRIs. Both 3.0 T and 1.5 T magnets were utilized, with 10/15 followup MRIs performed on the same scanner. Two staff neuroradiologists assessed non-contrast SWI, FLAIR, T2-weighted imaging, and T1-weighted imaging by consensus. On SWI, the presence and number of MHs (defined as <5 mm size) were recorded. Similarly, the presence of SAH (defined as sulcal hyperintensity on FLAIR, but dark and gyriiform on SWI), and IPH (defined as >5 mm size) also were recorded. Follow-up MRIs were reviewed similarly.

**Results**
Overall, any type of hemorrhage was present in 19 patients at presentation (17 patients with MH on SWI, 2 having SAH on SWI without MH). Of these, MH on SWI was found in 56.67% (17/30) at presentation and in 9/15 (60%) on follow-
Conclusion
Susceptibility-weighted imaging detected higher rates of hemorrhage (when considering MH), compared to the previously reported rates of hemorrhage (SAH and IPH) on conventional MR sequences, underscoring the potential need for SWI in evaluating PRES. Sulcal hyperintensity on FLAIR may not always be SAH. Also, MH on SWI typically persists, and appears to develop after PRES onset rather than being a coincidental finding. However, the clinical relevance of such MHs has not yet been determined.

Key Words: PRES, susceptibility-weighted imaging, microhemorrhage

Imaging Signs in Idiopathic Intracranial Hypertension: Are These Signs Seen in Secondary Intracranial Hypertension Too?

Hingwala, D. R. • Chandrasekharan, K. • Thomas, B. • Vaghelia, V.
Sree Chitra Tirunal Institute for Medical Sciences and Technology
Thiruvananthapuram, INDIA

Purpose
To evaluate the difference in the occurrence of the various "traditional" imaging signs of idiopathic intracranial hypertension (IIH) (perioptic nerve sheath distention, vertical buckling of optic nerve, globe flattening, optic nerve head protrusion and empty sella) in patients with idiopathic and secondary intracranial hypertension.

Materials & Methods
In a retrospective analysis, the MR imaging (MRI) findings of 21 patients with confirmed IIH (based on opening pressures on lumbar puncture and fundoscopy) and 49 patients with secondary intracranial hypertension [41 with tumors; eight with cerebral venous thrombosis (CVT)] were evaluated for the presence or absence of various "traditional" imaging signs of IIH as described above.

Results
Optic nerve head protrusion was associated significantly with IIH. The occurrence of globe flattening approached significance. There was no statistically significant difference in the occurrence of rest of the findings. Empty sella was the only finding that significantly increased the Odds ratio of having IIH. On subgroup analysis, globe flattening and optic nerve head protrusion occurred significantly more often in IIH than in tumors. However, there was no statistically significant difference in the occurrence of any of these findings in patients with IIH and CVT.

<table>
<thead>
<tr>
<th>IIH</th>
<th>Absent</th>
<th>Present</th>
<th>Secondary causes</th>
<th>Absent</th>
<th>Present</th>
<th>Fishers exact (p value)</th>
<th>Odds ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perioptic nerve sheath distention</td>
<td>1 (4.8%)</td>
<td>20 (95.2%)</td>
<td>8 (16.3%)</td>
<td>41 (83.7%)</td>
<td>0.261</td>
<td>0.256</td>
<td></td>
</tr>
<tr>
<td>Vertical buckling of optic nerve</td>
<td>8 (38.1%)</td>
<td>13 (61.9%)</td>
<td>26 (53.1%)</td>
<td>23 (46.9%)</td>
<td>0.303</td>
<td>0.544</td>
<td></td>
</tr>
<tr>
<td>Globe flattening</td>
<td>6 (28.6%)</td>
<td>15 (71.4%)</td>
<td>27 (55.1%)</td>
<td>22 (44.9%)</td>
<td>0.066</td>
<td>0.326</td>
<td></td>
</tr>
<tr>
<td>Optic nerve head protrusion</td>
<td>6 (28.6%)</td>
<td>15 (71.4%)</td>
<td>28 (57.1%)</td>
<td>21 (42.9%)</td>
<td>0.038</td>
<td>0.300</td>
<td></td>
</tr>
<tr>
<td>Empty sella</td>
<td>5 (23.8%)</td>
<td>16 (76.2%)</td>
<td>15 (30.6%)</td>
<td>34 (69.4%)</td>
<td>0.774</td>
<td>1.412</td>
<td></td>
</tr>
</tbody>
</table>

Conclusion
Except for optic nerve head protrusion and globe flattening, the majority of the reported signs of IIH on MRI are not helpful in differentiating between idiopathic and secondary causes of intracranial hypertension. Idiopathic intracranial hypertension is a diagnosis of exclusion. While secondary causes of raised intracranial pressure have obvious clinical findings on MRI, some conditions like CVT may have subtle signs and differentiating between primary and secondary causes may be difficult. In the absence of any evident cause of raised ICP, presence of optic nerve head protrusion or globe flattening can increase the confidence of making the diagnosis of IIH. The presence of sellar deformities also increases the odds of patient having IIH.
KEY WORDS: Idiopathic intracranial hypertension, secondary intracranial hypertension, imaging

Paper 489 Starting at 11:18 AM, Ending at 11:26 AM

Idiopathic Intracranial Hypertension: Relevance of a New MR Imaging Score

Roux, P. • Savatovsky, J. • Koskas, P. • Laffite, F. • Vignal, C. • Heran, F.

Fondation Ophthalmologique A. de Rothschild
Paris, FRANCE

PURPOSE
Idiopathic intracranial hypertension (IIH) is a headache syndrome characterized by raised cerebrospinal fluid (CSF) pressure of unknown origin. Its diagnosis is essential, as long-term course can lead to permanent blindness; but so far, the role of MR imaging (MRI) was limited to the exclusion of other diagnosis. Idiopathic intracranial hypertension is an increasing cause of headaches in young patients, and its early diagnosis is crucial as a delay in treatment exposes to a risk of nonreversible blindness. So far, the diagnosis of IIH relies on the modified Dandy diagnostic criteria, which include suggestive clinical presentation, exclusion of other diagnosis by brain imaging, and invasive measurement of lumbar CSF pressure. Some subtle MR signs are used routinely by neuroradiologists in order to suggest a diagnosis of IIH, but these signs have never been collectively validated in the literature. The aim of our study was to assess the sensitivity and specificity of these signs, in order to propose a reliable MRI score for the diagnosis of IIH.

MATERIALS & METHODS
We retrospectively analyzed 70 MR examinations of patients (mean age 33.7 +/- 12 years) who had a final diagnosis of IIH according to the Dandy criteria, including an elevated CSF lumbar pressure. We compared them with a control group of 30 patients (mean age 32.1 +/- 11 years) who presented with headaches, and for whom the investigations excluded the diagnosis of idiopathic or secondary intracranial hypertension. All patients underwent an MRI including T1-weighted sagittal, FLAIR axial, T2-weighted coronal enhanced venous MR angiography. Images were analyzed independently by two neuroradiologists. The following signs were studied: bilateral transverse sinus narrowing (either due to a “stenosis” by an arachnoid granulation, or related to hypoplasia), enlargement of the perioptic subarachnoid spaces, T2-weighted hyperintensity of the optic nerves, flattening of the posterior sclera, optic nerve tortuosity and “empty sella” appearance. We assessed the sensitivity and specificity of each sign, independently and combined in a five-points score.

RESULTS
The most sensitive sign was the enlargement of the perioptic subarachnoid spaces. Bilateral transverse sinus narrowing, optic nerves T2-weighted hyperintensity and flattening of the sclera were pathognomonic for IIH but not very sensitive. Noteworthy, so-called classical signs, such as optic nerve tortuosity were infrequent. None of these sign, taken individually, provided a sensitivity >90%, whereas our combined score demonstrated a sensitivity and specificity of 98% for a value ≥2.

Paper 490 Starting at 11:26 AM, Ending at 11:34 AM

Diffusion Tensor Imaging Parameters and Neurocognitive Performance in Adult Long-Term Survivors of Childhood Acute Lymphocytic Leukemia

Sabin, N. D. • Krull, K. R. • Liu, W. • Glass, J. O. • Srivastava, D. K. • Robison, L. L. • Hudson, M. M. • Reddick, W. E.

St. Jude Children’s Research Hospital
Memphis, TN

PURPOSE
Children who receive cranial radiation therapy (CRT) as part of their treatment for acute lymphocytic leukemia (ALL) are at risk for future neurocognitive deficits. Diffusion tensor imaging (DTI) has revealed changes in white matter (WM) structural integrity in the brains of ALL survivors who received CRT. In this study, we investigated the relationship between DTI parameters and results of neurocognitive testing in adult long-term survivors of childhood ALL who received CRT.

MATERIALS & METHODS
Previously, we objectively identified regions of WM most commonly affected by ALL therapy using a voxel-based analysis of T2-weighted imaging. T2-hyperintensities occurred predominantly in the WM tracts of the frontal lobe and extended posteriorly over the ventricles to the periatrial WM. The locations of the WM abnormalities caused by antileukemia treatment are expected to disrupt neural networks that support executive function. In this study, DTI works that support executive function. In this study, DTI parameters and results of neurocognitive testing in adult long-term survivors of childhood ALL who received CRT.

<table>
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<tr>
<th>Results</th>
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<th>Sensitivity</th>
<th>Specificity</th>
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<tbody>
<tr>
<td>Bilateral transverse sinus narrowing</td>
<td>0.969</td>
<td>0.825</td>
<td>1</td>
</tr>
<tr>
<td>Enlargement of perioptic subarachnoid spaces</td>
<td>0.923</td>
<td>0.897</td>
<td>0.850</td>
</tr>
<tr>
<td>T2WI hyperintensity of the optic nerves</td>
<td>0.691</td>
<td>0.743</td>
<td>1</td>
</tr>
<tr>
<td>Flattening of the posterior sclera</td>
<td>0.798</td>
<td>0.55</td>
<td>1</td>
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<tr>
<td>Optic nerve tortuosity</td>
<td>0.685</td>
<td>0.375</td>
<td>0.93</td>
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<tr>
<td>Flattening of pituitary gland (“empty sella”)</td>
<td>0.877</td>
<td>0.773</td>
<td>0.95</td>
</tr>
<tr>
<td>Composite score ≥ 3/5</td>
<td>1</td>
<td>0.825</td>
<td>1</td>
</tr>
<tr>
<td>Composite score ≥ 2/5</td>
<td>0.967</td>
<td>0.975</td>
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</tbody>
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CONCLUSION
Our results demonstrate that in patients with a suspicion of IIH, MRI can be used not only to exclude other causes of headaches, but also to establish a positive diagnosis thanks to a combined score. Therefore, MRI has the potential to provide a noninvasive positive diagnosis of IIH.

KEY WORDS: Idiopathic intracranial hypertension, optic nerve, MR imaging

Paper 490 Starting at 11:34 AM, Ending at 11:42 AM

Diffusion Tensor Imaging Parameters and Neurocognitive Performance in Adult Long-Term Survivors of Childhood Acute Lymphocytic Leukemia

Sabin, N. D. • Krull, K. R. • Liu, W. • Glass, J. O. • Srivastava, D. K. • Robison, L. L. • Hudson, M. M. • Reddick, W. E.

St. Jude Children’s Research Hospital
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<td>Flattening of pituitary gland (“empty sella”)</td>
<td>0.877</td>
<td>0.773</td>
<td>0.95</td>
</tr>
<tr>
<td>Composite score ≥ 3/5</td>
<td>1</td>
<td>0.825</td>
<td>1</td>
</tr>
<tr>
<td>Composite score ≥ 2/5</td>
<td>0.967</td>
<td>0.975</td>
<td>0.975</td>
</tr>
</tbody>
</table>
were extracted for the region of interest defined by the clusters on the right and left for each patient. All survivors also completed a comprehensive standardized neurocognitive evaluation within 1 week of completing the MRI. The DTI measures then were correlated with radiation dose and the neurocognitive measures using Pearson correlation analysis.

**RESULTS**

Higher FA values were associated with better performance on tests measuring processing speed (all p values ≤0.029), vocabulary (all p values ≤0.033), reading (all p values ≤0.046), nonverbal abstract reasoning (all p values ≤0.029), cognitive flexibility (all p values ≤0.047), and memory span (all p values ≤0.035). Radial diffusivity and AD demonstrated inverse associations with multiple measures of neurocognitive performance, often corresponding to the measures that demonstrated a positive association with FA. Of note, nonverbal abstract reasoning was strongly associated with FA values taken from the right hemisphere, while vocabulary and academic functions were associated with FA values taken from the left and right hemispheres.

**CONCLUSION**

In a group of long-term adult survivors of childhood ALL originally treated with CRT, correlations were demonstrated between FA, RD and AD values and performance on a variety of neurocognitive measures. These findings suggest an association between white matter structural integrity, as measured by DTI parameters, and neurocognitive status.

**KEY WORDS:** Diffusion tensor imaging, radiation therapy, neurocognitive performance

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**Paper 491 Starting at 11:34 AM, Ending at 11:42 AM**

Utility of Nonmodel-Based "Semiquantitative" Indices Derived from Dynamic Contrast-Enhanced T1-Weighted MR Perfusion in Differentiating Treatment-Induced Necrosis from Recurrent Progressive Brain Tumor

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**PURPOSE**

To assess the utility of nonmodel-based "semiquantitative" indices derived from dynamic contrast-enhanced T1-weighted MR perfusion (DCET1MRP) in differentiating treatment-induced necrosis (TIN) from recurrent/progressive tumor (RPT).

**MATERIALS & METHODS**

Twenty-three patients with previously treated brain tumors who showed recurrent or progressive enhancing lesions on follow-up MR imaging and also underwent DCET1MRP were included in the study. Another eight patients with treatment-naïve, high-grade gliomas who underwent DCET1MRP were included as controls in the study. Semiquantitative indices were derived from DCET1MRP enhancement curves which included maximum slope of enhancement in the initial vascular phase (MSIVP), normalized slope of the delayed equilibrium phase (nSDEP), initial area under the normalized time-intensity curve (nIAUC) at 60 and 120 secs (nIAUC60 and nIAUC120). These indices were calculated using in-house MATLAB-based software as described in Figure 1.

![Figure 1: Calculation of various non-model based indices obtained from the signal intensity (SI)-time curve.](image)

**RESULTS**

Fifteen (16.20 versus 7.88), mean nMSIVP (0.0468 versus 0.028), mean nIAUC60 (33.42 versus 25.35) and mean nIAUC120 (80.38 versus 65.25) compared with the TIN group. Normalized slope of the delayed equilibrium phase was significantly lower in the RPT group (7.45 x10⁻⁵ versus 15.1 x10⁻⁵) compared with the TIN group.

**CONCLUSION**

Dynamic contrast-enhanced T1-weighted MR perfusion is being used increasingly in various clinical trials involving brain tumors. However practical impact of DCET1MRP on routine neuro-oncologic imaging practice is restricted by the need of complicated multicompartment physiologic models and intensive computational requirements to derive pharmacokinetic metrics and the lack of an easy to use and yet robust commercially available software. We propose the use of these nonmodel-based "semiquantitative" indices derived from DCET1MRP in differentiating RPT from TIN which are relatively easy to derive, robust, reproducible and do not require a complicated model-based approach for calculation. These indices even although do not have a specific physiologic specificity, but have been successfully used in the past in evaluation of prostate, breast, cervical, and pancreatic cancers. They may still serve the purpose of a robust and easy to use clinical tool/noninvasive imaging biomarkers in day-to-day clinical practice which can help in quick and efficient decision making.

**KEY WORDS:** DCET1-MR imaging, semiquantitative, recurrent tumor
Susceptibility-Weighted Imaging Findings and Neurocognitive Performance in Adult Long-Term Survivors of Childhood Acute Lymphocytic Leukemia

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Purpose
Survivors of childhood cancer treated with cranial radiation therapy (CRT) demonstrate increased risk for neurocognitive deficiencies. Cranial radiation therapy also is associated with the development of foci of susceptibility change in the brain on MR susceptibility weighted imaging (SWI) representing hemosiderin. We sought to examine the association between the number of foci of susceptibility change and several measures of neurocognitive performance in adult long-term survivors of childhood acute lymphocytic leukemia (ALL) who received CRT as part of their primary treatment.

Materials & Methods
Thirty-seven adult survivors of childhood ALL who were treated originally with CRT underwent MR imaging (MRI of the brain), including SWI pulse sequences, on a 3 T platform. The MRI studies were performed roughly 22.9 years following diagnosis (range 20.4-32.8 years). The studies then were reviewed by a neuroradiologist who was blind to the CRT dose given to the survivors. Foci of susceptibility change for each study were counted, measured and categorized by anatomical location. The sum of the largest axial measurements of all the lesions then was obtained for each anatomical location as a lesion “volume.” All survivors also completed a comprehensive standardized neurocognitive evaluation within 1 week of completing the MRI. The number of lesions at each anatomical location and the “volume” of the lesions at each anatomical location then were correlated with radiation dose by t-test and a variety of neurocognitive measures using Pearson correlation analysis.

Results
Seventeen patients demonstrated frontal lesions, 10 had parietal lesions, 13 had temporal lesions, and nine had occipital lesions. Patients who received higher doses of cranial radiation (24 Gy) demonstrated a trend for greater number and “volume” of hemosiderin foci in the parietal (p=0.098 for number and p=0.053 for “volume”) and temporal lobes (p=0.0385 for number and p=0.053 for “volume”) than those in the lower dose group (18 Gy). The number and “volume” of occipital lobe lesions demonstrated significant inverse correlations with multiple measures of verbal memory (all p values ≤0.031 for number and ≤0.042 for “volume”). The number of temporal lobe lesions had a significant inverse association with long-term verbal memory (p=0.044) and an inverse trend was demonstrated for two other memory measures (p≤0.065). A significant inverse correlation between memory span and the number and “volume” of parietal lobe lesions was detected (p=0.015 for number and p=0.003 for “volume”). Significant inverse associations were seen between the number and “volume” of lesions in the occipital lobes and measures of visual attention and processing speed (p≤0.019 for number and p≤0.030 for “volume”). Significant inverse associations also were noted between the number of occipital lobe lesions and measures of cognitive flexibility (p=0.036) and mathematical calculation skills (p=0.041). The number of frontal lobe lesions demonstrated a marginal inverse association with a measure of abstract reasoning (p=0.057).

Conclusion
This study suggests a relationship between the presence of foci of hemosiderin within the brain, as detected by SWI, and decreased performance on a variety of neurocognitive measures in adult survivors of childhood ALL who received CRT for their disease.

Key Words: Susceptibility-weighted imaging, radiation therapy-related changes, neurocognitive performance

Diffusion-Weighted MR Imaging Findings in Brain Death

Selcuk, H.1 • Albayram, S.2 • Hasiloglu, Z. I.2 • Tureci, E.2 • Noory, M. A.2 • Battal, N.2 • Kizilkilic, O.2 • Islak, C.2
1Bakirkoy State Hospital, Istanbul, TURKEY, 2Istanbul University Cerrahpasa Medical School, Istanbul, TURKEY.

Purpose
The purpose of this study was to determine the role of diffusion-weighted imaging (DWI), and investigate the use of DWI in the diagnosis of brain death.

Materials & Methods
We prospectively evaluated 22 patients diagnosed with clinical brain death (BD) from 2002 to July 2010. All patients in the ICU with clinical BD were considered to be eligible. The ICU referred 22 BD patients for confirmatory MRI (9 women, 13 men; mean age: 39.63±15.1 years; age range: 9-66 years). Initial causes of BD were head trauma (n=7); intracerebral hemorrhage or cerebral stroke (n=2), subarachnoid hemorrhage resulting from aneurysmal rupture (n=10); anoxia with cardiac arrest (n=2) and intracranial tumor (n=1). All clinical criteria for BD were present in all 22 patients before MR imaging (MRI), including a positive apnea test. Diffusion-weighted images, conventional T1-weighted, T2-weighted, fluid-attenuated inversion recovery, and proton density-weighted images were obtained. In left hemisphere (right hemisphere in three cases, because of left hemisphere pathology), 13 distinct neuroanatomical structures were selected for the analysis. These structures were the frontal, parietal, temporal, occipital, and cerebellar gray and white matter; the putamen; the thalamus; and the pons. The regions of interest (ROIs) were manually drawn on the T2-weighted (b=0) images in which the structures could be identified easily. They subsequently were transferred to the equivalent ADC values maps. For each ROI, the surface area and the mean, SD, and range of the ADC values were obtained.

Results
For all cases, mean ADC values were (0.28±0.03)x10^-3 mm^2/s in the frontal white matter, (0.49±0.06)x10^-3 mm^2/s in the frontal cortical gray matter, (0.31±0.03)x10^-3 mm^2/s in the
temporal white matter, \((0.47\pm0.06)\times10^{-3}\) mm/s in the temporal cortical gray matter, \((0.32\pm0.03)\times10^{-3}\) mm/s in the parietal white matter, \((0.48\pm0.06)\times10^{-3}\) mm/s in the parietal cortical gray matter, \((0.33\pm0.03)\times10^{-3}\) mm/s in the occipital white matter, \((0.48\pm0.06)\times10^{-3}\) mm/s in the occipital cortical gray matter, \((0.32\pm0.03)\times10^{-3}\) mm/s in the cerebellar white matter, \((0.48\pm0.06)\times10^{-3}\) mm/s in the cerebellar cortical gray matter, \((0.42\pm0.03)\times10^{-3}\) mm/s in the pons, \((0.44\pm0.03)\times10^{-3}\) mm/s in the thalamus and \((0.45\pm0.03)\times10^{-3}\) mm/s in the putamen. For the BD patients, the ADC values in the cerebellar and cerebral white matter and gray matter and thalamus, pons and basal ganglia are significantly smaller than the control subjects \((p<0.0001)\). We determined that how ADC values in the basal ganglia are significantly smaller than the control subcortical white matter and gray matter and thalamus, pons and the thalamus and \((0.45\pm0.03)\times10^{-3}\) mm/s in the putamen. For the BD patients, the ADC values in the cerebellar and cerebrospinal fluid (CSF) and other white and gray matters, pons, thalamus, and basal ganglion are related to the diagnostic condition (brain death versus control) and also we determined the threshold ADC values to label a subject as BD or control. The sensitivity, specificity, positive and negative predictive values and correct classification rate of ADC cutoff values to distinguish BD from control groups were 100%.

**Conclusion**
The diagnosis of brain death is primarily clinical. In such circumstances, a confirmatory test verifying brain death is necessary. In addition to established clinical findings, DW imaging may be helpful in establishing the diagnosis of brain death in the future in a noninvasive manner.

**Key Words:** Diffusion imaging, brain death, MR imaging

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**Paper 494 Starting at 11:58 AM, Ending at 12:06 PM**

**Cumulative Cranial Radiation Dose in Patients Hospitalized for Subarachnoid Hemorrhage: Evaluation for Potential Deterministic Outcomes**

Vachha, B. • Lin, P. • Thomas, A. • Reddy, S. • Hackney, D.
Beth Israel Deaconess Medical Center
Boston, MA

**Purpose**
Patients with subarachnoid hemorrhage (SAH) often undergo multiple diagnostic and interventional studies that result in substantial radiation exposure. These have the potential to induce deterministic complications. Prior studies that estimated total radiation dose in hospitalized patients with SAH reported figures that would predict a near-universal occurrence of skin injury. The lack of such deterministic effects suggests these studies may have substantially overestimated the doses. This study estimates cumulative cranial radiation dose received by patients presenting with SAH during the course of a single hospitalization and attempts to predict the risk of deterministic outcomes.

**Materials & Methods**
We retrospectively reviewed radiation dose records of 35 consecutive patients (mean age: 57.1 ± 13.1 years; 18 females) with SAH and determined the cumulative cranial radiation dose from CT (CTA, CT, CTP) and angiography (diagnostic/coiling). CTDIweighted was converted to CTDIperipheral dose for more accurate estimate of skin absorbed dose. AP and lateral doses obtained during fluoro-interventional procedures were not added to one another as this would result in an overestimation of radiation dose to any area of skin. Instead, the mean cumulative dose to the cranium during hospitalization was calculated by adding the CTDI peripheral dose separately to AP and lateral doses to provide two separate cumulative doses.

**Results**
Mean length of hospital stay was 14.1 ± 8.1 days. Mean number of angiographic procedures performed was 1.6 ± 1.1. Mean number of CTAcs, CIs and CTPs of the head were 1.8 ± 1.2, 3.5± 3.2 and 0.4 ± 0.7, respectively. Mean cumulative radiation estimated as CTDIperipheral plus AP angiographic and CTDIperipheral plus Lateral angiographic doses were 2.9 ± 1.5 Gy and 1.7 ± 0.8 Gy, respectively. Mean total CTDI peripheral dose was 0.8 ± 0.6 Gy and accounted for 28% of the cumulative AP dose. Although this clearly overestimates skin dose, the sum of AP and Lateral angiographic dose plus CTDIperipheral was 5.3 Gy.

**Conclusion**
The combined cranial CT and angiographic doses are significant, but lower than previously reported. Our angiographic dose estimates retain at least three conservative assumptions, each of which leads to overestimates of actual dose: 1. Higher AP exposures in part reflect fluoroscopy during catheterization, including imaging over the torso and neck, rather than the head; 2. These estimates presume a very small distance between the tube and the head, which does not conform to typical angiographic practice. Larger distances substantially reduce dose by inverse square; 3. The geometry of angiographic suites dictates higher exposure to the right side and posterior portions of the head (entrance doses), while the left and anterior portions of the head receive (lower) exit doses. Our estimates of angiographic doses imply that CT exposure represents a significant fraction of radiation risk for these patients. Cumulative doses from CT and AP angiography in our study averaged over 2Gy which is just above the threshold where deterministic effects should be expected, not correcting for the factors noted above. These more realistic estimates may explain the lack of reported deterministic outcomes in our study population.

**Key Words:** Subarachnoid hemorrhage, radiation, deterministic outcomes

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**Paper 495 Starting at 12:06 PM, Ending at 12:14 PM**

**Flow Signals in Pterygoid Plexus at 3 T MR Angiography: Is this Occult Carotid Cavernous Fistula?**

Watanabe, R. • Kakeda, S. • Watanabe, K. • Nishimura, J. • Ohnari, N. • Korogi, Y.
University of Occupational and Environmental Health Japan Fukuoka, JAPAN

**Purpose**
We have noticed that high signals can be seen in the pterygoid plexus (PP) on routine 3DTOF MRA at 3 T (3 T MRA). The purpose of this study is to investigate the prevalence and etiologies of flow signal in the PP and cavernous sinus (CS) on 3 T MRA in a cohort of patients without signs or symptoms of carotid cavernous fistulas (CCF).
MATERIALS & METHODS
A computerized search of the radiology database (MRI files) for a 5-month period revealed data for patients who underwent 3 T MRA. This patient cohort was used to further select consecutive 406 MR examinations without gross lesions including the large territory infarction, venous thrombosis, or dural arteriovenous fistula. Two radiologists rated the flow signal on MRA source images using a five-point grading scale as follows: grade 0 = PP flow signal is less than or equal to background signal, grade 1 = PP flow signal is above background signal, grade 2 = PP flow signal is equal to that from arterial structures of the same size, grade 3 = high signal intensity is seen in less than or equal to one third of CS together with PP, grade 4 = high signal intensity is seen in more than one third of CS together with PP (Figure; arrows). In addition, findings at 3 T MRA were compared with those at digital subtraction angiography (DSA) in 74 patients.

RESULTS
Among 406 consecutive studies, the radiologists identified 55 (14%) patients (left 53, right 7, and bilateral 5) with evidence of high PP flow signal [grade 1, n = 12 (3.0%); grade 2, n = 14 (3.4%); grade 3, n = 28 (5.0%); grade 4, n = 6 (1.5%)]. The high signal intensity was significantly more common in the left PP than right PP (p < 0.01). Of 74 patients who underwent both 3 T MRA and DSA, 3 T MRA showed grade 3 or 4 in eight patients; however, CCF was not identified on DSA in any of them.

CONCLUSION
At 3 T MRA, the high signals of the left PP together with the left CS are seen frequently in the normal cases. This finding may be due to reverse flow, and should not be considered as an occult CCF.

KEY WORDS: Pterygoid plexus, MR angiography, flow signal

Thursday Morning
10:30 AM - 12:15 PM
Ballroom 6A

(46b) Brain: New Imaging and Processing Techniques
(Scientific Papers 496-508)

See also Parallel Session
(46a) Chiari, Tumor and Other
(46c) Pediatrics: Brain Tumors and Cerebrovascular Disorders
(46d) Head & Neck: Larynx, Nodes and Glands
(46e) Research Grant Writing Session - Part I

Moderator: Hugh J. Robertson, MD, FACR

Paper 496 Starting at 10:30 AM, Ending at 10:38 AM
Development of an Average Human Brain High Angular Resolution Diffusion Imaging Template

Varentsova, A. • Zhang, S. • Arfanakis, K.
Illinois Institute of Technology
Chicago, IL

PURPOSE
Diffusion MR imaging is the only noninvasive method to image the connectivity of the brain in vivo. However, the widely used diffusion tensor imaging (DTI) approach has a significant limitation; it can only resolve a single fiber direction within each voxel. High angular resolution diffusion imaging (HARDI) is a powerful extension of DTI capable of distinguishing intravoxel orientational heterogeneity, which is important for brain connectivity studies. Development of a HARDI template of the human brain may allow the development of a detailed atlas of the underlying neuronal tissue architecture. Also, a HARDI template may be used as a reference for comparison of microstructural integrity and brain connectivity across cohorts of subjects. However, lengthy HARDI acquisitions together with the complications associated with intersubject registration of HARDI data make the development of a HARDI template challenging. In contrast, the efficiency of low angular resolution diffusion imaging in terms of scan-time allows the usage of multishot pulse sequences minimizing image artifacts. The purpose of this study was to produce a human brain HARDI template by combining information from artifact-free low angular resolution datasets collected on 67 subjects.
MATERIALS & METHODS
Turboprop diffusion-weighted (DW) data (12 directions, b=900 s/mm$^2$) were acquired from 67 healthy subjects on a 3 T GE MRI scanner. The diffusion tensors of all subjects were coregistered, and the transformations were applied to the corresponding raw DW data of each subject. Due to the different spatial transformations applied to each voxel of each subject, each voxel in population space contained 804 DW signals (67 subjects × 12 DW signals per subject). The orientation distribution function (ODF) was reconstructed in each voxel from the normalized DW signals as a spherical harmonics series.

RESULTS
The figure shows an ODF map of the frontal lobe containing regions with a single fiber orientation, as well as heterogeneous fiber orientation (crossing fibers).

CONCLUSION
This works presents an artifact-free HARDI template of the human brain. Preliminary results show that the presented approach is capable of resolving intravoxel fiber crossings, and the information contained in the template is in agreement with underlying fiber anatomy of the human brain.

KEY WORDS: HARDI, brain, template

Paper 497 Starting at 10:38 AM, Ending at 10:46 AM

Rotational 3D Angiography

Vakil, P. • Hurley, M. C. • Ansari, S. A. • Carroll, T. J.
Northwestern University
Chicago, IL

PURPOSE
High frame-rate 3D CE MRA datasets can easily yield thousands of source images for interrogation by radiologists. While individual MIPs at various projection angles viewed as CINE videos are a useful method of presentation, they do not take advantage of the 3D nature of the MRA datasets. We present a novel reconstruction technique for the rapid visualization of a large 4D temporal/spatial CE MRA data set.

MATERIALS & METHODS
With IRB approval, we used a previously reported high frame-rate CE MRA technique called CAMERA with GRAPPA acceleration to image the whole head of a patient volunteer with a dural arteriovenous malformation (AVM). This technique acquires 48 slices in the sagittal direction at 0.8 frames/sec for 1.5 minutes resulting in 5400 source images. Our novel reconstruction algorithm visualizes this as a time-rotating MIP during contrast arrival. A sagittal MIP is rotated around the z-axis during bolus wash-in and wash-out allowing visualization of vessel hemodynamics at multiple projection angles.

RESULTS
Figure 1 shows a time series mosaic of a whole-head 3D CE MRA of a patient volunteer with a dural AVM. The CAMERA technique produces a high frame rate (0.8 sec/frame) visualization of vessel hemodynamics clearly depicting uncontaminated arterial and venous phases, and the rotating MIP reconstruction allows the 3D visualization of this data as a CINE video.

CONCLUSION
We believe this reconstruction technique has the potential to assist radiologists in diagnosis by quickly visualizing large 4D CE MRA datasets.

KEY WORDS: MR angiography, rotational, angiography
Sati, P.1 • Thomasson, D. M.2 • Biassou, N. M.2 • Pham, D.1 • Reich, D. S.1 • Butman, J. A.2

1National Institute of Neurological Disorders and Stroke/National Institutes of Health, Bethesda, MD, 2The Clinical Center of the National Institutes of Health, Bethesda, MD, 3Center for Neuroscience and Regenerative Medicine, Bethesda, MD

PURPOSE
To implement ultrafast high-resolution susceptibility-weighted imaging (SWI) by modifying the standard 3D gradient-echo (3D-GRE) SWI technique to use a segmented (multishot) 3D echo-planar imaging (3D-msEPI) readout.

MATERIALS & METHODS
Susceptibility-weighted imaging was performed at 3 T using (1) a flow-compensated 3D-GRE technique with one echo per excitation; and (2) a segmented (multishot) 3D-msEPI with 15 echoes per excitation. Geometric parameters were identical for the two sequences: 480×440×40 matrix resulting in 0.5×0.5×2 mm nominal resolution. Contrast parameters were similar with TR/TE 50/27 for 3D-GRE and 57/31 for 3D-msEPI. Using SENSE acceleration of two and prosat fat saturation, the imaging time was 7min 15sec for the standard 3D-GRE technique and 40 sec for the 3D-msEPI technique. Postprocessing included enhancement of the magnitude images using phase data and minimum intensity projection. These two sequences were compared in five healthy volunteers and 10 patients with a variety of intracranial pathologies.

RESULTS
Both the 3D-GRE SWI and the 3D-msEPI SWI generated comparable magnitude and phase images, although contrast-to-noise was slightly lower in the segmented EPI technique. Conspicuity of blood vessels, particularly the deep venous system, was comparable. Identification of hemorrhagic lesions and calcifications was not discernibly different. Echo-planar images are prone to large image distortions, particularly in regions of high susceptibility. However, we did not identify distortions of more than a few millimeters in the 3D-msEPI as compared to the 3D-GRE. Blurring of the 3D-msEPI due to sampling along the T2* decay also was not observed, and line profiles through comparable regions were quite similar with the two techniques.

CONCLUSION
For 3D-GRE SWI, contrast is generated by T2* dephasing necessitating long echo times (and therefore long TR). For resolving small veins and detecting microhemorrhages, conspicuity is enhanced by using high resolution resulting in a large number of phase and slice encoding steps. These requirements can lead to prohibitively long acquisition times, particularly in the acute setting where MRI may be used to evaluate stroke or traumatic brain injury. Since segmented EPI can be used to accelerate GRE sequences in the same manner that fast (turbo) spin echo can be used to accelerate spin-echo sequences, we developed a 3D-msEPI SWI technique. With this technique, acquisition time could be reduced over ten-fold, to under 1 minute, with little perceptible change in image quality. This has important implications for the use of SWI in the acute setting.

KEY WORDS: Traumatic brain injury, venography, hemorrhage

Sarkar, S. N.1 • Teich, D.1 • Hackney, D.1 • Busse, R.2 • Bhadelia, R.1
1Beth Israel Deaconess Medical Center, Boston, MA, 2GE Healthcare, Madison, WI

PURPOSE
Double inversion recovery (DIR) has shown promise for detecting cortical signal abnormalities, for example, detecting MS lesions not apparent on FLAIR or T2-weighted images. However, its tissue contrast detectability has not been well understood nor fully optimized. Here we have explored its potential to map differential tissue contrasts for gray matter structures with greater sensitivity than routine T2 sequence. An expanded contrast range may be useful for detecting intracortical lesions in MS or seizure. We have optimized a 3D DIR sequence at 1.5 T for detecting possible contrast variations among gray matter structures in brain and have applied this to two groups of patients for whom the disease process might involve widely different types of gray matter.

MATERIALS & METHODS
A 3D research DIR sequence (GE Healthcare) with long echo trains and low refocusing flip angles was optimized in a 1.5 T GE MR scanner using phantoms and normal volunteers. We varied the timing parameters, primarily the TI, to generate a range of gray matter signal intensities. The sequence then was applied to seven MS and six seizure patients. A 3D FSE T2 sequence also was run for comparing tissue contrast at the same locations. The results were analyzed by two independent readers and mean contrast-to-noise ratios (CNR) were computed for gray matter structures using the adjacent white matter as background. The computation was repeated bilaterally for six slices. The visible MS lesions were excluded from analysis.

RESULTS
Optimization of the DIR sequence timing parameters included not fully nulling the white matter by the inversion pulse but reducing its intensity to a level of 50-60% of the mean ROI magnitude of the lowest intensity cortical gray. This resulted in an expanded T2-weighted contrast range for cerebral gray matter. The second inversion time (TI2) was empirically established (150-200 ms) resulting in moderate gray/white differentiation but pronounced contrast variation within gray matter. In MS patient group mean CNR value in DIR images for cortical gray matter and hippocampal head was highest and similar while CNR for caudate nucleus and rest of the hippocampus were 20-30% lower than cortical.
GM. In seizure group the cortical as well as caudate gray matter DIR contrasts were almost equal while CNR at hippocampal head was about 25% higher than all other GM tissues. For 3D FSE T2, the spread in CNR values across cortical and deep gray matter was significantly narrow compared to the spread in DIR images.

CONCLUSION
T2-weighted optimized 3D double inversion recovery sequence seems to produce a wider range of tissue contrast in cortical and several deep gray matter structures than fast spin echo T2. Such a contrast variation within gray matter for DIR may be caused by several factors including tissue T1-dependent DIR process, intra-tissue susceptibility variations or nonuniform perfusion characteristics of blood in some of these structures. In summary, an expanded range of tissue image contrast as we have demonstrated here using DIR may prove useful for characterization of less apparent cortical lesions or early injury in hippocampal substructures.

KEY WORDS: Gray matter, inversion recovery, fast spin-echo

Paper 500 Starting at 11:02 AM, Ending at 11:10 AM
Cerebral Microhemorrhages Detected by Susceptibility-Weighted Imaging in Amateur Boxers

Hasiloglu, Z. I. 1  •  Albayram, S. 2  •  Selcuk, H. 2  •  Ceyhan, E. 1  •  Delil, S. 2  •  Arkan, B. 3  •  Baskoy, L. 1
1Istanbul University, Istanbul, TURKEY, 2Dr. Sadi Konuk Training and Research Hospital, Istanbul, TURKEY, 3Koc University, Istanbul, TURKEY

PURPOSE
Susceptibility-weighted imaging (SWI) is a new technique for evaluating diffuse axonal injury associated with punctate hemorrhages. The aim of our study was to determine the prevalence of cerebral microhemorrhages in amateur boxers compared with nonboxers by using SWI and to evaluate the sensitivity of SWI compared with T2-weighted fast spin-echo (T2 FSE) and T2*-weighted gradient-echo (T2*GE) sequences.

MATERIALS & METHODS
We performed cranial MR imaging with a 1.5 T scanner in 21 amateur boxers and 21 control subjects. The study protocol included conventional MR images, T2 FSE, T2*GE, and SWI sequences. The proportions of boxers and controls having cavum septum pellucidum (CSP), dilated perivascular space (DPVS), cerebral atrophy, cerebellar atrophy, ventricular dilatation, periventricular and subcortical white matter diseases (PSWMD), and microhemorrhages were computed and were compared using the Chi-squared test of proportions. The relationship between microhemorrhages and boxing-related covariates were assessed using the Wilcoxon rank sum test. The association between the categories was tested using Fisher’s exact test.

RESULTS
Using SWI, microhemorrhages were found in two (9.52%) of 21 boxers. The microhemorrhages were not visible on T2 FSE or T2*GE images. The proportion of subjects with microhemorrhages did not differ significantly between the boxers and control subjects (Chi-squared = 0.525, df = 1, p = 0.4688). The prevalence of CSP and DPVS was significantly higher in the boxers than in the control subjects.

CONCLUSION
More microhemorrhages were detected in amateur boxers than in controls, but this difference was not statistically significant.

KEY WORDS: Susceptibility-weighted imaging, cerebral microhemorrhages, amateur boxing

Paper 501 Starting at 11:10 AM, Ending at 11:18 AM
High-Resolution Time-Resolved Contrast-Enhanced MR Angiography of Brain Tumors at 3 T

Tsuchiya, K.  •  Imai, M.  •  Ohara, A.  •  Nitatori, T.  •  Kobayashi, K.
Kyorin University
Tokyo, JAPAN

PURPOSE
Time-resolved contrast-enhanced MR angiography (TCMRA) is a technique that can demonstrate tumor vascularity by combination of a rapid T1-weighted sequence and a bolus injection of Gd-based contrast agent. Time-resolved contrast-enhanced MR angiography has been known to provide images of a high signal-to-noise ratio at 3 T. The aim of this study was to assess the feasibility of high-resolution (HR) TCMRA of brain tumors at 3 T.

MATERIALS & METHODS
Our patient group comprised 24 patients with preoperative brain tumor (six with low-grade glioma, ten with high-grade glioma, four with meningioma, and four with others; 11 males and 13 females; age range, 19 to 91 years). Time-resolved contrast-enhanced MR angiography was performed on a 3 T system (Vantage Titan 3 T, Toshiba Medical Systems, Tochigi, Japan) using a 3D fast gradient-echo sequence in combination with parallel imaging and an efficient k-space filling method. Other imaging parameters included TR/TE (ms), 3.1/0.9; flip angle, 15; slab thickness, 85 mm (8.5 mm x 10 partitions); scanning plane, sagittal; acceleration factor, 3; and scanning time, 60 seconds. Although spatial resolution was 1.0 x 1.0 mm in our previous protocol at 1.5 T, the imaging matrix at 3 T was 192 x 256, which was interpolated to 512 x 512 resulting in intra-section spatial resolution of 0.5 x 0.5 mm. In addition, the TR was 3.1 ms that was shorter than 4.6 ms at 1.5 T; the temporal resolution was 0.79 s/frame. Time-resolved contrast-enhanced MR angiography images thus obtained were assessed visually by two experienced neuroradiologists regarding demonstration of tumor-related vessels and tumor stain.

RESULTS
In all patients, TCMRA images well demonstrated normal distal arterial branches (up to M4 of the middle cerebral artery) and cortical veins. In a total of eight patients with hypervascular tumor, feeding arteries, draining veins and
tumor vessels were depicted to a variable degree. Postprocessing by partial maximum intensity effectively visualized such findings in all of them (Figure).

**CONCLUSION**
HR TCMRA at 3 T can be a valuable technique that can facilitate demonstration of related vessels and a stain of brain tumors.

**KEY WORDS:** MR angiography, gadolinium, time-resolved

### Paper 502 Starting at 11:18 AM, Ending at 11:26 AM

**Four-Dimensional CT Angiography of the Brain Reconstructed from Data for CT Perfusion**

Tsuchiya, K. • Imai, M. • Tateishi, H. • Nitatori, T. • Koyanagi, M.
Kyorin University
Tokyo, JAPAN

**PURPOSE**
Employing a multidetector scanner for CT perfusion has made it possible to acquire source images as a 3D data set. This study was performed to assess the feasibility of reconstructing 4D (time-resolved 3D) CT angiograms of the circle of Willis (COW) from such data.

**MATERIALS & METHODS**
Our patient group comprised 12 patients with preoperative brain tumor (four with high-grade glioma, three with low-grade glioma, two with metastasis, two with meningioma, and one with lymphoma) that was located closely to the COW. We performed CT perfusion of the tumor on a 64-detector scanner at four sections that included the tumor using 25 mL of contrast agent (350 mgI/mL) followed by a saline flush of 40 mL at a rate of 3 mL/sec. Other scanning parameters included 80 kV, 100 mA, 2 mm x 16 collimation reconstructed to 4 8-mm sections (2 mm x 4 stacks) without a gap and 1.5 sec/rotation. Perfusion CT for 45 seconds was started after 5 seconds after injection initiation. Following obtaining perfusion maps of cerebral blood volume (CBV), cerebral blood flow (CBF), and mean transit time (MTT) by the deconvolution method, we generated serial angiographic images at a rate of 1.5 sec/frame by postprocessing using maximum intensity projection and volume rendering. Images thus obtained were compared visually with conventional CT angiograms performed after CT perfusion.

**RESULTS**
In all patients, we could obtain 4D CT angiograms that could be viewed from any angle. Major branches of the COW were visualized equally with conventional CT angiograms. Tumor vessels and tumor stain of hypervascular tumors also were well demonstrated.

**CONCLUSION**
It is possible to generate 4D CT angiograms from the data set for CT perfusion obtained using a contrast dose of 25 mL. This method can provide not only morphological information of arterial branches but also their hemodynamics.

**KEY WORDS:** CT angiography, perfusion, contrast material

### Paper 503 Starting at 11:26 AM, Ending at 11:34 AM

**Evaluation of the Clinical Utility of an Iterative Reconstruction Algorithm**

Spampinato, M. V. • Rumboldt, Z. • Joshi, G. • Huda, W. • Vincent, D. • Tipnis, S.
Medical University of South Carolina
Charleston, SC

**PURPOSE**
To compare image quality of head CT images reconstructed using standard filtered back projection (FBP) with those reconstructed using a novel iterative reconstruction CT algorithm called iterative reconstruction in image space (IRIS).
Materials & Methods
Thirty head CT images showing abnormal findings were selected and paired with an equal number of normal head CT images obtained at the same anatomical axial location. Each pair of images was processed using standard FBP and IRIS algorithm. Three observers (two experienced neuroradiologists and one neuroradiology fellow) independently and in a random order evaluated the pairs and assigned a score from 1 to 10. A score of 1 indicated a barely visible lesion, whereas a score of 10 indicated a readily visible lesion. Differential scores between the IRIS and FBP image pairs (D) were obtained, where positive values indicate a superior performance for IRIS, and vice versa. Differential scores were plotted as histograms for each individual observer, and also were pooled.

Results
Two observers had significantly more positive values of D than negative values with positive to negative ratios of 3 and 2. One observer had a positive to negative ratio of 1. The average ratio of positive to negative D values for all observers was 2.5. Pooled scores for D showed 18 values less than -1, 38 values between -1 and +1, and 34 values greater than +1, with positive to negative score ratio of about 2 (51/24). Nearly 20% of the cases had a D value equal to zero, which implies equal lesion visibility between the two reconstruction algorithms.

Conclusion
The use of iterative reconstruction can improve visibility of brain lesions on CT with potential overall improvement of diagnostic performance.

Key Words: Iterative reconstruction in image space, filtered back projection, image quality
Adaptive 4D Spiral CT Perfusion Postprocessing Vendor Variability: A Comparison of Absolute Values in Identical Source Datasets

Naveed, M. A. • Boulter, D. J. • Spampinato, M. V. • Roberts, D. R. • Cianfoni, A. • Mills, J. • Rumboldt, Z.
Medical University of South Carolina
Charleston, SC

**Purpose**

To compare cerebral blood flow (CBF), cerebral blood volume (CBV) and mean transit time (MTT) values in adaptive 4D spiral CT perfusion (CTP) datasets generated by both Siemens and GE postprocessing.

**Materials & Methods**

Adaptive 4D spiral volume CTP datasets in four patients with normal perfusion findings were first processed automatically using both Siemens and GE software packages. Three free-hand regions of interest were positioned at the right insula, basal ganglia, and occipital lobe. Mean values of CBF, CBV, and MTT were recorded. The effect of arterial input selection at various positions within the volume then was assessed in three additional patients with normal perfusion findings. These datasets first were processed automatically with Siemens software. For comparison, GE processing was performed three times for each patient by manually selecting an arterial input from the following locations within the volume: at the extreme edge, one quarter of the way through the volume, and in the center of the volume. Mean values of CBF, CBV, and MTT were recorded.

**Results**

Automatic postprocessing yielded greatly variable CBF measurements, with mean CBF measuring 68.8 for Siemens and 32.0 for GE. Mean CBV measurements also differed, measuring 3.69 for Siemens and 1.23 for GE. Mean transit time differed to a lesser degree, measuring 3.22 for Siemens and 2.61 for GE. When GE processing was performed with manually selected arterial inputs, the GE mean perfusion values were significantly lower than the Siemens values when a vessel at the edge of the volume was chosen. As the input vessel approached the center of volume, the CBF, CBV and MTT approached (but never reached) the Siemens values (Table 1).

Table 1: Comparison of Siemens and GE values for CBF, CBV and MTT in normal CTP

<table>
<thead>
<tr>
<th></th>
<th>Siemens</th>
<th>GE Edge</th>
<th>GE One Quarter</th>
<th>GE Center</th>
</tr>
</thead>
<tbody>
<tr>
<td>CBF</td>
<td>74.95±8.92</td>
<td>22.77±6.91</td>
<td>45.54±12.26</td>
<td>49.07±12.39</td>
</tr>
<tr>
<td>CBV</td>
<td>3.90±0.34</td>
<td>0.84±0.26</td>
<td>2.26±0.46</td>
<td>2.21±0.46</td>
</tr>
<tr>
<td>MTT</td>
<td>3.35±0.52</td>
<td>2.45±0.20</td>
<td>2.45±0.49</td>
<td>3.17±0.49</td>
</tr>
</tbody>
</table>

**Conclusion**

In patients with normal perfusion findings scanned with adaptive 4D spiral, automated CTP processing on Siemens and GE yields very different CBF, CBV and MTT values. However, this difference becomes less when the artery of input is manually selected from the center of volume for GE software. These differences may be related to the adaptive 4D spiral acquisition mode, for which nondedicated software could give erroneous results.

**Key Words:** CT perfusion, postprocessing

**References**

1. Teng, M. M. H. • Chiu, F. • Kao, Y.
   · Taipei Veterans General Hospital, Taipei, TAIWAN,
   · National Yang Ming University, Taipei, TAIWAN

MR Perfusion: Cerebrospinal Fluid Pixel Removal Using Cerebrospinal Fluid Mask Generated by the First Several Images and Otsu’s Thresholding Technique

**Purpose**

We evaluated the value of cerebrospinal fluid (CSF) pixel removal on the postprocessing of MR perfusion.

**Materials & Methods**

We postprocessed MR perfusion data in 31 patients with known significant unilateral carotid stenosis diagnosed on digital subtraction angiography, CT angiography, or MR angiography. The CSF pixels were removed using the mask generated by the first several images of brain perfusion and Otsu’s thresholding technique as described in the reference. The amount of CSF pixel to be removed can be adjusted by visual comparison of the perfusion image and CSF mask. We selected two levels of the brain for measurement of perfusion: one high ventricular level (the level at the body of lateral ventricle), and one supraventricular level (the first level above lateral ventricle). The supraventricular level was not included in MR perfusion study thus was not available for measurement in five patients. Totally 57 levels were evaluated, including 31 levels of high ventricular level and 26 levels of supraventricular level. For each level, we drew one region of interest (ROI) for each hemisphere and calculated the lesion-to-contralateral-hemisphere ratio of MTT and CBF.

**Results**

On visual comparison, the MR perfusion of brain parenchyma could be perceived more easily after removal of CSF pixels. On drawing the ROI after removal of CSF pixels, the inclusion or exclusion of CSF spaces did not change the measured data. The measured lesion-to-contralateral-hemisphere MTT ratios were all larger than one as expected both without and with removal of CSF pixels. The lesion-to-contralateral-hemisphere CBF ratios were inverted (larger than one) without CSF removal in two levels, in both without and with CSF removal in five levels, and with CSF removal in three levels. In these cases with inverted CBF ratios, an ROI drew inside the area with prolongation of MTT and corresponding contralateral brain showed low CBF on the side of carotid stenosis. More detailed data will be presented at the conference.
CONCLUSION
Removal of CSF pixel facilitated visualization of MR perfusion changes in brain parenchyma. Region of interest drawing could include CSF spaces in measurement of brain parenchyma perfusion data. All MTT ratios and majority CBF ratios were compatible with the clinical and angiographic information.

KEY WORDS: Brain perfusion, Otsu’s thresholding technique, carotid stenosis

Evaluation of a New Contrast Enhancement Tool in Computed Tomography Imaging of the Brain

von Gottberg, P. • Psychogios, M. N. • Knauth, M. • Schramm, P.
Universitätsmedizin Goettingen
Goettingen, GERMANY

PURPOSE
In computed tomography (CT) imaging of the brain a sufficient contrast-to-noise ratio (CNR) is crucial when referring to abnormalities of gray and white matter. Contrast-to-noise ratio can be improved by reducing noise or improving the contrast itself. Noise can be reduced by increasing dose but dose has to be limited to a medically justifiable exposition of the patient to ionizing radiation set in relation with the expectable diagnostic benefit of the examination. The ideal brain CT examination therefore would have a level of radiation as low as possible with a maximum CNR in the image (ALARA: as low as reasonable achievable). A new approach to this balancing act is contrast enhancement tool called “Neuro BestContrast” (Siemens Healthcare, Forchheim; Germany). This tool applies optimized lookup tables to improve the contrast with the goal to enhance the original CT data and allow better gray and white matter differentiation at the same radiation exposure. The aim of this study was to compare brain CT images generated with and without the tool to determine its effectiveness.

MATERIALS & METHODS
Forty-one patients received noncontrast brain CT before and after installation of the “Neuro BestContrast” tool at our institution. All examinations were carried out on a SOMATOM Definition AS+ 128-slice CT scanner (Siemens Healthcare, Forchheim, Germany). Three experienced neuroradiologists compared and scored the ability to differentiate gray and white matter in the temporopolar region, the frontal lobe, along the pericentral region, in the basal ganglia and along the insular cortex on a scale from 1 to 5, 1 being “excellent” and 5 being “undiagnostic”.

RESULTS
In all considered brain regions, the images using “Neuro BestContrast” scored significantly better (see Table 1 for summarized scores of the different evaluated brain regions before and after implementation of “Neuro BestContrast”). The biggest improvement was found for the insular cortex, followed by the frontal cortex. For the basal ganglia area, the smallest improvement was seen by the readers, those different results very likely result from the anatomy. Since the insular cortex is relatively narrow in comparison to other supratentorial cortical structures it might benefit the most from an improvement of contrast. However, for all evaluated brain regions, intraindividual contrast improvements showed statistical significance.

Table 1:

<table>
<thead>
<tr>
<th>Brain Region</th>
<th>Summarized scores without &quot;Neuro BestContrast&quot;</th>
<th>Summarized scores using &quot;Neuro BestContrast&quot;</th>
<th>Difference</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temporopolar region</td>
<td>140</td>
<td>118</td>
<td>22</td>
<td>p&lt;0.05</td>
</tr>
<tr>
<td>Frontal lobe</td>
<td>114</td>
<td>85</td>
<td>29</td>
<td>p&lt;0.05</td>
</tr>
<tr>
<td>Pericentral region</td>
<td>97</td>
<td>70</td>
<td>27</td>
<td>p&lt;0.05</td>
</tr>
<tr>
<td>Basal ganglia</td>
<td>116</td>
<td>96</td>
<td>20</td>
<td>p&lt;0.05</td>
</tr>
<tr>
<td>Insular cortex</td>
<td>136</td>
<td>100</td>
<td>36</td>
<td>p&lt;0.05</td>
</tr>
</tbody>
</table>

CONCLUSION
The contrast enhancement tool “Neuro BestContrast” allows for better anatomical differentiation of gray and white matter in all examined brain regions. It therefore can provide better contrast between brain structures at the same dose of radiation. Further studies should prove whether this tool may allow a better diagnosis of cerebral diseases in noncontrast CTs.

KEY WORDS: CT imaging, contrast enhancement tool, Neuro BestContrast

Dual Energy Spectral Head CT Improves Contrast Resolution over Polychromatic CT and Allows for Virtual Noncontrast Scans without Loss of Information

Bluestone, A. Y. • Ramachandran, S. • Pawha, P. • Tanenbaum, L.
Mount Sinai School of Medicine
New York, NY

PURPOSE
Dual energy spectral head CT (DECT) is a commercially available CT imaging and reconstruction technique that allows for improvement in low contrast detectability via tuned monochromatic (MC) imaging. Additionally, DECT can generate two types of virtual noncontrast (VNC) images from a postcontrast scan potentially eliminating the need for a noncontrast scan.
MATERIALS & METHODS
A retrospective review of routine 10 with and without contrast head CT scans performed on a GE 750 Discovery HDCT was performed using polychromatic precontrast and DESCT postcontrast CT head images. The ideal tuned MC energy for optimal gray-white differentiation was determined by Hounsfield unit spectral analysis of the data sets obtained. Dual energy spectral head CT data sets then were reconstructed at the tuned MC energy level. Two VNC data sets were created with MC imaging at 125 KeV and material basis based iodine suppressed imaging. Two neuroradiologists evaluated the tuned MC images against the polychromatic 140 KVP for low contrast resolution and overall diagnostic quality. The VNC sets were compared to the polychromatic unenhanced CT set for quality and diagnostic adequacy.

RESULTS
Clinical head CT images reconstructed with Monochromatic 68 KeV demonstrated better than expected gray-white contrast differentiation, and equivalent or better than expected diagnostic value. Additionally, the VNC data sets as compared with images reconstructed with polychromatic noncontrast CT demonstrated similar quality and diagnostic adequacy.

CONCLUSION
Dual energy spectral head CT image quality for CT of the head was equivalent or superior to polychromatic 140 KVP images for gray-white differentiation using monochromatic 68 KeV. Additionally, the VNC images were comparable to the polychromatic unenhanced CT images for quality and diagnostic adequacy. Clinical relevance/application: Tuned MC head images from DESCT are as good or better than traditional polychromatic studies. Derived VNC images may eliminate the need for routine unenhanced images and thus reduce overall patient radiation dose.

KEY WORDS: Dual energy spectral CT, virtual noncontrast, monochromatic

Thursday Morning
10:30 AM - 12:15 PM
Room 606 - 609

(46c) Pediatrics: Brain Tumors and Cerebrovascular Disorders
(Scientific Papers 509-521)

See also Parallel Session
(46a) Chiari, Tumor and Other
(46b) Brain: New Imaging and Processing Techniques
(46d) Head & Neck: Larynx, Nodes and Glands
(46e) Research Grant Writing Session - Part I

Moderator: Dennis Shaw, MD

Paper 509 Starting at 10:30 AM, Ending at 10:38 AM
Imaging of Pediatric Diffuse Leptomeningeal Glioneuronal Tumors

Torres, F. • Grimm, J. P. • Whitehead, M. • Panigrahy, A. • Nelson, M. D. • Bluml, S.
1 Kaiser Permanente Los Angeles Medical Center, Los Angeles, CA, 2 Childrens Hospital Los Angeles, Los Angeles, CA, 3 University of Pittsburgh, Pittsburgh, PA

PURPOSE
Diffuse leptomeningeal glioneuronal tumor is a rare and newly proposed pathologic entity with characteristic imaging findings that suggest the diagnosis. The goal of this study is to review these findings and to investigate the metabolic features of these tumors on MR spectroscopy.

MATERIALS & METHODS
The imaging findings in the brain and spine of five patients with pathology confirmed diffuse leptomeningeal glioneuronal tumor were reviewed. MR spectroscopy was obtained in all five of these patients (four at our institution). MR spectra from our institution were acquired with a standard single-voxel PRESS sequence with an echo time of 35ms. Spectra were processed with LCModel software and absolute concentrations of metabolites were obtained.

RESULTS
All five patients had diffuse leptomeningeal involvement with enhancement along the surfaces of the brainstem and spinal cord. Although none demonstrated a dominant
parenchymal lesion, three had more focal areas of avid enhancement in the suprasellar cistern. Four demonstrated characteristic “cysts” covering the surfaces of the brain, most prominently involving the cerebellar hemispheres. Occasionally these “cysts” appeared to even invade the brain parenchyma, perhaps along perivascular spaces. Two had focal “cysts” within the spinal cord. Diffuse areas of enhancement filling the basal cisterns and the spinal canal often were seen on delayed imaging (e.g., 30 min), but not on images immediately after contrast (Figure). Long-term follow up was obtained in three patients. Slow progression of disease was seen in two patients (over 4 and 7 years), and more rapid progression was seen in one patient (over 2 years). Spectra of these tumors showed features generally observed in brain tumors, such as prominent choline (Cho) relative to creatine (Cr) and elevated lipids. An unusually high N-acetyl-aspartate (NAA) peak was observed in all spectra (Figure) and NAA relative to Cho (NAA/Cho). One might speculate that partial volume with normal tissue could explain the presence of NAA, yet this is not consistent with other features of the spectra such as prominent Cho/Cr.

CONCLUSION
Diffuse leptomeningeal glioneuronal tumors are rare tumors with characteristic imaging findings. This includes diffuse leptomeningeal enhancement without a dominant parenchymal lesion, “cysts” along the surfaces of the brain and even invading the brain parenchyma and spinal cord, and delayed enhancement filling the basilar cisterns and spinal canal. Furthermore, these tumors demonstrate unusual spectra with prominent levels of NAA. These imaging and metabolic features may prove useful to differentiate these rare tumors from more common pediatric neoplasms.

KEY WORDS: Pediatric, tumor, glioneuronal

Paper 510 Starting at 10:38 AM, Ending at 10:46 AM

Using MR Spectroscopy to Distinguish Cortical Dysplasia from Cortically Based Neoplasms

Grimm, J. P.1 · Panigrahy, A.2, 3 · Zuccoli, G. 2 · Nelson, M. D.1 · Bluml, S.1, 3
1 Children’s Hospital Los Angeles, Los Angeles, CA, 2 Children’s Hospital of Pittsburgh of the University of Pittsburgh Medical Center, Pittsburgh, PA, 3 Rudi Schulte Research Institute, Santa Barbara, CA

PURPOSE
Cortical dysplasia (CD) sometimes can have overlapping imaging finding with neoplasms like dysembryoplastic neuroepithelial tumors (DNET), ganglioglioma (GG), oligodendroglioma (OG), and pleomorphic xanthoastrocytoma (PXA) based on MR imaging (MRI) alone. In vivo MR spectroscopy (MRS) is a widely available methodology that can be used in combination with MR imaging to characterize tissue at a cellular level by quantifying intracellular metabolites. The goal of this study was to review metabolic features of these lesions to determine whether MRS might improve initial diagnoses.

MATERIALS & METHODS
MR spectra from 19 patients [4 CD, 5 dysembryoplastic neuroepithelial tumors (DNET), 2 OG, 6 GG, 2 PXA] with confirmed pathology were analyzed. All MR spectra were acquired with a standard single-voxel PRESS sequence with an echo time of 35 ms. Spectra were processed and quantified with fully automated LCModel software. Metabolite ratios relative to creatine (Cr) are summarized in this preliminary survey.

RESULTS
Ganglioglioma and PXA had MRS features typically seen in tumors such as elevated lipids (Lip), lactate (Lac), and prominent Choline (Cho) which readily distinguished them from cortical dysplasia. Dysembryoplastic neuroepithelial tumors and OG shared some features of CD such as residual N-acetyl-aspartate and moderate Cho levels (Figure, Table). However, Lac was observed clearly in all DNET and OG whereas there was no evidence for lactate in the cortical dysplasia cases included in this study.

<table>
<thead>
<tr>
<th>Metabolite ratios (mean (stdev)) in various lesions</th>
</tr>
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<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>Cho/Cr</td>
</tr>
<tr>
<td>Lac/Cr</td>
</tr>
<tr>
<td>NAA/Cr</td>
</tr>
<tr>
<td>Lipids/Cr</td>
</tr>
</tbody>
</table>

Thursday
Figure. MR spectra of ganglioglioma (A), DNET (B), and cortical dysplasia (C).

**CONCLUSION**
MR spectroscopy is useful for distinguishing cortical dysplasia from other cortically based neoplasms.

**KEY WORDS:** MR spectroscopy, cortical dysplasia, neoplasm

**Paper 512 Starting at 10:54 AM, Ending at 11:02 AM**

**Medulloblastoma Metastatic to Sites Outside the Central Nervous System**

Yhu, S. • Young, R. J. • Ramaswamy, V. • Haque, S. • Gilheeney, S. • Khakoo, Y. • Dunkel, I.
Memorial-Sloan Kettering Cancer Center
New York, NY

**PURPOSE**
Medulloblastoma is a highly malignant neoplasm that may rarely metastasize to sites outside the central nervous system (CNS). We describe a series of cases of patients with CNS medulloblastoma who developed metastatic disease outside the CNS.

**MATERIALS & METHODS**
We retrospectively queried a departmental database for patients who had medulloblastoma and M4 or extra-CNS metastases over the past 17 years. Relevant demographic and clinical data were recorded with specific attention to histology, treatment regimens, and clinical course. Available CT, MR imaging and nuclear medicine scans were reviewed.

**RESULTS**
Eleven patients were confirmed to have CNS medulloblastoma and M4 metastases. The mean age was 15.4 years (range, 3.5-33.8 years). Desmoplastic medulloblastoma was the most common pathology (n=5) as compared to classic (n=4) and anaplastic (n=2) types. At initial diagnosis, patients were either M0 (n=9), M1 (n=1), or M2 (n=1) prior to progression to M4. All patients underwent gross total resection of the primary tumor and craniospinal radiation, while less than half (n=4) also received chemotherapy. The mean time from pathologic diagnosis of medulloblastoma to initial diagnosis of extra-CNS metastasis was 3.4 years (range, 0.2-17.4 years). Metastases occurred to bone (n=8, of which three were to the spine), bone and muscle (n=1), bone and lung pleura (n=1), and lymph nodes (n=1). Two patients who initially developed bone metastases later recurred with soft tissue metastases after an additional 2.1 and 16.6 years, respectively. Nine patients died from their malignancy, one patient is currently living, and one patient was lost to follow up. Median overall survival from time of medulloblastoma diagnosis was 3.9 years (range, 1.5-19.8 years), and from time of extra-CNS metastasis diagnosis was 2.4 years (range, 0.2-18.0 years).
CONCLUSION
Extra-CNS metastases may rarely occur in patients with medulloblastoma, even after prolonged periods after completion of treatment. These distant metastases most commonly occur to bone. Further work is necessary to determine optimal long-term imaging strategies for following these patients, such as whole body MR imaging.

KEY WORDS: Medulloblastoma, neoplasm, M4

Paper 513 Starting at 11:02 AM, Ending at 11:10 AM
Imaging of Murine Medulloblastoma Models on a Clinical MR Scanner: Basic and Advanced Techniques

Khanna, P. C., Friedman, S. 1 2 3 · Shaw, D. 1 2 3
1 Seattle Children’s Hospital, Seattle, WA, 2 Center for Integrative Brain Research, Seattle, WA, 3 University of Washington School of Medicine, Seattle, WA

PURPOSE
To investigate MR imaging (MRI) as a multifaceted tool in evaluating murine brain tumor models employing readily accessible 3 T scanners designed for clinical applications. Medulloblastoma is the most common pediatric posterior fossa tumor associated with significant treatment and tumor-related morbidity. We utilized two tumor models in conjunction with an experimental drug, to evaluate drug efficacy and thereby validate utility of MRI. Much drug development relies on animal tumor models and in vivo multi-time point MRI can increase efficiency and understanding of these studies.

MATERIALS & METHODS
Preliminary MRI of wild-type nontumor mice, transgenic (focal tumor) and knockout (diffuse tumor) mice was followed by volumetric imaging of both drug-treated and vehicle groups of knockout mice during and following treatment. Comparisons were made with histology (gold-standard). Cyclopamine derivative IPI-926 was administered via intraperitoneal route using different regimens. Philips Achieva 3 T (Philips Healthcare, Andover, MA) and a custom mouse head coil were utilized for conventional serial imaging in 36 mice and multispin-echo quantitative T2 mapping in four mice early in treatment course. One hundred twenty-four scans were postprocessed.

RESULTS
MR imaging at 3 T provided a robust way to measure tumor volume change in longitudinal samples. Conventional T2-weighted qualitative imaging yielded volumes that were well correlated to volumes measured at histology, validating this technique. IPI-926 was shown to result in necrosis, change in tumor volume and growth rate. Quantitative T2 pilot imaging early in the treatment time-course suggested that MRI parameters other than volume may be utilized to monitor early drug treatment effects.

CONCLUSION
Ultra-high field-strength magnets (>4T) are not essential in conducting high-quality basic and advanced translational MR imaging of small animals. Using standard 3T equipment with a well-sized head coil, MRI can be used as primary and intermediate endpoint, minimizing the use of study animals and reducing data variability.

KEY WORDS: Murine medulloblastoma models, basic and advanced MR imaging

Paper 514 Starting at 11:10 AM, Ending at 11:18 AM
Is There Correlation Between Tumor/Normal Cerebellum Apparent Diffusion Coefficient Ratios and Cell Densities of Pediatric Medulloblastomas and Pediatric Cerebellar Ependymomas?

Koral, K. 1 2 3 · Mathis, D. 4 · Gargan, L. 2 · Bowers, D. C. 1 2 · Marggraf, L. 1 2 · Gimi, B. 1
1 University of Texas Southwestern Medical Center at Dallas, Dallas, TX, 2 Children’s Medical Center, Dallas, TX, 3 Thayer School of Engineering at Dartmouth, Hanover, NH

PURPOSE
To investigate the correlation between ADC values and cell densities of pediatric medulloblastomas and pediatric cerebellar ependymomas.

MATERIALS & METHODS
Forty-one patients who had preoperative MR imaging and surgical pathology available between 01/01/2001 and 31/12/2009 were included. Apparent diffusion coefficient (ADC) values of solid tumor and normal cerebellum were measured on PACS by a pediatric neuroradiologist. Tumor/normal cerebellum ADC ratios were calculated and an ROC analysis was performed. The pathology slides were evaluated by a pathology attending and neuroradiologist. The tumors were classified according to the 2007 WHO classification of tumors of the central nervous system. Cell densities were calculated at random representative fields and expressed in cell number/mm².

RESULTS
There were 27 medulloblastomas [19 males, mean age= 6.16 years (1.15-14.18)] and 14 ependymomas [13 males, mean age=4.61 years (0.46-17.18)]. There were seven patients with WHO II ependymoma and seven patients with WHO III ependymoma. The mean tumor/normal cerebellum brain ratios obtained were 0.95 ± 0.21 for medulloblastomas and 1.64 ± 0.5 for ependymomas (mean ± std). ROC analysis distinguished between ependymomas and medulloblastomas (threshold = 1.2461; sensitivity = 100, specificity = 92.59).

The cell densities were not significantly different between medulloblastomas and ependymomas (Wilcoxon Exact test). The cell densities were significantly different between WHO grade II and WHO grade III ependymomas (p=0.0344, Wilcoxon Exact test), but curiously the cell densities were greater for WHO grade II ependymomas. WHO grade II ependymomas had lower tumor/normal cerebellum ADC ratios, compared with WHO grade III ependymomas (p=0.0189, Wilcoxon Exact test).

CONCLUSION
Tumor/normal cerebellum ADC ratio is a useful tool in distinguishing pediatric cerebellar ependymomas from medulloblastomas if a threshold of approximately 1.25 is used
Spontaneous Modifications of Contrast Enhancement: A New MR Imaging Sign Supporting the Diagnosis of Pilocytic Astrocytoma in Childhood

Di Lella, G. M. • Gaudino, S. • Quaglio, F. R. • Calandrelli, R. • Tartaglione, T. • Colosimo, C.
Catholic University Rome, ITALY

PURPOSE
MR imaging (MRI) is the gold standard in the diagnosis and follow up of pilocytic astrocytoma (PA). Pilocytic astrocytoma may appear as a cystic lesion with mural nodule, solid with intrinsic cysts or purely solid lesion; the solid part may enhance in a homogeneous or a heterogeneous fashion. Assessment of contrast enhancement (CE) pattern is essential for the diagnosis and follow up. Sometime PA may mimic high grade tumor, and biopsy may not always be possible. Our purpose was to evaluate CE changes of PA with serial MR, and to assess these CE “fluctuations” as a possible new MRI sign for PA.

MATERIALS & METHODS
Retrospective evaluation of MR exams of 140 patients with PA followed for an average of 4.5 years with serial MRI. We selected 14 patients (12/14 histologically proved PA, 2/14 radiologic diagnosis) off therapy, without NF1, without dimensional changes of tumor/residual tumor and with modifications of PA contrast enhancement (increase/appear and/or decrease/disappear of the CE). We calculated tumor size and areas of CE with a cross product. Descriptive statistics were calculated for continuous variables, effects of possible factors influencing changes of CE areas were tested.

RESULTS
Three of 12 PA were infratentorial, 10/12 supratentorial and 1/12 endoventricular. There was no significant correlation between age, gender, tumor localization, tumor size and CE areas.

CONCLUSION
The occurrence of CE spontaneous fluctuation in both residual and untreated PA and the absence of apparent relation with age, gender, tumor localization and size suggests that CE changes could be a peculiar characteristic of PA, probably due to its biologic behavior. A knowledge of this phenomenon will avoid misdiagnosis of isolated CE changes as progression/regression of PA, differently from the general statement concerning other diffusely infiltrating brain gliomas. In our opinion spontaneous fluctuations of CE could become a new MRI criterion for diagnosis PA.

KEY WORDS: Medulloblastoma, ependymoma, apparent diffusion coefficient

Perfusion Imaging of Pediatric Posterior Fossa Tumors

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Indiana University Indianapolis, IN

PURPOSE
To determine the perfusion characteristics of common pediatric posterior fossa tumors, and to evaluate the usefulness of perfusion MRI in differentiating low versus high grade tumors.

MATERIALS & METHODS
A total of 16 pediatric patients with histopathology proved posterior fossa tumors including medulloblastoma, ependymoma, and pilocytic astrocytoma were identified retrospectively in this HIPAA-compliant study. All underwent dynamic susceptibility-weighted contrast-enhanced (DSC) magnetic resonance (MR) perfusion using a contrast-enhanced echo planar sequence on 1.5 T MRI, prior to treatment, biopsy, or tumor resection. Color maps of relative cerebral blood volume (CBV) were generated from perfusion source images. Regions of interest (ROI) were placed on the CBV color map, in the highest perfusing areas of the tumor, excluding blood vessels, and compared to a ROI placed in normal white matter to generate a relative CBV (rCBV) ratio. Welch’s T-test was used to compare the mean difference between the low grade - pilocytic astrocytoma/ependymoma group and high-grade medulloblastoma group.

RESULTS
We retrospectively identified nine patients with pilocytic astrocytoma, two patients with ependymoma and five patients with medulloblastoma. Relative CBV ratio ranged from 1.0 to 3.6 in the pilocytic astrocytoma and ependymoma group, with a mean of 2.13. Relative CBV ratio ranged from 3.52 - 8.35 in the medulloblastoma group, with mean of 5.70. Welch’s T-test demonstrates significantly higher rCBV (3.49 mean difference, 0.95 CI ± 2.1, two tailed P=0.028) in patients with medulloblastoma than in patients with pilocytic astrocytoma and ependymoma.

CONCLUSION
Our findings demonstrate significantly higher rCBV ratio in patients with medulloblastoma when compared to patients with pilocytic astrocytomas and ependymomas. MR perfusion, in correlation with conventional MR imaging, may be useful in the presurgical assessment and treatment planning of pediatric posterior fossa tumors.
Paper 517 Starting at 11:34 AM, Ending at 11:42 AM

Does Cortical Venous Sinus Thrombosis Cause Subdural Hemorrhage in the Pediatric Population?

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Purpose
Unexplained subdural hemorrhage in infants and children is an accepted marker for abusive head trauma. It has been proposed that cerebral venous sinus thrombosis (CVST) is an initiating event for a subdural hemorrhage (SDH), a confounding diagnosis in child abuse. Some authors propose that CVST causes backpressure at the level of the dura causing extravasation of blood into the subdural space. The purpose of our study is to understand if cerebral venous sinus thrombosis causes subdural hemorrhage in the pediatric population.

Materials & Methods
We retrospectively identified 35 cases of cerebral venous sinus thrombosis, in patients ranging in age from 1 day old to 19 years of age. Neuroimaging studies then were reviewed by an attending pediatric neuroradiologist and neuroradiology fellow for the concurrent presence of subdural hemorrhage.

Results
In our 35 patients with cerebral venous sinus thrombosis, we identified one patient with a small tentorial subdural hematoma. This patient's SDH was thought to be birth related. Three false positive diagnoses of CVST were identified. The first false positive diagnosis occurred when an epidural empyema from mastoiditis compressed and displaced the venous sinus, mimicking CVST. In the two other patients, a SDH from head trauma compressed the venous sinus, resulting in false positive diagnoses of CVST. Lastly, in the patient’s with the most severe CVST, no abnormal extraxial fluid collections were identified.

Conclusion
We identified a subdural hematoma in 1/35 patients in the setting of cerebral venous sinus thrombosis. Our findings do not support the previous literature in abusive head trauma stating that cortical venous sinus thrombosis is associated with or leads to subdural hemorrhage in infants or children.

Key Words: Cortical venous sinus thrombosis, subdural hemorrhage, abusive head trauma

Paper 518 Starting at 11:42 AM, Ending at 11:50 AM

Calcifications Associated with Pediatric Intracranial Arterial Aneurysms: Incidence and Correlation with Pathogenic Subtypes

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Cincinnati, OH

Purpose
To characterize calcification patterns associated with childhood intracranial arterial aneurysms (IAA).

Materials & Methods
Patients with IAA less than 20 years of age were identified retrospectively by searching medical records at our institution using the search term “aneurysm” from 01/1993 to 6/2010. Medical record review confirmed each case. Patients without computerized tomography (CT) in the Picture Archiving Communication System were excluded. Patients that only had post-treatment CT were excluded if there was beam hardening artifact in the region of interest. Three fellowship-trained neuroradiologists independently reviewed each patient’s CTs for calcifications of the parent artery or aneurysm. Calcification patterns were classified as punctate, chunky (thick confluent mass of calcium with complex shape) or egg shell. The final classification for each lesion was determined by majority opinion. Calcification was correlated with characteristics of the patient (age, sex) and aneurysm (pathogenetic subtype, rupture status, size, morphology, location). The Fisher exact test was used to evaluate statistical significance.

Results
Thirty-three patients, with 44 IAA met inclusion criteria. Twenty males (M) and 13 females (F) ranged in age from 9 days to 19 years (mean 10 years). The 44 IAA included 19 idiopathic, five infectious, three traumatic, one oncotic and six flow-related IAA in patients with arteriovenous malformations (AVM). Ten aneurysms were associated with arteriopathies: two tuberous sclerosis (TS), one Cutis marmorata telangetasia (CMT), one Robert’s syndrome, one Alagille’s syndrome, one Loey’s syndrome. There were no parent artery calcifications. Aneurysm calcification (ANC) was present in eight of 33 patients including three of six with arteriopathies (2 TS, 1 CMT), two of 17 with idiopathic IAA, one of three with traumatic IAA, one of three with infectious IAA and one of one with an oncotic IAA. Aneurysm calcification was not present in any AVM patient. Excluding flow-related aneurysms, IAA in children with identifiable risk factors (arteriopathy, trauma, infection, tumor) were calcified more commonly than idiopathic IAA (p = 0.03). Approximately half of the pediatric IAA in this group (arteriopathy, infection trauma, tumor) were calcified. All calcified idiopathic IAA were dissecting posterior cerebral artery aneurysms. Multiple calcification patterns were observed reflecting a mixture of punctuate (5/8), chunky (3/8) and eggshell (5/8) phenotypes. Aneurysm calcification was not significantly associated with age (10 years and younger vs > 10 years), sex, rupture status, morphology ( fusiform vs saccular) or location (anterior vs posterior circulation).
CONCLUSION
Aneurysmal but not parent artery calcifications are associated with a significant minority of pediatric IAA. Most ANC are punctuate and/or eggshell. Aneurysm calcifications are uncommon in flow-related IAA associated with pediatric AVMs though pediatric IAAs with underlying risk factors such as arteriopathy, infection, trauma and tumor are more likely to be calcified than idiopathic IAAs of childhood.

KEY WORDS: Aneurysm, calcification, pediatric

Paper 519 Starting at 11:50 AM, Ending at 11:58 AM
Pediatric Nongalenic Pial Intracranial Arteriovenous Fistulas: Characteristics and Clinical Outcomes
Hetts, S. W. • Keenan, K. J. • English, J. D. • Dowd, C. F. • Higashida, R. T. • Fullerton, H. • Halbach, V. V.
University of California San Francisco
San Francisco, CA

PURPOSE
To retrospectively review and analyze patient data regarding intracranial non-Galenic pial arteriovenous fistulas (NGAVF) in patients 18 years of age or less evaluated at our tertiary referral hospital.

MATERIALS & METHODS
Under an IRB-approved protocol, 23 patients with NGAVF were identified from a neurointerventional radiology database out of a total of 388 pediatric patients with intracranial AVFs and AVMs. Three patients were excluded due to lack of clinical and imaging data. Patient information was extracted from medical records and imaging studies. Patient demographics, clinical presentation, lesion angioarchitecture, treatment approaches, angiographic outcomes, and clinical outcomes were categorized and assessed.

RESULTS
Six neonates (age 2 years) were treated for NGAVF. Presenting signs and symptoms are outlined in the Table. Gender ratio was 1:1, but boys were younger than girls at the time of first intervention (median 15.5 days for boys versus 1.43 years for girls). Follow-up time after treatment ranged from 1 day to 8.5 years, with median and mean follow-up times of 2.2 years and 2.8 years, respectively. Although 40% of patients had pial NGAVF alone, the other 60% also had coexistent pial nidus AVM, dural AVF, vein of Galen malformation (VOGM), or intracranial arterial aneurysms. A total of 36 transarterial, three transvenous, and one combined transarterial and transvenous interventions were performed in these patients. A median of 2 and average of 2.6 interventions were performed per patient, with a range of one to six interventions. All 20 patients were treated with coils, three were treated with glue (15%), one was treated with particulate embolics (5%), and one was treated with absolute ethanol (5%). Nine patients also were treated with surgery (45%), and one patient received stereotactic radiosurgery (5%) for an associated nidus AVM. Eight patients (40%) had their NGAVF completely obliterated at the end of treatment. At last follow up, seven of 20 patients had normal neurologic examinations and development. Four patients had both focal neurologic deficits and developmental delay. Two patients had focal neurologic deficits without developmental delay, while five patients had developmental delay without focal neurologic deficits. Six patients had seizure disorders. Two of 20 patients died during follow up. One patient with hydrops fetalis died on day 1 of life after a basilar artery avulsion occurred during embolization; the other patient was discharged in grave condition at 2.3 years of age and passed away at home.

Table

<table>
<thead>
<tr>
<th>Presentation Type</th>
<th>Fraction and (Percent) of patients with presentation type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seizure</td>
<td>8/20 (40%)</td>
</tr>
<tr>
<td>Hemorrhage</td>
<td>4/20 (20%)</td>
</tr>
<tr>
<td>Congestive Heart Failure</td>
<td>8/20 (40%)</td>
</tr>
<tr>
<td>Pulmonary Hypertension</td>
<td>5/20 (25%)</td>
</tr>
<tr>
<td>Respiratory Distress</td>
<td>1/20 (5%)</td>
</tr>
<tr>
<td>Focal Neurologic Deficit</td>
<td>4/20 (20%)</td>
</tr>
<tr>
<td>Hypotonia</td>
<td>4/20 (20%)</td>
</tr>
<tr>
<td>Clonus</td>
<td>0/20 (0%)</td>
</tr>
<tr>
<td>Hydrocephalus</td>
<td>2/20 (10%)</td>
</tr>
<tr>
<td>Headache</td>
<td>3/20 (15%)</td>
</tr>
<tr>
<td>Nausea/Vomiting</td>
<td>4/20 (20%)</td>
</tr>
<tr>
<td>Skull Bruit</td>
<td>9/20 (45%)</td>
</tr>
<tr>
<td>Congenital Heart Defect</td>
<td>5/20 (25%)</td>
</tr>
<tr>
<td>Murmur</td>
<td>7/20 (35%)</td>
</tr>
<tr>
<td>Dilated Facial Veins</td>
<td>1/20 (5%)</td>
</tr>
</tbody>
</table>

CONCLUSION
Pial NGAVFs constituted 6% of all pediatric intracranial arteriovenous shunting lesions in our series. Boys presented at younger ages than girls. Overall mortality and morbidity of these lesions appears similar to that reported previously for vein of Galen malformations despite a somewhat lower rate of angiographic cure.

KEY WORDS: Nongalenic, AVF, fistula

Paper 520 Starting at 11:58 AM, Ending at 12:06 PM
Is the PHACE Phenotype Associated with a Developmental Lesion of Trigeminal Autonomic Innervation? Analysis of Diffusion Tensor Metrics and Comparison with a Matched Control Population
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1Cincinnati Children's Hospital, Cincinnati, OH, 2University of Cincinnati, Cincinnati, OH, 3Mayfield Clinic, Cincinnati, OH

PURPOSE
PHACE is a complex neurocutaneous vascular phenotype that includes lesions of the cerebral circulation and the facial circulation. Since both circulations share trigeminal autonomic innervation, we sought to determine if structural asymmetry of trigeminal pathways is specifically associated with the PHACE phenotype.

MATERIALS & METHODS
Children with complicated facial hemangiomas were identified by searching the clinical database of our Vascular Anomalies Center. Only patients that had complete diffusion
tensor imaging (DTI) available for analysis were included. Patients meeting diagnostic criteria for “definite PHACE” (DP) according to the recently revised International Consensus Statement were confirmed by medical record review. The remaining patients were used as a control group with complicated facial hemangiomas (CFH). Age at time of DTI, sex, cerebellar phenotype, presence and type of arterial anomalies and location and extent of facial hemangioma were assessed by medical record review. Arterial anomalies and cerebellar phenotypes were confirmed by review of MRI studies. Diffusion tensor metrics (DTM) were quantified bilaterally in symmetric mirror image regions of interest (ROI) centered in five white matter regions: trigeminal tract complex (spinal trigeminal tract + trigeminal lemniscus), posterior limb of internal capsule (PLIC), superior cerebellar peduncle (SCP), middle cerebellar peduncle (MCP) and inferior cerebellar peduncle (ICP). DTM assessed included fractional anisotropy (FA), longitudinal diffusivity (LD), radial diffusivity (RD) and average diffusivity (D). The absolute relative difference between the ROI ipsilateral to the facial hemangioma and the ROI ipsilateral to normal face was determined for each DTM, for each white matter region [(DTM_Hemangioma side - DTM_Normal side) / DTM_Normal side x 100]. Results for the DP group were compared to the CFH group. Significance was assessed using a 2-tailed T test assuming unequal variance.

RESULTS
Four children (all female) were in the DP group with an average age of 6 months. All had an arterial anomaly (3 carotid and 1 subclavian), and three had focal cerebellar hypoplasia. Three children (all female) were in the CFH group with an average age of 5 months. The absolute relative difference in DTM parameters between the hemangioma side and the normal side was similarly small for the DP group and the CFH group in the cerebellar peduncles (SCP, MCP, ICP) and the posterior limb of the internal capsule (PLIC). The mean absolute relative difference (hemangioma side vs normal side) in DTM for the trigeminal tract complex in the DP group vs the CFH group was RD 15.0 vs 6.3 (p = 0.07); LD 9.3 vs 2.9 (p = 0.07); D 5.8 vs 2.0 (p = 0.07); FA 16.9 vs 13.7 (p = 0.40).

CONCLUSION
This preliminary investigation suggests that asymmetric structural abnormalities of the trigeminal pathways may be specifically associated with the PHACE phenotype.

KEY WORDS: PHACE, diffusion tensor imaging, anomalies

Paper 521 Starting at 12:06 PM, Ending at 12:14 PM
Distinguishing between Germinomas and Pineal Cell Tumors on MR Imaging

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PURPOSE
Tumors of pineal cell origin have different prognosis and treatment than those of germ cell origin. The recent literature suggests that these tumors often look alike. Our study aimed to differentiate between pineal cell tumor and germinoma based on ADC values, the homogeneity of the mass, and MR imaging (MRI) characteristics.

MATERIALS & METHODS
We enrolled 20 patients who had pretreatment MRI scans with histological verification of tumors of pineal cell origin and germinomas from 2002-2010. The MRI studies, performed at 1.5 and 3.0 T, were reviewed retrospectively and analyzed for ADC values and signal intensity values on T1-weighted and T2-weighted imaging pulse sequences based on mean and standard deviations (SD).

RESULTS
The 20 subjects (8 females and 12 males) ranged in age from 1.53-64.92 years with mean age of 23.88 years (SD 17.70 years). The mean age of germinomas was 13.66 years (SD 3.81 years), less than the mean of 29.38 years for pineal cell tumors (SD 19.88 years) (p = 0.016). The histopathologic diagnoses were pineocytoma (3 cases), pineoblastoma (6 cases), germinoma (7 cases), intermediate pineal parenchymal tumors (2 cases) and papillary tumors (2 cases). There was no significant difference in T1 and T2 intensity values between these two categories of neoplasms. However, germinomas showed statistically significant higher ADC values (mean 1590.69 x 10^-6 mm^2/sec, SD 532.96 x 10^-6 mm^2/sec) than pineal cell tumors (mean 883.58 x 10^-6 mm^2/sec, SD 317.48 x 10^-6 mm^2/sec) (p=0.002). The degree of enhancement of germinomas was mild (57.1%), moderate (14.3%) and marked (28.6%), whereas pineal parenchymal tumors were graded as mild (30.8%), moderate (38.5%) and marked (30.8%). Majority of both types of tumors were categorized as heterogeneous (71.4% for germinomas and 69.2% for pineal parenchymal tumors).

CONCLUSION
There are no definitive imaging characteristics that distinguish pineal cell from germ cell origin pineal region tumors. The degree of heterogeneity and enhancement do not differentiate the two. However, germinomas showed higher ADC values than the pineal cell tumors (p=0.002) and the patients were younger.

KEY WORDS: Germinoma, pineal cell tumor, MR imaging
While radiation therapy (RT) is a well-established treatment for early laryngeal cancer, the recurrence rate after RT is 5-13% for T1 and 25-30% for T2 glottic laryngeal cancers. Following recurrence, surgery is the only option for salvage. While most patients require total laryngectomy, partial laryngectomy via transoral laser microsurgery (TLM) has emerged as an important new approach with expanding indications. The purpose of our study is to present the CT findings following TLM for recurrent glottic cancer, and to our knowledge there is no large series of such cases reported in the radiology literature.

**RESULTS**
(A) Six of the 17 cases demonstrated mass-like enhancement of concern for tumor recurrence. Four of these six cases confirmed tumor recurrence on pathology. Two of these four patients were scanned at <90 days post-TLM, while the other two were scanned at >130 days. The remaining two cases with mass-like enhancement were compatible with treatment effect. Both of these patients were scanned at <90 days. (B) Twelve of the 17 cases had a CT within 90 days post-TLM. Eleven of these 12 cases had significant mucosal enhancement, and all 12 had significant laryngeal edema. The remaining five cases had the first post-operative CT at >130 days following TLM. One of these five demonstrated significant mucosal enhancement, while two had increased laryngeal edema. (D) Fourteen cases demonstrated air-filled mucosal/submucosal defects, while three did not. All three patients without a clear air-filled defect demonstrated tumor recurrence in our study. (E) Fifteen cases demonstrated changes within the cartilage following surgery.

**CONCLUSION**
(A) When imaging at <90 days following TLM, CT findings of mass-like enhancement were sensitive, however not specific for tumor recurrence (sensitivity=100%, specificity=50%) in our study. When imaging at >130 days post-op, mass-like enhancement was both 100% sensitive and specific in our study; however, these findings are limited by the small sample size. (B and C) Significant mucosal enhancement and increased laryngeal edema are seen more commonly when imaging is obtained at <90 days post-TLM in comparison to scans obtained at >130 days (p=0.001, p=0.015), and were not specific for tumor recurrence in our study. (D) An air-filled mucosal/submucosal defect was a common postoperative finding with TLM (82%), and the absence of such a defect was associated with recurrent tumor in our study (p=0.006).

**KEY WORDS:** Laryngectomy, transoral laser, postoperative CT

**Evaluation of Laryngeal Cancers with Combined CT Neck Imaging and Videostroboscopy**

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Houston, TX

**PURPOSE**
Definitive therapy planning and successful treatment of laryngeal cancer is dependent on early detection of primary and recurrent disease. A contrast-enhanced CT neck study is the gold standard for assessment of patients with head and neck malignancies. Videostroboscopy can help in the detection of subtle mucosal changes. The purpose of this study is to evaluate the added value of combined CT neck imaging and videostroboscopy in detecting recurrent laryngeal carcinoma.
Laryngeal videostroboscopy provides direct visualization and functional assessment of the larynx enabling detection of subtle changes, particularly those involving the true vocal folds. Our intent was to examine the complementary role of these two tools as a combined assessment for the evaluation of patients with laryngeal cancer.

**Materials & Methods**

The findings from contrast-enhanced CT neck imaging and laryngeal videostroboscopy were compared in a case series of newly diagnosed, and previously treated laryngeal cancer patients.

**Results**

Patients with small mucosal-based lesions, immediate subglottic involvement, and treatment changes undetectable on contrast-enhanced CT neck imaging demonstrated definitive findings on videostroboscopic examination. Although small submucosal lesions were detected based on changes in vibratory movements during videostroboscopy, the CT neck study provided better anatomical localization and characterization. Large volume disease was detected on both studies. The contrast-enhanced CT neck study with multiplanar reformatted images allowed delineation of the extent of the disease and the depth of invasion.

**Conclusion**

Our unique protocol combines contrast-enhanced CT neck imaging with laryngeal videostroboscopy. We believe that this integrated approach allows comprehensive examination and detection of laryngeal disease that is essential for accurate diagnosis and treatment planning in patients with laryngeal malignancy.

**Key Words:** Larynx, videostroboscopy, cancer

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**MR Lymphography of Normal Human Cervical Lymph Nodes Using Ferumoxytol**

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Oregon Health and Sciences University
Portland, OR

**Purpose**

The goal of this study was to demonstrate feasibility of MR lymphography in normal human cervical lymph nodes using ferumoxytol, an ultrasmall iron oxide nanoparticle (USPIO). Normal iron oxide nanoparticle uptake into lymph nodes may permit differentiation of benign from malignant nodes. Ferumoxtran-10, another USPIO, has been used successfully for MR lymphography. Ferumoxytol should confer similar benefit but could allow concurrent dynamic susceptibility contrast (DSC) perfusion imaging.

**Materials & Methods**

Images were obtained from an IRB-approved study of subjects with known central nervous system (CNS) neoplasm or suspected inflammatory disease. All patients signed informed consent. None had a history of neck malignancy. Neck images included baseline T1- and T2-weighted spin echo and T2* sequences on a 3 T scanner. Ferumoxytol doses ranged from 340-510 mg total, diluted in 15-19 mL saline, administered by intravenous injection. Identical sequences to baseline images were performed 24 hours postferumoxytol. Spin echo images confirmed node shape, characterization, location, and differentiated smaller nodes from vasculature. Size, shape, and signal intensity of nodes were recorded. Pre and postferumoxytol T2* images were assessed for USPIO uptake according to previously published MR lymphography criteria.

**Results**

A total of 123 lymph nodes were evaluated in four adults: two with primary CNS neoplasm and two with suspected demyelinating disease. One hundred ten of 123 (89.4%) lymph nodes revealed homogeneous hypointensity on 24-hour postferumoxytol T2* images (Figure). There were 9/13 (69.2%) heterogeneous nodes that demonstrated minimal internal hyperintense speckling with dominant hypointensity or focal nodal defects corresponding to fat signal on T1-weighted images, considered benign variants. The remaining 4/13 (30.8%) heterogeneous nodes demonstrated abnormal (“malignant”) 24-hour uptake patterns: two each remained homogeneously hyperintense or hypointense centrally with a hyperintense peripheral rim. Overall, 119/123 (96.7%) of lymph nodes demonstrated findings suggesting benign morphology.

**Conclusion**

Most (96.7%) cervical lymph nodes demonstrated a “benign” uptake patterns on T2* images 24 hours postferumoxytol administration. Abnormal uptake patterns may have been related to inflammation, undiagnosed malignancy, or inadequate ferumoxytol accumulation due to suboptimal timing after injection. Ferumoxytol may be a useful MR lymphography agent for head and neck cancer that requires further investigation to determine optimal imaging parameters.

**Key Words:** Lymph nodes, MR lymphography, USPIO

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Figure. Thirty-five-year-old female with no history of neck cancer shows normal lymph nodes (white arrows) and vasculature (black arrows): hyperintense nodes on precontrast T2* (left) become hypointense on postcontrast T2* (right). Vasculature (black arrows) is hyperintense precontrast; hypointensity at 24 hours reflects persistent intravascular contrast.
Intranodal Cystic Changes: A Potential Radiologic Signature/Biomarker to Assess the Human Papilloma Virus Status of Cases with Oropharyngeal Malignancies

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University of Michigan
Ann Arbor, MI

PURPOSE
To determine if there are lymph node imaging findings that can predict human papilloma virus (HPV) positivity in cases with oropharyngeal malignancy.

MATERIALS & METHODS
Pretreatment postcontrast neck CT of 49 patients (male = 37, female = 12; age range = 45-76 years) diagnosed with oropharyngeal malignancy (with available HPV data), were reviewed retrospectively. Metastatic lymph nodes were identified based on standard accepted size and morphologic criteria. Various lymph nodal parameters were studied, including presence of low attenuation foci and cystic foci in the metastatic lymph nodes, morphology of the smaller lymph nodes and matting of lymph nodes. Cystic focus in the lymph node was defined as low attenuation area (<25 HU) with more than 70% of its wall being well defined and smooth as opposed to irregular margin of the low attenuation necrotic intranodal focus. These parameters then were correlated independently with the available HPV status of these patients.

RESULTS
Of these 49 cases with oropharyngeal malignancies, 29 were HPV positive (+ve) and 20 cases were HPV negative (-ve). Eight cases (3 HPV +ve and 5 HPV -ve) did not show metastatic lymph nodes. Of remaining 41 cases with abnormal lymph nodes, 14 showed one or more lymph nodes with cystic foci. Of these, 10 were HPV +ve and 4 were -ve for HPV. Thus, majority of (10 of 14 = approx. 72%) the cases with intranodal cystic changes were HPV +ve, with resultant specificity, sensitivity, positive predictive value (PPV) and negative predictive value (NPV) of 73.3%, 38.4%, 71.4% and 40.7% respectively. Extended criteria [intranodal cystic focus in association with morphologically normal-appearing smaller (<1.5cm) lymph nodes] was seen in 5 HPV +ve cases and in none of the HPV -ve cases, with specificity as well as positive predictive value of 100% each.

CONCLUSION
Intranodal cystic changes seen on the pretreatment postcontrast CT neck of patients with oropharyngeal malignancies, have favorable association with HPV status of these cases. The criteria of intranodal cystic change, and particularly the extended criteria (i.e., intranodal cystic foci with morphologically normal-appearing smaller lymph nodes) can serve as some of the important radiologic signatures for assessing the HPV status of the cases with oropharyngeal malignancies. Favorable specificity and PPV results in this initial study, warrant larger prospective study. If the results are consistent, these finding may be used in addition to other molecular biomarkers to help identify those patients that may be amenable to nonsurgical organ preservation treatment options.

KEY WORDS: HPV, cystic lymph node, oropharyngeal malignancy

Enhancement Patterns of Metastatic Lymph Nodes on Multiphase Multidetector Computed Tomography

Guha-Thakurta, N. • Bredow, S. • Debnam, J. M.
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Houston, TX

PURPOSE
To characterize enhancement patterns of metastatic lymph nodes using multiphase multidetector computed tomography (4D-MDCT).

MATERIALS & METHODS
4D-MDCT images of 15 pathologically proved, metastatic papillary thyroid cancer cervical lymph nodes were analyzed retrospectively, pre and postintravenous contrast. As controls, 15 cervical lymph nodes in patients without known cancer, imaged by 4D-MDCT were evaluated. Regions of interest were outlined and Hounsfield units (HU) obtained at multiple time points. Baseline HU values were acquired on precontrast images. Postcontrast HU values were obtained at three time points including arterial phase at 25 seconds after injection (phase I) and, at two additional delayed time points viz. 55 and 85 seconds (phase II and III) respectively. These values were standardized to the ipsilateral common carotid artery enhancement during phase I and relative HU (rHU) values obtained. Additionally, contrast wash-in and wash-out was calculated using formulas previously published.

RESULTS
Metastatic nodes demonstrated the following mean rHU values at the four phases: baseline (0s) =0.12, phase I (25s) = 0.50, phase II (55s) = 0.31, phase III = 0.29 (85s). There was significant increase in the enhancement between the baseline and phase I in the metastatic nodes as opposed to that for normal lymph nodes (Figure 1). Further, enhancement was significantly greater at phase I than at phase II or III when compared to the baseline (p < 0.001). Concordantly they demonstrated maximum contrast wash-in at phase I (25 s) than at later phases (p < 0.001) (Figure 2). There was a steep decline in the enhancement at phase II and even more at phase III for the metastatic nodes.
CONCLUSION
Metastatic cervical lymph nodes demonstrate a greater wash-in of contrast on the arterial phase than on delayed phases typically acquired for evaluation of head and neck cancers.

KEY WORDS: Metastatic lymph nodes, head and neck, 4D-MDCT

Paper 527 Starting at 11:10 AM, Ending at 11:18 AM
Evaluation of the Accuracy of Four-Dimensional Computed Tomography for Preoperative Localization of Parathyroid Tumors in Primary Hyperparathyroidism

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Yale School of Medicine
New Haven, CT

PURPOSE
Sestamibi with SPECT (SeS) and ultrasound (US) traditionally have been utilized for preoperative identification of parathyroid tumors in primary hyperparathyroidism (pHPT). Four-dimensional computed tomography (4DCT) recently has been advocated for its accuracy in precise anatomical localization of parathyroid lesions and has been used as an adjunct to other imaging studies, especially in the remedial setting. Accuracy of 4DCT was evaluated in this study as the initial localization study in patients with pHPT.

MATERIALS & METHODS
Four-dimensional CT refers to high-resolution, multiphase imaging of the neck and upper thorax following intravenous contrast administration and creation of multiplanar reformats. Thin-cut (1.25 mm) CT was performed from the angle of the mandible to the level of the carina utilizing an initial noncontrast series followed by arterial, venous and delayed phases. Sixty-seven patients with biochemically unequivocal pHPT scheduled for minimally invasive parathyroidectomy (MIP) by a single surgeon (TC) from March 2009 - August 2010 underwent a preoperative 4DCT and were included in the study. Other imaging modalities (US and SeS) were obtained at the surgeon’s discretion. Intraoperative PTH measurements were employed in all patients to assess cure. Results of the imaging studies (4DCT, SeS and US), were compared to operative and pathologic findings.

RESULTS
Of the 67 patients evaluated by 4DCT, 64 had preoperative US, while SeS was performed in 25 patients. There were 15 men (22%) and 52 (78%) women. The average age was 61.9±13.1 years. Preoperative calcium and PTH levels averaged 11.3±1.01 mg/dl (reference range 8.2-10.2 mg/dl) and 133.3 pg/ml (reference range 10-65 pg/ml), respectively. A solitary adenoma was the cause of pHPT in 47 patients, whereas multiglandular disease (either double adenoma or hyperplasia) was present in the remaining 20 patients. A total of 99 parathyroid glands were excised. The weight of the glands averaged 409 mg (normal < 30 mg). Four-dimensional CT was able to precisely localize 63/99 (64%) glands. Of these, 25 (42%) were equally well seen on US and CT, 31 (52%) were better seen on CT as compared to US, while US was better than CT in 10 cases. Four-dimensional CT was able to precisely localize solitary adenomas in 39 of 47 (83%) patients and 48 of 66 (75%) glands greater than 100 mg in size. As compared to SeS, 4DCT was better than SeS in 13 patients, equal to SeS in four while SeS was better in five patients. Four-dimensional CT was able to correctly identify ectopically located parathyroid glands in 13 of 14 patients. It also was able to predict multiglandular disease in six of 10 patients. All patients achieved cure based on intraoperative normalization of intact PTH (defined as reduction of PTH level by 50% of baseline into the normal range) and normocalcemia during short-term follow up.

CONCLUSION
Four-dimensional CT is an improved localization modality in detecting parathyroid tumors in patients with pHPT, as compared to US and SeS. Preliminary findings suggest its usefulness in predicting both ectopically located parathyroid tumors and multiglandular disease in patients undergoing MIP for pHPT.

KEY WORDS: Hyperparathyroidism, 4D CT, primary
Diagnostic Accuracy of 4D-CT for Parathyroid Adenomas

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PURPOSE
Four-dimensional computed tomography (4D-CT) is a novel method of multiphase CT perfusion imaging. When applied to parathyroid adenoma imaging, this technique may allow for more robust diagnostic accuracy than traditional ultrasound and nuclear scintigraphy techniques. Utilizing principles of altered arterial perfusion and washout that guided early angiographic detection of parathyroid adenomas, the 4D-CT technique allows for multiphase detection and characterization of parathyroid lesions.

MATERIALS & METHODS
All 4D-CT studies performed at our institution between January 2009 and September 2010 for clinically suspected parathyroid adenomas were reviewed. A total of 24 cases were collected. Inclusion criteria was availability of final surgical pathology. No cases were excluded. In all cases, final reports from alternate parathyroid imaging modalities were obtained including parathyroid sonogram and nuclear sestamibi imaging with SPECT. Concordance of all imaging modalities was compared with final surgical pathology report and in instances of discrepancy, the operative report was reviewed. Sensitivity, specificity and accuracy of 4D-CT was ascertained including both the side and quadrant of pathologically proved lesion.

RESULTS
Analysis resulted in 22 true positive and 2 false negative 4D-CT cases of parathyroid adenomas. Of the true positive cases, 20 (91%) predicted the correct side of parathyroid lesion while 19 (86%) predicted the correct side and quadrant. Three (14%) cases of multifocal disease were included in the analysis, two (66%) of which were prospectively called multifocal. Overall, 4D-CT demonstrated a 92% sensitivity for parathyroid adenoma detection.

CONCLUSION
4D-CT demonstrated a high diagnostic accuracy for single and multigland disease in our cohort. Importantly, 4D-CT predicted the correct side of the lesion in > 90% of cases, allowing the surgeon to utilize a targeted minimally invasive operative approach. Furthermore, in many cases 4D-CT precisely localized the hypervascular gland and detected coexistent thyroid pathology. 4D-CT showed a promising ability to predict multifocal disease and allow for appropriate operative planning. 4D-CT also shows a higher sensitivity and accuracy than commonly cited for ultrasound or sestamibi imaging. The multiplanar reconstruction capabilities provide beneficial spatial information for optimal operative planning and intervention.

KEY WORDS: 4D-CT, parathyroid adenoma

Reduced Dose Dynamic CT Using Adaptive Statistical Iterative Reconstruction Allows for Precise Preoperative Localization of Parathyroid Adenomas

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PURPOSE
In recent years, dynamic MDCT has been described as an alternative method for parathyroid adenoma localization. Although CT provides superior anatomical detail to sestamibi scanning and ultrasound for surgical planning, dose considerations have prevented more widespread use. We evaluate the sensitivity of reduced dose dynamic CT (using ASIR reconstruction algorithm) for preoperative localization of parathyroid adenomas.

MATERIALS & METHODS
Fifty-nine patients referred for CT evaluation of primary hyperparathyroidism were scanned using a tailored dynamic CT protocol on a GE Discovery CT750 HD scanner. A reduced dose technique was employed using adaptive statistical iterative reconstruction (ASIR). Data were post-processed using a novel application of CT perfusion 4 software on a GE AW workstation. Enhancement curves and color maps were generated and analyzed during initial interpretations, in addition to conventional cross-sectional images. Scans were interpreted prospectively by a single neuroradiologist experienced in parathyroid imaging. Twenty-nine of 59 patients underwent parathyroidectomy surgery. CT reports, operative findings and pathology reports were reviewed for all 29 patients.

RESULTS
Thirty-four adenomas were found in 29 patients at surgery. Eighty-five percent (29/34) of adenomas were precisely localized preoperatively by reduced dose dynamic CT, with PPV of 94%. 96% of patients with unilateral disease were correctly lateralized to right or left side. Among patients with a single adenoma, 96% (22/23) were correctly localized preoperatively.
CONCLUSION
Dynamic MDCT performed using reduced dose techniques (including ASIR reconstruction algorithm) is an effective and practical tool for precise preoperative localization of parathyroid adenomas in patients with primary hyperparathyroidism.

KEY WORDS: Parathyroid, ASIR, adaptive statistical iterative reconstruction

Paper 530 Starting at 11:34 AM, Ending at 11:42 AM
Preoperative Cross-Sectional Imaging for Well Differentiated Thyroid Carcinoma

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PURPOSE
The revised American Thyroid Association (ATA) Recommendation 22 recommends against the routine use of preoperative CT or MR imaging for staging patients with well differentiated thyroid carcinoma (WDTC). However, there are special circumstances that warrant preoperative cross-sectional imaging, primarily to assess for invasive features of the primary tumor and lymphadenopathy (LAD). Potential indications for preoperative MR or CT include palpable or ultrasound (US) detected LAD, clinically aggressive features such as vocal cord paralysis (VCP) or fixed mass, and pathologic subtype such as medullary carcinoma. We hypothesized that the lack of specific guidelines could result in a large variation in clinical practice, and potentially over- or under-utilization of appropriate diagnostic tests that could alter surgical approach. Our aim was to demonstrate this variability amongst ordering physicians and to investigate the development of an imaging algorithm based upon a combination of clinical features, pathologic subtypes and US findings.

MATERIALS & METHODS
Three head and neck radiologists and one head and neck surgeon created an eight question survey, designed to poll head and neck surgeons, general surgeons and endocrinologists about their current practice with respect to ordering preoperative imaging for WDTC. After the physician answered the survey, a follow-up question was administered verbally regarding whether the clinician was aware of and followed the ATA recommendations.

RESULTS
Eleven thyroid surgeons and three endocrinologists, practicing at three academic medical centers, completed the survey (Table). They answered that the following clinical characteristics of the primary tumor would prompt cross sectional imaging: size (5/14), pathology (10/14, medullary), aggressive features or local invasion on US (12/14), clinical evidence of a VCP or fixed mass (12/14), palpable lateral LAD (11/14), US central LAD (8/14), US lateral LAD (10/14), age (0/14), thyroglobulin (0/14) and calcitonin (11/14). Finally, all surgeons stated that knowledge of lateral neck LAD would alter their standard surgical approach by adding a lateral neck dissection.

Proposed indications for preoperative cross sectional imaging in patients with WDTC
- Medullary pathology (and/or elevated calcitonin)
- Clinically aggressive features: VCP, fixed mass
- US findings suspicious for central or lateral LAD
- Palpable central or lateral LAD
- All recurrent thyroid tumors

CONCLUSION
This initial small survey demonstrated variation in clinical practice with regards to indications for preoperative cross-sectional imaging of WDTC and underscores the need for more specific guidelines or consensus statement. The results of preoperative cross-sectional imaging, specifically the presence of lateral neck LAD, alters surgical approach for all surgeons polled. Trends in this small group of expert thyroid surgeons and endocrinologists suggest the possibility of an imaging algorithm (Table) based upon clinical features, primary tumor characteristics, and pathologic subtype. American Thyroid Association should consider developing guidelines to address specific indications for preoperative cross-sectional imaging.

KEY WORDS: Thyroid carcinoma, neoplasm
Paper 531 Starting at 11:42 AM, Ending at 11:50 AM
MR and CT Imaging of Thyroid Cancer

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PURPOSE
To review and evaluate the cross-sectional imaging (CT and MR) characteristics of thyroid carcinoma.

MATERIALS & METHODS
This study is a retrospective review of the MR and CT imaging findings of the most recent 5 years of pathology proven thyroid carcinomas at an academic institution. The medical records were reviewed for patient age at the time of presentation, pathology, nodal metastases, clinical presentation, and prior cross-sectional imaging. The imaging findings, including CT and MR characteristics, nodal morphology, and tumor and nodal enhancement characteristics, cystic and necrotic foci, and extrathyroidal spread were reviewed.

RESULTS
The histology of 237 pathology proven cases was reviewed. The pathology revealed 209 (88%) papillary (conventional, tall cell, or follicular variant) (64 male, 145 female) cases, 16 (7%) follicular (conventional or Hurthle cell) (4 male, 12 female) cases, 8 (3%) medullary (5 male, 3 female) cases, and 4 (2%) anaplastic (2 male, 2 female) cases. The average tumor size (by histology) is as follows: papillary 1.8 (0.1 - 7.2) cm, follicular 3.0 (0.8 - 5.6) cm, medullary 1.4 (0.3-4.5) cm, and anaplastic 7.6 (4.6 - 8.9) cm. Patient age at the time of presentation by histologic type is as follows: papillary 44.8 (13-88) years, follicular 42.3 (17-73) years, medullary 47.8 (19-75) years, and anaplastic 73 (58-83) years.

CONCLUSION
Findings regarding the imaging characteristics of nodal disease (size, increased T1 signal intensity, hyperenhancing solid, and cystic or mixed solid and cystic composition) and extracapsular tumor extension and local invasion (tumor size and fat effacement) are similar to those seen in previously reported smaller case series. This study is intended to broaden the understanding of CT and MR imaging findings for all histological types of thyroid carcinoma.

KEY WORDS: Thyroid, cancer, lymph nodes

Paper 532 Starting at 11:50 AM, Ending at 11:58 AM
Core Biopsy versus Fine Needle Aspiration for Image-Guided Parotid Biopsy

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PURPOSE
The parotid gland can be involved by a wide variety of pathology, including infection, inflammation, neoplasm, and other etiologies. Parotid masses are difficult to diagnose without tissue sampling. Parotid lesions can be diagnosed via percutaneous image-guided biopsy, but techniques vary by radiologist and by institution. This study examines a series of image-guided parotid biopsies and evaluates the diagnostic accuracy and surgical concordance of image-guided fine needle aspiration (FNA) and core biopsy (CB) techniques.

MATERIALS & METHODS
Image-guided parotid biopsies performed from 2006 through 2010 were reviewed retrospectively by two neuroradiologists with Certificates of Added Qualification in Neuroradiology, one neuroradiology fellow, and one diagnostic radiology resident, including imaging reports, diagnostic images, CB pathology reports, FNA cytology reports, and surgical pathology when available. Additional data collected included age, gender, lesion size, imaging modality, needle gauge, and number of needle passes.

RESULTS
From 2006 to 2010, 85 image-guided parotid biopsies were performed on 80 patients. Five were performed using computed tomography (CT) guidance, and 80 were performed using ultrasound (US) guidance. Nine patients underwent both FNA and CB. Eight of the nine patients (88.9%) who underwent both FNA and CB had diagnostic results. Twelve of the 12 patients (100.0%) who underwent only CB had diagnostic results. Forty-seven of the 55 patients (85.5%) who underwent only FNA had diagnostic results. When counting the patients who had both FNA and CB, the diagnostic yield of FNA was 55 of 64 patients (85.9%) and the diagnostic yield of CB was 20 of 21 patients (95.2%). Twenty-six patients ultimately underwent surgical resection (SR). Two of two patients (100.0%) who underwent both FNA and CB, as well as SR, demonstrated concordance with surgical pathology results. Five of five patients (100.0%) who underwent CB alone and SR demonstrated concordance with surgical pathology results. Sixteen of 19 patients (84.2%) who underwent FNA alone and SR demonstrated concordance with surgical pathology results. Three of 19 patients (15.8%) who underwent FNA alone and SR demonstrated discordant findings compatible with false positive biopsy results. Three of the nondiagnostic FNA only specimens consisted of nonneoplastic cystic lesions, one of which was aspirated completely at the time of FNA. Overall diagnostic accuracy of all biopsies was 88.2%, and overall concordance with surgical pathology results of all biopsies was 88.5%.

CONCLUSION
Image-guided biopsy is an efficient and minimally invasive method to diagnose parotid pathology. In this study, CB demonstrated higher diagnostic yield (95.2%) and higher rates of concordance with surgical results (100.0%). However, when nonneoplastic cystic lesions are excluded, diagnostic yield of FNA alone increases to 90.3% (47 of 52 patients) or 90.2% (55 of 61 patients) when including patients who underwent both FNA and CB. Potential pitfalls include collaboration between FNA cytology results and core biopsy pathology results at the time of interpretation by the cytopathologist(s) and anatomical pathologist(s). In summary, both FNA and CB are effective methods of diagnostic parotid biopsy.

KEY WORDS: Parotid, biopsy, ultrasound
Purpose

Our study aims to create a high fidelity free-form temporal bone model (HFTBM) from a CT dataset utilizing rapid prototyping technologies. **Background:** The ability to create an artificial temporal bone would facilitate a paradigm shift in resident training as an alternative to classic cadaver-based education. A new training methodology is needed since access to cadaveric temporal bones and direct hands-on surgical experience are increasingly limited. At the same time public scrutiny regarding patient outcomes and surgical complications is appropriately omnipresent. We believe this method of surgical simulation may provide realistic tactile and visual feedback to a trainee and closely approximate the surgical environment.

Materials & Methods

Cadaveric CT images were imported to a 3D image processing program for segmentation. The segments then were exported to a stereolithography format file to facilitate photo printing using a Fused Deposition Modeling printer. The construct of our synthetic temporal bones utilizes “rapid prototyping” to create solid free-form fabrication. The final free-form fabricated model then was imaged for comparison against the original cadaveric specimen and presented for expert Neurotologic wet lab dissection.

Results

The HFTNM could be handled using conventional surgical instruments, in the same manner as a cadaver bone during dissection. Limitations in both osseous realism as well as in ossicular structure were encountered.

Conclusion

This model serves as an excellent replica of a human temporal bone and should be evaluated formally in its ability to facilitate trainee skill-set acquisition.

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**Thursday Morning**

**10:30 AM - 12:15 PM**

**Room 602-603-604**

(46e) Research Grant Writing Session - Part I

**Eileen W. Bradley, D. Sc**

**Presentation Summary**

Taking Charge of your own “Grant” Care. Once your application is written and ready to submit, you would be well served if you knew the internal workings of NIH, and the Center for Scientific Review, in particular. So we’ll start there, show you how you interact with NIH on Commons, how you find a review groups closest to your interests, and how to get your application reviewed in that specific study section. Then, we’ll look at what happens to your application as it goes through the review process, what the reviewers are looking for, what they are scoring, and finally look at your summary statement. Given all of that, we’ll address how you should write your grant to make it reviewer friendly. We’ll also take some time to look at NIH resources to show you what is already being funded in a particular scientific area by NIH, and what NIH is doing for New Investigators. There will be plenty of time for questions - so think up some difficult ones!!!!
Combining Genomic and Apparent Diffusion Coefficient Histogram Analysis in Bevacizumab-Treated Glioblastoma: Potential Link between Collagen Gene Expression and Early Recurrence

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Los Angeles, CA

PURPOSE
Apparent diffusion coefficient (ADC) histogram analysis can stratify outcome in patients with GBM. Therefore we measured gene expression levels based on ADC analysis to gain insight into differences in tumor biology that could explain this finding.

MATERIALS & METHODS
All patients enrolled in this retrospective study signed institutional review board-approved informed consent. The patients were part of a clinical study examining the effectiveness of bevacizumab as a first line therapy. Enhancing tumor volumes were segmented on pre-contrast T1-weighted images on prebevacizumab treatment scans using a semiautomated, adaptive thresholding technique so that all pixels above the threshold value were selected. The resulting ROIs encompassing the entire enhancing tumor volume were verified visually and mapped to the ADC images for histogram analysis using a two mixture normal distribution. Mean values for the lower peak (ADC_L, lower curve mean) then were generated and tumors were dichotomized using a cut-off for mean ADC_L of 1200 based on prior work. Tissue was processed on microarrays and gene expression levels from ADC_L < 1200 versus > 1200 tumors were compared. Genes with 2-fold or more differential expression with p < 0.05 were selected. Tissue sections were stained for collagen according to standard protocols. Cox model and the Kaplan-Meier method with log-rank test were used for statistical analysis.

RESULTS
Patients with ADC_L >= 1200 had significantly shorter progression free survival compared to patients with ADC_L < 1200 (p = 0.008). Thirteen genes were expressed at 2-fold or greater levels in tumors with ADC_L >= 1200 versus those with ADC_L < 1200. Six of these genes code for collagen or collagen-binding proteins. Patterns of collagen staining in high and low ADC tumors will be presented.

CONCLUSION
Our results show that the novel combination of genomics and imaging can provide insight into tumor biology. We hypothesize that diffusion in tumors may be reflective of the extracellular matrix composition as high ADC is associated with increase collagen and collagen-binding protein gene expression. This could be relevant to tumor invasiveness and potentially time to recurrence. Implications for anti-angiogenic therapy also will be discussed.

KEY WORDS: Glioblastoma, diffusion, bevacizumab

Reevaluating the Definition of Tumor Progression: Use of Perfusion MR Imaging to Quantify Glioblastoma Histologic Fraction Relative to Pseudoprogression and Radiation Necrosis

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PURPOSE
Contrast-enhanced MRI (CE-MRI) currently defines glioblastoma(GBM) progression following multimodality treatment; however, nontumoral radiation injuries such as pseudoprogression and radiation necrosis infer treatment success but mimic GBM. Both GBM and radiation injury commonly admix, meaning that actual histologic tumor burden represents a fractional subcomponent of CE-MRI
lesions. Although binarily classifying lesions (as all or no tumor) holds little prognostic value, quantifying histologic tumor fraction (relative to radiation injury) as a continuous variable correlates highly with survival. Diagnosis currently requires biopsy, although perfusion MRI (pMRI) measures of relative cerebral blood volume (rCBV) offer a safer, cheaper alternative. We compared three pMRI-based methods of predicting histologic tumor fraction and survival. We studied a new voxel-based thresholding method called pMRI fractional tumor burden (pMRI-FTB), along with previously published histogram-based peak-height-position (PHP) and mean-rCBV (m-rCBV).

**Materials & Methods**

With IRB approval, we recruited recurrent GBM patients undergoing surgical re-resection of new CE-MRI-enhancing lesions. Preoperative 3 T MRI (General Electric, WI), included pMRI (gradient-echo EPI; TR/TE/flip 1500ms/20ms/60°; 0.1 mmol/kg i.v.,preload dose; 0.05mmol/kg Gd-DTPA i.v.) and pre and postcontrast stereotactic T1-weighted spoiled-gradient refocused-echo MRI. We used Osirix (v3.6.1), IB-Neuro (v1.1.430), and IB-Suite (v1.0.454) (Imaging Biometrics, WI) to calculate coregistered rCBV maps using: 1) one-to-one voxel subtraction between pre and postcontrast SPGR, 2) a volume of interest (VOI) drawn around abnormal enhancing tissue, and 3) signal threshold adjustment to exclude nonenhancement and necrosis, forming a CE-MRI lesion mask. All mask voxels were categorized as radiation injury exclude nonenhancement and necrosis, forming a CE-MRI lesion mask. All mask voxels were categorized as tumor (rCBV>1.01) or radiation injury(rCBV<1.01), with pMRI-FTB representing the percentage of tumor voxels out of total mask voxels. This threshold was determined by coregistering rCBV with stereotactic biopsies. Peak-height-position and m-rCBV also were calculated. We correlated imaging with surgical tissue histologic tumor fraction and overall survival (OS) from the time of re-resection, using Pearson and log-rank analysis, respectively.

**Results**

Of 20 recurrent GBM patients, 12 were deceased at analysis. Histologic tumor fraction most strongly correlated with pMRI-FTB (r=0.82,p<0.0001) compared with PHP (r=0.68,p<0.001) or mean rCBV (r=0.52,p<0.02). Overall survival correlated only with pMRI-FTB (p<0.006) (Figure 1), and did not reach significance with mean rCBV (p=0.62) or PHP (p=0.20).

**Conclusion**

Perfusion MRI fractional tumor burden most strongly correlates with histologic fraction and OS, compared with other pMRI-based methods. Future applications include A) using pMRI-FTB to refine clinical trial endpoints such as progression free survival, and B) use of recurrence patterns to guide therapy and surgical biopsy.

**Key Words:** Glioblastoma, radiation, perfusion

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**Paper 536 Starting at 1:31 PM, Ending at 1:39 PM**

**Super Resolution White Matter Track-Density Imaging: Initial Clinical Feasibility Study in Human Brain Tumors**

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**Purpose**

Track-density imaging (TDI) is a recently developed method for diffusion MRI data reconstruction which depicts white matter structure at submillimeter spatial resolution. This technique provides a unique contrast which can be used to visualize fine anatomical detail at higher spatial and contrast resolution than conventional fractional anisotropy (FA) maps. The purpose of this study was to determine whether TDI could be used to distinguish between treatment-naïve glioblastoma multiforme (GBM) and metastatic disease, guided by the hypothesis that GBM demonstrate infiltrative growth through white matter tracts while noninvasive metastatic tumor growth displaces normal white matter tracts.

**Materials & Methods**

We performed TDI on 11 patients with previously untreated malignant brain tumors (7 glioblastoma multiforme and 4 melanoma metastasis). MR imaging data were obtained using a high angular resolution diffusion imaging sequence on a 3 T MR750 GE scanner (spin-echo EPI with ASSET=2, TR/TE=9s/94 ms, b=2000 s/mm², 55 directions, matrix = 128x128 zero-filled to 256x256, slice thickness 2.2 mm) and reconstructed at 250 micron resolution using probabilistic streamline tractography combined with the constrained spherical deconvolution (model order = 8, 0.1 mm step size, 1 million seed points). Track-density maps were co-aligned with contrast-enhanced T1 and T2 FLAIR MR images and reviewed together with FA maps by two blinded neuroradiologists. Track-density was assessed within the contrast enhancing lesion (CEL), in the peritumoral nonenhancing FLAIR lesion within 1 cm margin of CEL (PTL-N), and within the more remote nonenhancing FLAIR lesion beyond the 1 cm margin of PTL-N (PTL-F).

**Results**

Two features of track-density maps reliably distinguished between GBM and metastases. First, TDI consistently showed organized internal structure within non-necrotic CEL in cases with GBM, whereas metastases showed lower track density and lacked internal structure. Second, TDI showed white matter tumor infiltration in cases with GBM and white matter displacement in cases with metastases. Infiltrative disease was depicted as regions of white matter...
with similar track density to the primary tumor in both PTL-N and PTL-F, and displacement was seen as increased track density in PTL-N in metastatic disease. Assessment of internal white matter architecture and surrounding white matter on FA maps did not reliably distinguish GBM and metastases.

**CONCLUSION**

Track-density imaging improves evaluation of internal tumor architecture and surrounding white matter compared to conventional maps of diffusion anisotropy, and may provide a more accurate tool for distinguishing primary glial neoplasm from metastatic disease.

**KEY WORDS:** Track-density imaging, diffusion tensor imaging, brain tumor

**RESULTS**

Individually, six MRI features show association to survival with an unadjusted p-value < 0.05. Ependymal extension (F19), longest dimension of lesion size (F29), deep white matter invasion (F21) and the presence of satellites (F24) negatively correlate with survival. Location of the tumor in the right (usually nondominant) hemisphere (F2) is associated with better outcome. Patients with frontal lobe tumors (feature F1a) tend to survive longer than individuals with tumors elsewhere in the brain. Features best associated with survival are ependymal extension (P = 0.0012) and location in the frontal lobe (P = 0.0098). An optimized multivariate linear regression model constructed by the stepwise addition and subtraction of features has F19, F29, F1a, F21 and F2 as predictors. This model has better accuracy (76.8% rate of correct predictions) and sensitivity (identification of 72.4% of patients with survival greater than 1 year) than any model based on a single feature. We also examined linear regression models incorporating the most significant VASARI feature, F19, and expression of angiogenesis-related genes. A model based on ependymal extension, CCL5, ANG, TGFβ2 and TNF correctly predicts survival for 82% of patients. Expression of ANG (angiogenin) and TGFβ2 (TGF-beta 2) negatively correlate with survival, while CCL5 [chemokine (C-C motif) ligand 5] and TNF (tumor necrosis factor) positively correlate with survival.

**CONCLUSION**

A subset of VASARI imaging features correlate well with patient survival. Linear regression models incorporating multiple imaging features or a single VASARI feature (ependymal extension) and tumor gene expression can be used to predict patient survival. We are refining these models and are investigating whether including patient clinical characteristics into linear models can improve their predictive power.

**KEY WORDS:** Glioblastoma multiforme, gene expression, imaging features

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PURPOSE
Dynamic susceptibility-weighted contrast-enhanced (DSC) MRI with a bolus of gadolinium-based contrast agent (GBCA) is used widely for noninvasive assessment of tumor relative cerebral blood volume (rCBV) and has been suggested for evaluation of antiangiogenic therapy efficacy. In brain tumors with very permeable vasculature, such as glioblastoma multiforme (GBM), rCBV can be underestimated using GBCA, due to contrast extravasation. Administration of a loading dose of GBCA prior to DSC-MRI acquisition, referred to as the “preload method”, is one of the most commonly used extravasation correction methods. We evaluated tumor rCBV measurement using GBCA in comparison to the iron oxide nanoparticle blood pool agent, ferumoxytol, in patients with GBM. Moreover, we assessed rCBV measurement before and after antiangiogenic therapy with GBCA vs ferumoxytol using the preload method in a preclinical study.

MATERIALS & METHODS
Nineteen patients with biopsy-proved GBM underwent DSC-MRI with gadoteridol on the first day and with ferumoxytol on the second under three institutional review board-approved imaging research protocols on a 3 T MRI system. For DSC-MRI, dynamic T2*-weighted images were acquired using a gradient-echo echo-planar imaging pulse sequence. Gadoteridol was injected at a dose of 0.1 mmol/kg of body weight. Ferumoxytol was given at a dose of either 2 mg/kg or 1 mg/kg or at a constant dose of 75 mg regardless of body weight according to the protocols. Both contrast agents were administered intravenously at a rate of 3 mL/s. For the preclinical study 13 female athymic rats with intracerebral U87MG human grade IV glioma underwent 12 T perfusion MRI using gadodiamide (0.1 mmol/kg; n=13) and ferumoxytol (4 mg/kg; n=9) before and 48-72 hours after Bevacizumab treatment (45 mg/kg IV; n=6 with both contrast agents). Each perfusion study included three consecutive DSC-MRIs, designated as no preload, single-dose preload, and double-dose preload, respectively. Tumor rCBV was estimated from each DSC-MRI and each contrast agent, ferumoxytol-DSC-MRI was high for all rats and did not depend on preload condition. The magnitude of apparent antiangiogenic therapy response varied with a strong dependence on the dose of gadodiamide preload, while ferumoxytol-DSC-MRI captured decreased rCBV invariably regardless of the preload.

CONCLUSION
Due to GBCA extravasation, tumor rCBV can be underestimated, and the extend of underestimation was found to be dependent on preload dose. Unlike GBCA, ferumoxytol remains within the vascular space during DSC-MRI and provides more consistent assessment of rCBV in tumors with highly permeable vasculature, and antiangiogenic therapy efficacy in both preclinical models and human brain tumors.

KEY WORDS: Perfusion MR imaging, tumor blood volume, ferumoxytol

Role of Longitudinal Perfusion-Weighted MR Imaging Measures in Distinguishing Tumor Recurrence from Pseudoprogression in a Cohort of Patients with High-Grade Gliomas Receiving Radiation Therapy, Temozolomide and Paclitaxel Poliglumex

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PURPOSE
To evaluate treatment response using conventional and perfusion-weighted (PWI) MRI in a phase II study of PPX (microtubule stabilizer and mitotic inhibitor; radiosensitization index of 4-8) added to standard IMRT and TMZ therapy for newly diagnosed high-grade (WHO III-IV) gliomas. We hypothesized that treatment-related enhancement (pseudoprogession) will be prevalent in this population, and that PWI will aid in distinguishing true tumor progression from pseudoprogression in cases of progressive post-PPX enhancement.

MATERIALS & METHODS
Twenty-five patients (12 males, 13 females; median age 60) with histologically confirmed high-grade gliomas were enrolled in a phase II trial with adjuvant treatment started 3 weeks after surgery: daily TMZ (75 mg/m²) and weekly IV PPX (40-50 mg/m²) during IMRT (6 weeks; 2 Gy/fraction, 30 fractions), followed by maintenance TMZ. We computed volume of enhancement and FLAIR hyperintensity on baseline postop (pre-PPX) and all post-PPX MRI exams (IBSuite, Imaging Biometrics), and assessed response to treatment using updated response criteria for high-grade gliomas(RANO criteria). Perfusion-weighted imaging was performed (contrast agent preload, gradient-echo, TE=30ms, 90° flip angle, TR=1s, 120 time points) and cerebral blood volume (rCBV) was computed using postprocessing leakage correction and numerical integration of relaxivity-time data (IBNeuro, Imaging Biometrics). We registered post-Gd anatomical images to rCBV maps (IBSuite, Imaging Biometrics) and computed mean rCBV of enhancing voxels.
excluding necrosis and macroscopic vessels, normalized to rCBV in normal-appearing white matter on FLAIR images. Enhancing volume and rCBV were plotted over time. Clinical outcome was determined by clinical status (KPS) and histopathology when available. We compared rCBV in progressive disease versus pseudoprogression using the unpaired t-test.

RESULTS
Nineteen of 25 patients had post-PPX follow-up imaging, three of whom had no enhancement on follow-up exams (1 complete response, 1 stable disease, 1 progressive disease based on CSF cytology). Of the 16 patients with post-PPX enhancement, five were classified with progressive disease (mean time to progression = 4.6 months; rCBV at progression ranged from 2.66 to 6.25, mean = 4.1) and 11 remain on trial (mean 10.8 months; 1 complete response, 1 partial response, 9 with ascending/descending or stabilized enhancement patterns classified as pseudoprogression). For cases of pseudoprogression, rCBV at time of initial progressive enhancement ranged from 0.63 to 5.28 (mean 2.55), but subsequently stabilized or monotonically decreased, with no statistically significant increased rCBV compared with initial post-PPX baseline. Two cases of pseudoprogression were biopsied (necrosis and quiescent tumor cells with Ki-67 < 5%). Relative cerebral blood volume in progressive disease was not found to be significantly larger than rCBV at initial progressive enhancement in pseudoprogression (p=0.16, unpaired t-test).

CONCLUSION
There is substantial incidence of pseudoprogression in patients treated with PPX, TMZ, and RT, with enhancement persisting well beyond the 3-6 months typically associated with pseudoprogression. Relative cerebral blood volume in progressive disease may not significantly exceed that in pseudoprogression, and stable or decreasing rCBV on longitudinal follow-up exams may provide better indication of pseudoprogression than individual absolute rCBV values. Longitudinal evaluation with PWI may be a useful prognostic tool for monitoring treatment response in high-grade gliomas, and merits investigation in prospective studies.

KEY WORDS: Pseudoprogression, perfusion-weighted MR imaging, high-grade glioma

Paper 540 Starting at 2:03 PM, Ending at 2:11 PM
Deformable Anatomical Atlas Expands Preoperative, Intraoperative, and Postoperative Imaging Analysis of Eloquent Area Gliomas

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Houston, TX

PURPOSE
The purpose of this study is to assess the clinical utility of a deformable anatomical atlas (DAA) in patients with infiltrating glioma. There is a need for alternative preoperative planning in the subset of patients in whom diffusion tensor imaging (DTI), functional MR imaging (fMRI), or awake motor or speech mapping are not an option. This need also exists in institutions lacking the resources to implement DTI or fMRI. Alternative imaging analysis also is needed for patients who cannot complete the fMRI testing due to neurologic deficits and those in whom the tumor itself precludes successful measurement of DTI tracts. Deformable anatomic atlas also is useful in the many patients whose tumors do not involve the limited functions testable by DTI and fMRI.

MATERIALS & METHODS
We prospectively studied 17 patients with infiltrating glioma in eloquent areas to evaluate the utility of DAA in the preoperative, intraoperative, and postoperative setting. Conventional MR imaging was overlaid with DAA and correlated with available diffusion tensor images, fMRI, and pre and post operative clinical deficits.

RESULTS
Seven cases had informative preoperative fMRI studies of the hand (n = 3), Wernicke’s area (n = 1) and Broca’s area (n = 3). The DAA predictions correlated with the fMRI studies in all seven cases and DAA showed the relevant areas in an additional eight cases with nondiagnostic fMRI exams. Ten cases had informative preoperative DTI of the corticospinal tract (n = 3), the arcuate tract (n = 5) and both (n = 2). The DTI often was hampered by tumor/edema, but DAA was able to show the entire pathway of the arcuate tract (n = 7) and distinguishing corticospinal fibers from the corticospinal fibers (n = 3). Deformable anatomical atlas was superior to DTI and fMRI in defining structures within areas of tumor/edema. Seven of the 17 patients had significant postoperative deficits which could be explained by superimposition of the DAA. For example, one of these patients developed a small area of ischemia in the region of the hand fibers which were outside the surgical cavity. In the remaining 10 cases without deficits, DAA correctly showed the motor and speech areas were not involved in the resection.

CONCLUSION
Deformable anatomical atlas provided clinically useful information in patients imaged before and after surgery for glioma. This technology is a reliable alternative for patients in whom preoperative fMRI or awake speech or motor mapping are not feasible.

KEY WORDS: Deformable anatomical atlas, eloquent area gliomas

Paper 541 Starting at 2:11 PM, Ending at 2:19 PM
Relationship of Glioblastoma Multiforme to the Subventricular Zone Predicts Survival

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PURPOSE
The subventricular zone (SVZ) lines the lateral ventricles and is thought to represent the origin of neural and some cancer stem cells. Tumors contacting the SVZ may have higher potential to recruit migratory neural progenitor cells and thus
be more invasive with higher propensity for distant spread. The purpose of our study was to determine whether SVZ involvement in glioblastoma multiforme (GBM) is associated with a higher recurrence rate and shorter overall survival.

MATERIALS & METHODS
A retrospective review of MR imaging and clinical data from 91 patients with GBM who underwent surgical resection and chemoradiation at our institution between January 2000 and October 2008 was performed. Based on preoperative MR imaging, patients were classified as type I if the contrast-enhancing lesion contacted both the SVZ and cortex, type II if only the SVZ was involved, type III if only cortex was involved, and type IV if the lesion did not contact either the SVZ or cortex. Size of the contrast-enhancing lesion was estimated as a volume from two-dimensional measurements. Time to progression was calculated from time of diagnosis to disease progression based on MR imaging findings and clinical evaluation. Overall survival, from time of diagnosis to time of death or date of last contact if alive, was estimated based on Kaplan-Meier calculations. For each outcome, subsets were compared using the log rank test. Analysis of variance methods with post hoc tests were used to compare mean tumor size by type.

RESULTS
Of the 91 patients, 34% were categorized as type I, 20% as type II, 31% as type III, and 15% as type IV. Type I patients, with tumors contacting both the SVZ and cortex, had statistically significant decreased survival compared to all other types (median survival of 61.4 weeks versus 86.9 weeks, \( p = 0.02 \)). Estimated survival at 104 weeks for type I patients was 15% compared to 41% for all others. Overall survival was decreased for patients with tumors that involved the SVZ, types I and II, compared with tumors not contacting the SVZ, types III and IV, with survival at 104 weeks estimated to be 20% and 47%, respectively (\( p = 0.001 \)). Patients with SVZ involvement also demonstrated a more rapid time to progression of 23.9 weeks compared to 47.0 weeks for those not involving the SVZ (\( p = 0.003 \)). Although patients with type IV disease had smaller tumors, no significant difference in mean tumor size was found between tumors contacting the SVZ and those lacking SVZ involvement (\( p = 0.12 \)).

CONCLUSION
The results of our study show that patients with GBM involving the SVZ have a decreased overall survival and more rapid time to progression. We postulate that this more aggressive clinical behavior of GBMs involving the SVZ may be related to the recruitment of neural stem cells with more migratory potential and greater propensity for invasive proliferation. Subventricular zone involvement of GBM may hold prognostic implications, and the characteristic tumor recurrence along remote SVZ may have therapeutic implications in terms of planning radiation therapy.

KEY WORDS: Glioblastoma multiforme, subventricular zone
diffusion demonstrated elevated Mib-1 and total vasculature expression compared to nonreduced T2 hyperintense regions.

**CONCLUSION**
This study demonstrates that the presence of reduced diffusion and invasive T2 hyperintensity pattern on MR imaging following the administration of Bevacizumab should alert radiologists and neuro-oncologists to the presence of highly invasive phenotype of recurrent GBM.

**KEY WORDS:** Glioblastoma multiforme, Avastin, diffusion-weighted MR imaging

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**Paper 543 Starting at 2:27 PM, Ending at 2:35 PM**

**Survival Prediction in High-Grade Gliomas with Tumor Blood Volume and Permeability Estimates Using Perfusion CT**

Jain, R. • Narang, J. • Schultz, L. • Saksena, S. • Scarpace, L. • Ewing, J. R. • Mikkelsen, T.

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Detroit, MI

**PURPOSE**

Despite recent advances in treatment of high-grade gliomas, the overall survival is still very poor and various metabolic and physiologic imaging biomarkers have been used to predict survival. The purpose of our retrospective study was to assess the prognostic value of both cerebral blood volume (CBV) and permeability surface area-product (PS) measured using perfusion CT (PCT) in high-grade gliomas.

**MATERIALS & METHODS**

Between 2006 and 2009, 55 patients with high-grade gliomas (WHO grade III, n=15; WHO grade IV, n=40) underwent pretreatment PCT and were included for this study. Receiver operating characteristic (ROC) analyses were done to assess the possible different cutpoints for CBV, rCBV and PS parameters for differentiating between grade III and IV gliomas. Kaplan-Meier survival estimates were computed to describe the progression free survival (PFS) for the patients with high vs low PCT parameters, as well as grade III and IV gliomas. Logrank tests were done to compare PFS for the different groups. Cox proportional hazards regression analyses were done to adjust for demographic and prognostic factors when comparing PFS for PCT parameters.

**RESULTS**

The differences in PFS between high and low CBV (cutpoint 2.3 ml/100g, p=0.038), rCBV (cutpoint 2.9, p=0.002) and PS (cutpoint 2.0 ml/100g/min, p=0.012) were all significant in all high-grade gliomas (Figures 1A and 1B). After adjusting for age, KPS and type of initial surgery, the differences between high and low PCT remained significant for rCBV (p=0.017) and PS (p=0.027) and showed a trend for CBV (p=0.085). However, when adjustments also are made for WHO grade none of the differences for PCT parameters were statistically significant (CBV p=0.646, rCBV p=0.294 and PS p=0.495). For grade III gliomas, the differences in PFS between high and low PCT parameters only showed statistically significant difference for rCBV (p=0.003), whereas none of the PCT parameters showed any statistically significant difference for grade IV gliomas.

**CONCLUSION**

Blood volume and permeability estimates measured using PCT can help predict survival in high-grade gliomas and patients with high PCT parameters showed poor PFS as compared to low PCT group even after adjusting for age, KPS and type of initial surgery, however, not independent of the histologic grade. Relative CBV estimates did show statistically significant difference for PFS in grade III gliomas, whereas as PS estimates did not, suggesting that tumor blood volume might be a better predictor of PFS than permeability estimates in grade III gliomas.

**KEY WORDS:** CT perfusion, survival, gliomas
Dynamic Susceptibility Contrast MR Imaging Depicts Early Changes to Therapy (Nimotuzumab and Radiation Therapy) prior to Detectable Tumor Shrinkage on Conventional MR Imaging in a Rodent Brain Tumor Model

Schneider, J.¹ • Niehoff, P.¹ • Held-Feindt, J.¹ • Jansen, O.¹ • Ulmer, S.²

¹University Hospital of Schleswig Holstein, Kiel, GERMANY, ²University Hospital Basel, Basel, SWITZERLAND

**Purpose**

New therapy regimens for malignant glioma such as a combination of nimotuzumab and radiation therapy have been presented recently in phase III trials to be as effective as standard care, but to have fewer side effects. The aim of this study was to analyze whether early response to therapy can be depicted by MR imaging (MRI) in a rodent brain tumor model.

**Materials & Methods**

The study was approved by the ethical committee (IRB) according to local guidelines for animal care. We stereotactically implanted tumor xenograft (C6) in 10 male Wistar rats. Two weeks after the operation we performed a baseline MRI (matrix 128 x 128, FOV 64 mm) using a dedicated solenoid coil in a 3 T scanner (Philips, Best, The Netherlands). Five rats received a stereotactic fractionated radiotherapy (2Gy/die) plus intraperitoneal injection of nimotuzumab (50mg/KG/die) for 5 days, while the control group received no therapy. Body weight and neurologic status was monitored throughout the therapy. Another MRI was performed including a DSC-MRI (T2*-weighted) sequence (TR/TE=30/14 ms, matrix 64 x 64, FOV 90 mm; slice thickness of 1.5mm). Tumor dimensions as well as perfusion ratios were analyzed (nordicIce, NordicNeuroLab, Bergen, Norway).

**Results**

All animals tolerated the procedures well. All 10 rats lost some weight during therapy and tumor size increased (MacDonald criteria). Perfusion ratios were increased significantly in tumor tissue compared to the unaffected contralateral brain (p<0.05). Furthermore rCBV and rCBF decreased significantly in treated animals compared to the control group (2.3 to 4.6 in rCBV and 2.4 to 3.9 in rCBF respectively; paired two-tailed t-test, p<0.05).

**Conclusion**

Using standard clinical equipment and sequences, we were able to monitor tumor size as well as response to treatment in this rodent brain tumor model. The combination of intraperitoneal nimotuzumab and stereotactic fractionated radiation therapy led to a significant decrease of perfusion ratios already after 5 days of therapy prior to a noticeable decrease in tumor volume. Dynamic susceptibility contrast-MRI has proved to be a reliable method to monitor early response to treatment and could be a powerful tool in clinical routine to noninvasively detect responders to therapy from nonresponders.

**Key Words:** DSC-MR imaging, glioblastoma multiforme, nimotuzumab

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**Thursday Afternoon**

**1:15 PM - 2:45 PM**

**Ballroom 6A**

**(47b) Infectious Diseases/Metabolic Diseases**

(Scientific Papers 545 - 555)

*See also Parallel Session*

(47a) Brain: Neoplasms II, Glioma Grading and Outcomes

(47c) Epilepsy, Brain Neoplasms

(47d) Pediatrics: New Techniques (DTI, SWI, MRS, fMRI)

(47e) Research Grant Writing Session - Part II

Moderator: Daniel P. Hsu, MD

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Paper 545 Starting at 1:15 PM, Ending at 1:23 PM

**Balamuthia Mandrillaris Meningoencephalitis Associated with Solid Organ Transplantation: Review of Cases**

Khan, M. A. • Joyner, D. • Schlakman, B. • Hanigan, W. C. • Buciuc, R.

University of Mississippi Medical Center

Jackson, MS

**Purpose**

Balamuthia mandrillaris, a free-living amoeba responsible for granulomatous amoebic encephalitis (Gae) is a very rare cause of fulminant life threatening meningoencephalitis and has caused with little attention over 125 cases since 1975 with few survivors. Few clinicians are familiar with the disease, and diagnosis frequently is made postmortem. We report the first identified transmission of *B. mandrillaris* through solid organ transplantation.

**Materials & Methods**

Medical records, Radiology and histopathology were reviewed. Specimens were tested for *B. mandrillaris* at our hospital laboratory and the Centers for Disease Control and Prevention (CDC) by immunohistochemistry (Ihc), indirect immunofluorescent assay (Ifa) and real-time PCR.
RESULTS

Transplantation of two kidneys, a liver and a heart was performed at three different centers from a donor with presumptive diagnosis of autoimmune encephalitis. The kidney recipients received antilymphocytic antibody and 3 weeks later, developed sudden onset of fever, altered mental status with seizures. MR imaging brain from the donor and both kidney recipients at our institution demonstrated bilateral supra and infratentorial ring enhancing lesions with surrounding edema. Enhancement pattern was ring but with poorly defined borders and adjacent/surrounding leptomeningeal extension suggesting an invasive meningoencephalitis. In addition most of the lesions showed central T2-weighted hypointensities and focal dark signal on gradient images suggesting central hemorrhagic foci. These findings were seen consistently on all the imaging obtained in these patients suggestive of probable angioinvasive component. No hydrocephalus was noted on any of the cases which was in contrast to most of the previously reported cases. Histopathology of donor brain tissue revealed amoebae by lhc and B. mandrillaris by IFA and real-time PCR. These results were confirmed by brain biopsy in one of the kidney recipients and both recipients had CSF samples that were positive for B. mandrillaris by PCR. Head CT from the donor right before his demise showed diffuse SAH and there was significant hemorrhagic transformation of the lesions noted in one of the recipients before her demise further substantiating the angioinvasiveness of this organism. The 2nd recipient showed both radiologic and clinical improvement with appropriate treatment after diagnosis.

CONCLUSION

These are the first reported cases of B. mandrillaris transmission associated human to human solid organ transplantation. Donors with encephalitis of uncertain etiology may transmit unusual infections to recipients with devastating consequences. The consistent pattern of poorly defined ring enhancement and adjacent leptomeningeal enhancement with focus of central hemorrhage on radiologic imaging should be viewed especially with caution as this may suggest fulminant angioinvasive Gae. Clinicians should have a low threshold to suspect donor-derived infections in transplant patients receiving organs from donors with encephalitis and promptly report, test and treat all suspected cases.

KEY WORDS: Balamuthia, amebic encephalitis, transplantation

Paper 546 Starting at 1:23 PM, Ending at 1:31 PM

Herpes Encephalitis and Autoimmune-Mediated Limbic Encephalitis: Analysis of Common and Distinctive Features on MR Imaging

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University of California San Francisco
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PURPOSE

Herpes simplex virus encephalitis (HSE) and autoimmune-mediated limbic encephalitis (ALE) have overlapping clinical and imaging features. Correct diagnosis is imperative, as both are potentially reversible but their treatments are very different. The purpose of this study was to determine whether the MR imaging features of these disorders can reliably distinguish between these two conditions.

MATERIALS & METHODS

We retrospectively reviewed medical records and MR imaging (MRI) examinations for eight patients with CSF PCR-positive HSE and 13 patients with serum and/or CSF auto-antibody positive paraneoplastic or non-paraneoplastic ALE with abnormal MRIs seen at our institution over a 10-year period from 7/2000 to 7/2010. MR imaging studies were reviewed by two neuroradiologists on the basis of four imaging features: 1) presence and pattern of enhancement (pre and postcontrast T1-weighted sequences), 2) presence or absence of reduced diffusion (diffusion trace and ADC sequences), 3) presence or absence of cortical hemorrhage (GRE or b=0 diffusion sequences), and 4) anatomical distribution and symmetry of T2 prolongation (T2-FLAIR sequences). The association of each finding with HSE and ALE was tested using Fisher’s exact test.

RESULTS

The patients in the HSE group (5 male, 3 female) ranged in age from 10 to 80 years (median=59.5, interquartile range=35-84), and the patients in the ALE group (1 male, 12 female) ranged in age from 28 to 76 years (median=58.5, interquartile range=42-73). Cases with ALE included anti-NMDA receptor (n=2), anti-AMPA receptor (n=1), anti-Hu (n=1), anti-CV2 and anti-Ma-2 (n=1), anti-voltage gated potassium channel (VGKC) associated (n=6), and Hashimoto’s encephalopathy (n=2). Of the four imaging features reviewed, only leptomeningeal enhancement differed significantly, present in 6/8 of the HSE cases and in 1/10 of the ALE cases (p=0.013). Although more common in HSE than ALE, reduced diffusion was observed in less than 50% of each group (3/8 for HSE and 3/13 for ALE). Cortical hemorrhage was present in only 1/8 of the HSE patients and none of the ALE patients. Although the symmetry of T2 signal abnormalities was not significantly different, there was a strong trend towards more frequent unilateral T2 signal abnormalities in the HSE group (7/8) than in the ALE group (7/13) (p=0.17) and was observed in all cases with enhancement. Extratemporal limbic involvement (insula and/or cingulate cortex) was observed in 6/8 HSE cases and 6/13 ALE cases.

CONCLUSION

Herpes simplex virus encephalitis and ALE have many overlapping features on MRI, but our data suggests that leptomeningeal enhancement and unilateral T2 signal abnormalities favor HSV encephalitis. Immediate empiric antiviral treatment should be further emphasized in this subgroup of patients. This finding will need to be studied further in larger cohorts. Nevertheless, unless clinical history is compelling both diagnoses should be considered initially in patients with mesiotemporal lobe edema on MRI to prompt diagnostic work-up for both conditions.

KEY WORDS: Autoimmune, herpes, encephalitis
Granulomatous Amebic Encephalitis: MR Imaging Features

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Purpose
Granulomatous amebic encephalitis (GAE) is a rare but deadly condition that often is misdiagnosed on imaging studies. We present the imaging findings in four cases.

Materials & Methods
In the past 18 months we have had four patients die of GAE. Age range was from 2-27 years; one was female and three were males. Two patients were immunocompetent and two were immunosuppressed. One of the immunocompromised individuals had received a kidney/pancreas transplant inadvertently from an infected donor, who was thought to have died of a cerebral infarction. All four cases were confirmed at autopsy. In three of these the organism was positively identified as Balamuthia mandrillaris. In the 4th case, the organism was either Balamuthia or a closely-related Acanthameba species, but definitive serotyping was not available.

Results
Clinical presentation included headache (2 patients), seizure (1 patient), fever (1 case), and ataxia (1 case). The number of lesions per patient varied from two to more than 12. Individual lesions were typically round or ovoid, ranging from 1-3 cm in diameter. Lesions were found in the deep gray nuclei, the periventricular white matter, and the cortex. All were hypointense on T1-weighted imaging and iso- to hyperintense on T2. On FLAIR sequences, most lesions were isointense to gray matter in the center, with a surrounding area of high signal. Most of the lesions did not have restricted diffusion. Gadolinium enhancement was typically faint, ring shaped, and limited to the periphery of the lesions. One individual had multiple lesions that contained blood products on gradient-echo images. Meningeal enhancement was not a feature. Hydrocephalus developed in one case.

Conclusion
Because of its rarity, amebic encephalitis is seldom diagnosed pre mortem. MR imaging findings that should raise suspicion of this disease include rounded intracerebral masses that are hypointense on T1, iso to hyperintense on T1, and enhance sparingly around the periphery. Granulomatous amebic encephalitis occurs in both immunocompetent and immunocompromised individuals, and may be transmitted by organ transplantation.

Key Words: Encephalitis, cerebritis, ameba
pathologic changes such as inflammation and axonal degeneration. Regional differences in the ADC study may further indicate selective areas of functional impairment.

**KEY WORDS:** HIV subcortical brain injury, diffusion-weighted imaging, cognitive impairment

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**Paper 549 Starting at 1:47 PM, Ending at 1:55 PM**

**Reduced Microstructural Integrity in White Matter of Nondemented Elderly Subjects with Increased Levels of Systemic Inflammation**

Harmon, S.¹ • Fleischman, D. A.² • Dawe, R. J.¹ • Bennett, D. A.² • Arfanakis, K.¹,²

¹Illinois Institute of Technology, Chicago, IL, ²Rush University Medical Center, Chicago, IL

**PURPOSE**

The purpose of this work was to test the hypothesis that high levels of circulating inflammatory markers in nondemented elderly subjects are associated with changes in the microstructural integrity of white matter tissue, as assessed with diffusion tensor MR imaging (MRI).

**MATERIALS & METHODS**

Serum samples from 320 nondemented elderly participants of the Rush Memory and Aging Project, not taking anti-inflammatory medications, were assayed for C-reactive protein (CRP) and tumor necrosis factor-alpha (TNFα). Subjects were stratified into groups of high and low systemic inflammation based on a composite measure of CRP and TNFα. The first 15 MRI-eligible participants from the upper quartile of composite inflammation (age = 81.2 ± 3.6 years, education = 13.4 ± 2.5 years) and the first 14 participants from the lower quartile (age = 81.2 ± 6.1 years, education = 15.9 ± 1.8 years) were entered into the current investigation. Diffusion tensor imaging (DTI) data were collected for all subjects on a 1.5 T MRI scanner: TE=84.6ms, TR=5.4s, 36 oblique-axial slices, FOV=24cm, slice thickness=3mm, acquisition matrix=128×128, NEX=6, two b=0s/mm² images, 12 diffusion directions at b-value=900s/mm², scan time 7min and 33s. Voxelwise t-tests were used to compare fractional anisotropy (FA) and trace values between the groups with high and low levels of inflammation, using Tract-Based Spatial Statistics (TBSS). Only differences with p<0.05 were considered significant after correction for multiple comparisons. We then investigated the relation of mean FA and trace in regions with significant differences across groups to the composite measure of inflammation, total volume of white matter hyperintensities (WMH), age, sex and education.

**RESULTS**

Fractional anisotropy (Figure 1 left) and trace (Figure 1 right) were significantly lower and higher, respectively, in several white matter regions in the group of subjects with high levels of inflammation than in the group with low levels of inflammation (Figure 1). There were no regions with lower FA or higher trace in the group of subjects with low levels of inflammation. The effect of WMH volume on mean FA and trace was not significant.

**CONCLUSION**

This work demonstrated that in elderly persons without dementia, high levels of systemic inflammation were associated with significantly lower FA and higher trace in white matter throughout the brain. These results are in agreement with the findings of a recent study on FA of younger subjects. Our work suggests that high levels of systemic inflammation in nondemented elderly subjects may be a risk factor for reduced microstructural integrity of brain tissue.

**KEY WORDS:** Diffusion tensor imaging, inflammation, white matter

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**Paper 550 Starting at 1:55 PM, Ending at 2:03 PM**

**Comparison of the Added Value of Contrast-Enhanced 3D Fluid-Attenuated Inversion Recovery and Magnetization-Prepared Rapid Acquisition of Gradient-Echo Sequences in Relation to Conventional Postcontrast T1-Weighted Images for the Evaluation of Leptomeningeal Diseases at 3 T**

Fukuoka, H. • Hirai, T. • Okuda, T. • Shigematsu, Y. • Sasao, A. • Kimura, E. • Hirano, T. • Yano, S. • Yamashita, Y.

Graduate School of Medical Sciences Kumamoto University
Kumamoto, JAPAN

**PURPOSE**

The usefulness of contrast-enhanced 3D T2-FLAIR MR imaging for the evaluation of leptomeningeal diseases has not been systematically investigated. The purpose of this study was to assess the value added by contrast-enhanced 3D T2-FLAIR and MPRAGE sequences to conventional postcontrast T1-weighted images in the evaluation of leptomeningeal diseases. We also undertook in vitro studies in attempts to understand the consequences of our patient study.

**MATERIALS & METHODS**

Twelve patients with confirmed leptomeningeal diseases underwent postcontrast T1-weighted, MPRAGE, and 3D T2-FLAIR imaging at 3 T. Two radiologists independently assessed the presence of additional information on postcontrast 3D MR images compared with postcontrast T1-weight-
ed images. The effect of different gadolinium (Gd) concentrations and flow velocities on the signal intensity on 3D T2-FLAIR images was investigated in vitro.

RESULTS
According to both reviewers, 3D T2-FLAIR images yielded significantly more information than did MPRAGE images ($P < .05$ and $P < .01$, respectively). In the in vitro study, 3D T2-FLAIR was more highly sensitive to low Gd concentrations and less sensitive to high Gd concentrations than were T1-weighted or MPRAGE sequences. On 3D T2-FLAIR sequences, at a flow velocity exceeding 1.0 cm/s, the signal intensity of blood-mimicking fluids at concentrations of 0 and 0.1 mmol/L was as low as at 1.3 mmol/L.

CONCLUSION
For the depiction of leptomeningeal diseases, postcontrast 3D T2-FLAIR provides more additional information than postcontrast MPRAGE imaging. The superiority of the 3D T2-FLAIR sequence is associated with its high sensitivity to flow.

KEY WORDS: 3D FLAIR, meningitis, contrast enhancement

Paper 551 Starting at 2:03 PM, Ending at 2:11 PM

Resting-State Functional Connectivity Changes with Subthalamic Nucleus Deep Brain Stimulation in a Parkinson Disease Patient

Wu, J.1,2 • Beall, E. B.1 • Lowe, M. J.1 • Walter, B. L.3,4 • Machado, A.1 • Phillips, M. D.1

1Cleveland Clinic, Cleveland, OH, 2New York Medical College, Valhalla, NY, 3University Hospitals Case Medical Center, Cleveland, OH, 4Case Western Reserve University School of Medicine, Cleveland, OH

PURPOSE
The purpose of this study was to compare resting-state functional connectivity in a Parkinson disease (PD) patient between on and off subthalamic nucleus deep brain stimulation (STN-DBS) conditions using low-frequency BOLD fluctuations, also known as functional connectivity MR imaging (MRI). STN-DBS in PD has been shown to be efficacious in reducing the cardinal motor symptoms of bradykinesia, rigidity, and tremor. However, the exact mechanism of DBS and its effect on basal ganglia and thalamo-cortical functional connections remain under investigation. Assessing the functional connectivity of the basal ganglia and their cortical projections while in the resting state during continuously-on and -off DBS can provide greater insight into how functional networks are affected by DBS.

MATERIALS & METHODS
A whole brain T1-weighted MPRAGE and two whole-brain resting-state echo-planar (EPI) scans with 137 repetitions each, 31 axial slices of 4mm isotropic voxels, were acquired from a PD patient with unilateral left-sided STN-DBS implantation. The first EPI scan was acquired with DBS continuously on and the second with DBS off, both while resting with eyes closed. Scan protocols and data preprocessing, including spatial filtering as well as corrections for slice-common noise, physiologic noise, and rigid body motion, were performed following previously described methods. A priori defined regions of interest (ROI) were drawn for bilateral caudate head, putamen, globus pallidus, and thalamic nuclei on the MPRAGE and transformed into EPI space for both on and off condition scans. Seed-based correlation analyses were done to generate whole brain z-score maps of significant correlation to each reference ROI.

RESULTS
Compared to the DBS OFF condition, resting state functional connectivity with DBS ON showed significantly decreased bilateral connectivity for putamen and globus pallidus as well as increased connectivity of putamen and thalamus to left and right supplementary motor areas (SMA) and cingulate cortex. Also in the DBS ON condition, left putamen and globus pallidus were more negatively correlated with cuneus and precuneus regions.

CONCLUSION
This case study of a unilateral STN-DBS PD patient demonstrates stimulation-associated changes in resting state functional subcortical and thalamo-cortical connections. Unilateral stimulation appears to interrupt bilateral functional connectivity of the globus pallidus and putamen and strengthen connectivity of the thalamus and putamen to cortical regions. Past studies have shown that STN-DBS alters basal ganglia output and prevents the relay of synchronized globus pallidus interna oscillations to cortex. Our results suggest that STN-DBS similarly affects resting state connectivity in the basal ganglia by interrupting the synchrony of contralateral pallidal thalamic and putaminal nuclei. Such changes in baseline connectivity may lead to a normalization of thalamo-cortical connections, particularly thalamic output to the SMA. This finding is consistent with previous studies showing functionally hypoactive SMA in dopamine deficiency states and STN-DBS-associated restoration of SMA function with improved motor function. The precuneus is preferentially involved in resting states, but reversed patterns of task-related functional activation and deactivation in precuneus has been noted in PD patients compared to healthy controls.

Acknowledgement: This work was supported by the NIH, grant NS052566-01A1.

KEY WORDS: Parkinson disease, deep brain stimulation, resting-state functional MR imaging
Decreased Brain Stiffness in Alzheimer Disease Determined by MR Elastography

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**Purpose**
To test patient reproducibility of 3D MR elastography (MRE) using a novel soft vibration source and to determine if MRE can noninvasively measure a change in the elastic properties of the brain due to Alzheimer disease (AD).

**Materials & Methods**
To test the reproducibility of MRE, ten volunteers underwent four MRE examinations in two sessions. To examine the effect of AD on brain stiffness, 28 subjects were recruited including seven with AD, 14 age- and gender-matched Pittsburgh Compound B (PIB)-negative cognitively normal controls (CN-) and seven age- and gender-matched PIB-positive cognitively normal controls (CN+). Shear waves were introduced into the brain with a soft pillow-like vibration source utilizing a pneumatic actuator. MR elastography data were collected with a single shot spin-echo EPI pulse sequence on a 3 T MR imager with the parameters including: 55 Hz motion for the reproducibility study and 60 Hz motion for the AD study, FOV=25.6 cm, 60x60 imaging matrix reconstructed to 64x64, 3x ASSET acceleration, 2.5 mm thick slices (skip 1.5 mm) and 4 phase offsets requiring 3.5 minute acquisition time. The first harmonic data were inverted with a 3D direct inversion algorithm. The median stiffness for each individual was calculated from a global region of interest excluding SNR<5, 3 voxels from the edge of the brain and voxels with >30% CSF content.

**Results**
The median stiffness for the ten volunteers of the reproducibility study was 3.07 kPa (range: 2.81 to 3.21 kPa). The median and maximum coefficients of variation for these volunteers were 1.71% and 3.07%. The median stiffness of the 14 CN- subjects was 2.37 kPa (range: 2.17-2.62 kPa) compared to 2.32 kPa (range: 2.18-67 kPa) within the CN+ group and 2.20 kPa (range: 1.96-2.29 kPa) within the AD group. A significant difference was found between the three groups with both CN groups significantly different from the AD group.

**Conclusion**
The results demonstrate that 3D brain MRE can be performed reproducibly, and that AD pathology alters the mechanical properties of the brain which can be measured in vivo by MRE. Brain MRE is a new imaging modality that provides a unique class of information which heretofore has not been applied to AD. Measures of brain elasticity should provide unique insight into the fundamental ultrastructural alterations in the brain that occur with AD, as well as how these change with time, correlate with other disease biomarkers and with clinical expression of the disease.

**Key Words:** Alzheimer disease, MR elastography

Structural Neuroimaging Comparison of Adults with Childhood Lead Exposure: Qualitative versus Quantitative Findings

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**Purpose**
Despite largely successful public health efforts, lead exposure remains an international threat to healthy brain development in children. Significant and persistent deficits in cognition, executive functioning and social behaviors are associated with childhood lead exposure. Increased numbers of children with ADHD diagnoses in the United States recently have been attributed to lead exposure. These adverse outcomes are thought to reflect lead-induced, microscopic brain injury. With variable clinical presentations, conventional neuroimaging evaluations in children and adults with low to moderate blood lead levels (5-40 mcg/dL) are not obtained, as findings for such tests are usually negative or if present, nonspecific for lead exposure. However, recent advanced quantitative magnetic resonance imaging (MRI)
analyses (2-4) [voxel-based morphometry (VBM), diffusion tensor and functional MRI] in a prospective, longitudinal, birth cohort monitored for over 25 years find novel, adverse associations between adult neuroimaging outcomes and childhood blood lead concentrations. The purpose of our study was to qualitatively evaluate the images used in quantitative analyses to determine the value of radiologist review for assessing brain injury in a cohort of adults with significant childhood lead exposure.

Materials & Methods

One hundred fifty-nine participants (mean age 20.8 (SD=0.9) years, 83 male, mean childhood blood lead level of 13 mcg/dL, range 4-37 from 23 childhood assessments) of a longitudinal, lead cohort completed a brain MRI examination at 1.5 T. Cohort members were screened for neurologic conditions at birth and were healthy adults at time of the MRI. Experienced, board-certified neuroradiologists evaluated the participants' imaging with review criteria that included assessment of morphology and tissue signal characteristics, evidence of volume loss, appearance of encephalomalacia, presence of lesions, and evidence of prior hemorrhage.

Results

Review of imaging yielded three general categories for classification: 1) negative for imaging abnormalities (N=120, 75%), 2) incidental findings likely unrelated to lead exposure (N=9, 6%), 3) findings regarded as significant including volume loss, ventricular enlargement and encephalomalacia (N=30, 19%), all consistent with a developmental insult, such as lead exposure. Compared with the 3% prevalence rate of findings, excluding sinusitis, in a similarly aged cohort of healthy volunteers participating in an imaging study (5), the number of participants with imaging findings in the lead cohort is higher.

Conclusion

In an adult population with an established history of childhood lead exposure, qualitative assessment of brain MRI examinations demonstrated no evidence of structural abnormalities for the majority of cohort participants. While this result is expected, a significant number of cohort participants (19%) did demonstrate findings suggestive of a process manifesting in brain volume loss. The findings are consistent with those from a separate, quantitative, voxel-based morphometric analysis inversely associating gray matter volume with childhood blood lead levels (2). However, neuroimaging referrals remain unwarranted in persons without a clinical concern for lead encephalopathy.

Key words: Lead exposure, volume loss, MR imaging

Paper 554 Starting at 2:27 PM, Ending at 2:35 PM

Prevalence of the Radiologically Isolated Syndrome in Headache Patients

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Purpose

Headaches are a common indication for MR imaging (MRI). These studies frequently identify white matter hyperintensities (WMH) that may raise consideration of undiagnosed multiple sclerosis (MS). The radiologically isolated syndrome (RIS), or fulfillment of the Barkhof imaging criteria for MS in clinically asymptomatic patients, is a risk factor for the development of clinically isolated syndrome (CIS) and MS. We retrospectively reviewed a series of brain MRI studies performed for headaches in order to assess the prevalence of RIS in this population since this information will be important in patient counseling and future surveillance.

Materials & Methods

All consecutive patients having pre and postcontrast MRI scans from May 2008 to June 2010 were identified retrospectively using searches of billing and diagnostic codes for headache. Electronic medical chart review was used to exclude patients without a documented clinical history of headache and patients with a diagnosis of MS or CIS. All scans were analyzed in consensus by two reviewers on digital radiologic picture archiving and communication system (PACS). Axial T2-weighted spin-echo and axial and/or coronal FLAIR sequences were used to characterize location and number of WMH. Pre compared to postgadolinium T1-weighted images were used to identify enhancement. MR scans with excessive artifacts, incomplete coverage, lacking the above sequences, and exams demonstrating a structural cause of headache were excluded. Patients under 10 and over 55 years of age were excluded since a new MR diagnosis outside this age range is unlikely, because we hoped to limit senescent WMH as a confounder. Cases of RIS were graded according to the previously published Barkhof criteria. Given some ambiguity in definition, we recorded periventricular and juxtacortical lesions were defined two ways: 1) “Contact” where WMH touched cortex and ventricle respectively, versus 2) WMH within 3 mm of these structures. The prevalence of RIS among headache patients was calculated for each criterion separately as the number of patients fulfilling our age-modified RIS criteria divided by the total number of patients meeting all inclusion criteria.

Results

Three hundred and twenty-six of 564 (58%) patients had enhanced brain MRI meeting criteria for inclusion. There were 108 males and 218 females aged 10 to 55 (mean 34.5) years. Four of 326 patients (1.23%; 95% CI: 0.34% to 3.11%) fulfilled RIS criteria when juxtacortical and periventricular lesions were defined as “contact”. Twelve of 326 patients (3.68%; 95% CI: 1.92% to 6.34%) fulfilled RIS criteria when juxtacortical and periventricular WMH were defined as “within 3 mm”. The difference between “contact” and “within 3 mm” was not statistically significant.
Acute brain MRI findings varied widely in extent and distribution, underscoring the complex nature of this disease and reflecting the heterogeneous nature of findings at autopsy. Future studies correlating MRI findings with coma duration, clinical course and outcome may provide further insights into this common and frequently fatal condition.

**Key Words:** Malaria, tropical, parasite
Paper 556 Starting at 1:15 PM, Ending at 1:23 PM

Imaging and Pathology Correlations in Pediatric Cortical Dysplasia: Detailed MR Imaging, PET, and Immunohistochemical Analysis

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Purpose
Focal cortical dysplasia (FCD) is the most common pathology identified in children undergoing surgical resection for intractable epilepsy. Pathologic-imaging correlation in this patient group is limited. We performed immunohistochemical (IHC) histopathologic analysis correlated with findings on MRI and PET (including statistical parametric mapping; SPM-PET) to further our understanding of the pathologic changes underlying imaging abnormalities in this patient group.

Materials & Methods
Thirty-six consecutive surgically treated pediatric patients (mean: 10 years, 10 months) with intractable epilepsy and pathologically proved FCD were included (56 resection specimens). Immunohistochemical performed included glial fibrillary acidic protein (GFAP, a glial marker), and mammalian target of rapamycin (mTOR, which controls protein translation and regulates cell metabolism). Palmini’s pathologic classification of FCD was used. Glial fibrillary acidic protein staining was classified as superficial (sup-GFAP, subpial and/or molecular layer positive) or diffuse (diff-GFAP). mTOR+ is defined by more than two neurons showing positive cytoplasmic staining. Dedicated seizure protocol MRI was performed on all patients; 31 (85%) at 3 T. Intertictal PET was performed on 35 patients with additional SPM analysis in 30. MR imaging findings were classified as lesional (suggestive of a specific pathology) or nonlesional. Assessment for eight MRI features of cortical dysplasia was performed and a MRI CD score (sCD; 0–8) calculated for each resection region. Relative metabolism in the resection region was classified visually and by SPM-analysis.

Results
Eighteen patients (50%, 13:CD) had lesional, seven had non-specific, and 11 had normal MRI findings. Based on resection specimens, FCD classification was: Ia:6, Ib:23, Ila:24, IIb:3. Lesional MRI abnormalities were present in 0% Ia, 7:30% Ib, 10:42% Ila, and 3:100% of IIb (p = 0.025). Mean sCD was 0.167: Ia, 1.26: Ib, 1.79: Ila, and 3.33: IIb (range 0–6, p = 0.02). PET hypometabolism was present in 4:66% Ia, 15:65% Ib, 17:74% Ila, and 3:100% IIb (p = 0.155). SPM-PET hypometabolism was present in 3:50% Ia, 11:55% Ib, 14:67% Ila, and 3:100% IIb (p = 0.125). Diff-GFAP staining was present in 0% Ia, 5:22% Ib, 21:87% Ila, and 3:100% IIb (p < 0.0001). mTOR+ neurons were present in 1:17% Ia, 6:26% Ib, 17:71% Ila, and 3:100% IIb (p = 0.002). MRI imaging strongly correlated with GFAP staining pattern with 16(80%) lesional MRI resection regions exhibiting diff-GFAP staining (c/w 13 (36%), nonlesional, p = 0.002). Mean sCD was 2.24 in diff-GFAP regions vs 0.67 for sup-GFAP regions, p = 0.0002. A trend toward mTOR+ staining and MRI lesion visualization was present but did not reach statistical significance. mTOR+ correlated with the presence of SPM detected hypometabolism within the resection specimen (p = 0.03), otherwise no significant correlation between IHC and PET/SPM-PET was identified.

Conclusion
Diffuse cortical GFAP staining and mTOR+ neurons on IHC significantly correlates with type II FCD. Lesional MRI findings are more common in type II FCD and are strongly related to the extent of gliosis. Lesional mTOR expression correlated with SPM identification of hypometabolism in the resection region, of interest given its putative role in neuronal metabolism regulation.

Key Words: Dysplasia, epilepsy, MR imaging

Paper 557 Starting at 1:23 PM, Ending at 1:31 PM

FDG-PET SUV Analysis Can Identify Epileptogenic Tubs in Tuberous Sclerosis Complex

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Purpose
Children with tuberous sclerosis complex (TSC) and intractable epilepsy can achieve seizure freedom if an epileptogenic tuber can be identified and surgically resected. A noninvasive approach to epileptogenic tuber identification utilizing a combination of 18F-FDG PET-MRI fusion, magnetic source imaging (MSI), and EEG has been shown to be nearly as effective as traditional, more invasive localization methods. Until now, FDG PET has been used only in conjunction with MRI to compare the relative sizes of tubers and their associated hypometabolic regions. Using retrospective analysis of PET data, we assessed whether quantitative measurements of mean Standardized Uptake Value could give PET (PET-SUV) more diagnostic value in the characterization of epileptogenic tubers in TSC patients.

Materials & Methods
Twenty-one patients who had tuberectomy at UCLA since 2000 were included in this study. In these patients, suspected epileptogenic tubers first were localized noninvasively utilizing a combination of PET-MRI fusion, MSI, and EEG. With PET-MRI fusion, suspected epileptogenic tubers were defined as the lesions with the largest volume of hypometabolism relative to tuber volume. With MSI, suspected epileptogenic lesions were defined as those with a superimposed dipole cluster or those lying between focally scattered dipoles. Suspected epileptogenic tubers were only resected after confirmation of epileptogenicity by intraoperative electrocorticography. The PET-SUV data from these 21 tuberectomy patients was analyzed retrospectively. The mean SUV value of each hypometabolic tuber was calculated, and those with the lowest mean SUV values were defined as suspected epileptogenic tubers. The true positive rates of PET-SUV, PET-MRI fusion, and MSI for the detection of epileptogenic tubers were calculated using intraoperative electrocorticography as the gold standard.
RESULTS
Twenty-one were correctly identified as epileptogenic lesions using PET-SUV, while 57% (12 out of 21) were identified with PET-MRI fusion and 81% (17 out of 21) were identified with MSI.

CONCLUSION
PET is a more widely available modality than MSI or PET-MRI fusion and is shown in this study to be even more accurate than MSI for the detection of epileptogenic tubers. As such, we conclude that using lowest mean SUV values to rate than MSI for the detection of epileptogenic tubers. As MRI fusion and is shown in this study to be even more accurate than MSI for the detection of epileptogenic tubers.

KEY WORDS: Tuberous sclerosis complex, FDG-PET, epilepsy

Paper 558 Starting at 1:31 PM, Ending at 1:39 PM
Diffusion Tensor Imaging Assessment of the Epileptogenic Zone in Children with Focal Intractable Epilepsy

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PURPOSE
The aim of this study is to determine if diffusion tensor imaging (DTI) could identify structural changes in children with intractable epilepsy from MRI-visible focal cortical dysplasia (FCD) and MRI-negative localization-related epilepsy, and if the changes were concordant with the epileptogenic zone as defined by magnetoencephalography (MEG) dipole cluster.

MATERIALS & METHODS
Eight children with MRI-visible FCD and 16 with MRI-negative epilepsy underwent DTI and MEG. Twenty-six age-matched healthy children underwent DTI. Diffusion tensor imaging tract-based spatial statistics (TBSS) analysis was performed on controls across individual patient. The findings were categorized as lobar concordant, nonconcordant or negative. The areas of MRI-visible abnormality, MEG dipole cluster and abnormal DTI were outlined and the ranges of x-y-z-axes on MNI co-ordinates were assessed in those with MRI-visible FCD and MRI-negative epilepsy. Agreement between MRI-visible FCD, MEG dipole cluster and abnormal DTI statistical maps were compared between those with MRI-visible FCD and MRI-negative epilepsy using Chi-square test.

RESULTS
In MRI-visible FCD patients, abnormal FA, MD, λ1, λ2 and λ3 were lobar concordant with MEG dipole cluster in 4/8 (50.0%), 5/8 (62.5%), 3/8 (37.5%), 6/8 (75.0%) and 5/8 (62.5%) respectively. In MRI-visible FCD patients, abnormal FA, MD, λ1, λ2 and λ3 overlap with MEG dipole cluster on all three x-y-z-axes in 0/8 (0%), 4/8 (50%), 3/8 (37.5%), 6/8 (75%) and 4/8 (50%) respectively, and with FCD in 0/8 (0%), 3/8 (37.5%), 0/8 (0%), 3/8 (37.5%) and 1/8 (12.5%) respectively. In MRI-negative epilepsy patients, abnormal FA, MD, λ1, λ2 and λ3 were lobar concordant with MEG dipole cluster 11/16 (68.8%), 11/16 (68.8%), 8/16 (50.0%), 10/16 (62.5%) and 10/16 (62.5%) respectively, and overlap with x-y-z-axes of MEG dipole cluster in 8/16 (50%), 10/16 (62.5%), 7/16 (43.8%), 7/16 (43.8%) and 8/16 (50%) respectively. There were no significant differences between DTI lobar concordance with MEG dipole cluster in MRI-visible FCD and MRI-negative epilepsy.

CONCLUSION
Diffusion tensor imaging may identify white matter changes in children with MRI-visible FCD and MRI-negative epilepsy, which were lobar concordant with MEG dipole cluster in more than half the cases. We also have found the distributions of abnormal FA, MD, λ1, λ2 and λ3 in the x-y-z-axes were more likely to overlap the MEG dipole cluster compared to MRI-visible FCD, implying that abnormal DTI may identify seizure-induced changes rather than FCD. Our results using DTI TBSS to identify the epileptogenic zone in children with intractable epilepsy are encouraging. However, further technical developments in DTI analysis are required to further improve detection of the epileptogenic zone.

KEY WORDS: Epilepsy, diffusion tensor imaging, pediatric

Paper 559 Starting at 1:31 PM, Ending at 1:47 PM
Computer-Aided Diagnosis of Cortical Lesions in Epilepsy Patients

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PURPOSE
Epilepsy is one of the common neurologic syndromes with a lifetime incidence of 2-4% and about 50% of these patients suffer from partial seizures. Neuroimaging is used to determine the origin of these seizures. However, in up to 74% of these patients with location related (partial) seizures, MRI imaging (MRI) shows no abnormalities. Even with state-of-the-art imaging techniques many localization-related seizures remain cryptogenic. It is assumed that the majority of these patients have a small cortical dysplasia. Approximately 30% of patients with location related seizures have intractable epilepsy and detecting these lesions is of clinical importance because resection of these focal lesions may be the only viable therapeutic option and there is an excellent prognosis for seizure control following focal resection. There are three possible explanations for a negative MRI: 1) there is no lesion, 2) the lesion is not detected by the neuroradiologist or 3) the employed MRI technique is not sensitive enough to depict the lesion. The current study deals with the second possibility and we investigated the additional value of a computer-aided diagnostic technique for the detection of cortical lesions in a large series of patients with location related seizures.
**Materials & Methods**

We retrospectively analyzed all MRI studies from the tertiary referral epilepsy center Kempenaeghe, Heeze, the Netherlands acquired between 3-12-2008 and 23-12-2009. Only MRIs of patients with location-related seizures were selected. Patients with gross cerebral abnormalities were excluded. All scans were performed on a 3 T whole body scanner (Philips, Achieva, Philips Medical Systems, Best, the Netherlands). The scan protocol included a sagittal 3D T1-weighted scan with 1 mm slice thickness. This scan was used for the postprocessing. The other scans were an axial TSE-T2, axial FFE-T2, axial FLAIR, coronal FLAIR and a coronal IR. The MRI postprocessing was a voxel-based 3D MRI analysis based on standard procedures available within SPM5 (e.g., normalization, segmentation. Results were compared with a normal database of 50 subjects. The procedure was fully automated and generated feature maps of cortical thickness, gray-white junction and gray matter extension. These maps were evaluated visually and correlated with the full MRI study. Only when the cortical lesion also was visible on the original scans it was considered positive.

**Results**

A total of 289 MRIs were evaluated. In 45 of these patients a cortical lesion was described in the initial neuroradiologist’s report, based on only visual assessment. In 28 out of these 45 patients the computer-aided procedure also revealed the lesion. In five patients the computer-aided technique revealed a new cortical lesion, initially not depicted on visual assessment.

**Conclusion**

The diagnostic yield of MRI can be increased with computer-aided techniques, however it can not replace visual assessment. It is a valuable extension of the diagnostic armamentarium in epilepsy patients.

**Key Words:** Cortical dysplasia, epilepsy, computer-aided diagnosis

**Paper 560 Starting at 1:47 PM, Ending at 1:55 PM**

**T2-Weighted MR Imaging Tissue Contrast between Dentate Gyrus and Subiculum in Seizure: An Initial Comparison between 1.5 T and 3 T**

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**Purpose**

It is desirable to visualize structural and contrast variations for small structures within hippocampal volume since abnormalities in these subregions have been implicated in seizure and in several other neurologic disorders. Although submillimeter in-plane resolution is routinely achievable at 7 T and 3 T, hippocampal tissue MR contrast has not been addressed adequately for such structures. As resolution and SNR improve with field strength, we have asked whether the tissue contrast also improves at higher fields for small hippocampal structures like dentate gyrus and subiculum. We also have explored if one can routinely visualize structures like Dentate Gyrus Cell Layers (DGCL, thickness 100 μm) even at 1.5T utilizing susceptibility-induced edge broadening at long TE, ultra-low echo spacing sequences with low in-plane but high through-plane resolutions.

**Materials & Methods**

A 2D FSE T2MR sequence with short echo spacings (10-13ms) was used to scan hippocampal structures at 0.5x0.5x2 mm3 spatial resolution for five seizure patients at 3 T and four additional patients at 1.5 T. Also a modified 3D FSE T2 research sequence(GE) with long echo train and ultra-short echo spacing (4 ms) was used at 1.5 T to scan seven normal volunteers at 1x1x1.6±2 mm3 spatial resolution to test the feasibility of resolving low contrast, small structures using low echo spacings and thin slices. Mean contrast-to-noise ratios (CNR) were computed excluding MR visible lesions to evaluate by two readers dentate gyrus and subiculum against adjacent white matter.

**Results**

The dentate gyrus cell layers (DGCL) were visualized in 3D FSE T2 images at 1.5T even with 1 mm in-plane resolution (6 slices, 0.8mm apart, shown below). It also was visualized adequately in 2D FSE T2 images at 0.5x0.5x2 mm3 resolution both at 1.5 T and 3 T. At both field strengths normal hippocampi had similar CNR for dentate gyrus and subiculum (difference < 10%). However, in the affected side(at least one abnormal hippocampal slice) the dentate gyrus, away from visible lesions, had 15-20% higher CNR compared to subiculum.

**Conclusion**

Short echo spacing T2-weighted thin slice 2D or 3D FSE sequences with minimum volume averaging can image small substructures within hippocampus (for example DGCL, even at 1.5T) presumably utilizing susceptibility-induced signal decay in long TE sequences. Quantifiable differences in tissue contrast were observed between dentate gyrus and subiculum for epilepsy patients on the affected side and this contrast characteristics seemed to be similar for both field strengths in spite of higher SNR at 3 T.

**Key Words:** Hippocampus, high resolution, seizure
MR Imaging Features of Histiocytic Brain Tumors in Adults

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PURPOSE
To describe the MR imaging (MRI) features of parenchymal brain tumors during Langerhans cell histiocytosis (LCH), non-LCH: Erdheim-Chester disease (ECD) and Rosai-Dorfman (RD) and Histiocytic Sarcoma (HS) in adults.

MATERIALS & METHODS
Retrospective study of cerebral MRI of 16 patients with histologically proved histiocytosis (7LCH, 5ECD, 1 mixed form HL/EC, 1RD,1HS), with unique or multiple parenchymal brain masses. Conventional and in some cases multimodal MRI features are analyzed. Intracranial and systemic associated lesions are described.

RESULTS
Histiocytic brain tumors show similar MRI patterns. Masses are unique in two patients (12%) and multiple in 14 (88%). Subcortical supra and/or infratentorial (n = 11, 69%) and/or paraventricular (well delineated masses or linear enhancement of the ventricular wall) (n = 10, 63%) and/or brain stem lesions (n = 9, 56%) are associated variously. In three patients (29%), brain stem involvement is isolated. Masses always present with an hyperintense component on T2-weighted images, and often an associated portion with dark signal on T2-weighted images (n = 9, 56%); on diffusion-weighted images performed in five of nine patients, a hyposignal is noted with elevated ADC. Their enhancement is often homogeneous (n = 14, 88%). On MR proton spectroscopy performed in three patients (2HL, 1RD), choline is elevated. On perfusion performed in 1RD, masses are hyperperfused (x4). Four patients (25%) present with neurodegenerative lesions, nine (56%) with pituitary axis involvement. Central nervous system involvement is isolated in two patients (12%).

CONCLUSION
This study demonstrates that these histiocytic brain tumors have some similar MRI features. Histiocytic brain tumors are unusual but some characteristic MRI findings must lead radiologists to evoke the diagnosis and search for associated lesions (maxillo-facial/systemic).

KEY WORDS: Histiocytosis, Erdheim-chester disease, Rosai-Dorfman disease

Pretreatment Apparent Diffusion Coefficient Characteristics within Functional Diffusion Map-Classified Voxels Predicts Survival in Recurrent Glioblastoma Treated with Bevacizumab

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PURPOSE
To assess the ability of graded functional diffusion maps (fDMs) and apparent diffusion coefficient (ADC) characteristics to predict overall survival (OS) in recurrent glioblastoma (GBM) patients treated with bevacizumab.

MATERIALS & METHODS
Seventy-seven patients with recurrent GBMs were examined retrospectively. MR imaging (MRI) scans were obtained before and approximately 6 weeks after treatment with bevacizumab. Graded fDMs were created by registering datasets to each patient’s pretreatment scan, and then performing voxel-wise subtraction between post and pretreatment ADC maps. Voxels were categorized according to the degree of change in ADC within pre-treatment FLAIR and contrast-enhancing regions of interest (ROIs).

RESULTS
The volume of tissue showing decreased ADC within both FLAIR and contrast enhancing regions stratified OS (Log-rank, P < 0.05). Functional diffusion maps applied to contrast-enhancing ROIs more accurately predicted OS compared to fDMs applied to FLAIR ROIs. Graded fDMs (showing voxels with decreased ADC between 0.25 and 0.4 um2/ms) were more predictive of OS than traditional (single threshold) fDMs, and the predictive ability of graded fDMs could be enhanced even further by adding the ADC characteristics from the fDM-classified voxels to the analysis (Log-rank, P < 0.001).

CONCLUSION
These results demonstrate that spatially resolved diffusion-based tumor metrics are a powerful imaging biomarker of survival in patients with recurrent GBM treated with bevacizumab.

KEY WORDS: Functional diffusion map, glioma, bevacizumab
Paper 563 Starting at 2:11 PM, Ending at 2:19 PM

 Associations between MR Imaging and Genomic Features of Glioblastomas

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 PURPOSE

 Identify imaging features of primary glioblastomas that predict genomic features, including mutation status, gene expression, and DNA copy number variations.

 MATERIALS & METHODS

 MR images of 75 glioblastomas from The Cancer Genome Atlas (TCGA) of the National Cancer Institute were each reviewed independently by at least three individuals from a panel of six neuroradiologists. Images were evaluated according to 26 imaging features (VASARI feature set, https://wiki.nci.nih.gov/display/CIP/VASARI). Multireader assessment of each tumor was reduced to a single score for each feature. Genomic data for the tumors were obtained from TCGA’s publicly available information (TCGA, Nature 455:1061, 2008), including mutation status (presence versus absence of a gene mutation) for TP53, PTEN, EGFR, NF1, and IDH1 genes. On the basis of copy number data, subgroups were identified, including tumors with high-level EGFR gene amplification, with high-level PDGFRα amplification, with homozygous deletions of CDKN2A, and with deletions of NF1. Quantitative measurements of gene expression for TP53, PTEN, EGFR, NF1, IDH1, and TGFβ2 also were obtained. Applied statistical tests included Fisher’s exact test, Student’s t-test, and linear correlation.

 RESULTS

 Compared to all the other tumors, TP53 mutant tumors had a decreased mean tumor size (p=0.002), measured as the maximum tumor dimension in the T2-weighted or FLAIR images. A suggestion that EGFR mutation is associated with larger tumor size was identified (p=0.08). However, a comparison of tumors with the TP53 mutation versus tumors with the EGFR mutation demonstrated EGFR mutant tumors were significantly larger than TP53 mutant tumors (p=0.0005). Enhancing pial involvement also was found to be more probable for EGFR mutant tumors (p=0.05). Fisher’s exact test demonstrates an association between enhancing tumor (>5% proportion) and high-level EGFR amplification (p=0.01). The presence of enhancing pial involvement was associated with high-level EGFR amplification (p=0.02). There was a suggestion that having >5% proportion of necrosis is associated with high-level EGFR amplification (p=0.06). Fisher’s exact test demonstrated an association between the presence of CDKN2A homozygous deletion and the identification of an ill-defined nonenhancing tumor margin (p=0.007). The presence of enhancing pial involvement was also associated with the presence of a CDKN2A homozygous deletion (p=0.03). No significant associations with PDGFRα amplification or NF1 deletions were identified. There were suggestions NF1 deletion was associated with the presence of edema (>5% proportion) (p=0.06) and with the presence of nonenhancing tumor (>5% proportion) (p=0.06). A negative correlation between tumor size and IDH1 expression (r=0.33, p=0.006), and a positive correlation between tumor size (largest dimension on the basis of T2-weighted and/or FLAIR images) and EGFR expression (r=0.30, p=0.02) were statistically significant. Student’s t-test demonstrated the mean IDH1 expression in tumors without a significant proportion of enhancement (≤5% of the tumor volume) was less than the mean in tumors with >5% enhancement (p=0.049).

 CONCLUSION

 Multiple significant associations between imaging and genomic features in glioblastomas were identified. In particular, EGFR mutant tumors were significantly larger than TP53 mutant tumors, and were more likely to demonstrate pial involvement. CDKN2A homozygous deletion was associated with an ill-defined nonenhancing tumor margin and pial involvement.

 KEY WORDS: Glioblastoma, gene expression

 Paper 564 Starting at 2:19 PM, Ending at 2:27 PM

 Comparison of Apparent Diffusion Coefficient Diffusion Maps and Cerebral Blood Volume Perfusion Maps in Patients with Newly Diagnosed Glioblastoma: Establishing Order in Heterogeneity

 Radbruch, A. · Lutz, K. · Simon, D. · Wiestler, B. · Bäumer, P. · Stieltjes, B. · Floca, R. · Hartmann, C. · Wick, W. · Bendszus, M. · Heiland, S.

 'University of Heidelberg, Heidelberg, GERMANY, German Cancer Research Center, Heidelberg, GERMANY

 PURPOSE

 Diffusion MRI (DWI) and dynamic-susceptibility-contrast weighted perfusion MRI (DSC) have been proposed to distinguish areas of different malignancy in heterogeneous tumors such as glioblastoma. It is presently unclear if the regions identified by these two different imaging methods are overlapping. The aim of this study was to coregister apparent diffusion coefficient (ADC) and cerebral blood volume (CBV) maps to evaluate, whether or not areas of minimum ADC and maximum CBV are congruent.

 MATERIALS & METHODS

 Diffusion-weighted imaging, DSC and contrast-enhanced T1-weighted imaging was performed in 20 patients with newly diagnosed and histologically proved glioblastoma before surgery on 3 T MR system. Prior to DSC, a contrast agent bolus was injected as preload. Apparent diffusion coefficient and CBV maps were calculated using Siemens Syngo-Software. Afterwards, acquired maps were coregistered on the T1-weighted image, and thresholds of CBV and ADC were visualized using specially developed software based on MeVisLab (Fraunhofer MEVIS, Bremen, Germany). A region of interest was delineated manually on T1-weighted images encompassing the enhancing lesion
including a 1 cm margin. Within this ROI, pixels with ADC < the 30th percentile (minADC), pixels with CBV > the 70th percentile (maxCBV) and the corresponding overlap were calculated automatically and visualized on T1-weighted images. Additionally, two experienced neuroradiologists independently evaluated whether minADC, maxCBV and the overlap were located within the enhancing lesion or within the area surrounding the enhancing lesion.

**RESULTS**

MinADC and maxCBV areas showed an average overlap of 34.7±10.9 percent within the thresholded area. In 14 of 20 patients maxCBV areas were located mostly within the enhancing region whereas minADC areas were located in surrounding area. In six patients there was no significant distribution of minADC and maxCBV areas within the enhancing or the surrounding tissue.

**CONCLUSION**

Our study provides evidence, that diffusion and perfusion imaging visualize different aspects of tumor biology, that do not necessarily overlap spatially. Generally, low ADC values reflect high cellularity whereas high CBV values are consistent with increased vascularity. A possible explanation for the different location of the maxCBV areas located mainly within the enhancing area and minADC areas located within the surrounding tissue could be that migrating tumor cells in the invasion front, represented by areas of low ADC values, produce and secrete neoangiogenic factors, leading to a "trailing behind" of the vascular-rich tumor border, represented by high CBV values. Further studies, especially correlations with biopsies are needed to determine the exact correlation between ADC, CBV values and malignancy.

**KEY WORDS:** Glioblastoma, diffusion, perfusion
**Conclusion**
Contrast-enhanced black-blood imaging is significantly better for detection of small metastatic brain tumors than MP-RAGE.

**Key Words:** Brain, metastatic tumors, black-blood imaging

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**Perfusion-Weighted MR Imaging Derived Relative Cerebral Blood Volume is Predictive of Clinical Outcome in Primary Central Nervous System Lymphoma**

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**Purpose**
Primary central nervous system lymphoma (PCNSL) is a malignant neoplasm of the central nervous system in which only a fraction of those afflicted respond to standard high-dose methotrexate chemotherapy. Methotrexate with concurrent whole brain irradiation is a more aggressive treatment option used after standard treatment fails but is associated with long-term adverse effects. There is interest in identifying noninvasive methods to predict which patients will benefit from standard versus aggressive treatment. There is evidence that diffusion-weighted imaging can be used to differentiate between responding and refractory PCNSL patients prior to initiation of chemotherapy. The purpose of our study was to evaluate whether another physiologic imaging modality, perfusion-weighted MR imaging (PWI), can be used to predict clinical outcome in PCNSL patients receiving chemotherapy.

**Materials & Methods**
The study included 26 patients with previously untreated PCNSL who were treated uniformly with methotrexate-based chemotherapy. The diagnosis was made based on surgical biopsy of contrast-enhancing lesions based on MRI and all 26 had high-grade B-cell lymphomas. The preoperative MRI was used for quantitative analysis of anatomical MRI and dynamic susceptibility-weighted contrast-enhanced (DSC) PWI. Regions of interest were placed in all enhancing lesions and PWI variables were measured within the areas of enhancement. Average, minimum, and maximum lesion relative cerebral blood volume (rCBV) values of enhancing areas were normalized to a 50-mm2 region of interest drawn around the contralateral normal-appearing white matter in the same transaxial plane. The resulting T2* signal-intensity time curves produced rCBV, relative time to minimum (rTTM), relative mean time to enhance (rMTE), relative maximum slope of decrease (rMSD), relative maximum slope of increase (rMSI), relative percentage signal recover (rPSR), and relative peak height (rPH) for each examination. High and low groups of PWI values were stratified by the median value of the cohort. The Welch t test assessed differences between the groups. Survival analysis at 2 years and 5 years was performed.

**Results**
Overall survival analysis demonstrated that patients with worse clinical outcomes were noted to have a significant decrease in rCBV minimum, rCBV mean, and rTTM minimum (p=0.0397, p=0.0819 and p=0.0522 respectively for 2-year overall survival, and p=0.0155, p=0.0342, p=0.0241 respectively for 5-year overall survival). Progression-free survival analysis at 2 and 5 years was the same with significant decrease in rCBV minimum, rCBV mean and rTTM minimum (p=0.0095, p=0.0255 and p=0.0191 respectively) for patients with worse clinical outcome. Other variables measured (rPH, rPSR, rMSD, rMSI, rMTE) were not significant.

**Conclusion**
Our study suggests that rCBV derived from DSC perfusion MRI may potentially predict clinical outcome in patients with PCNSL undergoing methotrexate-based chemotherapy. We found that the lower the rCBV of the initial untreated tumor, the shorter the overall survival. We postulate that this poor outcome in patients with PCNSL that had lower rCBV may in part be due to impaired delivery of intravenous chemotherapy in tumors with lower vascular density. Future studies will include direct correlation between PWI and histopathology to determine whether rCBV is a reliable biomarker of tumor vascularity in PCNSL.

**Key Words:** Primary central nervous system lymphoma, relative cerebral blood volume
Thursday Afternoon
1:15 PM - 2:45 PM
Room 611 - 612

(47d) Pediatrics: New Techniques
(DTI, SWI, MRS, fMRI)
(Scientific Papers 567 - 577)

See also Parallel Session
(47a) Brain: Neoplasms II, Glioma Grading and Outcomes
(47b) Infectious Diseases/Metabolic Diseases
(47c) Epilepsy, Brain Neoplasms
(47e) Research Grant Writing Session - Part II

Moderator: Marvin D. Nelson, MD

Paper 567 Starting at 1:15 PM, Ending at 1:23 PM
Characterizing the X-Linked Leukodystrophy Pelizaeus Merzbacher Disease Using Diffusion Tensor Imaging

Laukka, J. J.1; Makki, M. 2; Kamholz, J. Y. 3; Garbern, J. Y. 4
1Michigan State University, East Lansing, MI, 2Wayne State University, Detroit, MI, 3University Childrens Hospital of Zurich, Zurich, SWITZERLAND, 4University of Rochester Medical Center, Rochester, NY

PURPOSE
To use diffusion tensor imaging to assess the effects of PLP1 mutations on water diffusion in central nervous system (CNS) white matter to understand the pathogenesis of Pelizaeus Merzbacher disease (PMD).

MATERIALS & METHODS
Twelve PMD patients with a range of PLP1 mutations ranging from mild to severe were analyzed by diffusion tensor imaging and compared to 12 age-matched control subjects. The axial (\(\lambda_{\perp}\)) and parallel (\(\lambda_{//}\)) diffusivities, apparent diffusion coefficient and fractional anisotropy were measured through six white matter structures that include the internal capsule (anterior and posterior limb), corpus callosum (genu and splenium), cerebral peduncles, and pons.

RESULTS
The most dramatic difference between PMD patients and age-matched controls was increased \(\lambda_{\perp}\), most marked in both limbs of the internal capsule, cerebral peduncles and the corpus callosum in PMD patients with severe PLP1 mutations and null mutations. Increased radial diffusion has been reported in dysmyelinating rodents, including the myelin synthesis deficient rat (\(md\)) that has a severe PLP1 missense mutation. Interestingly, \(\lambda_{//}\) was mildly increased in the severely affected patients and the PLP1 null mutations were relatively unaffected relative to controls.

CONCLUSION
Since the degree of myelination is relatively preserved in PLP1 null myelin, the increased radial diffusion is not the result of thinner myelin sheaths, but demonstrates a radial component due to the relaxed diffusional barriers imposed by PLP. Therefore the increased radial diffusion is more likely due to increased myelin water, due to decreased myelin compaction, described in Plp1 null mice, created by aqueous channels that span the myelin sheath. Additional factors, such as astrocytosis, also may contribute to the increased radial diffusion, but more likely to play a prominent role in \(\lambda_{//}\) in severe PLP1 mutations.

KEY WORDS: Pelizaeus Merzbacher disease, leukodystrophy, proteolipid protein

Paper 568 Starting at 1:23 PM, Ending at 1:31 PM
Pediatric Cervical Spinal Cord Diffusion Tensor Imaging in Normals and Patients with Spinal Cord Injury

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PURPOSE
The purpose of this study was to (a) evaluate the clinical utility of diffusion tensor imaging (DTI) in children using a newly developed inner-field-of-view (iFoV) sequence with spatially selective 2D RF excitations, (b) examine reproducibility of the DTI measures and (c) investigate DTI parameters in children with and without spinal cord injury (SCI).

MATERIALS & METHODS
Ten controls (mean age=16.1 years) without evidence of SC pathology and 10 patients (mean age=13.2 years) with chronic cervical cord SCI were recruited. Subjects and their parents provided IRB-approved informed assent and consent. The iFoV sequence was implemented on a 3.0 T Siemens Verio MR scanner and optimized to obtain various scanning parameters for imaging the pediatric SC. High-resolution axial DTI images were acquired to cover the cervical SC (C1-C7). The DTI parameters included: 20 directions, b=1000s/mm\(^2\), voxel size=1.2x1.2x3mm\(^3\), axial slices=35-45 (depending on subject’s height), TR=6100-8000ms, TE=115ms, averages=3 and TA=7min. Conventional T1- and T2-weighted scans also were obtained. Anesthesia was not administered. To test for reproducibility of the DTI measures, all subjects returned within 2 to 9 hours for a second scan. Initially motion correction of the DTI images was performed using the automated-image-registration algorithm. Next, tensor estimation was done using MedINRIA.
software. The following DTI indices were extracted from RoIs drawn at every axial slice location along the SC for both the 1st and 2nd scans: Fractional anisotropy (FA), mean diffusivity (MD), transverse diffusivity (TD) and longitudinal diffusivity (LD). These RoIs were carefully drawn so that there was a consistent sparring of the outer margin of the cervical cord that represented approximately one voxel width to minimize volume averaging with the CSF. The DTI imaging indices were reported at each disk level of the cervical SC as well as upper, middle and lower portions of the cervical vertebral body. The 10 patients with SCI represented a spectrum of cervical injuries ranging from C1 to C6 levels. Statistical analysis was performed to compare averaged DTI indices between the controls and the subjects with SCI and to test for reproducibility of the DTI measures.

RESULTS

The images obtained with the iFoV sequence produced reliable DTI data with reduced eddy current distortions and good delineation of gray white matter structures. The controls showed an average FA=0.54 0.08, MD=0.60x10^-3mm^2/s 0.17x10^-3, TD=1.00x10^-3mm^2/s 0.29x10^-3 and LD=0.40x10^-3mm^2/s 0.12x10^-3. The SCI subjects showed an average FA=0.30 0.12, MD=0.87x10^-3mm^2/s 0.45x10^-3, TD=1.07x10^-3mm^2/s 0.46x10^-3, and LD=0.73x10^-3mm^2/s 0.45x10^-3. Statistically significant differences were seen between the controls' averaged FA (p<0.0001) and LD (p<0.01) values compared to the patients'. Subjects with SCI showed reduced FA and increased LD compared to the controls. However, no statistical differences were seen in MD (p=0.09) and TD (p=0.73). Test-retest reproducibility showed an interclass correlation (ICC) of (>0.9) in both groups for all DTI parameters.

CONCLUSION

The DTI measurements in the pediatric population were obtained using a newly developed and optimized iFoV sequence. The differences in diffusion metrics between normal and patients with SCI were demonstrated. Reduced FA and increased LD were seen in patients with SCI in comparison with controls. Test-retest showed excellent reproducibility.

KEY WORDS: Diffusion tensor imaging, pediatric, reduced FOV

In Utero Tractography of Fetal Association Fiber Tracts

Mitter, C. S. • Brugger, P. C. • Schöpf, V. • Prayer, D. • Kasprian, G.

Medical University of Vienna
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PURPOSE

Association fiber tracts connect different cortical areas in the same hemisphere and therefore constitute an important anatomical substrate for a diverse range of higher cognitive functions. Association fibers have been investigated extensively in adult and pediatric subjects as well as in post-mortem samples of fetal brains but so far their development and 3D morphology has not been visualized and character-ized successfully in the living human fetus. We used diffusion tensor imaging (DTI) to visualize major association fiber pathways in living unsedated fetuses in utero.

MATERIALS & METHODS

Orthogonal axial diffusion tensor sequences (16 directions, reconstructed voxel size 0.94mmx0.94mmx3mm, b values of 0s/mm^2 and 700s/mm^2) of eight normal fetuses between gestational weeks (GW) 20-34 were performed using a 1.5 T superconducting MR unit. Color-coded fractional anisotropy (FA) maps were geometrically coregistered with multiplanar T2-weighted MR sequences. Main cortico-cortical association tracts were defined anatomically using a multiple ROI approach and calculated using a FACT algorithm (Philips Extended MR WorkSpace 2.6.3.2).

RESULTS

The uncinate fasciculus connecting the anterior temporal lobe and frontal lobe was visualized consistently in all eight subjects. The inferior fronto-occipital fasciculus originating in the frontal lobe and continuing posterior to the temporal lobe and sagittal stratum also was found in all eight subjects. In three cases fibers connecting the occipital lobe with the anterior temporal lobe inferior and lateral to the inferior fronto-occipital fasciculus were identified as the inferior longitudinal fasciculus. Cross-sectional comparison between different GWs showed an increase in the complexity, as well as developmental changes in the 3D morphology of developing association fiber tracts.

CONCLUSION

This study initially demonstrates the potential of DTI-based tractography to visualize major association fiber tracts previously described in the adult and post-mortem literature in living unsedated fetuses in utero as early as 20 GW. The ability to assess association fibers and their diffusion characteristics may provide important insights into the neurodevelopmental sequelae of intrauterine white matter damage on postnatal cognitive and behavioral outcomes.
**KEY WORDS:** Tractography, diffusion tensor imaging, fetal

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**Paper 570 Starting at 1:39 PM, Ending at 1:47 PM**

**White Matter Development during Childhood and Adolescence Assessed with ^1H MRSI and Diffusion Tensor Imaging**

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**PURPOSE**

In developing white matter, diffusion tensor imaging (DTI) can provide information on white matter integrity while ^1H MRS can measure concentrations of important neurochemicals. A comparison of these techniques may help to interpret findings in healthy children and patients diagnosed with white matter pathologies. The aim of our study was to apply DTI and high-resolution multiecho ^1H MRSI in a group of healthy children and adolescents to compare specific measures of white matter microstructure and metabolism.

**MATERIALS & METHODS**

Thirty-seven healthy children and adolescents, mean ages 12.1 years (range 5.5 - 17.6 years, 20 boys) were examined at 1.5 T with DTI and ^1H MRSI. Fractional anisotropy (FA), apparent diffusion coefficient (ADC), axial diffusivity (AD) and radial diffusivities (RD, mean value) were calculated in the cerebral peduncles, temporal white matter (WM), temporo-occipital WM, frontal WM, corona radiata, splenium and genu of the corpus callosum. Metabolite concentrations were expressed as choline (Cho)/creatine (Cr) and N-acetylaspartate (NAA)/Cr ratios, calculated in corresponding white matter regions. Linear mixed effects models (LME) analyses were used to evaluate age-, sex-, and hemisphere-related differences in the measured DTI and MRSI parameters. Linear regression analyses were employed to compare the DTI and MRSI parameters.

**RESULTS**

Linear mixed effects models analyses indicated a significant effect of age on all examined parameters (age: p<0.05 or interaction term age x region: p<0.05). However, the DTI analyses provided results of higher statistical significance than MRSI analyses. Linear regression analyses (including all available data) detected positive correlations between the NAA/Cr ratio and FA (Figure; r=0.126, p=0.009), AD (r=0.126, p=0.009), and RD (r=0.096, p=0.048). No correlations between Cho/Cr and any of the DTI parameters were detected. Linear mixed effects models analyses of DTI data indicated hemispheric differences (for all examined parameters except FA); no overall differences in metabolite ratios between hemispheres were detected by MRSI. No differences between boys and girls were detected.

**CONCLUSION**

The significant relationship between NAA/Cr and FA detected in our study is consistent with the current interpretation of NAA as a marker of tissue integrity and function. Our data also suggest that DTI may measure age-related differences in tissue integrity with a higher sensitivity than ^1H MRSI can assess changes in white matter metabolism. The lack of a correlation between the Cho/Cr ratio and DTI suggests that Cho/Cr provides metabolic information that is not associated directly with white matter organization.

**KEY WORDS:** DTI, MR spectroscopy, white matter

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**Paper 571 Starting at 1:47 PM, Ending at 1:55 PM**

**In Utero Tractography of Fetal Periventricular Crossroad Regions**

Mitter, C. S.¹ • Kasprian, G.¹ • Brugger, P. C.¹ • Schöpf, V.¹ • Kostovic, I.² • Prayer, D.¹

¹Medical University of Vienna, Vienna, AUSTRIA, ²University of Zagreb School of Medicine, Zagreb, CROATIA

**PURPOSE**

Various fetal brain abnormalities are associated with MR signal alterations of periventricular crossroad regions. Periventricular white matter (WM) areas contain complex intersections of thalamocortical, corticopontine/corticospinal, callosal and cortico-cortical association fiber tracts as well as external capsule fibers. We used DTI to segment and characterize individual fiber tracts of the parietal crossroad region in living unsedated fetuses in utero. We aimed at characterizing the 3D morphology and topographic relations of individual components as well as developmental differences across different gestational ages.
Materials & Methods
Seven normal fetuses between gestational week (GW) 20-34 were examined in a 1.5 T MR scanner using an axial diffusion tensor sequence (16 encoding directions, reconstructed voxel size 0.94mmx0.94mmx3mm, b values 0s/mm² and 700s/mm²). After coregistration with a T2-weighted image, specific fiber tracts of the parietal crossroad region were defined following the available post-mortem data, using a multiple ROI approach and calculated using a FACT algorithm (Philips Extended MR WorkSpace 2.6.3.2).

Results
Thalamocortical, corticopontine/corticospinal, external capsule and association fiber tracts were identified depending on their position, morphology and course as early as GW 20 and showed a laminar organization with sagittally oriented strata. Fiber tract components of the internal capsule that continued into the cerebral peduncles were identified as corticopontine/corticospinal fibers, while internal capsule fibers that turned medially into the thalamic region were identified as thalamocortical fibers. External capsule fibers and association fiber tracts also were found to be part of the parietal crossroad region and were located lateral to corticopontine/corticospinal and thalamocortical fibers.

Figure: Fetal periventricular crossroads at 27 GW. Thalamic radiation (dark gray), corticopontine/corticospinal fibers (light gray) and external capsule fibers (white) are arranged as sagittally oriented strata.

Conclusion
In utero tractography allows for 3D visualization and noninvasive in vivo detection of the main anatomical components of the posterior parietal crossroad region in unsedated fetuses as early as 20 GW. Due to the crucial functional importance of this specific WM region in the developing fetal brain, these results may serve as a basis for a more sensitive detection of acquired and/or malformative brain lesions and may help to further specify their postnatal sensorimotor as well as cognitive outcome.

Key Words: Tractography, diffusion tensor imaging, fetal

Purpose
Diffusion tensor imaging (DTI) of the spinal cord is shown recently to be feasible and could be of diagnostic value in diseases affecting the spinal cord. The majority of these studies are undergone in adults and focus on cervical spinal cord with limited comparison to normal cervical and thoracic spinal cord data. The goals of this study were 1) to evaluate the age-dependent evolution of the apparent diffusion coefficient (ADC) and fractional anisotropy (FA) values of the normal pediatric cervical and upper thoracic cord, 2) to evaluate whether there are differences of ADC and FA values between upper cervical (UC; C1-C4), lower cervical (LC; C4-C7) and upper thoracic (LT; T1-T4) levels.

Materials & Methods
A total of 56 children aged < 18 years with normal MRI studies of spinal cords, and without a history of spinal cord injury or systemic central nervous disease, were reviewed retrospectively. The DTI sequences of the spinal cord obtained from 1.5 T MR scanner were postprocessed to reconstruct the DWI, ADC, FA and color-coded FA maps. Automatic three-dimensional regions of interest (ROIs) were placed manually at the center of the cervical and upper thoracic cord at each vertebral level on a sagittal image. The ADC and FA values including the standard deviation (SD) were recorded and used to evaluate their relationship with age, gender and differences between three spinal levels (UC, LC, UT).

Results
The 56 pediatric subjects (26 males and 30 females) range in age from 2 months to 17 years with a mean age of 68.5 months (SD 59.1 months). Fractional anisotropy and ADC show statistically significant relationships with age for most of the 12 ROIs, increasing and decreasing, respectively. For ADC, a comparison of means between the three levels show statistical differences between the ROIs in the UC (989 10⁻⁶mm²/sec) and UT (885 10⁻⁶mm²/sec) (p < 0.001), and between the LC (954 10⁻⁶mm²/sec) and UT (885 10⁻⁶mm²/sec) (p =0.001). No differences were found between the levels for FA.

Conclusion
We showed that with increasing age (from neonatal period to adolescence), ADC values have a significantly decreasing trend while the FA values have a significantly increasing trend within the cervical and upper thoracic spinal cord. Our normative data will serve as an age-matched control group to quantify the changes in various childhood diseases affecting the spinal cord. We also showed that there are differences in ADC between UC, LC and UT in decreasing order across the age groups; therefore matching both the age and the spinal cord levels in comparing ADC values between normal and abnormal spinal cord is important in children.
**KEY WORDS:** Pediatric, spinal cord, diffusion tensor imaging

**Paper 573 Starting at 2:03 PM, Ending at 2:11 PM**

**Prospective Study of Multiregion, Serial Diffusion Tensor Imaging Measurements Performed at 3.0 T before and after Hematopoietic Cell Transplantation, with Clinical Correlation**

McKinney, A. M. • Nascone, D. • Loes, D. J. • Eisengart, J. B. • Zhang, L. • Tolar, J. • Sarikaya, B. • Orchard, P. • Provenzale, J. M.

'University of Minnesota & Hennepin County Medical Centers, Minneapolis, MN, 'Emory and Duke University Medical Centers, Atlanta, GA & Raleigh, NC, NC

**PURPOSE**

Preliminary studies of posterior-type X-linked adrenoleukodystrophy (ALD) have shown significantly different diffusion tensor imaging (DTI) fractional anisotropy (FA) and mean ADC (MADC) values in affected regions versus normal-appearing frontal white matter (NAFWM); NAFWM is variably different from controls. However, DTI has yet to be utilized serially on a tract-by-tract basis after treatment. Thus, our goal was to perform serial measurements in multiple sites pre and posthematopoietic cell transplantation (HCT), and to correlate them with MRI severity (Loes score) and clinical outcome.

**MATERIALS & METHODS**

Since 2007, our standard 3.0 T MRI protocol in evaluation for HCT of ALD patients has included 3.0 T 12-directional DTI, FLAIR, T2-weighted imaging, and pre/postcontrast 3D MPRAGE T1-weighted imaging, performed at time points <60 days prior to HCT (T0), 30-60 days post-HCT (T1), 90-120 days (T2), 180 days (T3), and at one year (T4). During that time, eight patients were transplanted who underwent such serial imaging. After IRB approval, a staff neuroradiologist serially measured FA and MADC in 19 regions, comparing them to eight control patients. Two other staff neuroradiologists recorded Loes scores. Four clinical scores were measured at T0 and T4: Verbal IQ (VIQ), Visual-Perceptual IQ (PIQ), and Adaptive Function (AF). Thereafter, MADC and FA were correlated with the Loes scores and clinical scores.

**RESULTS**

For NAFWM, MADC was not significantly different in patients versus controls at most time points (p>0.05); FA was significantly different at 3 points (p<0.05). Fractional anisotropy was significantly different from controls at each time within the cerebellar white matter (CWM), lateral geniculate, Meyer’s loop, optic radiations (OR), parietoocipital white matter (POWM), and callosal splenium (SPLCC); MADC was significantly different at most times within the CWM, POWM, and SPLCC (each p<0.05). Interestingly, anterior temporal white matter (ATWM) FA was significantly different from controls at T0 (p<0.05), but not at T4 (p=0.133), possibly a treatment response. Regarding Loes scores, MADC in the OR and POWM had the strongest correlations (r=-0.699-0.762, p<0.05) with Loes scores at T0 and T4, but with insignificant correlations at intermediate times (each p>0.05). OR FA had a strong negative correlation (r=-0.721-0.905) at each point; posterior or limb (PLIC, r=-0.786), POWM (r=-0.862), and SPLCC (r=-0.905) correlated only at T4 (each p<0.05). Regarding clinical scores, significant correlations existed between VIQ and: FA in the callosal genu (r=-0.852, p=0.031), PLIC (r=0.897, p=0.015), and optic tracts (p=0.043), and with MADC within the callosal body (BCC, r=-0.921, p=0.009) and NAWM (r=0.850, p=0.032). PIQ significantly correlated only with the superior cerebellar peduncle decussation (r=-0.804, p=0.029). AF significantly correlated with MADC in the OR (r=0.787, p=0.036) and PLIC (r=0.764, p=0.046), and with FA within the BCC (r=0.860, p=0.013) and trapezoid body (r=-0.814, p=0.026). Overall, six patients stabilized, and 2 progressively worsened.

**CONCLUSION**

We noted several important findings, one being that FA is typically abnormal in CWM and NAFWM, structures which usually appear normal. Also, improving FA within ATWM could relate to treatment response. DTI values in HCT are dynamic. However, values within areas at the disease’s edge (such as PLIC and BCC) may serially correlate with clinical scores.

**KEY WORDS:** Adrenoleukodystrophy, diffusion tensor imaging, hematopoietic cell transplantation

**Paper 574 Starting at 2:11 PM, Ending at 2:19 PM**

**DTI Analysis in Complex I Mitochondrial Disease without T2 abnormality**

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**PURPOSE**

Magnetic resonance imaging (MRI) and proton magnetic resonance spectroscopy (MRS) play an important role in the workup of mitochondrial disease (MD). Mitochondrial disease secondary to complex I dysfunction results from one of several different mitochondrial or nuclear defects. Patients with complex I disease commonly have been included under the spectrum of Leigh syndrome, presenting with lesions in basal ganglia, cerebellum, and brainstem and often are accompanied by high levels of brain lactate. We reviewed diffusion tensor imaging (DTI) findings in a group of children with complex I disease who did not demonstrate classic MRI or MRS findings of Leigh syndrome.

**MATERIALS & METHODS**

IRB-approved retrospective review: evaluation of MRIs, including DTI, in nine patients with complex I disease (confirmed with muscle biopsy) without characteristic Leigh imaging features on MRI or evidence of lactate on MRS and nine age- and gender-matched controls (5 female, 4 male; aged 1 - 13 years). Controls and patients were sampled within 6 months to minimize any impact of scanner fluctuation. Diffusion tensor imaging data including fractional anisotropy (FA) and apparent diffusion coefficient (ADC) maps were generated. Regions of interest (ROIs) were drawn
on the TRACE image, including cerebellum, white and gray matter, caudate nucleus, putamen, and thalamus. Regions of interest then were imported to FA and ADC images. Average values for each of the ROIs then were tabulated, with paired t-test comparisons completed between each patient and matched control performed in SPSS version 15.

**RESULTS**

The FA values in the caudate nucleus were significantly lower in MD patients than in matched controls (average MD FA = 0.17, s.d. = 0.03; controls FA = 0.22, s.d. = 0.02, p<0.001). In the other regions measured, FA did not vary significantly between patients and controls. The ADC values in the thalamus (average MD ADC = 0.81, s.d. = 0.03; controls ADC = 0.77, s.d. = 0.04, p<0.05) and white matter were higher in mitochondrial disease patients than in their matched controls (average MD ADC = 0.94, s.d. = 0.10; controls ADC = 0.86, s.d. = 0.08, p<0.05). Apparent diffusion coefficient results did not remain statistically significant after multiple comparison correction.

**CONCLUSION**

Diminished FA in otherwise normal-appearing caudate nuclei of patients with complex I mitochondrial disease suggest underlying altered structure in an area known to have high metabolic demands often impacted by complex I disease. These findings may foreshadow lesion development commonly seen in basal ganglia in many patients with complex I disease. Further work to evaluate the potential diagnostic utility of these changes and role in following disease progression will be useful to explore.

**KEY WORDS:** Diffusion imaging, mitochondrial disease, fractional anisotropy

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**Paper 575 Starting at 2:19 PM, Ending at 2:27 PM**

**Resting-State Functional MR Imaging of the Fetal Brain**

Schöpf, V. • Kasprian, G. • Mitter, C. • Brugger, P. C. • Prayer, D.

Medical University Vienna

Vienna, AUSTRIA

**PURPOSE**

The evolution of resting-state networks and the development of connectivity recently have been studied in premature infants (<41 GW) and older children (9-12 years) (for a review see Power, et al, 2010). While it has been proposed that the neuronal mechanisms underlying these activity networks evolve in utero and are supposed to be strongly connected to gestational age, this aspect has not been investigated yet. In this study, we aimed to demonstrate the feasibility of studying spontaneous resting-state activity of the fetal brain. Functional connectivity analyses allowing the characterization of interregional neural interactions during spontaneous activity during rest was used to study those underlying mechanisms. Furthermore, we proposed at describing subplate specific activity patterns and interactions with subcortical structures for different developmental stages.

**Materials & Methods**

Functional images of 10 fetuses with morphologically normal brain development, aged from gestational week (GW) 20-39, were acquired on a 1.5 T Philips Intera MR scanner using single-shot gradient-recalled echo-planar imaging. Between 10 and 15 axial slices (5 mm thickness) with a matrix size of 144 x 144, FOV of 250 x 250 mm and TE/TR of 50/1000 ms and a flip angle of 90°. Image pre-processing was performed with SPM8 (http://www.fil.ion.ucl.ac.uk/spm/) including motion correction. Brains were extracted as implemented in BET (brain extraction tool) version 2.1, as implemented in FSL (FMRIB’s Software Library, www.fmrib.ox.ac.uk/fsl). Data sets were inspected for “jerk-like” head movements, in which the fetal brain moved out of its original position and returning in space to its previous position after a few seconds. As realignment algorithms are not able to cope with “out-of-slice” movements affected image volumes were removed from the data sets and the remaining volumes were treated as one continuous data set. Postprocessing was performed using functional connectivity analysis implemented in Matlab (Matlab 7.8.0, Release 2009a, Mathworks Inc., Sherborn, MA, USA). Correlation maps were converted to z values by Fisher’s r-to-z transformation to enable parametric statistical comparison. Seed voxels were positioned by an experienced neuroradiologist.

**RESULTS**

Bilateral resting-state activity could be proved in cortical frontal, occipital, and temporal regions. Throughout the whole group subplate temporal, frontal and occipital seed regions could be proved to evoke bilateral activity patterns situated in corresponding subplate regions. Furthermore, temporal, frontal and occipital subplate regions showed high and consistent correlations with thalamic regions. We were able to categorize cortical activity projections for cortical seed regions into projections before and after GW 26.

**CONCLUSION**

We were able to show that resting-state measurements are possible in utero and can be analyzed by means of functional connectivity analysis. Resting-state measurements in the fetus may therefore allow for development of brain activity monitoring and provide important impact on the understanding of neuronal processes.

**KEY WORDS:** fetal fMRI, resting-state

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**Paper 576 Starting at 2:27 PM, Ending at 2:35 PM**

**Susceptibility-Weighted Imaging Postprocessing to Enhance Clinical Utility of Conventional 2D Gradient Echo in Pediatric Neuroimaging**

Soman, S. • Holdsworth, S. • Barnes, P. D. • Bammer, R. • Yeom, K.

Stanford University

Stanford, CA

**PURPOSE**

Susceptibility-weighted imaging (SWI) utilizes a high-resolution 3D gradient echo (GRE) acquisition together with phase postprocessing to accentuate the paramagnetic properties of blood products. Long scan time of 3D GRE (up to 10 mins) limits its utility. Our goal was to evaluate clinical
application of SWI phase and magnitude processing normally reserved for 3D GRE images to conventional 2D GRE with a shorter scan time (2.5 min).

**Materials & Methods**
Susceptibility-weighted imaging processing (SWIP) and phase unwrapping were performed on routine 2D GRE data of 50 consecutive pediatric brain MRI at 3 T resulting in: SWIP 2D GRE (2D SWI), SWIP 2D GRE minimum intensity projection (MinIP), 2D GRE phase unwrapped (GPU), and 2D GPU MinIP series. Two neuroradiologists compared these SWI-processed data against conventional 2D GRE.

**Results**
As compared to 2D GRE, 2D SWI showed new lesions in 18/50 cases. Lesions were more conspicuous on SWIP MinIP vs 2D GRE MinIP in 43/50 cases. However, lesions were less conspicuous in 23/50 cases on SWIP MinIP vs 2D SWI. In nine cases, GPU images distinguished calcium from hemosiderin (confirmed by CT). Detection of venous thromboses was more challenging on 2D SWI due to enhanced visualization of all venous structures (thrombosed and non-thrombosed). Catheter lumen and their drainage holes also were more conspicuous on 2D SWI, especially on phase images. Susceptibility-weighted imaging processing worsened metal and motion artifacts.

![Figure 1: More conspicuous blood products seen on SWI processed 2D GRE image (arrow)](image1)

**Conclusion**
Susceptibility-weighted imaging processing technique applied to 2D GRE images increased iron sensitivity with no additional scan time. The phase images distinguished calcium from hemosiderin. Limitations included: (1) obscuration of focal venous pathology with increased delineation of all venous structures, (2) worsened metal artifact, and (3) imprecise anatomical localization with MinIP. However, SWIP showed new lesions or increased sensitivity of the lesions in >50% of cases, which suggests this technique may be useful where long scan times of 3D SWI are difficult to implement.

**Key Words:** 2D gradient echo, susceptibility-weighted imaging, paramagnetic imaging

**Paper 577 Starting at 2:35 PM, Ending at 2:43 PM**

**Mitochondrial Disease Complex I Dysfunction without Basal Ganglia Lesions: MR Imaging and Spectroscopy**

Ishak, G. • Poliachik, S. L. • Friedman, S. D. • Saneto, R. P. • Shaw, D. W.
Seattle Children's Hospital
Seattle, WA

**Purpose**
Mitochondrial diseases (MD) are heterogeneous disorders resulting from mutations in nuclear or mitochondrial DNA. Those with MD secondary to complex I dysfunction often have been diagnosed with Leigh syndrome, typified by magnetic resonance imaging (MRI) findings of bilateral basal ganglia and/or brainstem lesions and proton magnetic resonance spectroscopy (MRS) lactate elevations. We reviewed a consecutive series of 15 patients diagnosed with complex I dysfunction to elucidate the spectrum of MRI and MRS findings.

**Materials & Methods**
IRB-approved retrospective review: 15 patients with complex I MD diagnosed by muscle biopsy (Bernier et al., 2002) were included in the study (7 female, 8 male; aged 1 - 13 years; mean 7 years). Patients received MRI brain scans (1.5 T or 3 T), including T2-weighted and FLAIR imaging sequences. Twelve of 15 underwent multivoxel magnetic resonance spectroscopy (MRS) through the level of the basal ganglia; PRESS TR = 1500, TE 30 and TE 135 or 288. Review of the MRI brain scans noted T2 abnormalities, while MRS was reviewed for presence of lactate.

**Results**
Of 15 patients, only 2/15 (aged 3 and 13 years) showed slightly elevated T2 intensity in the globus pallidus, posterior putamen or posterior midbrain. The remainder of the patients showed no sign of basal ganglia or brain stem lesions. Other findings included mild periventricular and subcortical white matter T2 and FLAIR hyperintensity (4), cerebellar atrophy (2), dysmyelination (2), and mild diffuse cerebral volume loss (3). Four of 15 patients had normal MRI outcomes. Only 3/12 undergoing MRS had measurable lactate: in lenticular nuclei (1), in the ventricles (1), and in the ventricles, basal ganglia and caudate nucleus (1). None of 12 patients with measurable lactate had basal ganglia lesions.

**Conclusion**
Though patients with complex I gene mutations often are diagnosed as having Leigh syndrome, commonly with bilateral and symmetric brainstem or basal ganglia lesions (Lebre 2010), most of these patients die in the first year of life (Distelmaier, et al, 2009). However, our patients are an older subset of the complex I disorder (average age 7 years) and...
this may be the reason behind our finding in a minority of complex I patients who do not have the typical imaging features of Leigh syndrome, despite the commonality of end enzyme deficits involved. Our study suggests complex I disease can present as a range of MRI and MRS findings with distinct gene mutations likely differentiating this group from those having Leigh syndrome.

**KEY WORDS:** Mitochondrial disease, basal ganglia lesion, spectroscopy

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### Thursday Afternoon

**1:15 PM - 2:45 PM**

**Room 602-603-604**

(47e) Research Grant Writing Session - Part II

Research Grant Writing - Part II
— Eileen W. Bradley, D.Sc

See also Parallel Session
(47a) Brain: Neoplasms II, Glioma Grading and Outcomes
(47b) Infectious Diseases/Metabolic Diseases
(47c) Epilepsy, Brain Neoplasms
(47d) Pediatrics, New Techniques (DTI, SWI, MRS, fMRI)

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### Evaluation of “Brachial Plexopathy”: Review of Anatomy, Pathology and “Best Practices”

**Mauricio Castillo, MD, FACR**

**Learning Objectives**

Upon completion of this presentation, participants will be able to:
1. Understand the many different ways to image the brachial plexus (BP) and protocols must be adapted to your clinicians needs.
2. Review the basic anatomy of the BP.
3. Review common traumatic, neoplastic and inflammatory lesions of the BP.

**Presentation Summary**

In this lecture we will review the following aspects for brachial plexus (BP) imaging: techniques and anatomy, trauma, tumors, and inflammation. Techniques: Protocols used at our University including those employing large and small fields of view will be provided. I also will briefly review MR neurography, DWI, and DTI of the BP although these techniques are mostly experimental and not reimbursed by insurance companies. The anatomy includes a review of the boundaries between roots, trunks, divisions, cords and branches as well as their surgical anatomy correlates (supra-and infra-clavicular). Examples of traumatic burning (stretch) injuries, avulsions, hematomas, pseudoaneurysms and what NIH is doing for New Investigators. There will be plenty of time for questions - so think up some difficult ones!!!!
Evaluation of "Horner's Syndrome": Review of Anatomy, Pathology and "Best Practices"

Deborah L. Reede, MD

PRESENTATION SUMMARY
Horner's syndrome (HS) occurs when there is interruption of the oculosympathetic pathway. The clinical symptoms may cause little if any functional impairment in most patients. Both benign and malignant disease processes are associated with HS; therefore, a thorough clinical evaluation is required. This presentation reviews the anatomy of the OSP and clinical findings associated with lesions along this pathway. Pathologies associated with HS at various levels of the OSP, classified as preganglionic HS (first and second order neuron HS) or postganglionic HS (third order neuron HS) are demonstrated. Once a lesion is localized clinically with a combination of physical examination and pharmacologic testing, the radiologic examination can be tailored appropriately. Cross-sectional imaging algorithms are presented for each potential level of involvement.

REFERENCES

Evaluation of “Tinnitus”: Review of Anatomy, Pathology and “Best Practices”

C. Douglas Phillips, MD, FACR

PRESENTATION SUMMARY
Tinnitus is a clinical problem with a wide range of potential pathology, as well as a high potential for a lack of imaging findings, even on a carefully directed imaging search. The purpose of this talk is to discuss the clinical problem of tinnitus, and to discuss the evidence-based approach to recommending imaging studies to evaluate these patients. Common pathology resulting in tinnitus will be discussed and the imaging findings reviewed. Hopefully, the attendee will gain some knowledge of the clinical problem of tinnitus and be able to serve as a more useful clinical consultant to manage this difficult issue.

Thursday Afternoon
3:15 PM - 4:45 PM
Ballroom 6 B/C

(49) ASPNR Programming: Phakomatoses Update 2011 (SAM* Session - #6) (AR)

(583) Clinical Features, Testing and Targeted Molecular Therapies in the Phakomatoses
— Bruce Korf, MD, PhD
(584) Neuroimaging Evaluation in NF1
— Tina Young Poussaint, MD
(585) Neuroimaging Evaluation of NF2, TS, vHL
— James G. Smirniotopoulos, MD

Moderator: Dennis Shaw, MD

*Qualified by the American Board of Radiology in meeting the criteria for self-assessment toward the purpose of fulfilling requirements in the ABR Maintenance of Certification Program Date: 4/11.

Clinical Features, Testing and Targeted Molecular Therapies in the Phakomatoses

Bruce Korf, MD, PhD

LEARNING OBJECTIVES
Upon completion of this presentation, participants will be able to:
1) Describe the major clinical features of neurofibromatosis, tuberous sclerosis complex, and von Hippel Lindau disease.
2) Identify the role of imaging in the evaluation of the child with NF-1.
3) Review the neuroimaging findings of NF-1 in children.
3) Discuss the optimal imaging protocols for evaluation of brain and spine manifestations of NF-1.

**PRESENTATION SUMMARY**

The term “phakomatosis” was coined early in the 20th century by the Dutch ophthalmologist Jan van der Hoeve, who noted spotty lesions in the eye in individuals with neurofibromatosis, tuberous sclerosis, and von Hippel-Lindau disease. Although the clinical features differ among the three disorders, and two (neurofibromatosis and tuberous sclerosis) have been found to be genetically heterogeneous, they are all dominantly inherited and are due to mutations in tumor suppressor genes (1). Neurofibromatosis is an umbrella term that encompasses three distinct disorders: NF1, NF2, and schwannomatosis (2). NF1 is characterized by the occurrence of multiple neurofibromas, including large plexiform neurofibromas, and a risk of malignant peripheral nerve sheath tumors. In addition, there are non-tumor manifestations of NF1, including café-au-lait spots, skinfold freckles, iris Lisch nodules, learning disabilities, and skeletal dysplasia. The NF1 gene encodes a GTPase-activating protein that regulates the signaling molecule Ras. NF2 leads to multiple schwannomas, especially of the vestibular nerves and other cranial nerves, but also spinal and peripheral nerves. Other tumors include ependymomas, gliomas, and meningiomas. The NF2 gene encodes a cytoskeletal protein that appears to be involved in the regulation of cell growth. Schwannomatosis is characterized by multiple schwannomas, but not vestibular schwannomas, and in at least some instances is due to mutation in the INI1/SMARCB1 gene, involved in chromatin remodeling. Tuberous sclerosis complex is characterized by hamartomatous lesions in multiple tissues, especially the brain, heart, kidneys, lungs, and skin (3). Many patients present with seizures, including infantile spasms, and developmental impairment. Hypopigmented macules, collagenous plaques, and facial angiofibroma occur on the skin. Renal lesions include angiomyolipomas and cysts. Affected females are at risk for the life-threatening complication lymphangiomatosis. Tuberous sclerosis complex is due to mutation in either the TSC1 or TSC2 genes, which encode the proteins hamartin and tuberin, which form a complex that regulates mTOR involved in control of cell growth. Von Hippel-Lindau disease is characterized by multiple hemangioblastomas in the cerebellum, brainstem, spinal cord, and retina (4). Other features include renal cysts and renal cell carcinoma, pheochromocytoma, and endolymphatic sac tumors (causing deafness). The gene encodes a protein involved in the cellular system that detects hypoxia. Neuroradiology plays a critical role in the diagnosis and management of all three disorders. MR techniques within the central nervous system.

**REFEENCES**

1. Williams VC, Lucas J, Babcock MA, Gutmann DH, Korf B, Maria BL. Neurofibromatosis type 1 revisited. *Pediatrics* 2009 (Jan);123(1):124-133

**Neuroimaging Evaluation in NF1**

**Tina Young Poussaint, MD**

**LEARNING OBJECTIVES**

Upon completion of this presentation, participants will be able to:
1) Identify the role of imaging in the evaluation of the child with NF-1.
2) Review the neuroimaging findings of NF-1 in children.
3) Discuss the optimal imaging protocols for evaluation of brain and spine manifestations of NF-1.

**PRESENTATION SUMMARY**

Neuroimaging, particularly MR imaging, plays an important role in the diagnosis and management of the child with neurofibromatosis type 1 (NF-1). NF-1 is the most common of the phakomatoses and is inherited as an autosomal dominant disorder with variable penetrance caused by defects in the NF-1 gene on chromosome 17, responsible for encoding the protein neurofibromin (1). This protein is a tumor suppressor that acts as a negative regulator of the Ras family GTPases (2). Patients with NF-1 typically present during the first decade of life. Cranial and intracranial manifestations inherent in NF-1 include NF spots or regions of myelin vacuolization (3,4), plexiform neurofibromas, astrocytomas, particularly in the optic pathways (5) and brainstem (as well as other locations), cerebrovascular abnormalities (6) (e.g., stenoses, occlusions, moyamoya syndrome, aneurysms, internal carotid dolichoectasia), and calvarial and orbital abnormalities (i.e., defects along the sphenoid wing and lambdoid suture). Spinal manifestations (7) of NF-1 include scoliosis (i.e., nondystrophic vs. dystrophic) with or without kyphosis, vertebral body scalloping, dural ectasia, meningoceles (lateral), neurofibromas (8), and intramedullary tumors such as astrocytomas. In this presentation, MR techniques and findings useful in evaluating these patients will be reviewed, as well as the common imaging manifestations within the central nervous system.


**Neuroimaging Evaluation of NF2, TS, vHL**

*James G. Smirniotopoulos, MD*

**Learning Objectives**

Upon completion of this presentation, participants will be able to:
1. Define the diagnostic criteria for Tuberous Sclerosis.
2. Describe the neuronal migration disorder of Tuberous Sclerosis.
3. Discuss the three neoplasms of NF2.
4. Plan screening exams for patients with VHL.

**Presentation Summary**

Tuberous sclerosis (TS) is an autosomal disorder or neuronal migration and maturation (1,2). Tuberous sclerosis has a prevalence of approximately 1/6,000 to 10,000 (3). The disease may be caused by mutations in the TSC1 gene (9q34) coding for protein “hamartin” or the TSC2 gene (16p13.3) coding for protein “tuberin”. The structural abnormalities in the brain are identified readily by MR imaging, and correlate with both the neurobiology and the clinical severity of the disease - seizures and mental difficulties. The original diagnostic “Vogt Triad” (seizures, retardation, and facial papules) is present in less than one third of patients (4). The current diagnostic criteria are complex and include these characteristic lesions: cortical tubers (hamartomas); subependymal nodules (hamartomas), white matter streaks, angiofibromas of the face and nails, hypopigmented macules, both angiomylipomas (AMLs) and cysts of the kidney, lymphangiomyomatosis (LAM) in the lungs, cardiac rhabdomyomas, and many other hamartomas (5). Approximately one seventh of TS patients will develop a subependymal giant cell astrocytoma (SGCA) (6). This is a slowly growing WHO Grade 1 tumor. However, it’s most common site of origin - attached to the caudate head near the foramen of Monro - may produce obstructive hydrocephalus. Current treatment regimens include antiepileptic drugs, and both everolimus and sirolimus (rapamycin) are used to control seizures in TS patients, also appears to help control growth of the SGCA (7, 8). Rapamycin may treat seizures in everolimus and sirolimus (rapamycin) are used to control seizures in TS patients, also appears to help control growth of the SGCA (7, 8). Rapamycin may treat seizures in TS patients, also appears to help control growth of the SGCA (7, 8). Rapamycin may treat seizures in TS patients, also appears to help control growth of the SGCA (7, 8). Rapamycin may treat seizures in TS patients, also appears to help control growth of the SGCA (7, 8). Rapamycin may treat seizures in TS patients, also appears to help control growth of the SGCA (7, 8). Rapamycin may treat seizures in TS patients, also appears to help control growth of the SGCA (7, 8). Rapamycin may treat seizures in TS patients, also appears to help control growth of the SGCA (7, 8). Rapamycin may treat seizures in TS patients, also appears to help control growth of the SGCA (7, 8). Rapamycin may treat seizures in TS patients, also appears to help control growth of the SGCA (7, 8). Rapamycin may treat seizures in TS patients, also appears to help control growth of the SGCA (7, 8).

**References**


Thursday Afternoon

4:45 PM - 5:00 PM
Ballroom 6 B/C

(50) Closing Remarks

— David B. Hackney, MD, FA
ASNR 2011-2012 President
Notes:
Decreased Accuracy of CT Angiography for Small Intracranial Aneurysms Compared to Digital Subtraction Angiography Is Operator Dependent and Not an Inherent Characteristic of CT Angiography

Byun, C. K. • Go, J. L. • Lerner, A. • Mogensen, M. A. • Shiroishi, M. S. • Law, M. • Kim, P. E.

University of Southern California Keck School of Medicine Los Angeles, CA

Purpose
CT angiography (CTA) provides high spatial resolution and extensive 3D information not available by conventional catheter digital subtraction angiography (DSA). Because there is no standardized methodology for postprocessing and evaluation of cerebral CTA, the approach to interpreting CTA varies widely (as do the results) among institutions. While there is virtual unanimity among published reports for the high detection accuracy of CTA for aneurysms larger than 4-5 mm, reports vary greatly in sensitivity results for smaller aneurysms. To address this wide variability in results, this study was performed to compare the efficacy of two common CTA evaluation methodologies: 1) Passive operator method, consisting of evaluation of a standardized set of images generated using a routine postprocessing protocol; and 2) Fully interrogative method, with comprehensive and active operator input, consisting of detailed evaluation of nonstandardized image sets which undergo extemporaneously varied postprocessing methods as needed.

Materials & Methods
Forty-five patients harboring 56 aneurysms of less than 5 mm in greatest diameter were evaluated utilizing 1 of 2 different postprocessing protocols: 1) 2D maximal intensity projection (MIP) multiplanar reformations (MPR) with fixed 5 mm thickness in standard transverse, coronal and sagittal planes, and 3D volume rendering (VR) using full-field views without volume-of-interest (VOI) sculpting; and 2) 2D MIP MPR with variable slab thickness and plane of orientation, combined with 3D VR with interrogative 3D VOI sculpting and rotational techniques. Aneurysm conspicuity was graded subjectively on a scale of 0 to 2: 0 - not visible to severely limited visibility, 1 - visible but partially obscured (some potential for nondetection), and 2 - clearly visible. All patients were referred for evaluation of subarachnoid hemorrhage as well as aneurysms discovered incidentally by other means such as MRA. Patients underwent CTA using either a 64-channel or 16-channel CT scanner. One hundred-120 cc of contrast were administered at 4 cc per second for each patient using semiautomated bolus timing. Effective pitch for both systems approached ~0.5. Postprocessing was performed on a Vitrea 2 workstation (Vital Images, Plymouth, Minnesota). Thirty-five patients had catheter-based DSA. Readers were blinded as to the number and location of aneurysms.

Results
With the passive operator method, 11, 12, and 33 aneurysms were graded 0, 1, and 2, respectively. The 11 “grade 0” aneurysms constitute false negatives, yielding a sensitivity of 81%. With the full interrogative method, 0, 10, and 46 aneurysms were graded 0, 1, and 2, respectively. No additional aneurysms were discovered in the 35 patients who underwent DSA.

Conclusion
Sensitivity of CTA for detection of small intracranial aneurysms rivals that of DSA but is largely dependent on CTA postprocessing technique. The rate of nondetection using the passive operator method in this study corresponds to some reported lower sensitivity rates for aneurysm detection, suggesting that less than optimal CTA evaluation methods were utilized in some reported series. CT angiography is highly sensitive for detection of small intracranial aneurysms, but the potential of CTA can be realized only by the dedicated use of a robust intricately interrogative post-processing evaluation methodology.

Key Words: CT angiography, aneurysm, postprocessing
Poster 002

Tale of Two Procedures: Trends in Cerebral Angiogram and Myelography Volumes from the National Inpatient Sample, 1997-2008

Leake, C. B.1 • Brinjikji, W.1 • Cloft, H. J.2 • Kallmes, D. F.2
Mayo Medical School, Rochester, MN, Mayo Clinic, Rochester, MN

PURPOSE
Neuroradiology fellowship directors have noted substantial decreases in invasive procedure volumes, especially in the era of noninvasive vascular imaging, with potentially detrimental effects on resident and fellow training opportunities. The aim of this study was to use a large national administrative database in order to determine trends in the utilization of inpatient, conventional cerebral angiograms and contrast myelograms from 1997 through 2008.

MATERIALS & METHODS
The Nationwide Inpatient Sample (NIS) database was utilized to identify hospitalizations with International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) procedure codes for contrast myelograms (87.21) and contrast cerebral arteriograms (88.41). Appropriate weights from the NIS database were applied for national estimates. Numerous demographic and hospital variables were examined including patient age, hospital teaching status and hospital location (metropolitan vs nonmetropolitan). Multiple linear regression analyses were used to assess utilization trends.

RESULTS
Between 1997 and 2008, over 1.13 million cerebral angiograms have been performed in the United States on an inpatient basis. From 1997 to 2008, there was a 145% increase in the number of hospital discharges for patients who had received a cerebral angiogram, with a year-to-year increase averaging 3.8%. The majority of the angiograms (94%) were performed at hospitals located in metropolitan areas and approximately 64% were performed at teaching hospitals. The number of angiograms performed at teaching hospitals increased 77% over the 12-year period with a year-to-year increase of approximately 6% (p<0.001). Conversely, angiograms performed at nonteaching hospitals only increased 3% over the same time period. In contrast to angiograms, there has been a steady decrease in the number of inpatient contrast myelograms performed in the United States, diminishing from 27,582 in 1997 to 7,086 in 2008, which represents a 74% decrease over that time. Similar to cerebral angiograms, the majority of myelograms were performed at hospitals located in a metropolitan area. The percentage of myelograms performed at teaching hospitals was equal to those performed at nonteaching hospitals. The number of myelograms performed at teaching hospitals decreased by approximately 68% from 1997 to 2008, with a statistically similar decrease of 80% observed at nonteaching hospitals (p=0.24).

CONCLUSION
Even in the era of rapid growth of noninvasive vascular imaging, the numbers of conventional cerebral angiograms has increased steadily, especially at teaching hospitals. In contrast, the volume of myelograms has decreased steadily. These findings suggest that numbers of conventional angiograms may still be sufficient for training neuroradiology fellows.

KEY WORDS: Angiogram, myelogram, national inpatient sample

Poster 003

Comparison of Gadofosveset Trisodium Steady-State MR Angiography with First Pass and 3D Time of Flight MR Angiography in the Follow Up of Coiled Cerebral Aneurysms

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1University of Toronto, Toronto, ON, CANADA, 2St. Michael's Hospital, Toronto, ON, CANADA, 3Sunnybrook Health Science Center, Toronto, ON, CANADA

PURPOSE
The purpose of this study is to compare three MR angiographic techniques; 3D time of flight (TOF) MR angiography (MRA), first pass contrast-enhanced MRA, and steady-state contrast-enhanced MRA. The first pass and steady-state MRA techniques are performed with Gadofosveset trisodium (Vasovist). Our hypothesis is that steady state MRA is the optimal technique for detection and measurement of residual aneurysm remnants based on improved image resolution.

MATERIALS & METHODS
This was an ethics committee approved study. Eight consecutive patients with 14 coiled aneurysms underwent routine surveillance including the three MRA techniques. Two blinded independent expert interventional neuroradiologists evaluated the MRA techniques based on three questions. 1) Is there satisfactory vessel conspicuity? 2) What size is the coiled aneurysm remnant? 3) Do you recommend retreatment?
ment or follow up? The test characteristics of the three MRA techniques were evaluated using the steady-state MRA as the standard.

**RESULTS**

Satisfactory conspicuity of the perianeurysmal vascular anatomy was present in 12 (86%) TOF MRAs, 14 (100%) first pass MRAs, and 14 (100%) steady-state MRAs. Five residual aneurysm remnants greater than 2 mm were described on the steady-state MRAs. Of these, four were identified on TOF MRA (sensitivity 80%, specificity 89%), and five were demonstrated on steady-state MRA (sensitivi-ty 100%, specificity 100%). The one aneurysm remnant not seen on TOF MRA measured 5 mm on the first pass and steady-state MRAs.

**CONCLUSION**

First pass and steady-state contrast-enhanced MRA techniques were superior to 3D TOF MRA in the follow up of coiled cerebral aneurysms. Although there was no statistically significant difference between first pass and steady-state contrast-enhanced MRAs for detecting residual aneurysm remnants, the tendency of the first pass MRA was to slightly underestimate the aneurysm remnant size.

**KEY WORDS:** Aneurysm, MRA, vasovist

**Poster 004**

**High-Resolution MR Imaging of Cerebral Vasculopathy: Initial Experience**

Mahmoud, S. Y. M. • Ahmed, M. • Bricker, A. • Cummings, C. L. • Hui, F. K. • Jones, S. E. • Lockwood, D. • Phillips, M. D. • Uchino, K. • Wolfe, K.

Cleveland Clinic Foundation
Cleveland, OH

**PURPOSE**

Digital subtraction angiography (DSA), MR angiography (MRA), and CT angiography (CTA) all have been used to characterize intracranial vascular abnormalities. However, all of these techniques characterize the intravascular space, rather than the vessel wall. While ultrasound can characterize vessel wall lesions, the presence of the skull impedes accurate imaging of the intracranial vasculature. Endovascular probes are available, but are not advanced easily into the deep cerebral vasculature. The development of high spatial resolution MRA (HRMR) techniques to improve our understanding of the blood vessel walls of the intracranial circulation may yield benefits in patient selection for varying medical, surgical and interventional therapies. We present a survey of cases demonstrating the utility of HRMR in cases of cerebral vasculopathy.

**MATERIALS & METHODS**

All studies using a recently developed HRMR protocol at the Cleveland Clinic were reviewed by two staff neuroradiologists and categorized according to vascular findings, pathologic states, and technical limitations. Illustrative cases were selected to highlight potential diagnostic applications of this technique, as applied in a busy clinical setting.

**RESULTS**

Forty-six HRMR examinations were reviewed for 42 patients, of whom four had follow-up HRMR imaging. Patients included 17 males and 25 females, with ages ranging between 14 to 82 years (mean 48.5 SD 16.83). Positive findings for presumed vasculitis included vessel wall enhancement with wall thickening, +/- vessel luminal narrowing, and was identified in 18 studies (43%). Two patients had vessel narrowing/occlusion without significant wall enhancement. Aneurysms were identified in 11 studies(26%), and dissection was identified in three patients. Another study had fibromuscular dysplasia, another had moyamoya disease. Remaining six studies were negative for vascular wall abnormalities. Internal carotid was affected in 14 patients(four aneurysms, two dissections and eight vasculitis changes). Middle cerebral in 18 patients (four aneurysms, 11 vasculitis, two stenosis without enhancement and one dissection). Anterior cerebral artery was affected in six patients (five vasculitis and one dissection). Posterior cerebral in four patients (was stenotic with enhancing wall in one patient, stenotic in a patient with presumed vasculitis of other vessels, isolated stenosis in one study and stenotic in a patient with dissection). Anterior communicating was affected in four patients(aneurysms in three patients and vasculitis in one study). Posterior communicating had enhanced wall and stenosis in one vasculitis patient and superficial temporal in two patients. Twenty-one patients showed vascular wall enhancement(18 studies of presumed vasculitis, two aneurysms, and one dissection). Thirteen patients showed luminal vessel narrowing (two isolated stenoses, and one patient with dissection, and 10/18 of the presumed vasculitis group). Three of 18 of the presumed vasculitis group showed vessel wall thickening.

**CONCLUSION**

High spatial resolution MRA techniques are a novel method of evaluating vascular wall abnormalities. Increasing experience with the technique will allow better understanding of normal findings and pathologic states. High spatial resolution MRA can afford excellent discrimination of vessel wall thickening and enhancement, which may be helpful in diagnosis as well as monitoring treatment response. More research is needed to better understand the role HRMR can play in the evaluation of cerebrovascular disease.

**KEY WORDS:** High-resolution MR, cerebral vasculitis, post-contrast

**Poster 005**

**Classification of Persistent Primitive Trigeminal Artery on MR Angiography: An Analysis of 20 Cases**

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**PURPOSE**

The purpose of this study is to demonstrate persistent primitive trigeminal artery (PPTA) on MR imaging (MRI) and MR angiography (MRA) while emphasizing its anatomical vascular relationships and to reclassify these variations for a
comprehensive understanding based on the embryologic types of the posterior communicating artery (P-com) and the relationship with the basilar artery (BA).

**Materials & Methods**

Of the total 8629 patients who underwent MRI and MRA from Jan 2008 to Nov 2010 in our hospital, we analyzed the MRA of 20 patients with a PPTA. All 3D TOF MRA (1.5 T or 3 T) and three TFCA were evaluated retrospectively with special attention given in order to define the relationship of the PPTA, BA, and P-com and to determine the original site of the PPTA from the ICA, the size of the PPTA (larger than M1 or smaller than M1 - assuming your readers will know what M1 refers to as well as its size), as well as its course (intrasellar or parasellar). Clinical configurations and associated abnormal vascular lesions also were described. From these data, all PPTA variations were compared to its previously reported classification.

**Results**

Twenty (13 women and 7 men, 43 ~ 76 years of age, mean age 60.2 years) of the 8629 patients had a PPTA (2.3%). Five patients with focal neurologic symptoms showed acute cerebral infarction in the right corona radiata, acute infarction on the anteromedial side of the pons, medulla, and chronic infarction in basal ganglia and temporal lobe. A patient with visual disturbance had a meningioma involving the cavernous sinus. Five patients had aneurysms (25%) in the ICA and MCA, the ipsilateral or contralateral side to the PPTA origin. There were five types of PPTA: type 1, PPTA inserted in the BA with adult type PCAs (n = 10); type 2, PPTA inserted in the BA with fetal type PCAs (n = 2); type 3, PPTA inserted in the BA and terminating in the ipsilateral PCA with contralateral fetal type PCA (n = 1); type 4, PPTA inserted in the BA and terminating in the contralateral PCA with ipsilateral fetal type PCA (n = 4); and type 5, PPTA terminating in the AICA with no interposition of the BA (n = 3). Severe hypoplasia of the proximal BA was found in 10 patients. Fourteen of our 10 study patients (70%) showed the parasellar course (a lateral type) of PPTA, while six (30%) had the intrasellar course (a medial type) of PPTA.

**Conclusion**

Three-dimensional TOF MRA can be used for identifying of PPTA and making a classification indirectly in daily practice. There were five types of PPTA in our study and the incidence of PPTA with type I was greater than that of other types of PPTA.

**Key Words**: Persistent primitive trigeminal artery, MR angiography, classification

**Poster 006**

**Atypical Presentation of Posterior Reversible Encephalopathy in Two Patients with Sepsis**

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**Purpose**

Reversible posterior encephalopathy syndrome (PRES) is characterized by a wide array of nonspecific neurologic symptoms and has distinctive radiologic appearance that usually manifests as abnormal signal in the bilateral posterior or white matter and occasionally in the gray matter in the parietal, temporal and occipital lobes, compatible with vasogenic edema. We report atypical presentation of this syndrome with uncommon involvement of the superior frontal and cerebellar hemispheres in two nonhypertensive patients with septic shock and respiratory failure.

**Materials & Methods**

The clinical data of two patients were reviewed retrospectively. Magnetic resonance images were obtained within 2 hours of the seizure onset and at 3-5 weeks follow up. Review of the relevant literature was performed.

**Results**

Each patient presented with septicemia and respiratory failure. After initial improvement of the symptoms the mental status of both patients suddenly declined and they developed focal motor seizures. Their blood pressures were elevated mildly. MR imaging (MRI) studies demonstrated foci of bilateral abnormal hyperintense T2 and FLAIR signal involving the subcortical and deep white matter in the posterior and paramedian parietal, inferior occipital and inferior temporal lobes. Additionally the superior frontal lobes and bilateral cerebellar hemispheres showed similar signal abnormalities. Follow-up MRI in 5 and 3 weeks demonstrated resolution of the abnormal findings on MRI. During the past decade PRES has been associated with hypertension, preeclampsia/ eclampsia, and autoimmune diseases such as SLE, Wegener’s, polyarthritis nodosa, scleroderma. In the younger population there are known associations with post-streptococcal glomerulonephritis and Henoch-Schonlein Purpura. Reversible posterior encephalopathy syndrome associated with infection/sepsis/shock was first reported in 25 patients by Bartynski, et al (2006). Eighty-four per cent of those patients had G+ organisms cultured from their blood like the cases in our study. The Bartynski study demonstrated greater vasogenic edema in normotensive patients than in hypertensive patients. Recent studies demonstrate that in 40% of patient with nonhypertensive secondary to infection/sepsis/shock and overall in 25% of all patients with PRES, the blood pressure is within the normal range, in contrast to the earliest reported cases of PRES.

**Conclusion**

Up until recently the most popular pathophysiologic theory for PRES is severe hypertension with failed autoregulation that causes injury to the capillary bed resulting in hyperperfusion and brain edema. However, the presence of mild hypertension or the absence of hypertension in patients with infection/sepsis/shock beckons another theory which considers immune mediated endothelial injury/dysfunction and...
vasoconstriction as the primary insult, resulting in hyperperfusion, ischemia and ultimately vasogenic edema. Perhaps intermittent episodes of hypertension occur in sepsis, but are difficult to recognize because of confounding factors such as pain. Further investigations will be necessary to bring clarity and confirm the mechanism of this clinico-neuroradiologic entity.

**Key Words:** Atypical, posterior reversible encephalopathy, sepsis

**Poster 007**

Oculopneumoplethysmography and MR Angiography for the Detection of Carotid Artery Stenosis

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**Purpose**

Oculopneumoplethysmography (OPG) is a noninvasive investigation, initially conceived in the 1970s, which uses measurement of ocular systolic pressures via vacuum pressure applied to the sclera in order to make determinations regarding the presence or absence of hemodynamically significant carotid artery system stenoses. The purpose of this study was to assess the accuracy of OPG for the diagnosis of carotid artery stenosis both as a stand-alone test and in conjunction with carotid system MR angiography (MRA).

**Materials & Methods**

This retrospective study reviewed patients who had undergone OPG and digital subtraction angiography (DSA) (90 patients, 174 vessels) in close temporal proximity to determine the accuracy of OPG with DSA as the reference standard. Three carotid artery stenosis thresholds (≥ 50%, ≥ 70%, ≥ 80%) were analyzed. The accuracy of the combination of OPG and MRA was analyzed in a subset of patients (54 patients, 94 vessels) who underwent OPG, MRA and DSA. In an attempt to standardize MRA interpretation and ensure that a numeric percentage carotid stenosis was recorded for all vessels, all MRAs were reviewed independently by an experienced neuroradiologist (J.T.W.) blinded to the results of both the OPG and DSA.

**Results**

The sensitivity and negative predictive value of OPG increased with higher degree stenoses and for lesions ≥ 80% these values were 85.3% and 94.2% respectively. Specificity and positive predictive values were lower at all thresholds and were 72.9% and 49.3% respectively at the ≥ 80% stenosis threshold. For MRA alone, specificity and NPV were high (92.3% and 92.1% at the 70% and 80% stenosis thresholds respectively) but PPV was only moderate (63.2% for the highest grade group), suggesting a significant number of false positive results. When OPG and MRA were concordant, the sensitivity and specificity for ≥ 80% stenoses were 91.0% and 97.8% respectively, PPV and NPV were 91.0% and 97.8% respectively when these tests were in agreement.

**Conclusion**

Oculopneumoplethysmography appears to be an accurate rule-out test for hemodynamically significant carotid artery stenosis. Oculopneumoplethysmography augments the accuracy of MRA for detection of carotid artery disease and when these two tests are negative, disease appears to be effectively excluded. The data suggest that OPG in conjunction with MRA is particularly useful in reducing the number of false-positive results as compared to MRA alone.

**Key Words:** Carotid artery stenosis, oculopneumoplethysmography, MR angiography

**Poster 008**

Automated Trajectory Analysis in Deep Penetrating Head Injury

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**Purpose**

Traumatic brain injury (TBI), in particular penetrating head injury, is the signature injury of recent military conflicts in Iraq and Afghanistan. Currently, there is no consistent reporting or effective data management of penetrating head injuries (PHI). We created and validated a novel semiautomatic trajectory imaging analysis software for penetrating head injuries that estimates the volume and anatomical structures of expected tissue damage. Trajectory imaging analysis of penetrating head injury provides rapidly needed clinical information that establishes prognostic indicators in the acute trauma clinical care setting.

**Materials & Methods**

We randomly selected penetrating head injuries from the Vietnam Head Injury Study (VHIS) registry and analyzed the injuries using software designed to map the trajectory of head penetrating projectiles using noncontrast enhanced head CT. A cylindrical injury probability zone was produced by recording entrance wound and terminal fragment locations in 91 CT scans. In addition to this volume of potentially damaged tissue based on locations and fragment size, specific anatomical regions, intersected by the probability injury zone, were automatically generated using the Analysis of Brain Lesion (ABLe) software with the Automated Anatomical Labeling (AAL) atlas. Comparison of this simplified path was made with manual tracings of encephalomalacia to demonstrate potential use of automated systems in lieu of more resource-intensive processing. Additionally, comparison of a radiologist versus a nonradiologist on trajectory estimates was performed. Kappa analysis and Dice similarity coefficients were used for quantitative comparison of anatomical regions and volume estimation. Lastly, an overlay of all manual tracings of PHI was computed to show spared areas of the brain in this population.
RESULTS
We determined the percentage of AAL structures intersected by the calculated trajectory cylinder of probable injury, by analyzing the overlap of the spatially normalized lesion image with the AAL atlas image in MNI space. Preliminary results demonstrate high specificity of the anatomical regions identified with out semiautomated trajectory cylinder and manual tracings of tissue damage. Initial comparison of radiologist versus nonradiologist estimates demonstrated that semiautomation with less skilled operator may be possible with training and certain limitations. Overlay of all manual tracings support a concept previously called zona fatalis; a central area of the brain where damage is associated closely with death by exception.

CONCLUSION
We believe that these preliminary results demonstrate the potential for semiautomation of preliminary zone of central nervous system (CNS) tissue injury caused by a penetrating projectile. There is overlap with manually traced regions from a prior study. We hypothesize that chronic zones of injury also may reflect long-term effects of interrelated neural pathways, ballistic dynamics and probable tumbling effects of blast fragments at the time of injury. We believe that these efforts may lead to future predictive modeling for long-term clinical effects of initial trajectory assessments.

KEY WORDS: Trauma, TBI, brain

Poster 009
Metabolic Dysfunction in the Basal Ganglia and Thalamus of Mild Traumatic Brain Injury Patients with Corresponding Perfusion Abnormality

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Purpose
Many Americans sustain a mild traumatic brain injury (mTBI) annually, resulting in long-term cognitive, physical, and behavioral problems. We hypothesize that adult mTBI subjects (n = 6) with persistent (90-700 days postinjury) neurocognitive deficits with prolonged cerebral metabolic alteration, specifically decreased NAA in the deep gray structures, seen on 3D magnetic resonance spectroscopic imaging (MRSI) will have abnormal perfusion-weighted MRI (PW-MRI). Mild traumatic brain injury is a common cause of chronic debilitating symptoms. Management of mTBI is hindered by vague symptoms and nonspecific imaging findings. MR spectroscopic imaging and PW-MRI may aid in diagnosis and treatment.

MATERIALS & METHODS
Three-dimensional MRSI (PRESS TR/TE = 1700/144 msec, voxel size 1cm3) and perfusion-weighted MRI (PW-MRI; TR/TE = 1400/32 msec) were acquired at 3 T. LCmodel was used to semi-quantitatively measure the mean N-acetylaspartate/creatinine (NAA/Cr), NAA/choline (NAA/Cho), and Cho/Cr ratio for each lobar and hemisphere region. Spectra from mTBI subjects were compared to control ratios of age-matched healthy subjects (n = 6). Perfusion-weighted MRI source data were processed to create relative cerebral blood flow (CBF) and cerebral blood volume (CBV) maps. In mTBI subjects, CBF and CBV values were compared between voxels with normal metabolite ratios and those with abnormal metabolite ratios. Statistical significance was measured using independent samples t-test.

RESULTS
In mild TBI subjects, voxels in the left basal ganglia which showed abnormally low Cho/Cr due to decreased Cr, showed significantly higher (p < 0.05) CBF (mTBI 210.8 ± 86.68 ), CBV (mTBI 12 ± 5.16 ), and significantly lower MTT (mTBI 3.32 ± 0.02 ) compared to normal voxels (67.6 ± 38.76, 5.64 ± 2.51, and 5.15 ± 1.01, respectively). In the left thalamus of mTBI subjects, voxels with abnormally high NAA/Cr due to decreased Cr levels showed significantly higher (p < 0.05) CBF (233.7 ± 26.05) and CBV (14.9 ± 3.22) compared to normal voxels (83.4 ± 58.82 and 6.79 ± 3.98, respectively).

CONCLUSION
MR spectroscopy imaging and PW-MRI are valuable tools which can identify abnormalities in mTBI patients that are otherwise not identified on other imaging modalities. These changes may identify underlying pathophysiologic changes associated with long-term cognitive deficits.

KEY WORDS: Mild traumatic brain injury, MR spectroscopic imaging, perfusion-weighted MR imaging

Poster 010
Evaluation of a Novel Readout-Segmented Approach to Diffusion-Weighted MR at 3 T Utilizing a 32-Channel Head Coil

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Purpose
To evaluate a readout-segmented echo planar imaging (rs-EPI) approach to diffusion-weighted (DWI) brain MR imaging (MRI) with a navigator-based phase correction and reacquisition versus single-shot EPI (ss-EPI) DWI with a focus on possibilities with the former sequence relative to the greater signal-to-noise ratio (SNR) afforded by utilization of a 32-channel head coil.

MATERIALS & METHODS
Thirteen subjects (10 volunteers and three stroke patients to date) were evaluated with ss- and rs-EPI DWI at 3 T. Both sequences first were performed utilizing a 12-channel head
coil, a parallel imaging factor (IPAT) of 2, a constant field of view (220x220 mm2), 192x192 matrix size, and the minimum allowed TE (rs-EPI: TE 63 ms, 9 readout segments (ROS), 1 scan average (NSA); ss-EPI: TE 76 ms, NSA 4). Additional SNR available with the 32-channel coil was exploited to either 1) increase the parallel imaging factor while maintaining in-plane resolution (IPAT=3, 192x192 matrix; rs-EPI: TE 58 ms, NSA=2, ROS=7 versus ss-EPI: TE 76 ms, NSA=4) or alternatively to 2) increase in-plane spatial resolution (256x256 matrix, IPAT=2; rs-EPI: TE 68 ms, NSA=1, ROS=13 versus ss-EPI: TE 109 ms, NSA=2) versus the 12-channel scans. Signal-to-noise ratio and artifactual pontine distortion from susceptibility artifacts were quantified, and a blinded neuroradiologist ranked the scans in terms of spatial resolution, susceptibility artifacts, image blur, and overall preference (the latter being decided among all 12- and 32-channel scans). Additional sequences performed in stroke patients utilizing the above 12-channel protocol were assessed similarly.

RESULTS
Signal-to-noise ratio was not significantly different between the low-resolution (IPAT=3) 32-channel scans (9.6±1.4 ss-EPI versus 8.0±1.3 rs-EPI). Signal-to-noise ratio was statistically lower (p<0.04) with the high-resolution scans (IPAT=2), but among them greater with rs-EPI (p=0.002; 5.5±.06 rs-EPI versus 4.7±0.5 ss-EPI). Severity of artifactual pontine distortion was greatest with the ss-EPI sequences (10-17%), the high-resolution rs-EPI sequence having significantly less distortion (p <0.02; 4.4±3.3%), and the low-resolution rs-EPI having even less (p<0.05; 2.3±1.8%). The assessment of the blinded reader in terms of susceptibility artifact agreed with the quantitative distortion assessment. In every case, image blurriness was ranked: low-resolution ss-EPI > high-resolution ss-EPI > low-resolution rs-EPI> high resolution rs-EPI. When asked for the choice of the top two sequences from among the 32-channel scans, in every instance the blinded reader selected the two 32-channel rs-EPI scans. The reader expressed a similar preference for rs-EPI DWI in patient scans.

CONCLUSION
Substantial image quality improvements are possible with rs- versus ss-EPI DWI regardless of the head coil, 12- or 32-channel, utilized. Acquisition with the latter allows for implementation of greater IPAT factors or acquisition of scans at a higher resolution without significant SNR or acquisition time penalty. In this situation, rs-EPI presents further advantages in that higher resolution can be achieved by increasing the number of readout segments without increasing echo-spacing (i.e., the principle determinant of susceptibility artifacts) or TE (i.e., an important determinant of SNR) to the degree necessary with ss-EPI.

KEY WORDS: DWI, readout-segmented EPI, 3 T MR imaging

Poster 011
Limbic System: The Emotional Nervous System
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PURPOSE
Limbic system is the seat of memories and emotions. It has a very complex anatomy and connections. Here, we attempt to present a simplistic approach to the anatomy and also discuss the various pathologies that may affect the important parts of the limbic system.

MATERIALS & METHODS
From our extensive database of cases from neuroradiology departments of adult and children’s hospitals, cases that depict anatomy and various pathologies of the limbic system are selected and presented in our poster in an organized fashion.

RESULTS

CONCLUSION
The limbic system, so-called the primitive or the visceral brain, is a complex structure. Understanding the anatomy, afferent and efferent connections, and pathologies of this pathway is interesting and helpful in explaining the imaging approach to the limbic system.

KEY WORDS: MR imaging, limbic system, hypothalamus

Poster 012
Imaging Characteristics of Central Pontine Myelinolysis and Extrapontine Myelinolysis
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PURPOSE
To review presentations, clinical features and imaging characteristics of the central pontine myelinolysis (CPM); to be familiar with other areas of involvement in the brain beyond the pons so as to help identify extrapontine myelinolysis

PURPOSE
To review presentations, clinical features and imaging characteristics of the central pontine myelinolysis (CPM); to be familiar with other areas of involvement in the brain beyond the pons so as to help identify extrapontine myelinolysis
To understand the pathogenesis underlining the disease processes so as to make a prompt diagnosis of CPM and/or EPM and facilitate prompt treatment.

Materials & Methods
Patients presented with nonspecific neurologic symptoms such as vomiting, lethargy, seizures, progressive mental status changes, etc. Underline diseases include alcoholism, diabetes, etc. CT and MR imaging (MRI) of the brain were obtained. Locations and features of the imaging abnormalities were analyzed and characterized. Diagnosis of CPM/EPM was made combining the characteristic imaging findings and the clinical history as well as patients’ electrolyte abnormalities with subsequent rapid correction of hyponatremia.

Results
Central pontine myelinolysis is a clinical challenging diagnosis because of its nonspecific clinical presentations. Imaging studies play a critical role in identifying this disease entity. CT could be normal but may show an ill-defined hypodense area in the central pons. On the MRI, there are confluent hyperintense T2 signals in the central pons with sparing of the periphery and bilateral corticospinal tracts. These areas usually show restriction diffusion but their ADC values varied from normal to mildly hyperintense. The enhancement pattern is heterogeneous and variable. Extrapontine sites of involvement include basal ganglia, thalami, internal capsules, subcortical white matters, the cerebellum, etc. MR imaging appears to be the most sensitive tool for diagnosis.

Conclusion
Central pontine myelinolysis is an under-diagnosed disease entity associated with high morbidity and mortality. It is an acute demyelinating process usually caused by rapid correction of hyponatremia although other medical conditions independent of sodium osmolarity were discovered more recently. It typically involves the central pons, but also associated with demyelination of other areas of the brain (EPM). There are three subtypes: CPM, CPEPM, and EPM without CPM. The most common underline cause is chronic alcoholism. Other underline disease processes include diabetes, liver transplant, renal insufficiency, etc. Clinical presentations are nonspecific and vary from a large range of neurologic findings. MR imaging is the most sensitive way to detect pontine and extrapontine involvement of CPM/EPM. Familiar with their typical imaging characteristics, combined with the patients’ clinical history and symptoms will help make the accurate diagnosis so as to facilitate the prompt treatment and achieve the more favorable outcome.

Keywords: Central pontine myelinolysis, extrapontine myelinolysis, osmotic demyelinating syndrome

Poster 013
Automated Classification of Radiology Reports to Facilitate Retrospective Study of Brain Imaging

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Purpose
Unstructured brain imaging reports provide invaluable data that can be used in retrospective imaging research. However, identifying examinations appropriate for a given research question from the text of radiology reports can be challenging. The commonly used tool of keyword-based searching of reports often produces many false-positive cases that then require labor-intensive manual review to evaluate for appropriateness. In this study, we apply a text mining technique to classify radiology reports in order to identify cases for retrospective research in brain imaging.

Materials & Methods
Using the machine learning text-mining-based text classification methods implemented in LingPipe, we evaluated the performance of a dynamic language model classifier and a naïve Bayes classifier in classifying brain imaging reports. The training dataset consisted of 11,430 sentences from 8,537 radiology reports randomly selected from a total of 5,104,594 reports in all disciplines of radiology and an additional 2,895 reports randomly selected from brain CT and brain MR imaging (MRI) studies. The additional brain imaging reports are included to ensure adequate coverage of brain imaging. The training sentences are categorized manually into seven predetermined categories (Positive, Differential, Posttreatment, Negative, Normal, History and Unknown) by radiologists. The duplicated sentences and sentences that contain no useful information were removed manually from the training dataset and the commonly used phrases that do not contribute to classification were deleted from the sentences in the training set. A 10-fold cross-validation approach was used to evaluate the performance of classification models. Finally, the classification models were generated using the training dataset and then were used to classify brain imaging reports for cases of sellar/suprasellar masses and colloid cysts.
RESULTS
Quad-grams were found to give the best performances and were used in this study. In the 10-fold cross-validation analysis, the average accuracies for dynamic language model classifier and the naïve Bayes classifier were 88.5% with 95% CI of 1.9% and 85.9% with 95% CI of 2.0%, respectively. The dynamic language model classifier performed slightly better. The dynamic language model was used to classify 1397 brain imaging reports that contain keywords “sellar mass”, “suprasellar mass” or “colloid cyst”. These reports were independently manually classified by radiologists. When compared to the manual classification, the prediction model produced an accuracy of 88.2% with 95% CI of 2.1% for 959 reports that contain “sellar/suprasellar mass” and an accuracy of 86.3% with 95% CI of 2.5% for 437 reports of “colloid cyst”.

CONCLUSION
Automated classification of brain imaging reports using machine-learning techniques can effectively facilitate the identification of suitable cases for retrospective research. Utilization of such a tool could dramatically improve radiologists’ ability to perform retrospective research.

KEY WORDS: Radiology report classification, data mining, machine learning

Poster 014
Significant Volume Reduction and Shape Abnormalities of Basal Ganglia in Cases of Chronic Liver Cirrhosis

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PURPOSE
Chronic liver disease frequently includes cognitive and movement disorders, which suggests an alteration of the basal ganglia (BG). With the exception of BG hyperintensities evident on T1-weighted images indicative of manganese deposition, radiographic findings are nonspecific. Volumetric and morphometric analysis of subcortical nuclei is limited. Whether or not BG undergoes degeneration, and whether or not this change is associated with pallidal hyperintensity and cognitive performance currently is unknown in cirrhotic patients.

MATERIALS & METHODS
The volumes of subcortical nuclei of 28 chronic liver disease patients and 28 control patients were compared. Using 3D T1-weighted MR images, the volume and shape of each nucleus was automatically analyzed via the functional MRI (fMRI) of the Brain Software Library. Correlations between the subcortical volume and other clinical variables, including the pallidal signal intensity, were assessed by multiple regression analysis.

RESULTS
Child B and Child C liver disease patients displayed significantly smaller bilateral putamen volumes than control patients (Figure 1), and Child C patients also demonstrated smaller left caudate nucleus and left amygdala volumes than control patients. Pallidal hyperintensity correlated with the BG volume decrease, which was linearly related to worse cognitive performance. The nonuniform distributed shape abnormalities in the striatum further support the ascending spiral interconnecting theory of the striatum.

CONCLUSION
These findings strongly suggest that atrophy in the BG develops according to the severity of the liver cirrhosis. The manganese deposition increases the risk of deep gray matter atrophy. These findings uphold the value of additional psychomotor research associated with liver cirrhosis.

KEY WORDS: Basal ganglia, liver cirrhosis, shape analysis

Poster 015
Comparison of Pseudo-Continuous Arterial Spin-Labeled and Dynamic Susceptibility Contrast-Enhanced Perfusion Imaging in Acute Ischemic Stroke before and after Reperfusion Therapy

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PURPOSE
Imaging of ischemic penumbra with MR imaging (MRI) in the setting of acute ischemic stroke has depended upon the use of dynamic susceptibility contrast- (DSC) enhanced techniques to identify regions of reversible injury. However in the setting of acute ischemic stroke, the patient’s glomerular filtration rate (GFR) often is unknown. When time is critical in the clinical decision-making process to decide to pursue recanalization therapies that may salvage brain tissue, it is not feasible to delay perfusion imaging for the return of laboratory values. Arterial spin-labeled (ASL) techniques provide cerebral flow (CBF) measures without the use of contrast and thus is ideal for the use in MRI stroke imaging in the acute setting. In this study, we conduct a comparison of perfusion measures obtained using ASL versus DSC imaging in the setting of acute ischemic stroke, before and after reperfusion therapy.
Materials & Methods
A total of 33 studies with 18 cases of acute ischemic stroke during a period of 6 months were evaluated with both ASL and DSC as part of a complete MRI protocol, using Siemens 1.5 and 3 T MRI scanners. Serial imaging (up to three time points within the subacute period) with both ASL and DSC techniques was obtained in 11 cases before and after reperfusion therapy, including IV-tPA and endovascular therapies such as IA-tPA, Merci, Penumbra, other neurointerventional recanalization techniques, or any combination of arterial recanalization techniques. Visual assessment of the FLAIR, DWI, ASL and TTP was performed with three observers.

Results
Both ASL and DSC imaging quality was excellent. Arterial spin-label imaging consistently demonstrated hyperperfusion in regions corresponding to delayed TTP and areas of diffusion-weighted imaging signal abnormality. Arterial spin-labeling was equivalent to DSC imaging in demonstrating areas of brain parenchymal hypoperfusion. Additionally, areas of post-treatment hyperperfusion were more conspicuous on ASL imaging than DSC imaging, especially after clot retrieval recanalization therapy.

Conclusion
Arterial spin-labeling and DSC perfusion imaging are equivalent in the identification of areas of hypoperfusion in the acute ischemic stroke setting. Furthermore, ASL is more sensitive than DSC in identifying areas of hyperperfusion, or luxury perfusion, after recanalization therapy. Arterial spin-labeling, without the use of gadolinium contrast, is an ideal technique for imaging acute ischemic stroke, especially when the patient’s GFR is unknown. This technique would avoid potential complications, such as nephrogenic systemic fibrosis or contrast allergy, posed by gadolinium contrast agents.

Key Words: Arterial spin labeling, acute ischemic stroke, cerebral perfusion imaging

Poster 016
Voxel-Based Assessment of Gray Matter Volumes in Chronic Carbon Monoxide Intoxication

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Purpose
Patients with carbon monoxide (CO) intoxication may or may not develop delayed neuropsychiatric syndrome (DNS). The association between morphologic differences and clinical neuropsychologic deficits in chronic stage is still unknown. However, smaller differences in brain structure may be overlooked in conventional imaging study. Voxel-based morphometry (VBM) is a fully automated method of analysis which allows for unbiased exploration of gray matter density changes. The aim of the study is to evaluate the structure and cognition deficits in CO intoxication with or without DNS using VBM analysis.

Results
The patient groups performed worse neuropsychologic subtest results than healthy controllers (P<0.05) with the worst tendency in DNS group. All patients showed extensively reduced regional GMV in bilateral frontal and parietal lobes mainly, and some in left thalamus, bilateral basal ganglia, bilateral temporal, and left occipital lobes. The DNS group revealed further volume atrophy in bilateral thalami, frontal, parietal, right occipital lobes, and bilateral cerebella, compared with no DNS group. The DNS group revealed more perceptual organization deficits than no DNS group. This correlated with reduced GMV in bilateral superior parietal lobule, bilateral thalami, and right uvula (P<0.05) (Figure 1).

Conclusion
In chronic stage after CO intoxication, the patients with DNS experienced worse outcome cognitively and morphologically than patients without DNS. Voxel-based structural deficits in selective brain structures help to characterize a subgroup of patients who exhibited poor clinical performance after CO intoxication.

Key Words: Carbon monoxide intoxication, delayed neuropsychiatric syndrome, voxel-based morphometry

Figure 1. Locations and plots of significant clusters where a relationship exists between picture completion performance and GM volume detected from group analysis between with or without DNS, while controlling for age, education, gender, and TIV. The linear relationships between the four significant GM clusters [(a) right thalamus, (c) left thalamus, (d) right superior parietal lobule, (f) left superior parietal lobule] and picture completion performance are plotted. The cluster of GM abnormalities located on bilateral thalami (b) and superior parietal lobules (e) are overlaid on the T1 MNI template.
Automatic Selection of Arterial Input and Venous Output Functions on CT Brain Perfusion Images Using Independent Component Analysis

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PURPOSE
We propose a new automatic technique for the selection of arterial input function (AIF) and venous output function (VOF) on CT brain perfusion images for automatic calculation of parametric images.

MATERIALS & METHODS
CT brain perfusion images were acquired routinely from patients with cerebral vascular diseases such as stenosis and acute ischemic stroke. The first step was to identify bone on CT images using Otsu’s automatic thresholding technique. Brain pixels inside the bone were subjected to the following processing procedure. The independent component technique was applied to brain pixels on CT brain perfusion images. Three output images corresponding to: 1) normal arteries, 2) stenotic arteries, vein, and choroid plexus, and 3) brain parenchyma, were segmented automatically. Vessel pixels were identified by applying Otsu’s technique to the first and second output images corresponding to arterial and venous phases described above. By comparing the time-to-peak and area-under-curve of signal-time curve for these identified vessel pixels, one arterial pixel and one venous pixel were selected for measuring AIF and VOF, respectively. The VOF was used to calculate cerebral blood volume (CBV), the AIF was used to calculate cerebral blood flow (CBF), and mean transit time (MTT) was calculated as: MTT = CBV/CBF.

RESULTS
The figure illustrates two output images corresponding to arterial (A) and venous (B) phases of the independent component analysis result for a patient with a unilateral carotid stenosis. Only arteries on the normal side appear on the arterial-phase image (A). However, arteries on the stenotic side, vein, and choroid plexus can be found on the venous-phase image (B). A pixel selected at the anterior cerebral artery (pointed by an arrow) on the arterial-phase image is used for measuring AIF; and a pixel selected at the straight sinus on the venous-phase image (marked by a cross) is used for measuring VOF. After automatically selecting AIF and VOF, hemodynamic parametric images such as: CBV, CBF, MTT subsequently were calculated for the evaluation of brain perfusion.

CONCLUSION
By using this automatic AIF and VOF selection technique, hemodynamic parametric images can be generated promptly after the CT scan was completed. An accurate and fast diagnosis can be performed for immediate patient care.

KEY WORDS: CT, brain perfusion, image processing
onds at 10% duty cycle and 230 kHz using an Insightec ExAblate 4000. The tubes then were reimaged immediately after sonication. Signal intensities of the three MR imaging sequences were measured and normalized to background signal for each time point. Pre and postsonication measurements were compared using t-tests. Representative samples of the pre and postsonication clot also were sent to pathology for hematologic analysis.

RESULTS
Visual inspection of the tubes prior to sonication demonstrated well formed clot. After sonication, the clot in the treatment tube was fully lysed as evidenced by physical and hematologic evaluation. The difference between pre and postsonicated normalized signal intensity ratios demonstrated statistical significance only on T2 and GRE sequences (p < 0.001). However, significant blooming artifact limits interpretation on GRE. Evaluation of these findings over the 48-hour period demonstrates that there is no statistical significance in the difference of imaging characteristics between 3 to 48 hours (p > 0.45).

CONCLUSION
T2 is the most appropriate sequence for the evaluation of mechanical MRgFUS sonothrombolysis of an in vitro clot. These findings are consistent across the oxidative states of clot up to 48 hours. These findings remain to be validated in vivo.

KEY WORDS: Focused ultrasound, sonothrombolysis, intracerebral hemorrhage

Poster 019
Clinical Utility of Functional MR Imaging in Surgical Planning for Patients with Intracranial Tumors

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PURPOSE
Studies have shown that functional magnetic resonance imaging (fMRI) activation patterns are consistent with the cortical responses seen during intraoperative brain mapping. However, more research is needed to better characterize the true clinical utility of preoperative fMRI, especially as an adjunct to preop risk assessment and surgical planning. This is particularly important in determining the extent to which fMRI can be used as a predictive model of surgical morbidity and mortality.

MATERIALS & METHODS
Seventeen hundred and twenty-seven adult patients undergoing resection of an intracranial mass between 2001 and 2009 at the University of Wisconsin were identified via retrospective review of neurosurgical case logs. Two hundred and seventy-eight patients were included in the study with the following inclusion criteria: pathologic diagnosis of glial or metastatic tumor, supratentorial cortical location, and first-time diagnosis of intracranial mass. Exclusion criteria included all tumors not of glial or metastatic origin, sellar, infratentorial, ventricular or subcortical location, and/or recurrent tumor. In addition to all pertinent demographic data, information regarding patient morbidity (motor and language deficits) and mortality was reviewed. Out of 278 patients, 160 patients did not receive preoperative fMRI and 118 patients received preoperative fMRI.

RESULTS
Preliminary analyses of patients who underwent preop fMRI showed significant relationship between motor and language LAD (Lesion to Activation Distance) and existence of either pre or postoperative motor (p < 0.001) and language deficits (p = 0.009) (see Figure). Increasing age was associated with motor and language deficits (p = 0.02 and p = 0.04 respectively). Right-handedness related with language deficits (p = 0.05). Survival analysis revealed that pre - and postoperative deficits, grade, tumor location, as well as LAD predict mortality. Further analyses of patients who did not receive fMRI is in progress to characterize these relationships.

CONCLUSION
In patients who had preop fMRI, motor deficits increased linearly as distance from tumor to primary sensorimotor cortex (SMC) decreased. Language deficits increased exponentially as distance from tumor to language areas decreased below 1 cm (see Figure). Postoperative mortality analysis shows an interaction effect between motor or language LAD and mortality predictors (grade, tumor location). These findings are directly applicable to preoperative neurosurgical risk assessment and planning. Further analysis with patients who did not receive fMRI is underway to determine the role of fMRI in clinical diagnostic and preop assessment of patients with intracranial tumors.

KEY WORDS: fMRI, brain tumor, motor deficits
Differentiation of Central Nervous System Lymphoma from Glioblastoma with Combined Use of CT Value and the Maximum Standardized Uptake Value on 18F-FDG PET/CT

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PURPOSE
To determine whether mean CT values at the area of thresholds of 90% of the maximum standardized uptake value (SUV max) in tumors on 18F-FDG PET/CT have added value in differentiating central nervous system (CNS) lymphoma from glioblastoma multiformes (GBMs).

MATERIALS & METHODS
18F-FDG PET/CT in EIGHT patients with CNS lymphoma and in 18 patients with GBM were reviewed retrospectively. The SUV max of these tumors were measured. Then the mean CT values of the tumors were quantitatively determined at the area of thresholds of 90% of the SUV max. The SUV max and the mean CT value for malignant lymphomas were compared statistically with those for GBMs. Statistical analysis was performed to determine the optimal cut-off values of SUV max and CT values for differentiating GBMs from CNS lymphomas. The diagnostic accuracy was compared between single cut-off value (SUV max alone) and the combined cut-off value (combination of SUV max and CT values).

RESULTS
The SUV max for malignant lymphoma ranged from 7.6 to 27.4 (mean ± SD, 19.14 ± 7.01) and that for glioblastoma ranged from 4.5 to 23.3(10.36 ± 4.24). The mean CT value for malignant lymphoma ranged from 35.4 to 50.6 H.U. (40.25 ± 4.85) and that for glioblastoma ranged from 28.1 to 40.1 H.U. (34.38 ± 3.45). The SUV max and the mean CT value for malignant lymphoma were significantly higher than those for glioblastoma (both P values < 0.01). Using a combined cut-off value of SUV max of less than 15 and mean CT value of 39 H.U. or less for differentiating GBMs from CNS lymphomas. The diagnostic accuracy was compared between single cut-off value (SUV max alone) and the combined cut-off value (combination of SUV max and CT values).

CONCLUSION
The SUV max and the mean CT value for malignant lymphoma were significantly higher than those for glioblastoma. The combined use of these values may improve the differential diagnosis of these tumors.

KEY WORDS: PET/CT, glioblastoma, malignant lymphoma

Intraventricular Meningioma: Analysis of 42 Cases

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PURPOSE
Meningioma, the most common nonglial tumor, accounts for approximately one fourth of all primary intracranial neoplasms. However, an intraventricular location is rare (< 7% of meningiomas).

MATERIALS & METHODS
We retrospectively reviewed the clinicopathologic and imaging findings on CT (32/42) and MR (37/42) of 42 pathologically confirmed cases of intraventricular meningioma (IVM) collected from 1984-2009.

RESULTS
All 42 tumors were surgically confirmed as intraventricular. The most common location was the lateral ventricle atrium: left (18/42) and right (12/42). Two cases were in the 3rd ventricle and one in the 4th. The age range was 8 to 80 years, mean 39.9 years. The female-to-male ratio was (27/15). Most patients had an insidious onset of nonspecific symptoms over 2 years or less, including headache and visual problems. Three cases were incidental, noted on a CT or MRI after a head injury. In this series, (36/42) were WHO grade 1: meningothelial 12; fibrous 11; transitional 7; psammomatous 5; and “angiomatous” 1. All three patients with atypical (Grade 2) and all three with anaplastic (Grade 3) meningioma were male. Both pediatric patients were male and <10 years old. The most common postoperative complication was homonymous hemianopsia. Intraventricular
meningioma are well defined, circumscribed lesions within the ventricle. Tumors (≤4.0) cm were lobulated, (>4.0 to 5.0) cm were round to lobulated; and (>5.0) cm were lobulated. On CT without contrast, IVM was iso- or hyperattenuating (to brain) (28/32). Discrete calcification was seen on CT in 25 cases. Psammomatous IVM were the most densely and frequently calcified of the subtypes (4/5). On contrast CT, (30/32) had robustly enhancing homogeneous intraventricular masses. On T1-weighted MR imaging (MRI), IVM appeared isointense (18/37) or hypo-intense to gray matter; and, on T2-weighted images hyper- (29/37), (4/37), iso- (4/37) hypo-intense to gray matter. Most had homogeneous signal, while (7/37) were heterogeneous - most evident on T2-weighted images. All 36 meningiomas were vibrantly enhancing on MR with contrast (1 patient had only noncontrast MR). MR imaging showed areas of periventricular parenchymal edema in 29/36 cases. Hydrocephalus produced by lateral ventricular meningioma was localized to the ipsilateral trigone and temporal horn (dilation of posterior and inferior horn). However, four cases had bitemporal hydrocephalus; three were located in left atrium and one in right atrium. Catheter angiography, available for 25 cases, demonstrated the classic appearance - a hypervascular mass with increasing blush throughout the arterial phase, persisting well into the late venous phase, and with slow washout. Tumors in the atrium often were (8/18) supplied by both anterior and lateral posterior choroidal arteries. Two patients had calcifications visible on scout or plain film.

**Conclusion**

Although uncommon, meningiomas represent an important differential diagnosis for intraventricular masses. Intraventricular meningioma are usually vibrantly enhancing round to lobulated intraventricular masses in the atrium. Most patients had intermittent or vague symptoms for 2 years or less before diagnosis, and some were incidental findings. The meningothelial and fibrous subtypes were the most common and psammomatous IVM were densely calcified and visible on plain radiography in 2/5 cases.

**Key Words:** Intraventricular meningioma, pathology, MR imaging

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**Poster 022**

**Metastatic Brain Tumor on PRESTO before and after Gamma Knife Radiosurgery**

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**Purpose**

The aim of this study was to clarify the characteristics of susceptibility imaging using the principle of echo-shifting with a train of observation (PRESTO) technique for metastatic brain tumor at 3 T before and after gamma knife radiosurgery (GKR).

**Materials & Methods**

A total of 41 metastatic brain tumors in 14 patients (9 men, 5 women) were investigated before and after GKR on 3 T MR imaging (MRI). Locations of primary cancers were the lung (11 patients), kidney (1 patient), colon (1 patient) and uterus (1 patient). Mean patient age was 62 years (range, 44-80 years). The interval between GKR and follow-up MRI was 1-12 months (mean, 3.8 months). PRESTO and contrast-enhanced T1-weighted imaging were performed using a 3 T system using Achieva (Philips, Best, the Netherlands). Two neuroradiologists evaluated tumor size and signal voids (“dark spots”) in tumor on magnetic resonance images before and after GKR.

**Results**

Mean tumor diameter decreased significantly from 7.2 mm before GKR to 5.3 mm after GKR (P<0.0001). Use of 3 T PRESTO detected “dark spots” in 25 lesions (60.98%) in tumors before GKR. Mean area of “dark spots” on PRESTO was increased significantly after GKR from 22.4% to 71.78% (P<0.0001, Wilcoxon signed-ranks test).

**Conclusion**

The “dark spots” in metastatic brain tumor on PRESTO increase after GKR.

**Key Words:** Metastatic brain tumor, MR imaging, PRESTO

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**Poster 023**

**Evaluation of Vasodilatory Response to Acetazolamide Challenge in Meningioma by the 123I-IMP Dual-Table Autoradiographic Method**

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**Purpose**

This is the first investigation of vasodilatory response (VR) to acetazolamide challenge in meningioma by the 123I-IMP dual-table autoradiographic method.

**Materials & Methods**

Thirteen patients with meningioma, who underwent 123I-IMP dual-table autoradiographic method, were enrolled in this study (male 7 and female 6). Regions of interest were placed over the tumor and the contralateral normal parietal cortex. The radioisotope (RI) counts in the tumor and the parietal cortex were evaluated respectively before and after acetazolamide challenge (tumor counts before acetazolamide challenge: Tacz, normal cortex counts after acetazolamide challenge: Cacz). To compare tumor uptake to normal cortex uptake, the ratio of Trest to Cacz (rest T/C) and that of Tacz to Cacz (acz T/C) were calculated respectively. And rest T/C was compared to acz T/C to evaluate the change of uptake ratio of tumor to normal cortex between before and after acetazolamide challenge. To evaluate the vasodilatory
response to acetazolamide challenge in the tumor, the ratio of Tacz to Trest (TVR) and that of Cacz to Crest (CVR) were calculated respectively, then TVR was compared to CVR.

**RESULTS**

Rest T/C is 0.66-1.20, (mean 0.94, SD 0.18) and six meningiomas presented lower (restT/C<1) and seven meningiomas presented higher (restT/C>1) uptake to the normal cortex before acetazolamide challenge. While, acz T/C is 0.55-0.89 (mean 0.68, SD 0.10) and all meningiomas presented lower uptake to normal cortex after acetazolamide challenge. And acz T/C is significantly lower than rest T/C (P<0.0001). TVR was 1.54-2.43 (mean 2.07 SD 0.27) and CVR was 2.6-3.14 (mean 2.83, SD 0.15). TVR was significantly lower than CVR (P<0.0001).

**CONCLUSION**

Vasodilatory response to acetazolamide challenge in meningioma was lower than that in normal cortex. And meningioma presents lower uptake to normal cortex after acetazolamide challenge, regardless of the tumor uptake before acetazolamide challenge.

**KEY WORDS:** Intratumoral blood flow, meningioma, 123I-IMP

**Poster 024**

Analysis of Language and Memory Lateralization by Functional MR Imaging and WADA Test in Epilepsy and Effect of Gender on Postoperative Seizure Improvement

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**PURPOSE**

The intracarotid sodium amobarbital procedure (ISAP or WADA test) lateralizes cerebral functions to the cerebral hemispheres preoperatively. Functional magnetic resonance imaging (fMRI) is used increasingly to analyze preoperative language lateralization. In this study, concordance of fMRI with WADA was examined in patients with medically intractable seizures. The relationship of the distance between the epileptic focus to functional activation area with patients’ postoperative deficits in language also is analyzed.

**MATERIALS & METHODS**

This study includes 17 patients with preoperative fMRI and WADA (n = 17 for language tests, n = 9 for memory, age range: 12-49 years). The images were analyzed using established fMRI paradigms for language and memory (Moritz/Haughton 2003). Activation of Broca’s and Wernicke’s areas were measured in three dimensions. A threshold-dependent lateralization index (LI) was calculated for language areas: LI = [(L-R)/(L+R)] * ½. L<0.25 is considered left-hemisphere dominant, 0.25< LI < -0.25 considered bilateral, and LI<-0.25 considered right dominant. An experienced technologist’s interpretation of memory lateralization was utilized for analysis. Standard neuropsychiatry WADA test procedures were used for comparison. The shortest distance between a language area to the border of surgical focus (LAD) was measured (<10 mm, 10-20 mm, or >20 mm) and compared with postoperative language deficits. The effect of gender on postoperative seizure improvement also was analyzed. Improvement (binary decision) was based on postoperative neurologic assessment at 6 months and/or reduction in seizure medication dose at 6 months. Chi square tests, Fisher’s exact test, ANOVA, and Student’s t-test were performed for statistical analysis.

**RESULTS**

Concordance between fMRI and WADA is 82.4% (p = 0.88) for language dominance and 66% (p = 0.64) for memory. No correlation was found between LAD and postop language or memory deficit (p-value = 0.46 for language; p = 0.37 for memory). Females demonstrated increased postoperative seizure improvement (Fisher’s p-value = 0.009; female = 12; male = 7). Gender groups had no significant difference in terms of age, handedness, preoperative seizure types, or location of surgical focus.

**CONCLUSION**

Language concordance between fMRI and WADA is similar to that reported in prior studies (Binder, et al, 2006; Swanson, et al, 2007). Targets for future studies include further examination of the concordance of fMRI with WADA for memory paradigms and further correlation of LAD with language/memory deficits. However, this study clearly demonstrates fMRI as a useful preoperative adjunct to WADA for language lateralization in patients with medically intractable seizures.

**KEY WORDS:** WADA, language, memory
Poster 025

Corpus Callosum Damage in Patient with Carbon Monoxide Poisoning: A Diffusion Tensor Imaging-Based Probabilistic Topography

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PURPOSE
Carbon monoxide (CO) poisoning causes diffuse white matter injury and results in different neuropsychiatric complications. Diffusion tensor image (DTI) provides a noninvasive method to explore white matter (WM) pathways and its integrity. To determine if microstructural changes occur in corpus callosum (CC), which is the largest commissural fiber connecting bilateral hemisphere, we use tractography-based method to parcellate CC in CO poisoning patients with and without delay sequel.

MATERIALS & METHODS
Diffusion tensor imaging was performed in 10 patients with delayed sequelae (DS), 10 patients without delayed sequelae (NDS) after CO intoxication and in fifteen sex- and age-matched healthy volunteers on a 3 T GE Sigma Excite MR scanner with an 8-channel head coil. The DTI image was processing using FMRIB Diffusion Toolbox (FDT) of functional magnetic resonance imaging (fMRI) of Brain’s Software Library (http://www.fmrib.ox.ac.uk/fsl/) tools. Probabilistic tractography from voxels within the CC was performed using Bayesian techniques. Cortical connectivity information was used to divide the CC into seven subregions with highest probability of connectivity to distinct cortical areas. Diffusion tensor imaging parameters, including fractional anisotropy (FA), first eigen value (FEV) and radial diffusivity (RD), were analyzed using ANCOVA with age and sex as the covariates.

RESULTS
Significantly reduced FA and increased RD, suggesting demyelination, was found in DS group relative to that in controls in the prefrontal (PFC), premotor (PMC), primary motor, sensory, posterior parietal and occipital areas (p<0.05). The DS group also experienced worse DTI parameters than NDS group in PFC and PMC areas (p<0.05). In NDS group, DTI parameters also were declined in all CC subareas than controls, though difference was not significant (Fig. 1).

CONCLUSION
Our findings provided evidence of reducing interhemispheric connectivity with fiber demyelination in CO poisoning. The worst DTI parameters might relate to delayed cognitive encephalopathy. This topography of the CC may serve as a landmark to further understand the correlations between the CC, brain intercommunication, and functional cytoarchitecture.

KEY WORDS: Carbon monoxide poisoning, diffusion tensor imaging, corpus callosum

Poster 026

White Matter Involvement in Sporadic Creutzfeldt-Jakob Disease

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PURPOSE
To explore diffusion tensor imaging (DTI) metrics changes in the gray and white matter of sporadic Creutzfeldt-Jakob disease (sCJD) and possibly identify a specific pattern of subcortical white matter (WM) involvement.

MATERIALS & METHODS
Twenty-six sCJD patients [F:M 12:14; mean age 62(9) years] matching the 2007 UCSF sCJD criteria, and nine healthy controls [F:M 4:5; mean age 62(16) years] seen at the Memory and Aging Center of UCSF were studied with the same 1.5 T GE MRI. Diffusion tensor imaging parameters: Axial T1-weighted 3D FSPGR volume imaging (TE/TR 6/27, voxel 0.94x0.94x3, matrix 256x192, FOV of 75) and DTI scan with 15 directions (3mm slice thickness, TR/TE 9000/69, b=1000s/mm² and one b=0s/mm² reference image)
were acquired on a 1.5T. The mean diffusivity (MD), axial diffusion (DA) radial diffusion (DR) and fractional anisotropy (FA) maps were calculated by in-house software after eddy-current correction. We performed cortical gray matter and white matter segmentation with Freesurfer 4.5 image analysis suite; with the same tool we performed a parcellation respectively of the cortex and subcortical white matter into 34 regions of interest (ROIs) for each hemisphere (Desikan-Kyliany Atlas). The DTI maps were coregistered to the T1 space by using an affine alignment (FLIRT) followed by a nonlinear alignment (FNIRT) of the FA map to the T1 volume. The fidelity of the registration was confirmed by visual inspection. The average of the DTI parameters in the total white matter mask and the average of MD and FA in each gray and white matter ROI were calculated. We performed the Van der Waerden version of the Krustal-Wallis nonparametric test to compare the differences between the two groups for the DTI parameters in each ROI.

RESULTS
In the total white matter we observed statistically significant reduction of MD (p=0.0015), DA (p=0.0002), DR (p=0.0163) in the sCJD patients versus controls. In most of the white matter ROIs the average MD was significantly lower (P<0.01) in sCJD compared to the controls with an almost symmetric pattern of involvement; the average FA was significantly lower in sCJD (P<0.05) compared to the controls bilaterally in the entorhinal and posterior right posterior cingulate, in the left rostral middle frontal insula, parahippocampi, in the right lateralorbitofrontal, medial orbitofrontal, caudal anteriorcingulate, rostral anteriorcingulate, middle temporal and temporal pole WM. No FA changes were found in the occipital and parietal WM ROIs. In the cortical ROIs we observed a statistically significant MD reduction (p<0.01) bilaterally in the isthmuscingulate, parahippocampal, bankssts, fusiform, inferiortemporal, middletemporal, inferiorparietal, precuneus, supramarginal, in the left postcentral, left superioparietal, left cuneus, in the right posteriorcingulate and in right lateraloccipital. No significant MD differences (p<0.01) were observed in the frontal lobe. In the deep nuclei we observed statistically significant reduction of MD (p<0.01) bilaterally in the caudate, thalamus, putamen and in the left pallidum.

CONCLUSION
In this study we show a significant global involvement of the white matter in sCJD. We hypothesize that this could be mainly the expression of primary changes of the disease, and not due to secondary degeneration of WM.

KEY WORDS: Diffusion tensor imaging, sporadic Creutzfeldt-Jakob disease

Poster 027
Differentiation of Brain Abscesses from Necrotic GBM and Cystic Metastatic Brain Tumors with Use of Diffusion Tensor Imaging

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PURPOSE
The differentiation of abscess from GBM and metastasis may not always be possible based on diffusion-weighted imaging. Our hypothesis was that differences in diffusion anisotropy as detected by diffusion tensor imaging (DTI) allow differentiation of abscess from GBM and metastasis.

MATERIALS & METHODS
Preoperative DTI was performed in 15 patients with brain abscess, 15 patients with necrotic GBM and 24 patients with solitary cystic metastasis. FA, ADC, linear (Cl), planar (Cp) and spherical (Cs) tensors were measured in four different manually segmented, nonoverlapping regions of interest (i.e., cystic cavity, enhancing rim, immediate and distant perifocal edema for all patients). FA maps were assessed visually for the presence of hyperintense rim in the perifocal edema. Mean values of all tensor metrics for each region of interest (ROI) and the incidence of hyperintense FA rim were statistically compared among groups. The diagnostic performance of all tensor metrics in differentiating abscess from GBM and metastasis were evaluated with receiver operating characteristic curve analysis.

RESULTS
Abscess was significantly different from GBM for all tensor metrics measured in cystic cavity and immediate perifocal edema, and for all tensor metrics except Cl in the enhancing rim. Abscess was significantly different from metastasis for all tensor metrics measured in cystic cavity and enhancing rim, and for FA, ADC and Cl in immediate perifocal edema. The incidence of hyperintense FA rim was significantly higher in GBM (93.3%, p <.001, Odd ratio = 91) and metastasis (84.6%, p <.001, Odd ratio = 35.7) as compared with abscess (13.3%). The three tensor metrics with highest discriminating power were FA, CI and Cs of cystic cavity.

CONCLUSION
Diffusion tensor imaging is able to differentiate abscess from GBM and metastasis with qualitative assessment and quantitative measurement.

KEY WORDS: Diffusion tensor imaging, brain abscess, GBM
**Poster 028**

**Decreased White Matter Integrity in Acute Carbon Monoxide Intoxication**

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**Purpose**

Human toxicity often is overlooked in carbon monoxide (CO) intoxication because CO is tasteless and odorless and its clinical symptoms and signs are nonspecific. It may develop hypoxic brain damage which predominates in the cerebral cortex, cerebral white matter and basal ganglia. The aim of the study is to evaluate the integrity of white matter after acute CO intoxication and the relationship with clinical comorbid conditions by diffusion tensor imaging (DTI).

**Materials & Methods**

Diffusion tensor imaging scan was conducted on 20 patients with acute CO intoxication and 20 sex- and age-matched healthy volunteers. Tract-based spatial statistics was used for voxelwise analysis of whole brain white matter DTI measures. The diffusion measures were correlated with Glasgow coma scale, capillary blood pH value, white-blood cell count, serum carboxyhemoglobin, potassium, and creatinine (Cr) level when these patients arrived at the emergency room.

**Results**

Regions characterized by low fractional anisotropy (FA) and high radial diffusivity (RD) included corpus callosum, external capsule, corona radiata, superior longitudinal fasciculus, and inferior longitudinal fasciculus, indicating demyelination process. Greater diffusion abnormalities in sections of inferior longitudinal fasciculus were associated with decreased capillary blood pH value. Lower FA measures in corpus callosum fiber tracts were correlated with elevated serum Cr level, indicated rhabdomyolysis.

**Conclusion**

The findings indicate that acute CO intoxication will develop demyelination in selective white matter tracts. Worse clinical condition may predict the severity of white matter damage which can assist the guidance of clinical management.

**Key Words:** Carbon monoxide intoxication, diffusion tensor imaging, tract-based spatial statistics

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**Poster 029**

**Assessing the Chronic Neuropsychologic Sequelae of HIV-Negative Cryptococcal Meningitis Using Diffusion Tensor Imaging**

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**Purpose**

The high rate of neuropsychologic sequelae in cryptococcal meningitis (CM) survivors indicates that initial antifungal therapy is far from being satisfactory. This prospective cross-sectional study applied diffusion tensor imaging (DTI) on HIV-negative CM patients to determine if microstructural changes in brain tissue are associated with subsequent cognitive symptoms.

**Materials & Methods**

Fifteen patients with HIV-negative CM and 15 sex- and age-matched healthy volunteers were evaluated and compared. All underwent complete medical and neurologic examinations, and neuropsychologic testing. Brain DTI was obtained to derive the fractional anisotropy (FA) and apparent diffusion coefficient (ADC) of several brain regions. Correlations among DTI parameters, neuropsychologic rating scores, and cryptococcal-antigen titer in CSF were analyzed.

**Results**

Significant ADC values increased and FA values decreased in HIV-negative CM patients in multiple selected regions of interest, including the genus of the corpus callosum and the frontal, parietal, orbito-frontal, and periventricular white matter and lentiform nucleus (Figure 1). Higher CSF cryptococcal-antigen titer on admission was associated with poorer DTI parameters \((r = -0.666, p = 0.018)\), which were linearly related to worse cognitive performance during follow up.

**Figure 1.** The relationship revealed linear correlation \((p < 0.05)\) between mean FA (b), mean RD (c) and capillary blood pH value, located on corpus callosum (splenium), which ROI drawn on the mean FA skeleton (a). The relationship revealed linear correlation \((p < 0.05)\) between mean FA (e), mean RD (f) and capillary blood pH value, located on right ILF/IFO, which ROI drawn on the mean FA skeleton (d). ILF= inferior longitudinal fasciculus; IFO= inferior frontooccipital fasciculus.
The decline in brain DTI parameters in the associated brain areas indicate an HIV-negative CM microstructural pathology that is related to neuropsychologic consequences.

**Key Words:** Diffusion tensor image, cryptococcal meningitis, cognition

**Poster 030**

Effect of Fiber Orientation Distribution Function Reconstruction on Probabilistic Tractography

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**Purpose**

In neurodegenerative diseases conventional magnetic resonance imaging (MRI) identifies areas of injury, but poorly measures the degree of injury. Diffusion tensor imaging (DTI) is an advanced MRI technique that holds promise to identify fiber tracks in the CNS. However, conventional tractography fails in lesions and with crossing fiber tracks1. High angular resolution diffusion imaging, combined with reconstruction of the diffusion probability density function (PDF), allows tracking algorithms to potentially work through lesions and crossing fibers2,3. The persistent angular structure (PAS) reconstruction has demonstrated more precision as compared to other PDF reconstruction methods4, but has rarely been used due to its computational cost. Recent advances have reduced this cost5, so we investigate this method as a basis for probabilistic tractography. We present our initial results of probabilistic tracking with the PAS and compare with probabilistic tracking using spherical deconvolution (SD).

**Materials & Methods**

Probabilistic tractography with each of the two probability distribution functions was performed using HARDI scans from 17 healthy controls and 10 multiple sclerosis patients. Three tracking problems were presented to each algorithm: tracking across the splenium corporis calloso, finding the corticospinal tract from the mid-pons to the motor cortex and tracking from the left to right hand motor areas. Identical tissue, seed and target masks were used for each test. Finally, we performed our comparison of the tracking results qualitatively, by tracking efficiency and by tracking consistency.

**Results**

Probabilistic tractography with SD was more efficient in attempts per track in two of the three cases, and was faster on average than with PAS. However, PAS reconstruction produced lower dispersion tracks as measured with the Hausdorff distance.

**Conclusion**

Probabilistic tractography using a PDF generated via persistent angular structure was able to generate tracks across the splenium, following the corticospinal tract from the peduncle to the cortex, and in 23 out of 27 cases from the left to the right hand motor area. We demonstrate the ability of probabilistic tractography with PAS to find a path through the dense crossing fibers of the superior longitudinal fasciculus as well as through multiple sclerosis lesions.

**Key Words:** Tractography, Diffusion Imaging

**Poster 031**

Imaging Characteristics in Patients with Potentially Treatable Voltage-Gated Potassium Channel Antibody Associated Limbic Encephalitis

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**Purpose**

Limbic encephalitis (LE) is an autoimmune disease often associated with certain tumors. Recently, there has been recognition that LE occurs also in patients without tumors, but with antibodies (Ab) to voltage-gated potassium channel (VGKC) complexes. Moreover, some LE patients with malignancies also have VGKC-Ab. Immunotherapies are being explored in LE patients with VGKC-Ab. As the long-term consequences of LE frequently are devastating, and the disease is potentially treatable, it is important that neuroradiologists recognize the existence of this entity. The imaging characteristics of LE in patients with VGKC-Ab are described.

**Materials & Methods**

Following IRB approval, 18 patients with LE with VGKC-Ab were identified. Chart reviews were performed. All available imaging was reviewed cooperatively, consensus reached at time of interpretation, and results tabulated. There was variability in the imaging sequences performed and in the availability of contrast-enhanced images, particularly in studies performed at outside institutions. Due to the retrospective nature of the study, in some cases it was difficult to temporally relate treatment regimens with specific imaging studies.

**Results**

Twelve male and six female patients with LE with VGKC-Ab were identified, (mean 54 years old, range 8–74 years). Three patients had malignancies (NHL, metastatic prostate adenocarcinoma, and thymoma). There was no known malignancy in 15 patients at the time of diagnosis or at clinical follow up (10 months to 8.5 years). Common clinical presentation scenarios included evolving cognitive decline, personality changes, and development of various seizure types, including simple partial and complex partial most frequently, as well as generalized. Three patients had normal imaging at presentation. In the 15 cases with abnormal MRI at presentation, imaging findings revealed enlargement of the amygdala and/or hippocampus with associated signal abnormality on T2-weighted images, unilateral in eight (53%) and bilateral in seven (47%). Seven cases (47%) demonstrated mild, smudgy enhancement. In two cases (13%), there was also restricted diffusion. In six cases with either initial negative or unilateral presentation, subsequent short-term follow-up studies demonstrated progression to bilateral findings. Mesial temporal sclerosis was identified in
eight patients (44%) at long-term follow-up exam (greater than 1 year). In one patient referred to our institution, imaging findings had been interpreted as glioma leading to temporal lobectomy. Pathology demonstrated moderate to marked gliosis as can be seen as sequelae of chronic seizures.

**CONCLUSION**

Imaging findings associated with VGKC-Ab appear to be within the realm of those typically associated with paraneoplastic LE. Confounding interpretation is the fact that imaging is evaluating a dynamic pathologic process, likely reflecting not only the primary pathologic inflammatory process, but findings also associated with engendered seizure activity. Superimposed immunotherapy and antiepileptic drug treatments likely also contribute to imaging findings. Future prospective studies are anticipated to permit more discrete analysis of the various contributors to imaging findings. In summary, autoimmune epilepsy may be permitting more discrete analysis of the various contributors to seizure activity. Superimposed immunotherapy and antiepileptic drug treatments likely also contribute to imaging findings. Recognition of imaging findings may prevent unnecessary invasive procedures and allow early institution of therapy.

**KEY WORDS:** Limbic encephalitis, epilepsy, voltage-gated potassium channel antibody

**Poster 032**

**Spectrum of MR Findings of Acute Wernicke Encephalopathy: Does Atypical Findings Show at Nonalcoholic Patients, Always?**

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**PURPOSE**

The purpose of our study was to show spectrum of MR findings of Wernicke encephalopathy in patients with and without history of alcohol abuse.

**MATERIALS & METHODS**

We retrospectively evaluated MR imaging findings of 20 consecutive patients [M:F = 11/9, mean age: 53.7 (50~63) years] with Wernicke encephalopathy. Six patients had history of alcohol abuse and 14 patients had depression or had been receiving total parenteral nutrition (TPN) due to various causes including cancer. Clinical manifestation and MR findings were analyzed in alcoholics and nonalcoholic patients with consensus; location of lesions, enhancement pattern, diffusion characteristics on DWI, etc. Treatment and outcome also were documented.

**RESULTS**

Fifty percent (10/20) showed changes in consciousness, 40% (8/20) had ocular symptom, and 35% (7/20) had ataxia. Involved area of MRI brain imaging was at thalamus (19/20), mamillary bodies (18/20), periaqueduct area (20/20), medulla (10/20), cerebellar peduncle (2/20), and cortex (6/20). Six patients (30%) alcoholics and 14 patients (70%) nonalcoholics had cortical involvement. On diffusion-weighted imaging (DWI), two patients had diffuse high signal intensity along cortex of both frontal lobes. Contrast enhancement in the periaqueduct area (5/20), mamillary bodies (5/18), medial thalami (2/18), cortex (2/18) was observed. Four patients (65%) alcoholics and three patients (20%) nonalcoholics had thiamine medication and improved clinical manifestation. Four patients showed stupor to comatous mentality and cortical involvement at the same time. Six patients are alert mentality as well as no cortical involvement.

**CONCLUSION**

Wernicke encephalopathy is characterized by a quite distinct pattern of MR alterations, which include symmetric high signal intensities in the thalami, mamillary bodies, tectal plate, and periaqueduct area. Cortical involvement of patients with Wernicke encephalopathy is not uncommon and this finding may not be an indicator distinguishing between alcoholics and nonalcoholics. Also atypical MR findings, especially cortical involvement may be more related to clinical severity than to alcohol use.

**KEY WORDS:** Wernicke encephalopathy, MR imaging

**Poster 033**

**Cerebral Edema in Cirrhotic Patients with and without Spontaneous Portosystemic Shunt: A Voxel-Based Morphometry Study**

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**PURPOSE**

Hepatic encephalopathy (HE) is a well-known complication after the transjugular-intrahepatic-portosystemic shunt. Cerebral edema occurs immediately after procedure due to neurotoxins bypassing the liver. Liver cirrhosis and portal hypertension may develop the spontaneous portosystemic shunt (PSS). However, the role of spontaneous PSS to the brain is still unclear. The purpose of this study is to evaluate the structural change in cirrhotic patients with and without spontaneous PSS by using voxel-based morphometry (VBM).

**MATERIALS & METHODS**

Total 41 cirrhotic patients and 22 age/gender-comparable healthy controls were enrolled in this study as the group with spontaneous PSS (n=25), the group without spontaneous PSS (n=16), and the group of healthy controls. Voxel-based morphometry was conducted to investigate the differences in gray matter volume between these groups and to determine which structural abnormalities existed.

**RESULTS**

Cirrhotic patients with spontaneous PSS showed volume reduction in bilateral basal ganglia after comparing with the group without PSS and healthy controls (Figure 1a).
However, the volume of bilateral thalami, hippocampi, parahippocampi, and insular and cingulate cortices were significantly greater in the cirrhotic patients with PSS. Furthermore, the group with PSS revealed more volume increase in bilateral thalami, parahippocampi and cingulate cortices than the group without PSS (Figure 1b).

(Figure 1) Superimposed images of the brain with statistical t map depicting the volume difference between groups: (a) Normal controls and cirrhotic patients without PSS had greater volume in bilateral basal ganglion than patients with PSS. Portosystemic shunt with neurotoxin deposition in basal ganglion may lead to tissue damage and atrophy. No significant volume difference between the normal group and the group without PSS. (b) The size of bilateral thalami, hippocampi, parahippocampi, and insular and cingulate cortices were significantly greater in the group with PSS, in comparison not only with normal controls but also with the group without PSS. The spontaneous PSS increases the risk of cerebral edema.

**CONCLUSION**

Except volume reduction in basal ganglia, cirrhotic patients with spontaneous PSS revealed significant volume increase in selective gray matter indicating cerebral edema. Our results supplement relevant information and bedside assessments on cirrhotic patients with repeated HE.

**KEY WORDS:** Portosystemic shunt, liver cirrhosis, voxel-based morphometry

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**Poster 034**

**Alteration of Brain Water Diffusivity in Cirrhotic Patients with and without Spontaneous Portosystemic Shunt: a Tract-Based Spatial Statistics Study**

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**PURPOSE**

Spontaneous portosystemic shunt (PSS) is a well-known complication of liver cirrhosis and portal hypertension. However, its impact to brain water diffusivity still is not well delineated. The purpose of this study is to evaluate the white matter diffusivity with diffusion tensor imaging (DTI) by tract-based spatial statistics (TBSS) method in cirrhotic patients with and without PSS and correlating to portal vein flow, shunt severity and lab data.

**MATERIALS & METHODS**

Diffusion tensor imaging data were collected from 25 cirrhotic patients with spontaneous PSS, 16 cirrhotic patients without PSS, and 22 age/gender comparable healthy controls. Four DTI parameters, fractional anisotropy (FA), first eigenvalue (FEV), radial diffusivity (RD) and apparent diffusion coefficient (ADC) were compared among the three groups by analyzing DTI data using TBSS. Portal vein flow was measured by Doppler ultrasound. Shunt severity was defined after review of CTA or MRA of liver.

**RESULTS**

Cirrhotic patient with PSS showed decreased FA, increased RD (Figure 1) and increase ADC after comparing with cirrhotic patients free of PSS and health controls. No significant difference of FEV among the three groups. Also, no significant difference of FA, RD (Figure 1) and ADC between cirrhotic patients free of PSS and health controls. Lower portal vein flow, lower albumin level, higher ammonia level and increase severity of spontaneous PSS correlated with lower FA.

(Figure 1) Group comparisons of FA and RD using tract-based spatial statistics. The skeleton image (green color, FA>0.2) overlaid with the mean FA image as background.
The significance was calculated by uncorrected threshold free cluster enhancement (TFCE) method with P<0.05. (a, b, c) Significant FA value difference between groups. (d, e, f) Significant RD value difference between groups. (a, d) Cirrhotic patient with PSS (designated as shunt group) vs. Control. (b, e) Cirrhotic patient without PSS (designated as no-shunt group) vs. Control. (c, f) Cirrhotic patient with PSS vs. Cirrhotic patient without PSS.

CONCLUSION
Cirrhotic patients with spontaneous portosystemic shunt showed significant increase of brain water diffusivity and association with poor clinical profile. Portosystemic shunt blood flow bypassing liver has edematogenic effect to brain may explain that no significant DTI parameter difference between cirrhotic patients without spontaneous PSS and control group. In addition, TBSS is a promising method in examining the white matter degeneration in cirrhotic patient with spontaneous portosystemic shunts.

KEY WORDS: Portosystemic shunt, DTI

Poster 035

3D Pseudo Continuous Arterial Spin-Labeled Perfusion MR Imaging in Patients with Alzheimer Disease: A Correlative Study with 99mTc-ECD SPECT

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PURPOSE
To compare the use of whole brain pseudo continuous arterial spin labeling (ASL) and 99mTc-ECD SPECT to assess cerebral blood flow (CBF) in patients with Alzheimer disease for the validation of quantitative pseudo continuous ASL perfusion in an altered hemodynamic state.

MATERIALS & METHODS
Seventy-five patients with Alzheimer disease were studied with pseudo continuous ASL and conventional MRI (3 T, GE Medical Systems, Milwaukee, USA). Cerebral blood flow also was evaluated with 99mTc-ECD SPECT. The average values within regions of interest (ROIs) drawn on coregistered pseudo continuous ASL and 99mTc-ECD SPECT images were used for the linear regression analysis and to assess the effect of transit time on the quantification using pseudo continuous ASL.

RESULTS
In all patients there was a significant correlation between the CBF values from pseudo continuous ASL and 99mTc-ECD SPECT.

CONCLUSION
Pseudo continuous ASL MRI showed regional hypoperfusion with Alzheimer disease in brain regions similar to those seen in 99mTc-ECD SPECT. Quantification of CBF using pseudo continuous ASL is feasible and reasonable, even when employed in a routine clinical setting.

KEY WORDS: Alzheimer disease, pseudo continuous arterial spin labeling

Poster 036

Evaluation of the Evolution and Relevance of in vivo MR Imaging Blood-Brain Barrier Permeability Measurements in a Rat Model of Ischemic Stroke

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PURPOSE
To evaluate the predictive value of blood-brain barrier (BBB) permeability measurements extracted from perfusion-weighted MR imaging for hemorrhagic transformation in stroke.

MATERIALS & METHODS
Spontaneously hypertensive rats and Wistar rats with unilateral, 2-hour filament occlusion of the right MCA underwent imaging during occlusion, postreperfusion at 4 hours and 24 hours. Blood-brain barrier permeability was imaged by dynamic contrast enhancement imaging technique and quantified by Patlak analysis. Cresyl-violet staining was used to detect and characterize hemorrhage on histology in sacrificed rats at 24 hours, immediately following the last imaging study. Permeability changes were evaluated at baseline, after reperfusion and at 24 hours, in animals with or without macroscopic hemorrhage. Receiver-operating characteristic curve (ROC) analysis was performed to determine the most accurate permeability threshold to predict hemorrhagic transformation.

RESULTS
In animals that showed macroscopic hemorrhage at 24 hours, BBB permeability values in the whole infarcted hemisphere were 0.28 ± 0.02, 0.51 ± 0.19, and 0.42 ± 0.09 ml/min • 100ml (µ±σ) during occlusion, 4-hour postreperfusion and 24-hour postreperfusion, respectively. Blood-brain barrier permeability values on the contralateral hemisphere in the same animals were 0.27 ± 0.04, 0.36 ± 0.16, and 0.26 ± 0.11 ml/min • 100 ml, respectively. In animals without a macroscopic hemorrhage at 24 hours, BBB permeability values in the infarcted hemisphere were: 0.27 ± 0.06, 0.49 ± 0.24, 0.45 ± 0.18 ml/min • 100 ml. The predictive value of BBB permeability in terms of macroscopic hemorrhage at 24 hours was characterized on the ROC analysis by an area under the curve of 0.679. Combining BBB permeability with reperfusion information mildly increased the area under the curve to 0.761. Overall, the negative predictive value of BBB permeability measurements was significant, while the positive predictive value was limited. For instance, for a BBB permeability threshold of e.g., 0.35 ml/min • 100 ml positive and negative predictive values were 6.4% and 97.6% respectively.
CONCLUSION
Altered BBB permeability is a necessary but not sufficient condition to cause hemorrhagic transformation in rats with an infarct. Further research is needed to identify the additional risk factors that need to be present, in combination with an increased BBB permeability, to perfectly predict hemorrhagic transformation in the setting of stroke.

KEY WORDS: Ischemic stroke, hemorrhagic transformation, blood-brain barrier permeability

Poster 037
Correlation of CT Perfusion Occipital Blood Flow Asymmetries with Asymmetric Posterior Communicating Arteries in Stroke Patients

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PURPOSE
The University of Colorado Denver stroke program has used CT perfusion (CTP) and CTA (CT angiography) for stroke alert patients for over 5 years. During this time we identified multiple cases of subjective occipital perfusion asymmetry that coincided with asymmetries between the posterior communicating artery diameters. To further evaluate, we measured the posterior communicating artery (PCA) distribution mean transit time (MTT), time to peak (TTP) and cerebral blood flow (CBF) and compared these parameters to the ratios of the diameters of the first segments (DP1) of the posterior cerebral arteries and the diameter of posterior communicating arteries (DPcom).

MATERIALS & METHODS
The study was granted IRB-exempt status by the hospital. Stroke patients were evaluated with dynamic CTP and CTA. Only patients without evidence of posterior circulation embolic events were included. Thirty-five patients from the time period of 1/2005-7/2006 have been analyzed thus far. Patients were segmented into those with and without perceived asymmetries in the occipital lobe perfusion parameters (TTP, MTT and CBF) using manufacturer’s standard software. Thirteen patients had perceived asymmetries in occipital perfusion parameters. Images were reanalyzed with an independent deconvolution-based software package (Vitrea). We measured voxel means and standard deviations for each left and right PCA territory perfusion parameter using uniform regions of interest (ROIs). We measured DP1 and DPcom using standard PACs software tools (McKesson) and calculated DP1/DPcom. Left-right differences in the same perfusion parameters were calculated and plotted against left-right P1/Pcom differences and the data fit by linear regression.

RESULTS
Current results demonstrate positive correlations between increasing difference in TTP and MTT and increasing P1/Pcom ratios, i.e., the greater the difference in P1/Pcom between occipital lobes, the greater the difference in the perfusion parameters. Cerebral blood flow demonstrated a similar but negative correlation, as expected.

CONCLUSION
These results demonstrate that posterior circulation perfusion asymmetry correlates with asymmetric occipital supply differences (persistent fetal circulation) and are consistent with our previously-presented hypothesis (ASNR 2008) that the posterior circulation perfuses slightly more slowly than the anterior circulation.

KEY WORDS: Perfusion, PCA, anatomy

Poster 038
Assessment of EC-IC Bypasses Patency in Patients with Moyamoya Phenomenon: Comparison of 3 T Time-of-Flight MR Angiography with CT Angiography

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PURPOSE
Moyamoya phenomenon is a nonatherosclerotic occlusive disorder that classically involves the proximal intracranial arteries, and may result in cerebral ischemia or hemorrhage. Extracranial-intracranial bypass is a surgical technique for augmenting the deficient cerebral blood supply. Digital subtraction angiography (DSA) is the gold standard for evaluating bypass patency. Computed Tomography angiography (CTA) was shown 100% sensitivity and specificity with high diagnostic confidence in comparison to the DSA, and has became an accepted noninvasive method for evaluating EC-IC bypass patency. Our goal was to evaluate EC-IC bypass patency in patients with moyamoya using time-of-flight MR angiography at 3 T, using CTA as a reference standard.

MATERIALS & METHODS
We retrospectively analyzed a consecutive series of 17 EC-IC bypasses using 3 T TOF MRA done between August 2007 to June 2010 in 11 patients with moyamoya phenomenon. Two interventional neuroradiologists, blinded to the clinical history, independently reviewed 3 T TOF MRA and CTA for each patient. Conventional DSA was available in five patients with 8 EC-IC bypasses.
RESULTS
3 T TOF MRA accurately depicted the patency of 14 EC-IC bypasses and demonstrated one EC-IC bypass occlusion correctly. The other 2 EC-IC bypasses were incorrectly categorized as occluded on MRA. The sensitivity for confirming patency was 87.5% (C.I. 0.06 to 0.98).

CONCLUSION
3 T TOF MRA is a reasonably accurate technique for confirming EC-IC bypass patency. The technique avoids the radiation exposure and contrast injection needed for routine follow up with CTA.

KEY WORDS: Time-of-flight MR angiography, moyamoya, EC-IC bypass

Poster 039

Pixel-Based Analysis of Apparent Diffusion Coefficient in Perihematomal Edema: Associated Factors and Outcome Predictive Value for Intracerebral Hemorrhage

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PURPOSE
Perihematomal edema (PE) develops within first few days after primary intracerebral hemorrhage (ICH) and is associated with patient’s outcome. Diffusion MR imaging (MRI) can help characterize components of edema. Cytotoxic edema decreases apparent diffusion coefficient (ADC), whereas vasogenic edema increased ADC. However, the overall mean ADC value within edema, as used in most studies of perihematomal edema, may be a mixture of reduced ADC due to cytotoxic edema or ischemia, canceled out by the effect of vasogenic edema which would elevate the ADC value, thus decreasing the sensitivity and specificity for predicting outcome. In this study, we investigated the components of PE with pixel-based analysis of ADC value.

MATERIALS & METHODS
Forty-six patients with ICH were enrolled for clinical evaluation and MRI scans within 24 hours after ICH. The pixels with edema were classified into three categories: cytotoxic, vasogenic and undetermined based on the ADC value of the ipsilateral pixel divided by the mean ADC value of the contralateral mirror region of interest. The percentage of cytotoxic and vasogenic edema then were calculated and correlated with patients’ clinical outcome according to Modified Rankin Scale (mRS) at 6 months after ICH.

RESULTS
Table 1 shows the correlation coefficients of clinical variables with percentages of cytotoxic edema. Among the clinical variables tested, age was positively correlated with percentage of cytotoxic edema whereas serum hemoglobin level was correlated with it negatively. Table 2 shows the predictors of functional outcome at 6th month after ICH. In multivariate analysis, age, NIHSS scale, percentages of cytotoxic and vasogenic edema were all associated with mRS at 6th month after ICH.

Table 1. Correlation between clinical variables and percentages of cytotoxic edema

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient (95%CI)</th>
<th>p value</th>
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<tbody>
<tr>
<td>Age</td>
<td>0.065 (0.031–0.100)</td>
<td>0.005*</td>
</tr>
<tr>
<td>Hemoglobin</td>
<td>-0.427 (0.747–0.107)</td>
<td>0.010*</td>
</tr>
<tr>
<td>Creatinine</td>
<td>0.856 (0.303–2.917)</td>
<td>0.145</td>
</tr>
<tr>
<td>White cell count</td>
<td>0.133 (0.062–0.328)</td>
<td>0.175</td>
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<tr>
<td>Systolic blood pressure</td>
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<tr>
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<td>0.256</td>
</tr>
<tr>
<td>Platelet count</td>
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<td>0.096</td>
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<tr>
<td>Serum Glucose</td>
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</tr>
<tr>
<td>GCS</td>
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<td>0.198</td>
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<tr>
<td>NIHSS</td>
<td>0.115 (0.049–0.221)</td>
<td>0.003*</td>
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<tr>
<td>Hematoma size</td>
<td>0.000 (0.000–0.000)</td>
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<td>Total edema volume</td>
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<td>Cytotoxic edema</td>
<td>0.047 (0.021–0.074)</td>
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<td>Vasogenic edema</td>
<td>-0.028 (-0.039–0.001)</td>
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*Significant differences were defined as those with p values less than or equal to 0.05.

Table 2. Predictors of functional outcome at 6th month

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<td>0.566</td>
</tr>
<tr>
<td>Total edema volume</td>
<td>0.000 (0.000–0.000)</td>
<td>0.523</td>
</tr>
<tr>
<td>Cytotoxic edema</td>
<td>0.047 (0.021–0.074)</td>
<td>0.001*</td>
</tr>
<tr>
<td>Vasogenic edema</td>
<td>-0.028 (-0.039–0.001)</td>
<td>0.041*</td>
</tr>
</tbody>
</table>

*Significant differences were defined as those with p values less than or equal to 0.05.

Conclusions
The pathophysiologic process within perihematomal edema is complicated. A small amount or absence of perihematomal edema on conventional MRI and CT, as well as a normal or less decreasing of the mean ADC value, do not always indicate lesser perihematomal injury and a favorable outcome. The pixel-based analysis of ADC may help us to know the component of perihematomal edema and may be helpful for decision making and for predicting outcome.

KEY WORDS: Intracerebral hemorrhage, apparent diffusion coefficient, perihematomal edema
Poster 040

CT Perfusion as a Prognostic Marker for the Development of Stroke in Transient Ischemic Attack Patients with Nonsignificant Carotid Artery Stenosis

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PURPOSE
Stroke is a leading cause of long-term, acquired adult disability. Identifying its predictors is critical in shaping the management of patients who are at risk. Patients with nonsignificant carotid stenosis and poor cerebral perfusion, however, may have a higher stroke risk than patients with normal cerebral perfusion. CT perfusion may therefore play a role in stroke prevention by acting as a stratifying factor in determining whether a symptomatic patient with nonsignificant internal carotid artery stenosis could benefit from more aggressive nonsurgical management. We hypothesize that in patients with nonsignificant stenosis (0 - 59%), cerebral blood flow, blood volume, and mean transit time as measured by CT perfusion during a transient ischemic attack (TIA) would be decreased in subjects more likely to have a stroke or TIA within 3 months, 6 months, and 1 year intervals.

MATERIALS & METHODS
A prospective study was performed to evaluate the risk of stroke or recurrent TIA in symptomatic patients using CT perfusion. Difference in outcome between groups with differing cerebral perfusion scans was analyzed using nonparametric ANOVA statistical models. Patients who presented to a tertiary care emergency room with a TIA were studied. Subjects received a cerebral CT scan, CT angiogram, and CT perfusion, all blindly analyzed by a neuroradiologist for the degree of ICA stenosis, and size of perfusion (blood volume, blood flow, and mean transit time) defects. The perfusion abnormality was measured applying the ASPECTS method to MCA territory defects. Stroke risk factors were collected and an ABCD2 score was calculated to determine a subject’s baseline stroke risk. Subjects were classified into two groups by degree of stenosis: significant (>60 - 99%) and nonsignificant (0 - 59%). Three months, 6 months, and 1 year following initial assessment, each subject was contacted for a secondary assessment of neurologic status for the primary outcome, a subsequent stroke or for the secondary outcome, a TIA event.

RESULTS
Thirty-five patients consented to participate; however, five were lost to follow up and one was excluded for subsequent diagnosis of hemiplegic migraine for a total of 29 eligible patients. There is no correlation between the presence or size of CT perfusion defect and occurrence of stroke or recurrence of TIA at 3, 6 or 12 months. CT perfusion may show that high ASPECTS can be correlated with low likelihood of stroke or TIA 3 months postinitial TIA event.

CONCLUSION
There have been few studies to differentiate between how aggressively one should manage those with nonsignificant carotid artery stenosis (0 - 59%). In our study, CT perfusion parameters including blood flow, blood volume, and mean transit time during a TIA event were not shown to be an effective indicator of stroke or TIA within 3 months. Conversely, a high ASPECTS score on CT perfusion does show a low likelihood of stroke or TIA in 3 months postinitial TIA.

KEY WORDS: Stroke, perfusion, carotid artery stenosis

Poster 041

White Matter Hyperintensities and Cognitive Dysfunction in Alzheimer Disease

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PURPOSE
The effect of white matter lesions or vascular atherosclerosis on cognitive function is not fully understood. In this investigation we examined the influence of white matter lesions on cognitive decline in Alzheimer disease.

MATERIALS & METHODS
One hundred and forty-two patients (44 men, mean age 65.7 ± 7.6 years; mean education period 7.8 ± 5.0 years) were included; all were diagnosed as having Alzheimer disease. Patients were divided into four groups based on the severities of white matter hyperintensities in brain magnetic resonance (MR) images, and Mini-Mental Status Examination (MMSE) scores and clinical dementia patings (CDR) were compared.

RESULTS
Mean MMSE score was 21.0 ± 4.3 and mean CDR 1.2 ±0.6. Mini-Mental Status Examination and CDR were worsened compared.

CONCLUSION
The presences of white matter hyperintensities were associated with MMSE and CDR deteriorations, and the authors recommend that these features should be regarded as correctable risk factors of hastening cognitive decline in Alzheimer disease.

KEY WORDS: White matter hyperintensities
Factors Influencing Successful Recanalization after IV-rtPA Treatment in Acute Ischemic Stroke: The Successful Recanalization Score

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PURPOSE
We determined the incidence and significant predictors of successful recanalization, defined as angiographic recanalization and a good clinical outcome, after IV-rtPA in acute ischemic stroke. A successful recanalization score was devised and tested.

MATERIALS & METHODS
One hundred twenty-six consecutive patients with anterior circulation ischemic stroke receiving IV-rtPA were reviewed retrospectively. This study was approved by the institutional review board and all patients provided informed consent. Imaging included a baseline noncontrast CT (NCCT) and CT angiography (CTA). Recanalization was assessed on a 24-hour CTA. Clinical outcome was determined by a 90 day Modified Rankin Score (mRS). Successful recanalization was defined as angiographic recanalization (TIMI score>=2) with a good clinical outcome (mRS <=3). Logistic regression analysis determined predictors of successful recanalization and the successful recanalization score (SRS) was devised and tested using Akaike’s information criteria (AIC).

RESULTS
Mean age was 72.8 ± 12.1 years (male 64/126, 51%). Successful recanalization occurred in 37% (46/126) of all patients. Patients with successful recanalization had fewer neurologic deficits (p = 0.001) and higher ASPECT scores (p = 0.005) than those without successful recanalization. Admission NIHSS score (p = 0.026) and the site of vessel occlusion (p = 0.016) were significant predictors of successful recanalization. Distal occlusions were more likely to have a better outcome [OR 2.9, 95%CI (1.357 - 6.385); p = 0.005]. The SRS performed better for predicting successful recanalization compared with either NIHSS or occlusion location alone (AIC 146.9; R2 12.5%; p<0.0001).

CONCLUSION
Milder baseline stroke deficit, distal vessel occlusion and the successful recanalization score are significant predictors of successful recanalization.

KEY WORDS: Acute stroke, recanalization, thrombolysis

Rate of Hematoma Expansion in Primary Intracerebral Hemorrhage Predicts Mortality and Clinical Outcome: A Prospective Study

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PURPOSE
Intracerebral hemorrhage (ICH) results in high mortality and morbidity for patients. Our previous retrospective study has shown that ICH patients with a higher rate of hematoma expansion had a higher mortality rate compared to patients with a lower rate of hematoma expansion. We performed a prospective study to validate the predictive value of the rate of hematoma expansion.

MATERIALS & METHODS
We prospectively collected all patients with primary ICH who presented to the emergency department over 1.5 years. A total of 160 patients received baseline noncontrast CT (NCCT) within 24 hours of admission and underwent follow-up NCCT within 48 hours. The ICH volume and the intraventricular extension were calculated on the CT images. Patient’s clinical and demographic information were obtained at admission. In-hospital mortality, and modified Rankin Scale (mRS) at 3 months were recorded. All variables were analyzed using univariate analysis to find potential predictors. An ordinal multivariate logistic regression analysis was performed to determine independent predictors of in-hospital mortality and poor clinical outcome.

RESULTS
Independent factors associated with in-hospital mortality from ICH were initial ICH volume (p<0.0001), rate of ICH expansion (p = 0.0022), and blood glucose level (p = 0.01). Rate of ICH expansion was an independent predictor of in-hospital mortality (odds ratio: 5.6, 95% CI 1.9 to 16.7, p = 0.0022). Factors independently associated with the 3-month clinical outcome were mean arterial blood pressure of patients (p = 0.024), presence of intraventricular extension (p = 0.0081), initial ICH volume (p = 0.0071), and rate of ICH expansion (p = 0.0011). Rate of ICH expansion was an independent predictor of the 3-month clinical outcome (odds ratio: 11.2, 95% CI 2.6 to 47.6, p = 0.0011) (Figure1).
**CONCLUSION**

The rate of hematoma expansion is an independent predictor of in-hospital mortality and poor clinical outcome in primary ICH, and thus, may guide clinicians’ patient selection for aggressive treatment.

**KEY WORDS:** Intracerebral hemorrhage, mortality, stroke

**Poster 044**

**Spot Sign Score Identifies Rapid Bleeding in Spontaneous Intracerebral Hemorrhage**

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**PURPOSE**

To determine whether spot sign score correlates with rate of hematoma expansion and whether rate of expansion predicts in-hospital mortality and clinical outcome in spontaneous intracerebral hemorrhage (ICH).

**MATERIALS & METHODS**

The study included 367 consecutive patients presenting to the emergency department (ED) from January 1, 2000 to December 31, 2008 with nontraumatic ICH. All received noncontrast head CT (NCCT) and multidetector CT angiography (MDCTA) on presentation to the ED and a follow-up NCCT within 48 hours. Imaging was used to determine the hematoma location and volume, rate of expansion, and spot sign score. Primary outcome measures included in-hospital mortality and modified Rankin Scale at discharge. Regression analysis was performed to correlate spot sign score and rate of hematoma expansion.

**RESULTS**

Intracerebral hemorrhage expansion was identified in 194 of 367 patients (53%). In a multivariate analysis, rate of ICH expansion predicted mortality (Hazard Ratio 1.1, CI 1.08-1.12, p<0.0001). Patients who expired had an average rate of ICH expansion of 2.8 ml/hr compared to 0.2 ml/hr in survivors. Spot sign score on presentation to the ED correlated with the rate of hematoma expansion.

**CONCLUSION**

Rate of hematoma expansion predicts outcome in spontaneous ICH. Spot sign score on presentation correlates with rate of expansion, supporting the hypothesis that high spot sign scores reflect active bleeding in acute ICH.

**KEY WORDS:** Intracerebral hemorrhage, stroke, computed tomography

**Poster 045**

**Time Alone Is Not Brain**

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**PURPOSE**

“Time is brain” has been the guiding principle in the management of acute ischemic stroke (AIS). However there are patients who present with small infarct volumes several hours after stroke onset suggesting significant variability. Our goal was to evaluate whether a correlation existed between time since stroke onset and baseline infarct size.

**MATERIALS & METHODS**

We analyzed 98 anterior circulation AIS patients who presented to our ED in 2008, were imaged by MR imaging (MRI) within 24 hours of onset, and who had definite times of stroke onset, or were discovered within 30 minutes of last seen well. We calculated infarct volumes on diffusion-weighted imaging (DWI)/apparent diffusion coefficient (ADC) images using dedicated software.

**RESULTS**

Intracerebral hemorrhage expansion was identified in 194 of 367 patients (53%). In a multivariate analysis, rate of ICH expansion predicted mortality (Hazard Ratio 1.1, CI 1.08-1.12, p<0.0001). Patients who expired had an average rate of ICH expansion of 2.8 ml/hr compared to 0.2 ml/hr in survivors. Spot sign score on presentation to the ED correlated with the rate of hematoma expansion.
RESULTS

We found no significant correlation between infarct volumes and stroke onset time ($r = -0.07, P = 0.48$). The proportion of patients with infarct volume >100 cc within 3 hours of onset (2/20, 10.0%) was similar to the proportion with >100 cc volume after 3 hours of onset (8/78, 10.3%; $P = 0.70$). Moreover, when dividing the patients into four groups based on time (0-3 hours, 3-6 hours, 6-9 hours, > 9 hours), the results were again similar (10.0%, 12.5%, 4.3%, and 14.3%, respectively). There was no significant difference in the proportion of patients with large infarct volumes as the time from stroke onset increased ($P = 0.74$) (Figure). When looking at only those patients with proximal artery occlusions (ICA or M1 segment), we again found no correlation ($r = 0.15, P = 0.39$), and no difference in the proportion of patients who had large strokes when analyzed using the 2 time classes ($P = 0.97$) or the 4 time classes ($P = 0.42$).

CONCLUSION

In a broad population of anterior circulation AIS, there is no correlation between infarct volume and time since stroke onset. A longer time from onset did not result in a greater proportion of strokes >100 cc. Our findings suggest that time alone is not brain, and that additional factors that impact infarct size should be considered in treatment decision making.

KEY WORDS: Acute ischemic stroke, infarct size, diffusion-weighted imaging
CONCLUSION
Proof of concept for automated assessment of collateral vessels is presented: software-based collateral index in acute stroke CTA images highly correlated with reference collateral scores. The collateral index can be classified to generate rater-based collateral scores. The results encourage further development of software for automated collateral scoring in acute stroke imaging.

KEY WORDS: Collaterals, stroke, software

Poster 047
Effect of Altering Temporal Acquisition Intervals on the Quantitative Measurement and Qualitative Interpretation of Whole Brain CT Perfusion Imaging

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PURPOSE
Perfusion imaging of whole brain z-axis coverage can be achieved using shuttle mode acquisition. The radiation dose can be reduced by increasing the time intervals of dynamic image acquisition. We assessed the effect of altering temporal resolution on calculated perfusion parameters and qualitative interpretations of whole brain perfusion maps.

MATERIALS & METHODS
The perfusion data of eight patients presenting with stroke symptoms between July 2009 and March 2010 were acquired at 1.5 second intervals. By using data obtained at every other or every third time point, longer acquisition intervals of 3.0 and 4.5 second respectively were simulated from the source data. Quantitative measurement of penumbra and normal cortex were compared between 1.5 versus 3.0 and 1.5 versus 4.5 second data sets. In addition, the perfusion maps of these data sets were assessed by three neuroradiologists independently for presence and size of defect, quality of the maps, and congruity of final interpretation.

RESULTS
The mean relative cerebral blood flow (rCBF) values of the penumbra were overestimated at both 3.0 (p<0.0001) and 4.5 (p<0.0001) second acquisition interval as compared to 1.5 second. There is significant difference (p=0.0005) between the mean rCBF values obtained from penumbra and healthy tissues at 1.5 second acquisition interval but not at 3.0 and 4.5 second. In terms of qualitative interpretations, however, there was no difference in detection of defect comparing 1.5 versus 3.0 second and 1.5 versus 4.5 second, with excellent reader agreement. The size of defect is underestimated on the 3.0 and 4.5 second maps for three out of eight patients based on rCBF and MTT, but no difference was detected using time to peak (TTP). The quality of the 4.5 second maps was significantly lower compared to 1.5, but not 3.0 compared to 1.5.

CONCLUSION
Although there was no difference in the qualitative detection of defect comparing 1.5 second to 3.0 and 4.5 second intervals and assessment of defect size on TTP maps, there was significant difference in quantitative measurement and qualitative assessment of defect size on CBV and MTT maps.

KEY WORDS: Perfusion, stroke, shuttle

Poster 048
Diffusion Tensor Imaging of the Corpus Callosum in Multiple Sclerosis Patients: Differences between Enhancing and Nonenhancing Cohorts

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PURPOSE
To analyze the differences in diffusion tensor imaging (DTI) derived metrics of the corpus callosum (CC) in relapsing remitting and secondary progressive multiple sclerosis patients with enhancing and nonenhancing lesions.

MATERIALS & METHODS
The study was approved by the IRB. Diffusion tensor images of 32 patients with relapsing remitting MS (RRMS) and 14 patients with secondary progressive MS (SPMS) were analyzed retrospectively on a GE Advantage workstation to generate fractional anisotropy (FA) and mean diffusivity (MD) maps. Fractional anisotropy and MD values were calculated by freehand regions of interest at the level of genu, midbody and splenium of corpus callosum by two neuroradiologists who were blinded to clinical information. The conventional images also were reviewed to enable generation of four groups: I - RRMS with no lesion enhancement. II - RRMS with enhancing lesions. III - SPMS with no lesion enhancement. IV - SPMS with enhancing lesions. Differences in FA and MD between groups I and II, and between III and IV were studied using the unequal variance independent samples t-test. Differences were evaluated in all three regions of the corpus callosum.
RESULTS
Significant differences were seen in mean FA values in all three regions of the CC between groups III and IV by reader I (p = 0.004, 0.01 and 0.005 for genu, body and splenium) and in the genu and splenium of CC by reader II (p = 0.04, 0.001 respectively). All three regions of the CC demonstrated lower FA values in group IV (enhancing SPMS) compared to group III. No significant differences in MD values were seen between groups III and IV in all CC regions by both readers. Also, none of the regions in the CC showed significant differences in MD and FA values between groups I and II (for both readers).

CONCLUSION
Fractional anisotropy of SPMS patients with enhancing lesions appears to be significantly lower than that seen in SPMS patients with no actively enhancing foci, suggesting that there may be more white matter damage in the former. Hence we may be able to use FA as a marker for disease activity and possibly for follow up. We presently are studying longitudinal FA changes prospectively in SPMS patients and its correlation with clinical outcome measures to better understand pathophysiology of SPMS.

KEY WORDS: Diffusion tensor imaging, multiple sclerosis, corpus callosum

Poster 049
Brain MR Imaging and 25-Hydroxyvitamin D
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PURPOSE
Vitamin D is active in the healthy function of the human brain; low levels may be associated with poor cognitive function in the elderly. A recent study showed an association between low levels of serum 25-Hydroxyvitamin D and MR imaging (MRI) evidence of large vessel infarction and white matter hyperintensities (WMH) in patients over the age of 65 years. Less than 10ng/mL vitamin D is considered deficient, 10-20 ng/mL is insufficient. The purpose of this pilot study is to evaluate the relationship between serum vitamin D levels and the MRI appearance of the brain in nonelderly adult subjects.

MATERIALS & METHODS
Under IRB approval 56 patients who had a serum vitamin D level drawn and a standard MRI of the brain within 3 months of each other were identified. Patients’ age ranged from 31-69 years, 14 from each decade. Retrospective analysis includes 25-Hydroxyvitamin D, clinical factors and qualitative and volumetric study of routine brain MRI. Clinical characteristics included possible confounding factors such as age, hypertension, migraine, trauma, multiple sclerosis, cigarette and alcohol use in addition to standard profile. The MRI studies were evaluated by two senior neuroradiologists for infarction, atrophy, perivascular spaces, WMH (type-punctate and confluent; location- juxtacortical, cortical and periventricular) and a general impression. Statistical methods: Spearman correlation coefficient was computed to assess the relationship between vitamin D level and WMH; a Chi-square test or a Fisher’s exact test was used to assess the association between hypertension and presence of WMH. p<0.05 = statistically significant; p<0.10 = marginally statistically significant. Additional analysis and quantitative evaluation will be presented. Volumetric measurements are obtained by a semi-automated segmentation algorithm for WMH developed for the pre-existing MRI data.

RESULTS
Seven patients were excluded because of insufficient MRI studies or overwhelming pathology. Twenty-five patients had WMH, 24 had no WMH, the average vitamin D levels were 34 and 33 ng/mL respectively. One patient had MRI evidence of a cortical infarction and a vitamin D level of 11. Three patients had lacunar infarcts with vitamin D levels of 9, 19 and 11ng/mL. Among age 51~60 patients (n = 13), low serum vitamin D was marginally statistically correlated with punctate central WMH (Spearman’s correlation coefficient: -0.53, p = 0.064); Among patients 51 and older (n = 26), low serum vitamin D was marginally statistically correlated with juxtacortical punctate WMH (Spearman’s correlation coefficient: -0.35, p = 0.084); Hypertensive patients have significantly more central punctate WMH, p = 0.0005; juxtacortical punctate WMH, p = 0.0035; periventricular confluent WMH, p = 0.0038; and marginally more periventricular punctate WMH present than nonhypertensives, p = 0.0760.

CONCLUSION
In this pilot study low serum vitamin D marginally correlated with juxtacortical and central punctate white matter hyperintensities among patients >51 years old. Four patients with low vitamin D had infarcts. Further study of the role of vitamin D in the healthy brain and in the prevention of disease in adult patients is indicated. The possibility of reversing or delaying WMH in patients with low vitamin D should be investigated.

KEY WORDS: MR imaging - brain, vitamin D

Poster 050
Naming Impairment and Gray Matter Loss in the Conversion from Mild Cognitive Impairment to Alzheimer Disease
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PURPOSE
Our goal was to assess the correlation between regional gray matter (GM) volume loss and naming ability measured using the Boston Naming test in amnestic mild cognitive impairment (MCI) patients with conversion to Alzheimer disease (AD).
Materials & Methods
The 30-item Boston Naming test (BNT) was administered to 35 subjects (21 males, mean age 72.3 years) participating in the AD Neuroimaging Initiative with documented MCI-to-AD conversion, 12 months before the diagnosis of AD. The sample was divided into two groups, 21 subjects with BNT score below or equal to the median (low BNT) and 14 subjects with BNT score above the median (high BNT). Brain MR images (MRIs) obtained 1 year before the diagnosis of conversion from MCI to AD and at the time of the conversion were available for each patient. The Clinical Dementia Rating scale was used to assess disease severity. Voxel-based morphometry with SPM5 was used for MR image postprocessing. Comparison between longitudinal imaging data was conducted using paired t-tests and results were considered significant when the p-value was less than 0.05 with false discovery rate correction for multiple comparisons.

Results
There were no significant differences in demographics or disease severity between the two groups. Low BNT subjects showed significant GM volume loss in the bilateral frontal and parietal lobes during the 12 months preceding the diagnosis of AD. There were no significant changes in GM volume in the high BNT group during the 12 months preceding the conversion to AD.

Conclusion
Patients with MCI-AD conversion and naming deficit undergo faster GM atrophy than patients without naming deficit. The accelerated progression of neocortical frontal and parietal atrophy in MCI-AD converters presenting with naming dysfunction has potential important implications for therapeutic approaches and prognosis in AD.

Key Words: Alzheimer disease, mild cognitive impairment, MR imaging

Poster 051
Atypical Brain Stem Variant of Posterior Reversible Encephalopathy Syndrome
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Purpose
Posterior reversible encephalopathy syndrome (PRES) is characterized by clinical symptoms associated with imaging features of the typical presence of bilateral and symmetric vasogenic edema in the parietal and occipital lobes. Posterior reversible encephalopathy syndrome rarely presents with predominant involvement of the brain stem and medulla oblongata (variant). So, the purpose of this study was to investigate the differences between typical PRES and variant type.

Materials & Methods
We retrospectively evaluated MR imaging (MRI) and clinical findings of 44 patients (mean age: 40 and 59 years, male = 20, female = 24) with PRES. These patients were divided into two groups. In group I, 28 patients had typical distribution of lesions without brain stem involvement. In group II, 16 patients had brain stem involvement of lesions. We assessed the MR imaging features, clinical data, and patients’ outcome.

Results
Mean systolic blood pressure (BP) was 164.25 ± 34 (range: 110-210) in group I and 185.37 ± 30 (range: 140-250) in group II. Systolic BP was higher in group II (p = 0.047) but others were not significantly different between the two groups; age, sex, predisposing factor, symptom, and prognosis. Follow-up MR was performed in 25 patients (group I n = 14, group II n = 11). Twenty-three of these patients had reversibility of lesion on follow up (group I: 13/14, group II: 10/11). Seven patients had sequela. In group I, three patients had sequela (2: encephalomalacia, 1: diffuse brain atrophy) and in group II, four patients had sequela (3: encephalomalacia, 1: death). However, there is no significant difference in the two groups. Except for death, four of six patients who had sequela on follow-up imaging, had hemorrhage or no reversibility of lesion. Five patients had involvement of brain stem only. These patients were recovered completely without sequela and lesions disappeared on follow-up imaging.

Conclusion
Systolic BP has an influence on involvement of brain stem but involvement of brain stem does not have an influence on the prognosis of the patient. It seems that the influencing factor to prognosis is not distribution of lesion but reversibility of lesion and hemorrhage.

Key Words: Hypertension, encephalopathy

Poster 052
Differentiating Tumefactive Demyelinating Lesions and Primary Central Nervous System Lymphoma Using Quantitative Apparent Diffusion Coefficient Analysis
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Purpose
Acute mass-like demyelinating lesions of the brain, referred to as tumefactive demyelinating lesions (TDLs), can pose a considerable diagnostic challenge as they can simulate aggressive tumors on imaging. Due to their frequent multifocal involvement, TDLs can mimic primary central nervous system lymphoma (PCNSL), and invasive biopsy often is required to make a diagnosis. Surgical biopsy, however, may not always provide a definitive answer since corticosteroid therapy, which is given frequently to patients with suspected TDLs or PCNSL prior to biopsy, can confound histopathologic analysis leading to inconclusive results. The purpose of our study was to determine whether diffusion-weighted
imagining, which can provide an indirect assessment of tissue cellularity and extracellular mobility, can differentiate TDLs, a hypocellular process, from PCNSL, a hypercellular neoplasm.

**Materials & Methods**

Since 2002, 24 patients presented with newly diagnosed TDLs (10 male, 14 female; mean age: 35 years, range: 16-53 years) confirmed either pathologically (n = 12) or clinically (n = 12) based on history, imaging findings, cerebrospinal fluid (CSF) analysis, and follow-up evaluation at our institution. For a comparison cohort, the pretreatment MR imaging (MRI) scans of 28 immunocompetent patients (14 male, 14 female; mean age: 64 years, range: 30-91 years) with PCNSL initially diagnosed by surgical biopsy during that same time period were randomly selected from our institutional tumor database. Apparent diffusion coefficient (ADC) maps were constructed from diffusion-weighted images obtained with b-values of 0 and 1000 s/mm^2 utilizing the FuncTool application of an AW Workstation (GE Healthcare; Waukesha, WI). Lesions then were manually segmented from the ADC maps using coregistered contrast-enhanced T1-weighted images as well as T2-weighted and fluid attenuated inversion recovery images to exclude adjacent edema and fluid within the ventricular system. Mean, minimum, and maximum lesion ADC values for each patient were normalized to bulk free fluid ADC, measured within the lateral ventricles. Normalized relative ADC (rADC) values subsequently were compared between TDL and PCNSL patients with a two-tailed Welch’s t test; results were declared significant if p < 0.05. A threshold analysis was conducted after excluding any partial or complete rim of reduced diffusion during TDL segmentation.

**Results**

Mean, minimum, and maximum rADC were 0.435±0.133, 0.241±0.072, and 0.669±0.207 (mean ± standard deviation) for TDL patients and 0.315±0.074, 0.143±0.079, and 0.650±0.178 for PCNSL patients. A statistically significant difference was found for mean and minimum rADC (p = 0.0004 and p < 0.0001, respectively) while maximum rADC was statistically indistinguishable (p = 0.719). After excluding partial or complete rims of reduced diffusion (seen in 14 of 24 cases), all TDL but only five of 28 PCNSL patients had minimum ADC greater than 0.192.

**Conclusion**

Mean and minimum rADC values successfully differentiated TDL and PCNSL patients with a promising threshold value for minimum rADC. Maximum rADC values were indistinguishable, likely from partial volume averaging with adjacent edema or ventricular CSF, which demonstrate facilitated diffusion at lesion boundaries. In combination with clinical evaluation and conventional imaging findings, diffusion MRI characteristics can support a more confident diagnosis of TDLs and potentially prevent unnecessary brain biopsies to exclude PCNSL.

**Key Words:** Tumefactive, demyelinating, diffusion

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**Poster 053**

**Association between Linear Measurements of Corpus Callosum, Gait and Balance in the Elderly**

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**Purpose**

Computer generated measurements of corpus callosum have been linked to gait impairment in the elderly. However, these measurements are difficult to use in routine clinical practice. The purpose of this study was to evaluate the relationship between linear measurements of corpus callosum thickness with gait and balance in elderly individuals.

**Materials & Methods**

Two hundred seventy-seven community-dwelling elderly subjects of Nutrition, Aging and Memory in Elderly (NAME) study had neurologic, neuropsychologic examinations and brain MR imaging. Gait function was assessed using Tinetti gait (0-12), and balance (0-16) scores. Midsagittal reformats of 3D T1-weighted magnetization prepared rapid acquisition gradient-echo images were used to measure the corpus callosum thickness on a clinical PACS workstation. Thickness of the genu, anterior one third, mid-body, posterior one third and splenium as well total anterior-posterior length of corpus callosum were determined. Simple and partial correlation (after adjustments for age and minimental status examination score) were assessed between thicknesses of different portions of corpus callosum and Tinetti scores. A p value of <0.01 was considered significant.

**Results**

There was significant correlation between genu thickness and gait and balance scores (p<0.001) that persisted after adjustment for age. The splenium thickness significantly correlated with gait (p<0.001) scores and was associated with both gait and balance scores after adjustment for age. After adjustment for MMSE, the genu thickness was only related with balance scores but splenium thickness remained associated with both gait and balance scores.

**Conclusion**

The independent association between linear measurements of the genu and splenium thickness with gait and balance scores indicates that atrophy of these portions of corpus callosum is a marker of gait impairment in the elderly. This simple measurement may be helpful in assessing patients with gait impairment.

**Key Words:** Gait, MR imaging, corpus callosum
Effect of Motion and Eddy-Current Correction on the Reproducibility of Corticospinal Diffusion Tensor Tractography in Normal Subjects and Stroke Patients

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Purpose
In this study, we first establish the reproducibility of corticospinal diffusion tensor tractography (DTT) in healthy subjects and stroke patients with unilateral hemiparesis. The intra-rater, inter-rater, intra-session, and inter-session reproducibility of DTT derived indices [fiber numbers, fractional anisotropy (FA), apparent diffusion coefficient (ADC), and three eigenvalues] are measured. The second part of this study is to assess the effect of motion and eddy-current correction on the reproducibility of corticospinal DTT derived indices in both healthy subjects and stroke patients. The results of this study may be applied in the longitudinal follow-up of the therapy effects on stroke patients.

Materials & Methods
Institutional review board approval and written informed consent were obtained prior to examination. Ten normal subjects (mean age 25.8 ± 6.8 years) and 15 patients (mean age 49.6 ± 9.1 years) with chronic stroke were enrolled. Two DTI scans of the 10 healthy subjects were obtained in one session and the third scan was obtained 1 week later on a 3 T MR scanner. Three scans of the 15 patients were obtained on 3 separate days. Bilateral corticospinal tracts in each scan of all healthy subjects and stroke patients were reconstructed twice: one time with motion/eddy-current correction and the other without. Three methods were used to compare the bias of DTT derived indices with and without correction: repeated ANOVA, ICC based on linear mixed models, and Bland-Altman plot.

Results
In all DTT derived indices, the FA has the highest ICC test-retest reproducibility (0.86-0.91), while the ADC has the lowest one (0.74-0.80). With repeated ANOVA, the differences of the DTT indices between with and without correction have p-values all above 0.05 in both normal subjects and stroke patients

Conclusion
Retrospective motion and eddy-current correction method do not show statistical significant effect on the measured values and reproducibility of corticospinal DTT derived indices in both cooperative normal subjects and stroke patients using 3 T clinical diffusion-weighting schemes.

Key Words: Eddy-current correction, motion correction, diffusion tensor tractography

Characterization of Glial Cell Intratumoral Functional MR Imaging Resting-State Networks Using Graph Theoretical Analysis: A Preliminary Investigation

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Purpose
Previous studies have demonstrated that graph-theoretical analysis of structural tissue-architecture associated with prostate and tongue tumors can provide prognostic information. To date, no studies have investigated the application of similar graph theoretical analysis methods applied to resting-state functional magnetic resonance imaging (RS-fMRI) BOLD signal from tumors, such as brain glial cell malignancies. The purpose of this study, therefore, was to determine if graph theory network metrics can be used to characterize glial cell tumors using RS-fMRI signal extracted from the lesion using a voxel-wise approach. We hypothesized that some network metrics might vary according to glial tumor type.

Materials & Methods
Four patients with brain tumors were scanned in a 1.5 T GE scanner using an 8-channel head coil (GE Medical Systems, Milwaukee, WI, USA) for collection of structural anatomical (3D SPGR) MRI and RS-fMRI BOLD data as part of routine presurgical fMRI motor and language mapping evaluation. In order to evaluate network metrics within each patient’s tumor, a region of interest was drawn manually around the lesions and remaining brain masked out. Data from each voxel within the tumor was used to generate a binarized adjacency matrix from which graph theory metrics (clustering coefficient, characteristic path length, local efficiency; global efficiency; and small-worldliness) were computed.

Results
Patients included a 69-year-old female with right frontoparietal glioblastoma multiforme (GBM), 42-year-old female with left temporal astrocytoma, 37-year-old male with left frontal oligodendroglioma, and 45-year-old male with right frontal oligodendroglioma. Comparison of network metrics between astrocytomas and oligodendrogliomas demonstrated similar values for clustering coefficient (p>0.05), characteristic path length (p>0.05), local efficiency (p>0.05), and global efficiency (p<0.05), with a trend for significance for small-worldness (p = 0.06).

Conclusion
Intratumoral graph theory network metrics can be computed from RS-fMRI BOLD signal, and may vary by tumor type. Most network metrics were similar between tumor types; however, the astrocytomas demonstrated lower small-worldness than the lower grade gliomas, indicating a more random pattern of internodal connectivity. Further characterization of network characteristics of glial tumors could lead potentially to novel functional imaging markers with which to study disease progression, guide therapy and predict outcomes.

Key Words: Graph theoretical analysis, resting-state fMRI
Poster 056

Combining Connectivity Maps to Predict Routes of Progression in Malignant Gliomas: A Prospective and Retrospective Analysis

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PURPOSE
To determine the predictive value of diffusion tensor imaging (DTI) in the progression of malignant gliomas.

MATERIALS & METHODS
We prospectively identified seven patients with pathologically confirmed malignant gliomas and retrospectively identified nine more patients with malignant gliomas from an institutional database. Diffusion tensor imaging was acquired before chemoradiation therapy in all 16 patients. Using DTI & FiberTools, a Monte Carlo simulation and multiple iterations were performed to generate probabilistic maps that displayed the probability of connectivity between two locations. For each patient, a region of interest (ROI) was drawn around the tumor in three dimensions, and two suspected progression pathways were determined: 1) the longest fiber tract extending from the tumor and 2) the fiber tract with the maximal local connectivity surrounding the tumor. These predicted pathways then were compared to the actual site of progressive disease on follow-up MR imagings obtained every 2 months. Progressive disease was defined using revised response assessment criteria as greater than 25% increase in enhancing disease, new enhancing disease, or significant increase in nonenhancing disease (in patients receiving antiangiogenic therapy).

RESULTS
All 16 patients had progressive disease in at least one of the two predicted pathways. The longest fiber tract correctly predicted 14/16 sites of progression. The maximal connectivity fiber tract correctly predicted X/Y sites of progression. In five of 16 cases, the tumor grew in more than one direction. The mean time to progression was ZZ months (range, A-B months).

Maximal fiber length. (A) Connectivity map demonstrates the longest fibers (arrow) extending anteriorly in the periatrial region. Contrast T1-weighted imaging (B) 10 months later reveals progressive disease (arrow) in the same location that is new from pretreatment scan (not shown).

Poster 057

Diffusion Tensor Metrics of Epidermoids

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PURPOSE
To establish normative values of various parameters on diffusion tensor imaging (DTI) like fractional anisotropy (FA), apparent diffusion coefficient (ADC) and the different tensor metrics in the evaluation of epidermoid tumors.

MATERIALS & METHODS
MR imaging of 34 cases of epidermoid tumors [28 histopathologically proved, six diagnosed based on classical imaging features on conventional MR imaging (MRI) which included DTI sequence in addition to the conventional MRI sequences was evaluated retrospectively]. Region of interest (ROI)-based measurements of the FA and ADC values and linear (CL), planar (CP) and spherical (CS) anisotropy values and mode values of epidermoid tumors were performed. Mean values for each parameter were calculated. In addition, the t-test was applied to mean values of CL and CP to see if the difference was statistically significant.

RESULTS
The mean FA, ADC, CP, CS, CL and diffusion mode values with standard deviation and minimum and maximum values are summarized in the table.

<table>
<thead>
<tr>
<th></th>
<th>FA</th>
<th>ADC</th>
<th>Planar</th>
<th>Spherical</th>
<th>Linear</th>
<th>Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>0.466</td>
<td>0.831</td>
<td>0.495</td>
<td>0.422</td>
<td>0.073</td>
<td>-0.663</td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>0.085</td>
<td>0.150</td>
<td>0.126</td>
<td>0.124</td>
<td>0.031</td>
<td>0.264</td>
</tr>
<tr>
<td>Range</td>
<td>0.375</td>
<td>0.699</td>
<td>0.631</td>
<td>0.592</td>
<td>0.151</td>
<td>1.104*</td>
</tr>
<tr>
<td>Minimum</td>
<td>0.255</td>
<td>0.462</td>
<td>0.164</td>
<td>0.156</td>
<td>0.022</td>
<td>0.962</td>
</tr>
<tr>
<td>Maximum</td>
<td>0.630</td>
<td>1.161</td>
<td>0.795</td>
<td>0.748</td>
<td>0.174</td>
<td>0.142</td>
</tr>
</tbody>
</table>

The unit of ADC is 10⁻³ mm²/sec. FA and other DTI metrics are dimensionless. *Only one patient had mode value greater than zero. Remainder of the cases had negative mode values. Also, there was a statistically significant difference between mean planar and linear anisotropy values (p < 0.001).

CONCLUSION
Diffusion tensor imaging and diffusion tensor metrics are superior to routine diffusion-weighted sequence in imaging epidermoids. Quantification of DTI can provide objective
accurate parameters for evaluation of intracranial epidermoids. The FA and CP values within this tumor are high and mode values are mostly negative. This is probably due to structured orientation of keratinous material oriented along a plane. Thus, DTI and diffusion tensor metrics afford information about cytoarchitectural organization of intracranial epidermoids.

**KEY WORDS:** Epidermoid, diffusion tensor imaging, diffusion tensor metrics

**Poster 058**

**Comparison of Functional MR Imaging and Transcranial Magnetic Stimulation for Primary Motor Cortex Localization**

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**PURPOSE**
Transcranial magnetic stimulation (TMS) is an imaged-guided technique for motor cortex localization and can be used to provide complementary information to functional MR imaging (fMRI) or magnetoencephalography (MEG). During TMS, a current is passed through a hand-held coil creating a brief magnetic pulse. The magnetic field passes the skull painlessly and induces a focal electrical field within cortex causing neuronal depolarization and contraction of contralateral muscles. We compared TMS and fMRI localization of primary motor cortex in healthy adults.

**MATERIAL & METHODS**
Following IRB approval, 10 subjects underwent 3 T MRI fMRI using a thumb abduction task. A structural scan was transmitted to a neuronavigational system to provide stereotactic guidance for TMS application. Next, single-pulse TMS was performed to identify the site leading to the most robust contraction of the contralateral abductor pollicis brevis muscle. This site was labeled on the structural scan within the neuronavigational system. The investigator applying TMS was blinded to the fMRI activation. Finally, TMS-derived center of gravity (CoG) maps were created based on the weighted motor evoked potential (MEP) amplitudes obtained along a 7 x 7 grid (points 1 cm apart along the scalp centered at the site of maximal muscle contraction). The fMRI motor activation sites (highest z-value) were coregistered with the TMS activation sites (extrapolation of the TMS site on the scalp along a perpendicular trajectory down to the closest underlying cortical surface).

**RESULTS**
Using a 1 sample t-test with a cut-off distance of 10 mm for detecting a difference in techniques, we determined that TMS and fMRI are not statistically different (p value = 0.16). However, the TMS sites were systematically more inferior-laterally located along the motor strip than the fMRI sites. Subjects in which the TMS CoG map provided a well defined point of activation tended to correlate more closely with the fMRI activation site.

**CONCLUSION**
Like other investigators (Lotze, 2003), we found a systematic difference between TMS and fMRI. This may be due to factors including orientation of the TMS coil to the cortical surface and limitations of our method for extrapolating TMS scalp sites to cortex not reflecting individual variability in cortical geometry. Despite these limitations, TMS may be a useful clinical mapping technique providing crucial complementary information about the functional relevance of an activation site.

**KEY WORDS:** Functional imaging, transcranial magnetic stimulation

**Poster 059**

**Pulsed Arterial Spin Labeling Time-Series Data Can Be Used to Accurately Compute Graph Theory Metrics of Global Distributed Brain Connectivity**

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**PURPOSE**
Graph theory network analysis methods applied to resting-state functional magnetic resonance imaging (RS-fMRI) blood oxygen level dependent (BOLD) data have begun to shed light upon changes in the central nervous system (CNS) at the level of whole-brain distributed network connectivity that appear to underlie a variety of neurodegenerative and psychiatric disorders. Using RS-fMRI for graph theoretical analysis requires collection of rapid whole brain time-series data to identify low frequency statistical interdependences between brain regions or voxels. Pulsed arterial spin labeling (PASL) perfusion MRI generates similar whole brain time-series data (tag and control pairs) at repetition times (TR) of 3-6 seconds, compared to a typical TR of 2 seconds for RS-fMRI. Little is known about the accuracy of graph theory network metrics computed using PASL data. The purpose of this study was to determine if graph theory methods can be applied accurately to PASL time-series data. We hypothesized that PASL data would yield similar network metrics, as compared to RS-BOLD data.
Materials & Methods
An institutional ethics committee approved this study. Thirty-one normal control subjects were scanned in a 1.5 T GE scanner using an 8-channel head coil (GE Medical Systems, Milwaukee, WI, USA) for collection of structural anatomical (3D SPGR) MRI and Rs-fMRI BOLD, and PASL perfusion data. The PASL tag and control time series was combined in a variety of ways for graph analysis: the full time series; tag images only; control images only; tag + control; tag - control; and control - tag. All data were motion-corrected and normalized to a standard template using SPM. A binarized adjacency matrix for each imaging time series across subjects was generated at a network cost of 0.3 from which common graph theory network metrics (clustering coefficient, characteristic path length, local efficiency, global efficiency, and small-worldness) were computed. One-way between group analysis of variance with post-hoc analyses were conducted to explore the impact of each sequence(RS-fMRI and PASL) on computed network metrics.

Results
There were no statistically significant differences between graph network metrics computed from RS-fMRI and PASL time-series data for clustering coefficient $[F(6,210)=1.671, p=.129]$ or characteristic path length $[F(6,210)=1.811, p=.098]$. There was, however, a main effect of time-series data type for local efficiency $[F(6,210)=2.559, p=.021]$, global efficiency $[F(6,210)=2.969, p=.008]$, and small-worldness $[F(6,210)=9.209, p<.0005]$. Post-hoc analyses revealed differences for some of the PASL time-series data as compared to RS-fMRI, but not for the full time-series PASL and tag only time-series data.

Conclusion
Accurate graph metrics can be computed from time-series data generated from standard clinical PASL MRI. This allows for a single perfusion study to also provide graph theory network connectivity metrics without requiring a separate time-consuming Rs-fMRI acquisition. Translation and broad clinical implementation of graph theoretical analysis techniques to clinical PASL perfusion MRI data may lead to the discovery of novel functional imaging markers that improve the ability to diagnose disease and predict outcomes associated with central nervous system dysfunction.

Key Words: Graph theoretical analysis, resting-state fMRI

Poster 060
Pattern of Susceptibility-Weighted Imaging in Central Nervous System Toxoplasmosis Infection in a Series of AIDS Patients

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Purpose
The diagnostic role of MR imaging (MRI) in evaluating patients with central nervous system (CNS) toxoplasmosis (CNST) has been well established, but the incidence of susceptibility imaging (SWI)-related abnormalities on MRI has not been explored yet in CNST; notably, SWI is more sensitive in detecting small deposits of hemorrhage and/or iron. Thus, we explored the utility of SWI for initial and follow-up MRI in patients with clinically confirmed CNST.

Materials & Methods
We retrospectively reviewed 11 patients (8 males, 3 females) MRIs with clinically confirmed CNST (based on treatment response). Five of the 11 had follow-up MRI within 30-60 days. The majority of lesions followed by MRI were evaluated using a 3.0 T magnet (34/36). A senior radiology resident and staff neuroradiologist jointly reviewed the MRIs, recording the number of lesions, locations, and size on FLAIR, diffusion-weighted imaging (DWI), contrast-enhanced (CE) T1-weighted imaging and SWI. For the five patients with available follow-up imaging, the number, imaging pattern, and evolving appearance were recorded.

Results
Mean time to follow-up MRI was 77 days. A total of 272 lesions were seen, with 37 lesions followed on MRI in five patients. Of the 37 lesions total initially, 37 were positive on FLAIR, 11 on SWI, 28 on DWI, and 17 having CE. Twenty-seven of 37 FLAIR-positive lesions became SWI-positive on subsequent MRI, regardless of CE or reduced diffusion. Of 28 DWI-positive lesions, 10 were initially SWI-positive, while 21 were SWI-positive at follow up. Of 17 CE-positive lesions, seven were initially SWI-positive, with 13 SWI-positive at follow up. Notably, of the 37 FLAIR-positive lesions, 11 were SWI-positive initially, and 27 were SWI-positive at follow up ($p=0.054$). There was poor agreement between the presence on DWI ($p=0.888$) or CE with SWI ($p=0.1168$) on the initial exams, and within the five patients with follow up. The majority of CE-positive lesions ($n=17$) were CE-positive on follow up ($n=13$) in those same locations.

Conclusion
Although the vast majority of lesions were FLAIR-hyperintense, the most informative finding was the eventual development of SWI-positive lesions in the majority of FLAIR-positive lesions (approximately three quarters). This is
regardless of whether or not these lesions enhance or demonstrate restricted diffusion. In addition, once a lesion is positive on SWI, it remains so. Most apparent is the dynamic nature of these lesions; thus, there is poor correlation between the initial presence of abnormalities on SWI, DWI, and CE. We presume these represent microhemorrhages initially, but could represent microcalcification chronically related to inflammation.

**KEY WORDS:** Toxoplasmosis, susceptibility-weighted imaging

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**Poster 061**

**Intra and Interobserver Variability in Measurements of High-Grade Gliomas**

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**PURPOSE**

Bidimensional tumor measurements indicating a >25% increase in tumor size generally are accepted as indicating tumor progression by neuro-oncologists. We assessed intra and interobserver variability of such measurements.

**MATERIALS & METHODS**

Ten patients with contrast-enhancing, biopsy-proved glioblastoma multiforme underwent MR imaging (MRI) in three orthogonal planes on two occasions 1 month apart. Nine readers measured tumor diameters in each plane on anonymized digital images. Seven of these readers repeated measurements 6 weeks later. Products of tumor measurements were calculated and determinations of tumor progression (defined as > 25% increase in area) were made. We performed a univariable analysis to compare the difference of the product of each plane between two readings of each reader and also calculated the consistency of determination of rate of progression on each reading based on those measurements. We also tested the homogeneity of any pair of two different readers by determining simple Kappa coefficients for the first and second readings by the same reader and across different readers. The simple Kappa coefficients were estimated for each pair readers (p< 0.05 for all tests). The SAS statistical package V9.2 (SAS Institute, Inc., Cary, NC) was used for all data managements and analyses.

**RESULTS**

The paired t-test between the first and second readings for each reader showed that four of seven readers were found to have a statistically significant difference between readings in at least one imaging plane. Assessment of consistency of disease progression judgments between first and second readings showed that, on average, each reader was consistent only 63% of the time (range: 40%-80%). The Kappa coefficient for agreement of a reader with himself with regards to progression/lack of progression on different readings was relatively low, at 0.23. When assessing rate of agreement for any set of two readers, we found the chance for disagreement was higher than the chance of agreement in 26% of the pairs. Pairwise Kappa correlation coefficients showing likelihood that two readers would agree with one another regarding progression or lack of progression was very low, at 0.05 (i.e., essentially only a 50% chance of agreement).

**CONCLUSION**

Intra and interobserver variability for determining tumor progression was very low, indicating that manual measurements by individual readers are relatively unreliable.

**KEY WORDS:** Neoplasm, variability, measurements

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**Poster 062**

**Differentiation at 3 T High b-Value Diffusion (b = 3000 s/mm²) MR Imaging between Tumor Recurrence and Radiation Injury in Treated Gliomas**

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**PURPOSE**

Theoretically, higher b-value diffusion-weighted imaging (DWI) improves contrast because it reflects tissue diffusivity better and is less subject to the T2 shine-through effect. The purpose of this study was to assess whether DWI at b = 3000 s/mm² is more useful for discriminating glioma recurrence from radiation injury than DWI at b = 1000 s/mm² at 3 T.

**MATERIALS & METHODS**

We retrospectively reviewed conventional follow-up MR images, DW images acquired at b = 1000 and 3000 s/mm², and apparent diffusion coefficient (ADC) maps that were obtained starting 1 month after the completion of radiation treatment in patients with histologically proved gliomas. All MR studies were performed on 3 T units. We studied 11 patients with areas of abnormally enhancing tissues. The final diagnosis was established histologically, or by the patients’ clinical course and a combination of imaging studies. Visual assessments recorded on a 5-point scale and quantitative assessments based on the DWI signal intensity (SI) ratio (tumor SI/normal SI), and ADC values were compared on DW images acquired at b = 1000 and 3000 s/mm².

**RESULTS**

Of the 11 patients, six suffered tumor recurrence; five manifested radiation injury. At visual assessments, hypointensity was more conspicuous in patients with tumor recurrence, and hypointensity was stronger in the presence of radiation injury on DW images acquired at b = 3000 than b = 1000 s/mm². Quantitative assessments showed that at both b-values the mean SI ratio was significantly higher in patients with tumor recurrence than radiation injury. The difference between the SI ratio of tumor recurrence and radiation injury was larger at b = 3000 than at b = 1000 s/mm². At b = 3000 s/mm² the mean ADC value was significantly lower in the presence of tumor recurrence than radiation injury. On the other hand, there was no significant difference in the mean ADC value at b = 1000 s/mm².
Conclusion
At 3 T, DWI at \( b = 3000 \text{ s/mm}^2 \) may be more useful than at \( b = 1000 \text{ s/mm}^2 \) for the discrimination between glioma recurrence and radiation injury.

Key Words: Diffusion-weighted imaging, glioma, recurrence

Poster 063
New Patterns of MR Perfusion Images in High-Grade Glioma Patients Treated with Bevacizumab

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Genève, SWITZERLAND

Purpose
The purpose of this study is to identify new MR imaging (MRI) brain perfusion patterns in patients with high-grade brain tumors treated with bevacizumab (Avastin®), an inhibitor of neoangiogenesis.

Materials & Methods
Thirteen patients diagnosed with high-grade gliomas were studied by 3 T MRI (Siemens scanner Erlangen, Germany). The protocol consisted of the following sequences; axial T1-weighted spin-echo imaging, axial T2-weighted fast spin-echo imaging, 3D FLAIR, axial DTI, axial T2-weighted gradient-echo imaging, perfusion, axial T1-weighted post-gadolinium imaging (0.2mmol/kg of body weight) and a 3D T1-weighted gradient-echo postgadolinium imaging. The criteria used in the evaluation of tumor progression comprised the analysis of edema using FLAIR sequences and the perfusion of lesions using rCBV and T1-weighted post-gadolinium images.

Results
Of the thirteen patients, (10 men and 3 women, mean age of 49.8 years: range 22-68 years), ten were diagnosed with glioblastoma, one high grade anaplastic ependymoma, one anaplastic pleomorphic xantho-astrocytoma and one with gliomatosis cerebri. MR imaging showed tumor hypoperfusion and progression of disease in six patients (46.2%). Seven patients (53.8%) presented hyperperfusion of their tumors with progression occurring in six patients (85.7%), and one (14.3%) presented stable disease.

Conclusion
Treatment with bevacizumab (Avastin®) alters the process of angiogenesis which may result in hypoperfusion in patients with disease progression. This new pattern must imperatively be known in order to avoid erroneous interpretation of imagery results in the follow up of these patients.

Key Words: Avastin, glioma

Poster 065
Correlation of Perfusion Permeability Estimates with Genes Related to Angiogenesis Regulation in Glioblastoma

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Purpose
The integration of imaging and genomic data is critical for a better understanding of gliomas, particularly considering the increasing focus on utilization of various imaging biomarkers for patient survival and treatment response. The purpose of this study was to correlate permeability surface area-product (PS) measured using perfusion CT (PCT) with the Gene Ontology biologic process pathways for positive and negative regulation of angiogenesis in glioblastoma.

Materials & Methods
Fifteen patients with WHO grade IV gliomas underwent pre-treatment PCT using 64-slice CT scanner and PS maps were generated using perfusion CT 3.0 (Advantage Windows, GE, Milwaukee, WI) software. Tumor specimens were analyzed by The Cancer Genome Atlas (TCGA) projectand genomic data was obtained retrospectively from TCGA. The Agilent gene expression micorarrays from the TCGA were interrogated for correlation between PS estimates and gene expression across the entire genome. There were 18233 named genes represented by 56821 probes. Of these 3184 genes (17.4%) were found to have a significant Pearson’s correlation coefficient at p<0.05 with the expression of at least one probe (5365 total probes). Given our interest in PS estimates well correlation with permeability (p<0.05). The maximum absolute correlation coefficient with associated p-value is given for each of these genes: VASH2 Vasohibin 2 (-0.74, p=0.002), CCR3 Chemokine (C-C motif) receptor 3 (-0.56, p=0.030), TNFRSF1A Tumor necrosis factor receptor superfamily, member 1A (0.68, p=0.006), HIF1A Hypoxia inducible factor 1 alpha (0.66, p=0.008), CX3CL1 Chemokine (C-X3-C motif) ligand 1 (0.60, p=0.017), KDR VEGFR-2 (0.58, p=0.024), GATA4 GATA binding protein 4 (0.58, p=0.024), ITGB2 (0.58, p=0.025), RUNX1 Runx-related transcription factor 1 (0.54, p=0.042), FGF2 Fibroblast growth factor 2 (0.53, p=0.042). In the negative regulation of angiogenesis pathway (GO:0005923), we observed expression levels for 41 genes (145 probes) of which eight genes (19.5%) had significant correlation with permeability (p<0.05). The maximum absolute correlation coefficient with associated p-value is given for each of these genes: AMOT Angiomotin (-0.62, p=0.015), CX3CR1 Chemokine (C-X3-C motif) receptor 1 (-0.61, p=0.016), NF1 Neurofibromin 1 (-0.55, p=0.034), PTPRM Protein tyrosine phosphatase, receptor type, M, member 1.

Results
We observed expression levels for 54 (195 probes) genes in the positive regulation of angiogenesis pathway (GO:0045766), of which 10 genes (18.5%) had significant correlation with permeability (p<0.05). The maximum absolute correlation coefficient with associated p-value is given for each of these genes: VASH2 Vasohibin 2 (-0.74, p=0.002), CCR3 Chemokine (C-C motif) receptor 3 (-0.56, p=0.030), TNFRSF1A Tumor necrosis factor receptor superfamily, member 1A (0.68, p=0.006), HIF1A Hypoxia inducible factor 1 alpha (0.66, p=0.008), CX3CL1 Chemokine (C-X3-C motif) ligand 1 (0.60, p=0.017), KDR VEGFR-2 (0.58, p=0.024), GATA4 GATA binding protein 4 (0.58, p=0.024), ITGB2 (0.58, p=0.025), RUNX1 Runx-related transcription factor 1 (0.54, p=0.042), FGF2 Fibroblast growth factor 2 (0.53, p=0.042). In the negative regulation of angiogenesis pathway (GO:0005923), we observed expression levels for 41 genes (145 probes) of which eight genes (19.5%) had significant correlation with permeability (p<0.05). The maximum absolute correlation coefficient with associated p-value is given for each of these genes: AMOT Angiomotin (-0.62, p=0.015), CX3CR1 Chemokine (C-X3-C motif) receptor 1 (-0.61, p=0.016), NF1 Neurofibromin 1 (-0.55, p=0.034), PTPRM Protein tyrosine phosphatase, receptor type, M, member 1.
tyrosine phosphatase, receptor type, M (0.83, p=1.2E-4), CDH5 (0.58, p=0.024), ADAMTS1 (0.55, 0.035), KLK3(0.54, p=0.037), PML (-0.54, 0.038).

**Conclusion**

Our preliminary results show correlation of PS estimates with genes related to angiogenesis. Genes known to promote angiogenesis such as TNFRSF1A, HIF1A, KDR, FGF2 showed a statistically significant positive correlation where as genes known for inhibition of angiogenesis such as VASH2 and AMOT showed significant inverse correlation. These studies indicate that further investigation with a larger study number is warranted, and that correlation of imaging/perfusion parameters such as PS estimates obtained in vivo with genomic profile of gliomas potentially could lead to their use as imaging biomarkers.

**Key Words:** CT perfusion, TCGA, genomic analysis

**Poster 066**

**Erdheim-Chester Disease of the Central Nervous System**

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**Purpose**

Erdheim-Chester disease is a rare, non-Langerhans cell histiocytosis which can involve the central nervous system. The demographics and imaging findings in 11 patients with this disease are reviewed. We present manifestations which have not been described previously and findings on advanced imaging techniques.

**Materials & Methods**

CT, MR and PET/CT studies of the brain, maxillofacial region, and spine were reviewed in 11 patients with Erdheim-Chester disease. The studies were evaluated for disease presence in the following locations: intra-axial and extra-axial intracranial compartments, skull, pituitary gland, orbit, paranasal sinuses, and the spine. In addition, one patient was studied with MR spectroscopy and MR perfusion; several patients were evaluated with diffusion tensor imaging.

**Results**

Eight out of the 11 patients had disease of the central nervous system. The most common location of involvement was the pons and brachium pontis, followed by the hypothalamus and pituitary gland. PET/CT demonstrated FDG avidity of all lesions, including within the spine. Newly described findings include a stellate appearance of a supratentorial extra-axial lesion and right lateral ventricular ependymal enhancement with extension to the lentiform nucleus. MR spectroscopy of an extra-axial lesion demonstrated a lack of normal brain metabolites with a possible lipid peak. The dynamic susceptibility sequence of this lesion showed a relative lack of blood flow compared to white matter, despite the enhancement on the dynamic contrast-enhanced image and T1-postcontrast images. Diffusion tensor imaging of a pontine lesion showed no fiber tract disruption.

**Conclusion**

Erdheim-Chester disease has variable imaging appearances in the central nervous system. Neuroradiologists should be aware of these findings to avoid mistaking them for other disease processes. Further study will be necessary to define the significance of findings on advanced imaging techniques.

**Key Words:** Erdheim-Chester disease

**Poster 067**

**Diffusion Tensor Imaging and MR Perfusion-Weighted Imaging in Differentiating between Intracranial Dural Metastases and Meningiomas**

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**Purpose**

It can be a diagnostic dilemma, to preoperatively differentiate between intracranial dural-based metastases and meningiomas, on conventional MR images. The purpose of this study was to evaluate the utility of diffusion tensor imaging (DTI) and dynamic susceptibility-weighted contrast-enhanced MR perfusion imaging (DSC-PWI) with regard to this differentiation.

**Materials & Methods**

Retrospectively, 21 patients with histology-confirmed meningiomas and 18 cases of intracranial dural-based metastases were enrolled in this study. The studies had been done on a 1.5 T and 3 T GE scanner with precontrast DTI protocol that included TR/TE = 12000/101.7 ms, FOV = 24 x 24 cm²; Matrix = 128 x 128, thickness = 3 mm and gap=0 mm in 3 T scanner (or thickness = 5 mm with gap=1 mm in 1.5 T) using 25 noncollinear gradient directions with a b-value of 1000 sec/mm². Dynamic susceptibility-weighted contrast-enhanced-PWI was performed as axial single-shot, gradient-echo, echo-planar imaging sequence (TR/TE =1500/50 milliseconds; flip angle, 80°; FOV = 24x 24cm²; matrix = 96 x 128; thickness = 3 mm and no gap) obtained during the first pass of a bolus of gadoversetamide. The mean trace apparent diffusion coefficient (trace ADC), minimum ADC, mean fractional anisotropy (FA), maximal FA and maximal relative cerebral blood volume (rCBV) ratio were calculated for all lesions. For statistical evaluation we used Mann-Whitney U test and the receiver operating characteristic (ROC) analyses to determine the lesion separating threshold.

**Results**

The mean FA and maximal FA values of meningiomas (0.256±0.066 and 0.375±0.085, respectively) were significantly higher than for intracranial dural-based metastases (0.126±0.024 and 0.161±0.036, respectively), p<0.001. There was no significant difference in mean ADC, minimal ADC values and maximal rCBV ratio between these two types of tumors (p>0.05). The maximal FA showed a slightly higher sensitivity while the specificity was the same for both maximal FA and mean FA in distinguishing intracranial dural-based metastases from meningiomas (Table 1).
Table 1: Statistical analysis of imaging parameters in differentiating between meningiomas and intracranial dural-based metastases.

<table>
<thead>
<tr>
<th>Index</th>
<th>meningiomas (Mean±SD)</th>
<th>intracranial (Mean±SD)</th>
<th>p value W Test</th>
<th>Area under curve</th>
<th>Cutoff value</th>
<th>Sensitivity</th>
<th>Specificity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean FA</td>
<td>0.25±0.066</td>
<td>0.12±0.024</td>
<td>p&lt;0.001</td>
<td>0.94</td>
<td>0.157</td>
<td>0.96</td>
<td>0.889</td>
</tr>
<tr>
<td>Maximal FA</td>
<td>0.37±0.085</td>
<td>0.16±0.036</td>
<td>p&lt;0.001</td>
<td>0.98</td>
<td>0.213</td>
<td>0.982</td>
<td>0.889</td>
</tr>
<tr>
<td>Mean ADC</td>
<td>0.83±0.024</td>
<td>0.92±0.283</td>
<td>0.133</td>
<td>0.343</td>
<td>0.825</td>
<td>0.509</td>
<td>0.333</td>
</tr>
<tr>
<td>Minimal ADC</td>
<td>0.72±0.123</td>
<td>0.79±0.23</td>
<td>0.874</td>
<td>0.483</td>
<td>0.714</td>
<td>0.526</td>
<td>0.444</td>
</tr>
<tr>
<td>Maximal rCBV</td>
<td>7.39±6.56</td>
<td>5.01±3.27</td>
<td>0.617</td>
<td>0.503</td>
<td>4.97</td>
<td>0.513</td>
<td>0.478</td>
</tr>
</tbody>
</table>

CONCLUSION

The results suggest that mean and maximal FA values can be helpful adjuvant imaging parameters to differentiate between intracranial meningiomas and dural-based metastases.

KEY WORDS: Meningioma, metastases, diffusion tensor imaging

**Poster 068**

**Perfusion MR Imaging in Differentiating High-Grade from Low-Grade Gliomas**

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**PURPOSE**

To correlate perfusion MR imaging with histologic grade of cerebral gliomas.

**MATERIALS & METHODS**

Relative cerebral blood volume (rCBV) maps were determined in 22 patients with pathologically proved gliomas (11 glioblastomas, 8 anaplastic gliomas and 2 low-grade gliomas) by dynamic contrast-enhanced T2*-weighted MR imaging. MR examination was completed with conventional T1- and T2-weighted imaging. The rCBV maps were calculated with an independent workstation by fitting a gamma-variate function to the contrast material concentration versus time curve. Relative CBV ratios obtained between tumor and normal white matter were compared between glioblastomas, anaplastic gliomas and low-grade gliomas by means of receiver operating characteristic (ROC) analysis.

**RESULTS**

Mean rCBV ratios were 4.85 (±1) for glioblastomas, 3.87 (±0.7) for anaplastic gliomas and 1.65 (±1.6) for low-grade gliomas. Receiver operating characteristic analysis demonstrates significant differences between glioblastomas and anaplastic gliomas (p<.05), between anaplastic gliomas and low-grade gliomas (p<.05) and between glioblastomas and low-grade gliomas (p<.01). The rCBV ratio cutoff value between high-grade gliomas and low-grade gliomas was 2.52 with a sensitivity and specificity of 100% and 75% respectively.

**CONCLUSION**

Perfusion MR imaging is a reliable technique for differentiating high-grade from low-grade gliomas.

**KEY WORDS:** Glioma, perfusion, low-grade/high-grade

**Poster 069**

**Short-Term MR Imaging Characteristics and Response to MR Image-Guided Laser Ablation Therapy**

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**PURPOSE**

MR imaging (MRI)-assisted laser thermal ablation is still in its early stages of development. It is an alternative minimally invasive surgical option in patients who either have "non-operative" tumors or who are at poor surgical risk. We would like to report our initial observations of the MRI in patients who have undergone laser ablation therapy.

**MATERIALS & METHODS**

Three patients with primary neoplasms of the brain with three different histologies (anaplastic ependymoma, PNET, and glioblastoma multiforme) are reported. Using standard navigation techniques and a Medtronic StealthStation® neuronavigation system, a laser probe is placed strategically within the tumor bed. With the patients awake in the MRI suite, a 15-W 980-nm diode laser is inserted into the planned target in the tumor. On a GE Excite 1.5 T MRI, MR-based thermal imaging is accomplished using 2D fast RF-spoiled gradient echo (SPGR) images with sequential multiphase and extended dynamic range (echo time - 20 ms, repetition time 37.5 ms, flip angle - 30 degrees, bandwidth - 10kHz). During laser ablation, the temperature of the tumor core and surrounding brain is measured by the MRI thermometry software. The brain-tumor interface temperature is limited to 50°C in order to avoid damage to nearby normal structures. Sequential MRI follow-up studies were performed at approximately the following post-thermal ablation intervals: 3 days, 1 week, 1 month, 2 months, and 3 months. The lesion size and edema were measured in three dimensions and were compared based upon composite volume measurements.

**RESULTS**

We have made the following postablation imaging observations: 1. The volume of the central tumor mass 24 hours postablation increases in size, peaking at 3 days to 1 week. 2. The central tumor mass remains stable for 2 to 3 months. In the two lesions with three-month follow up (anaplastic ependymoma and PNET), the decrease in size of the enhancing tumor mass is dramatic. The third lesion does not yet have 3 month follow up but has followed the previously described pattern in every other way at 2 months. 3. Postablation, perifocal edema increases dramatically but begins to decrease within 2 months. 4. The immediate postablation scans show ring-like peripheral enhancement with a central nonenhancing “ghost” that has maintained this morphology throughout the follow-up period. 5. Both the intensity of enhancement and the thickness of the enhancing ring decrease immediately post-thermal ablation and subtly decrease progressively with time. 6. In all three of our cases, we have observed persistent enhancement at 2 to 3 months. With the short-term follow up that we have at this time, we have interpreted our findings as favorable with respect to tumor therapy.
CONCLUSION
Initial three-month observation of imaging findings in patients who have undergone MRI-guided laser ablation therapy has a favorable imaging trend. Our initial imaging results within 3 months of follow up in three different histologies suggest that from a morphologic perspective this technique offers favorable outcomes. Long-term follow-up studies are warranted.

KEY WORDS: Laser, thermal, ablation

Poster 070
Radiology Imaging Findings in Gliosarcoma: A Retrospective Analysis

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PURPOSE
Gliosarcomas are rare tumors with poor prognosis composed of intermingled malignant glial and sarcoma elements with an estimated incidence of 1.8-8.0% of all malignant astrocytic neoplasms. We aim to review the imaging findings in eight patients with gliosarcoma that were treated in our center between 2002 and 2010. This study, to the best of our knowledge, is the largest describing the imaging manifestations of this rare tumor.

MATERIALS & METHODS
Five females and three males with ages ranging from 19 to 66 years (median age: 51 years) diagnosed with gliosarcoma underwent brain MRI and four had CT. Two radiologists reviewed all images retrospectively.

RESULTS
All lesions were located supratentorially. Five were in the parietal lobes. The other three were at occipital lobe, temporal lobe and occipitoparietal lobes. Tumors were iso or hyperdense on CT with calcifications in all three cases. Cystic component and hemorrhage could be identified in one case. MR imaging showed variable appearance on both T1- and T2-weighted images. In general, the tumors had a tendency for hypointense signal on T1 and hyperintense signal on T2. Six tumors showed intense ring-like enhancement and two heterogeneous enhancement of mainly a solid tumor. Associated dural and/or ependymal involvement was present in all cases and moderate to severe edema was evident in seven. Interestingly, three cases had a pre-existing lesion at the same site at least two of which were benign appearing. Two other female patients had associated small meningiomas.

CONCLUSION
Although our study revealed no unique radiologic features for gliosarcoma, it is important to note that they all demonstrated either dural or ependymal involvement or both. Calcification, hemorrhage or cystic component are described with a tendency for ring-enhancement pattern. Interestingly pre-existing benign-looking lesions and associated remotely located small meningiomas also are described.

KEY WORDS: Gliosarcoma, MR imaging
Poster 071

Multivariate Analysis of Morphologic and Diffusion MR Imaging Correlates of 1p and 19q Codeletion in a Large Cohort of Oligodendrogial Tumors

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PURPOSE
The codeletion of chromosomes 1p and 19q in oligodendrogial tumors is associated with a favorable clinical outcome. Our goal was to identify the best MR imaging (MRI) predictors of 1p/19q status in a large series of oligodendrogial tumors.

MATERIALS & METHODS
Consecutive subjects were included who had 1) a diagnosis of previously untreated oligodendrogial tumor, 2) 1p and 19q chromosomal analysis from tumor specimen, and 3) an available preoperative MRI. While blinded to 1p19q status, images were evaluated for morphologic features, including: location, bilaterality, overall degree of circumscription, sharp/indistinct border on T1-weighted and T2-weighted, smooth/irregular contour on T2-weighted, homogeneity on T1-weighted and T2-weighted, paramagnetic susceptibility effect, necrosis/cystic change, and contrast enhancement. Mean, maximum, and minimum ADC values were also obtained from a representative image of each tumor. The correlation of 1p/19q codeletion status with these imaging features, tumor type, and tumor grade (grade 2=low, grade 3 and 4=high) was assessed.

RESULTS
One hundred sixty-six patients met criteria. Median interval between date of MRI and pathologic sampling was 3.5 days. Eighty-two percent of oligodendrogliomas and 50% of oligoastrocytomas were 1p19q codeleted. In univariate analysis, several features strongly correlated with codeletion. Tumors centered in the frontal and parietal lobes were more likely to be codeleted relative to tumors in the insular and temporal lobes (p=.0023). Morphologically ill-defined tumors were more likely to be codeleted, as ~70% of tumors which lacked either an at least partially circumscribed margin, or sharp T1-weighted or T2-weighted border were codeleted, compared to only ~16% of tumors which demonstrated at least one of these features (p<.0001). Tumors with lower mean/maximum ADC values also were more likely to be codeleted (p=.001). From a multivariable logistic regression model, the most significant predictors were mean ADC (p=0.007), circumscription (p=0.02) and tumor histopathology (p=0.01). The discriminatory power from this model was high (C-statistic of 0.865).

CONCLUSION
1p/19q codeletion is strongly predicted by frontal/parietal location, lack of tumor margin circumscription, lower mean ADC values, and tumor histopathology. In select patients, imaging correlates of a genetic subtype of oligodendrogial tumors which is associated with improved clinical outcome could potentially obviate the need for chromosomal analysis.

KEY WORDS: Oligodendroglioma, oligoastrocytoma, 1p19q

Poster 072

Superior Longitudinal Fasciculus and Arcuate Fasciculus Tumor Involvement Analysis by T2 FLAIR versus Diffusion Tensor Imaging at 3 T

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PURPOSE
The involvement of the superior longitudinal fasciculus (SLF) and the arcuate fasciculus (AF) by a tumor can be critical when determining how a tumor will be resected and if postoperative language deficits might result. The white matter anatomy at 3 T utilizing T2 FLAIR technique has been underappreciated. The difference of the compactness of the fiber tracts likely plays a large role in the ability of T2-weighted techniques to visualize white matter tracts. Diffusion tensor imaging (DTI) has a well established role in displaying the superior longitudinal fasciculus and the arcuate fasciculus. We hypothesized that T2 FLAIR will demonstrate the position of the SLF and the AF robustly in the presence of brain tumors.
MATERIALS & METHODS

Our imaging database was searched for cases of brain tumor mapping that were performed at 3 T (Achieva, Philips Healthcare, Best, Netherlands). The MRI exams consisted of a 3D volumetric high-resolution T2 FLAIR sequence (0.43 mm x 0.43 mm x 0.6 mm) and high-resolution DTI images (2 mm x 2 mm x 2 mm, 16 directions of gradient sampling). There were 32 subjects (19 male, 13 female, 14-74 years) enrolled in this retrospective study. The T2-FLAIR volumetric images were reconstructed in the axial and coronal planes. The DTI images had fractional anisotropy (FA) maps calculated and then color coded in the standard red, green, and blue fashion to denote major fiber tract orientation. The color FA maps were evaluated in axial, sagittal and coronal planes. Tractograms of the AF were created on the Philips Extended Work Space (turning angle threshold = 27, FA lower limit = .15). The amount of involvement of the SLF was analyzed by the color FA maps and the T2 FLAIR images. The amount of involvement of the AF was evaluated by AF tractogram versus T2 FLAIR images. The correlation coefficient was used to compare the involvement of the SLF or the AF as determined by the DTI techniques versus T2 FLAIR.

RESULTS

There was a correlation of 0.98 when comparing T2 FLAIR and color FA maps for determining SLF involvement by tumors. A correlation of 0.60 was present comparing the T2 FLAIR and tractography analysis of AF involvement.

CONCLUSION

We detected a marked correlation between utilizing volumetric T2 FLAIR images and color FA maps in determining SLF involvement by tumors. This indicates that T2 FLAIR can greatly help a radiologist demarcate the SLF and this can be vitally important for surgical planning. There was a moderate correlation between T2 FLAIR analysis and tractography analysis of AF involvement. The only modest correlation of T2 FLAIR to AF tumor involvement is expected since the AF subcomponent of the SLF is not seen distinctly and the position can be approximated on only T2 FLAIR.

KEY WORDS: Superior longitudinal fasciculus, arcuate fasciculus

Poster 073
Persistent Diffusion Restriction Indicative of Treatment Necrosis in Glioblastoma Multiforme Evaluated with FDG PET

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PURPOSE

To demonstrate geographic lesions characterized by diffusion restriction in patients with treated glioblastoma multiforme (GBM) that are metabolically inactive and likely represent treatment necrosis rather than viable tumor.

MATERIALS & METHODS

FDG PET was performed in GBM patients on treatment protocols when progression vs radiation necrosis was not firmly established by MR imaging (MRI) alone. Retrospective review identified five patients in which FDG PET evaluated the development of new diffusion restriction. MR imaging, including apparent diffusion coefficient (ADC) (computed from 15 direction B-1000 DTI), T1 postcontrast (3D T1FFE), perfusion (CBF and CBV from DSC-MRI following preinjection to eliminate permeability effects), and FDG PET were evaluated. Clinical and imaging outcomes were reviewed.

RESULTS

In all 5 cases a region of diffusion restriction in the deep white matter was identified. All shared MRI features (Figure 1) including relatively homogeneous markedly decreased ADC (A), a ragged margin of thin peripheral enhancement (B), hypoperfusion (C) with CBV and CBF less than that of white matter (WM) and not distinguishable from the noise level. In each case FDG uptake (D) was less than that of WM and not differentiable from noise. On follow up of 5-17 months (mean 10 months) (E) these lesions did not develop high perfusion, nodular enhancement, or metabolic uptake or other signs of conversion to viable tumor. Progression occurred at sites distinct from the region of diffusion restriction. Furthermore, unlike the transient diffusion restriction seen in stroke, the diffusion restriction in these cases persisted without apparent change for months.

CONCLUSION

Diffusion restriction associated with GBM has been associated with increased cellularity and increased metabolic activity indicative of viable tumor. Hence, the development of diffusion restriction can be interpreted as an ominous ffind-
ing, indicating progression, recurrence, or transformation to high grade. The series of patients in this report indicate that radiation/treatment necrosis can result in regions of marked and persistent diffusion restriction which can be differentiated from viable tumor by concomitant hypoperfusion and lack of FDG uptake. Interestingly, the persistence of the diffusion restriction for months distinguishes it from the cytotoxic edema identified in acute infarcts. Although it may be that this pattern of necrosis is unique to specific therapies, such as antiangiogenic agents, this has to be determined yet. Nevertheless, radiologists need to be aware that the development of diffusion restriction in the setting of GBM can represent necrosis and not necessarily viable tumor.

**KEY WORDS:** Progression, angiogenesis, perfusion

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**Poster 074**

Dynamic Contrast-Enhanced MR Imaging Correlates of Histologic Features in Glioblastoma Multiforme

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**PURPOSE**

Glioblastoma multiforme (GBM) are characterized by vascular proliferation, necrosis and mitotic activity. Dynamic contrast-enhanced MRI (DCE-MRI) provides a noninvasive method for characterizing the tumor microvascular environment. It was hypothesized that DCE-MRI parameters would correlate with histologic microvascular features in GBM.

**MATERIALS & METHODS**

Twenty-eight patients with subsequently histologically proved GBM underwent preoperative T1-weighted DCE-MRI. Parametric maps of \(K^{\text{trans}}\) (contrast transfer coefficient), \(v_e\) (measure of extravascular extracellular space), \(v_p\) (measure of plasma volume per unit of tissue) and EnF (enhancing fraction) were generated. Surgical specimens were assessed semiquantitatively for the presence of necrosis, mitotic activity, histologic patterns, and tumor vascularity. Image analysis using CD34 immunostaining was used to quantify endothelial surface area (ESA), vascular surface area (VSA) and vascular profile count (VPC). The relationships between individual MRI parameters and histopathologic features were examined.

**RESULTS**

Significant relationships were identified between \(v_e\) and mitotic activity (Figure 1), \(p<0.012\), and \(v_e\) and the presence of prominent fibrillarity, \(p<0.007\); \(VPC/mm^2\) correlated with \(v_p\), \(p<0.042\) and with EnF, \(p<0.036\) (Figure 2); \(K^{\text{trans}}\) correlated with the presence of frank necrosis (\(p<0.005\)) and EnF showed a nonsignificant trend with decrease in relation to necrotic volume.

**CONCLUSION**

As expected, a correlation was identified between \(v_e\) and a histologic marker of vascularity (VPC). Interesting, \(v_e\) was identified as a potential correlate of mitotic activity in GBM. This was an unexpected finding and may reflect cell density dependent growth inhibition. Further work is warranted to examine this in more depth.

**KEY WORDS:** DCE-MR imaging, histopathology, glioblastoma multiforme

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**Poster 075**

Predicting Recurrent Tumor Versus Radiation Necrosis Using Advanced MR Imaging

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**PURPOSE**

A common problem in the care of brain tumor patients is new enhancing abnormalities adjacent or distant to the site of the resection. The current study focuses on the assessment of advanced MR imaging (MRI) biomarkers as a means to differentiate tumor from radiation necrosis.
Materials & Methods
Brain cancer patients at our institution who have a new enhancing lesion after treatment undergo an advanced MRI protocol, which consists of conventional MRI with T2, T2 FLAIR, diffusion tensor, and pre and postcontrast T1-weighted imaging. Additionally, multivoxel 1H spectroscopy and perfusion imaging (both dynamic contrast-enhanced (DCE) and spin echo dynamic susceptibility-enhanced (DSC) imaging) is performed. Patients receiving subsequent biopsy or surgery within 20 days of imaging were assessed retrospectively and the performance characteristics of conventional, perfusion, and spectroscopic imaging data for predicting tumor versus treatment-related necrosis were calculated. Pathology results were graded on a 5 point scale with the clinically important cut-off of significant residual/recurrent tumor used to calculate performance. Patients subsequently were followed clinically.

Results
Of the 110 patients imaged, 41 patients received biopsy or surgery for clinical indication. After exclusion for timing of tissue sampling, nonglial cell primary tumor, untreated tumors and treatment regimen, 14 cases were selected for further analysis with a spectrum of pathology findings. All patients selected had WHO grade 3 or 4 brain tumors and received treatment with temozolomide, resection and radiation, which ended 76-1504 days before imaging. Four patients also received bevacizumab. All patients except four were followed for greater than 6 months. Conventional MR imaging with comparison to prior studies and reference to clinical history, by two expert neuroradiologists with greater than 20-years experience each, yielded a sensitivity and specificity (Se/Sp) of 0.67 and 0.60, respectively. The best performing advanced MRI measures were maximum Ktrans of greater than 0.025 min⁻¹ (Se/Sp 1.00/0.60) and average plasma volume fraction (vp) of enhancing lesion greater than 0.013 (Se/Sp 0.78/1.00) for tumor. Maximum vp of greater than 0.015 and choline to NAA ratios of less than 2.8 also performed well (Se/Sp 0.78/0.80 for both).

Conclusion
It is often difficult to discern necrosis related to tumor from radiation-induced necrosis, but this determination can be critical in subsequent management. In this cohort of patients, DCE measures of Ktrans and vp were found to be most valuable in making this determination. This further improved with exclusion of patients treated with bevacizumab. Interestingly, significant elevation of the choline to NAA ratio, previously reported as a high-grade tumor marker, was a better predictor of necrosis. This could be from altered tumor biology after treatment. Other previously reported values for tumor performed poorly, such as DSC negative enhancement integral, DCE positive enhancement integral, choline to creatine ratio, lipid levels, and apparent diffusion restriction. Multiparametric combinations of the advanced MRI measures may further improve sensitivity and specificity and such analyses are ongoing. Further research in this area is needed to help guide clinical treatment decisions and avoid unnecessary biopsies with the potential for undersampling.

Keywords: Necrosis, glioma, perfusion

Poster 076
Post-Mortem Alterations in Fractional Anisotropy and Mean Diffusivity in Fixed Cerebral Hemispheres
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Purpose
The purpose of this work was to investigate the post-mortem changes in diffusion tensor properties throughout fixed human cerebral hemispheres [as measured with MR imaging (MRI)] over time.

Materials & Methods
Four hemispheres were placed in formaldehyde solution and were imaged with DTI, twice within 48 hours postmortem and approximately once per week thereafter, until 1 month postmortem. One brain donor had also undergone MRI 1 year prior to death, so antemortem DTI data were available for this subject. All post-mortem imaging was conducted at room temperature using the same clinical 3 T Philips Achieva MRI scanner (Best, Netherlands) using the following scan parameters: resolution = 1.8 x 1.8 x 2.0 mm³, TE = 53 ms, TR = 35.5 s, b = 0, 1000, 2000, 3000, 4000, 5000, 6000 s/mm², 15 diffusion directions, scan time = 55 min. All diffusion-weighted volumes from a given hemisphere were registered to the same T2-weighted volume. Mean diffusivity (MD) and fractional anisotropy (FA) were calculated for each imaging session and the changes in these quantities over time were observed.

Results
For the hemisphere that had been imaged both antemortem and postmortem, voxelwise comparison showed 92% reduction in white matter MD and 78% reduction in gray matter MD just 22 hours after death (the time of the first post-mortem scan) compared to 1 year antemortem. There was little correlation between ante-mortem and post-mortem MD values. Conversely, FA values were not altered substantially in the first 22 hours after death. Ante-mortem and post-mortem FA values gathered from all brain voxels were highly correlated (r = 0.78, p = 1.0e-12). Following the first post-mortem scan of each hemisphere, FA in the major white matter tracts decreased by approximately 30% over a timespan of 1 week (Figure). Over the next 3 to 4 weeks, FA measurements stabilized somewhat and remained lower than the initial post-mortem FA. The noise of the FA measurements increased in the later scan sessions. Results were similar for major white matter tracts in all four hemispheres.
CONCLUSION
Post-mortem DTI should be conducted as soon as possible after death, preferably within 24 hours, in order to obtain FA values that are most similar to those that would have been measured in vivo just before death and, thus, are most likely to be related to histologic data. For MD, there does not appear to be a strong relationship between ante-mortem and post-mortem values.

KEY WORDS: Postmortem, diffusion, MR imaging

Poster 077
Translation of Post-Mortem Volume Measurements of Subcortical Gray Matter to in vivo Studies

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PURPOSE
The purpose of this work was to determine the relationship between the volume of subcortical gray matter structures measured with MR volumetry in vivo and postmortem.

MATERIALS & METHODS
High-resolution anatomical images of six elderly humans (mean = 88.9 years, st.dev. = 1.31) were collected in vivo and postmortem. For the post-mortem acquisition, a brain hemisphere from each subject was imaged. The cerebellum and brainstem were removed and the hemisphere was stored in a container filled with formaldehyde solution. For the segmentation of the eight subcortical gray matter regions 18 manually segmented T1-weighted image volumes (http://www.cma.mgh.harvard.edu/ibsr) were used. Each of the 18 image volumes was registered to the in vivo and post-mortem data using nonrigid registration (ART). The output transformation that maps each of the 18 image volumes to each subject’s data was applied to the labeled volumes using nearest neighbor interpolation. The final segmentation of each region was obtained by combining all 18 labeled volumes using a vote-rule based on maximum frequency. Further improvement of the results was obtained by the use of gradient maps for the anatomical images and two-class gray/white matter segmentation obtained by FSL. The volume of each segmented region was normalized to the intracranial volume. Post-mortem volumes were plotted as a function of the in vivo volumes. Finally, the shape differences between in vivo and post-mortem data were obtained using the SPHARM-PDM UNC Toolbox.

RESULTS
A linear relationship was demonstrated between the normalized post-mortem and in vivo volumes of the subcortical gray matter regions, described by: y=0.8791x+0.0086, p<10^-10 (Figure 1). Shape analysis provided additional evidence on the contraction of the surface of these structures.

CONCLUSION
The observed shrinking of the subcortical gray matter regions may be due to a reduction in water content of brain tissue after death. The present investigation facilitates translation of post-mortem MR volumetric measurements to in vivo studies.

KEY WORDS: Segmentation, volumetry

Poster 078
Effects of Age, Gender, and Hemispheric Location on T2 Hypointensity in the Pulvinar at 3 T

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PURPOSE
The signal changes of the pulvinar with aging have not been established, though pulvinar hypointensity may be recognized frequently on T2 and diffusion-weighted images. Previous studies have reported the signal loss on T2-weighted imaging with aging in the globus pallidus, red nucleus, substantia nigra, and dentate nucleus, presumably due to the
increase of iron deposition. The purpose of this study was to evaluate the effect of age, gender, and hemispheric location on T2 hypointensity in pulvinar.

**Materials & Methods**

The imaging database was searched for subjects with unremarkable brain 3 T MR findings. One-hundred forty-three subjects (F=91, M=52, 8-91 years old) were enrolled in this retrospective study. MR images were analyzed with regard to signal intensity of the pulvinar relative to the thalamus and cerebral white matter on FLAIR images, respectively. The multivariate linear regression was used to study the age effect on the signal ratio of pulvinar to thalamus or white matter with adjustment for the hemispheric effect for male and female groups respectively.

**Results**

In the male group, the slopes of the regression lines were $-0.00358$ (p<0.0001) and $-0.00437$ (p<0.0001) for the ratio of pulvinar to thalamus and white matter, respectively. In the female group, the slopes were $-0.00152$ (P<0.0001) and $-0.00157$ (p = 0.0002) for the ratio of pulvinar to thalamus and white matter, respectively. The male subjects had more rapid decrease of signal ratio with age than the female ones, with p = 0.0002 or 0.0006 for the ratio of pulvinar to thalamus or white matter, respectively. The right pulvinar had lower signal ratios than the left one in both male and female subjects.

**Conclusion**

We detected a significant association between pulvinar signal on T2-FLAIR images and age, a linear signal decrease with age. The signal changes also are asymmetric and gender related. We speculate that T2 hypointensity in the pulvinar may be reflective of increased iron deposition.

**Key Words:** Pulvinar, T2 hypointensity

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**Poster 079**

**Significant Differences in MR Perfusion in Lupus Patients Compared to Healthy Controls**

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**Purpose**

Systemic lupus erythematosus (SLE) is an autoimmune disorder with an annual incidence of 2.0-7.6 per 100,000. Neuropsychiatric systemic lupus erythematosus (NPSLE) occurs in 25-70% of patients with SLE and is associated with increased morbidity and mortality. The clinical manifestations of NPSLE include: headache, stroke or stroke-like symptoms, psychosis, seizures and cognitive dysfunction among others. Although clinical assessment is the cornerstone of the NPSLE diagnosis, this diagnosis can be difficult to make and is frequently presumptive. Our objective with this study was to search for a perfusion parameter that could be used as a diagnostic marker for NPSLE patients so that we could make inroads in terms of diagnosis and therapy.

**Materials & Methods**

Eighteen SLE patients with no neurologic symptoms (17 females, 1 male, mean age 42.7±14.3 years), 19 NPSLE (19 females, mean age 43.3±11.6 years), and 19 healthy controls (HC) (19 females, mean age 44.5±14.3 years). All subjects had conventional 3 T MR imaging (MRI) of the brain. Perfusion measurements(CBF, CBV, and MTT) were obtained using Philips T2* perfusion tool software. Perfusion was generated from an arterial input function (AIF) obtained using the right middle cerebral artery. The ratio of CBF, CBV, and MTT of eight different brain regions were compared between the three cohorts by two-sample t-test or Wilcoxon rank-sum test when appropriate (lack of normality). A probability (p) value of 0.05 or smaller was considered significant for all hypothesis tests.

**Results**

Several significant differences were seen between the HCs and the SLE patients in terms of relative cerebral blood flow in the following areas: right posterior thalamus(p = 0.03), right hypothalamus (p = 0.042), and posterior cingulate gyrus (p = 0.048), and the left parahippocampal gyrus (p = 0.048). Additionally, there also was a statistically significant difference between CBV in the left hypothalamus region (p = 0.048). Healthy controls and NPSLE patients showed a significant difference in the CBV of the posterior cingulate gyrus(p = 0.045). Testing for equality of variances revealed significant differences in the CBV between the SLE and NPSLE patients (p = 0.001) as well as between HC and NPSLE (p<0.0001). Overall, the NPSLE patients had higher variability than the other two cohorts. In terms of the CBF the healthy controls and the NPSLE had significantly different variability (p = 0.03) and the NPSLE patients has higher variance than the HC group.

**Conclusion**

Several statistically significant differences in perfusion patterns were found in patients with lupus with and without neuropsychiatric symptoms compared to HCs. Differences
in CBF were seen in SLE patients compared to HC patients, this may be in part due to vascular changes secondary to SLE. Interestingly, no statistically significant difference in CBF was seen between the NPSLE and HC patients. One of the most significant findings was that the perfusion parameters for the NPSLE patients showed increased variability compared to the HC and SLE patients, and maybe this is why we and others have found it difficult to find a specific/singular perfusion target in which to help diagnose neuropsychiatric lupus.

**KEY WORDS:** MR imaging perfusion, neuropsychiatric lupus, systemic lupus erythematosus

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**Poster 080**

**Diagnostic Yield of Head CT for Headache in the Low Risk Patient**

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**PURPOSE**
Headache is a common patient complaint, accounting for up to 4.5% of emergency department (ED) visits. It remains one of the most common primary chief complaints associated with computed tomography (CT) imaging in the ED accounting for 7.5% of CT-associated ED visits in 2007. Excessive imaging has come under scrutiny in recent years due to mounting concern about the risks of radiation exposure and rising health-care costs. Prior studies have examined the role of head CT for the evaluation of headaches in the ED setting. However, methodologic concerns have limited their value. Our goal was to reassess the diagnostic value of emergency head CT in the work-up patients with isolated chief complaint of headache utilizing contemporary CT equipment and protocols.

**MATERIALS & METHODS**
The study group was composed of ED patients presenting to a metropolitan tertiary care center from September 2010 to November 2010. All patients presenting with a chief complaint of “headache” who subsequently received an unenhanced head CT were included in the study. Patients were identified through a search of the radiology information system (RIS). Of 714 reviewed studies, 557 were excluded if there was any additional history other than “headache.” Of the 157 remaining, confirmation of the history was accomplished by review of the electronic medical record. Based on this review, patients were excluded if risk factors existed for acute intracranial pathology. These included, but were not limited to: head/neck trauma, altered mental status, recent head/neck surgery, anticoagulation therapy, atrial fibrillation, and malignancy, prior intracranial bleed, known aneurysm, uncontrolled HTN or clinical diagnosis of stroke. After exclusion criteria were applied, a total of 46 patients were included in the study. Findings were categorized as “normal” (no abnormalities), “incidental” (findings do not explain patient’s symptoms), or “abnormal” (findings do explain patient’s symptoms). Calculations were performed using Microsoft Excel.

**RESULTS**
Of the patients in the study, 65.3% were female. Age range was 18-77 years (mean, 39.4 years). No scans demonstrated findings that explained the patients’ symptoms. Sixty-three percent of the studies were normal. Incidental findings were present in 37% of patients. Incidental findings included sinus mucosal disease, diffuse brain atrophy, chronic small vessel disease, chronic lacunar infarcts or large vessel distribution infarcts, subarachnoid cyst, and calcified meningioma. Zero studies were diagnostic of the patients’ symptoms.

**CONCLUSION**
This study demonstrates the low diagnostic value of unenhanced head CT for the evaluation of headaches in the low risk patient. Radiation exposure is significant. Unenhanced head CTs average 75 mGy (CTDIvol) per scan based on ACR/ASNR reference standards. With an estimated 1.215 million ED visits involving head CT for headache evaluation, a significant dose reduction and cost savings potentially could be achieved through more judicious use of CT. Given the findings in this study, patients may be better served by a careful clinical history, appropriate neurologic exam, and, if indicated, MR imaging of the brain.

**KEY WORDS:** Headache

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**Poster 081**

**Factors Determining the Clinical Significance of an “Empty” Sella Turcica**

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**PURPOSE**
The “empty” sella turcica is characterized by intrasellar herniation of the subarachnoid space, resulting in a flattening of the pituitary gland, with or without enlargement of the bony sella turcica. This appearance on MR imaging (MRI) often represents an incidental finding as the result of an anatomical defect in the diaphragm sella, but also may be a sign of chronically elevated intracranial pressure in the setting of idiopathic intracranial hypertension (IIH), a potentially treatable condition that can result in insidious vision loss. The purpose of this study was to evaluate clinical and MR imaging (MRI) factors that may help determine whether the finding of an “empty” sella is incidental or requires further evaluation.

**MATERIALS & METHODS**
Forty-five patients with clinically-documented IIH, and 92 patients with the term “empty sella” reported on a brain MRI examination (but without history of pituitary abnormality/surgery, clinical diagnosis of IIH, or intracranial abnormality on MR imaging) were enrolled retrospectively in this IRB-approved study. MR images for both the IIH and incidental “empty” sella groups were evaluated for maximum anterior-posterior (AP) and cranial-caudal (CC) sella turcica dimensions, AP diaphragm sella dimension, AP position of the pituitary infundibulum along the diaphragm sella, flattening and height of the pituitary gland, scalp soft tissue thickness at the coronal suture, and posterior soft tissue
thickness at the C2/3 level. Both groups also were evaluated for presence or absence of orbital findings suggestive of IIH (posterior scleral flattening, optic nerve sheath dilation, prelaminar optic nerve protrusion, and optic nerve vertical tortuosity). Age, gender, presenting clinical symptoms, and MR imaging measurements were compared between the two groups. Sellar and pituitary dimensions also were correlated with patient age in each group.

**RESULTS**
The mean age of the IIH group (36.1 years; SD = 11.7) was significantly younger ($P < 0.05$) than that of the incidental “empty” sella group (54.3 years; SD = 14.3). Patients in the IIH group were significantly more likely to have presenting symptoms of headache (93% versus 33%) or visual complaints (62% versus 28%; both $P < 0.05$). Nearly all the IIH patients (96%) demonstrated an “empty” sella appearance. There were no significant differences between the two groups in measures of AP and CC dimensions of the sella turcica, AP diaphragm sella dimension, infundibular position, or degree of pituitary flattening. The IIH group demonstrated significantly greater mean scalp thickness (9.0 mm versus 6.4 mm; $P < 0.05$) and neck soft tissue thickness (19.5 mm versus 13.8 mm; $P < 0.05$). While the vast majority of the IIH group (93%) had one or more orbital findings to suggest IIH, the incidental “empty” sella group rarely had any of these findings (14%). There was a modest age-related correlation with diaphragm sella width ($r = 0.53$) in the IIH group, but not the incidental “empty” sella group ($r = 0.13$).

**CONCLUSION**
Using a combination of clinical factors and imaging characteristics the significance of the MR imaging finding of an “empty” sella can be determined with a high degree of confidence.

**KEY WORDS:** Empty sella, idiopathic intracranial hypertension, sella turcica

**Poster 082**

**Quantitative Assessment of Extracranial Venous Drainage and Cerebral Perfusion in Multiple Sclerosis Patients and Normal Controls Using 4D Flow, ASL, and PW Imaging**

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**PURPOSE**
Chronic cerebrospinal venous insufficiency (CCSVI) hypothesizes an association between venous stenoses/impaired extracranial venous drainage and multiple sclerosis (MS). We recently found MS patients have greater IJ flattening and more non-IJ collaterals than normal patients without MS. We now seek to determine any corresponding quantitative differences in extracranial venous drainage and cerebral perfusion.

**MATERIALS & METHODS**
Gender and age-matched normal ($n=10$) and MS patients ($n=10$) underwent TRICKS MRA/MRV (TRICKS) of the head and neck, bolus perfusion-weighted imaging (PWI), arterial spin labeling (ASL), and time-resolved, 3D velocity encoded MR imaging (4D Flow) at 3 T. Perfusion-weighted imaging, ASL, and 4D Flow data were analyzed using in-house software programs. Two experienced neuroradiologists reviewed vascular imaging without any knowledge of cohort status and assigned scores (normal=0, mild=1, moderate=2, severe=3) for the presence and severity of non-IJ collaterals (TRICKS). PWI (CBV, MTT, TMax) and ASL. Cerebral blood flow (CBF) data were calculated for ROIs including either white matter or gray matter at the level of the centrum semiovale. For 4D Flow data, manual segmentation (ROI analysis) was performed at similar levels in the upper, mid-, and lower jugular veins in normal and MS patients. Correlations between collateral scores and flows were tested with Jonckheere-Terpstra nonparametric test for trend. Comparison of jugular venous flow between groups was done using a Mann-Whitney test stratified by location (upper, mid, lower). Comparisons of cerebral perfusion employed a standard t-test.

**RESULTS**
There were six (75%) and five (83%) women in the normal and MS cohorts, respectively. The mean ages of the two cohorts were 46.2 and 42.6 years. The mean EDSS of our MS cohort was 3.25 (1–6). Seven patients (88%) have relapsing-remitting MS. Arterial spin labeling, PWI, and 4D Flow data were available for 20, 19, and 14 patients, respectively. Right dominant IJ drainage was seen in seven (88%) normal patients and three (50%) of MS patients. The average collateral scores were 0.8 and 1.8 for normal and MS patients, respectively. There was correlation between higher collateral scores and reduced internal jugular blood flow ($P = 0.01$). A near significant difference in jugular blood flow was seen between normal patients and MS patients ($P = 0.06$). Arterial spin labeling CBF for white and gray matter was 20.3 and 41.9 ml/100 g/min in normal patients and 22.8 and 45.6 ml/100 g/min in MS patients ($P > 0.05$). Similarly, PWI demonstrated no differences in CBF between the two groups. Mean transit time and Tmax values for white/gray matter were 8.4/9.3 and 2.5/1.8 seconds, respectively in normal patients and 7.2/8.3 and 2.7/2.3 seconds in MS patients ($P < 0.05$).

**CONCLUSION**
There is a correlation between higher collateral scores and reduced jugular blood flow. Even though there was a nearly significant difference in jugular blood flow between normal and MS patients in this small study, no differences were seen in cerebral perfusion. Thus, to date, we find no direct evidence that the non-IJ collaterals, more commonly seen in MS patients, insufficiently drain the brain of MS patients in the position in which our images/data are acquired. The relationship between impaired extracranial venous drainage (CCSVI) and MS disease requires further study.

**KEY WORDS:** CCSVI, phase-contrast imaging, jugular vein
Identification of Venous Signal on Arterial Spin Label MR Images Improves Diagnosis of Dural Arteriovenous Fistulae and Small Arteriovenous Malformations

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PURPOSE
Dural arteriovenous fistulae (dAVFs) and small arteriovenous malformations (AVMs) are difficult to detect on conventional MR imaging (MRI)/MR angiography (MRA) or CT angiography (CTA) examinations, and often require digital subtraction angiography (DSA) for definitive diagnosis. In arterial spin label (ASL) imaging, the decay of the labeled blood water is short compared with capillary transit times, and therefore ASL signal typically is not seen within veins. Since they lack a capillary bed, dAVF/AVMs have shortened blood transit times, and venous ASL signal can be seen. This study assessed the clinical value of the “venous ASL sign” to detect dAVF or small AVMs.

MATERIALS & METHODS
Two neuroradiologists and one neurologist reviewed MRI studies of 26 patients who also underwent DSA for suspected vascular lesions, of which 15 were positive for dAVF or small AVM (<2 cm). Pseudocontinuous ASL was performed at 1.5 T with a background-suppressed 3DFSE readout. Using a five-point scale, the readers assessed the likelihood of a positive DSA study before and then after reviewing the ASL findings. In addition to the presence of high ASL signal in venous structures (“venous ASL sign”), the readers also documented the presence of other imaging findings, including acute or chronic hemorrhage, edema, abnormal MRA, serpiginous vessels, and venous enhancement. Sensitivity and specificity, logistic regression, and receiver-operator characteristic (ROC) analyses were performed.

RESULTS
Venous ASL signal was seen frequently in DSA positive cases, as demonstrated in Figure 1, for a patient with a small dAVF draining into the left transverse sinus. The sensitivity, specificity, positive predictive value, and negative predictive value of the venous ASL sign for predicting a positive DSA study was 78%, 85%, 88%, and 74%, respectively. There was a significant increase in the area-under-the-curve (AUC) of the ROC for the readers after review of the ASL images (AUC = 0.798 pre-ASL; AUC = 0.891 post-ASL; p=0.02). This effect was mainly due to an increase in sensitivity. Multivariate logistic regression identified venous ASL signal as the strongest predictor of positive DSA study, with an odds ratio of 17.3 (95% confidence interval: 2.8-108).

CONCLUSION
Presence of the venous ASL sign improved the ability to identify dAVF and small AVMs using MRI. Attention to this sign may improve triage to DSA in patients with suspected small vascular malformations.

KEY WORDS: Arterial spin labeling, arteriovenous malformation, dural arteriovenous fistula

Changes in Arteriovenous Malformation Angio-Architecture and Hemodynamics after Stereotactic Radiosurgery Assessed by Dynamic MR Angiography and Phase-Contrast Flow Assessments: A Prospective Follow-Up Study

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PURPOSE
This study was designed to assess the effects of arteriovenous malformation (AVM) volume on blood flow characteristics and changes in the angioarchitecture and hemodynamics induced by radiosurgery by using MR PC measurements.

MATERIALS & METHODS
Sixty-five patients (31 males, 34 females; average age 37 years) with cerebrovascular AVMs underwent a prospective MR imaging (MRI) protocol shortly after or before stereotactic radiosurgery including morphologic series, gadobutrol-(Gadovist®) enhanced MR angiography (MRA) and bilateral ECG triggered MR PC measurements of the internal carotid artery (ICA). For statistical analysis patients were assigned to two each of three subgroups in respect to AVM volume. Statistical analysis included two-group mean comparison tests and linear regression analysis for identification of relationships between AVM volume and ICA blood flow characteristics (p = 0.05). Totally, 34 patients of the initial group underwent follow up within the time range from 2 up to 4 years.
RESULTS
The subgroup with the smallest AVM volume (3.5 to 10 ccm) and in 22 cases (34%), AVM volume exceeded 10 ccm. Over all subjects, a significant relationship between mean arterial blood flow in the ICA on the side of the lesion and the AVM volume was revealed (p = 0.0002). In large (volume >10 ccm) and medium-sized AVMs, (3.5 <10 ccm) the ICA blood flow was increased significantly on the side of the malformation (9.56 ± 3.57 ml/sec vs 6.04 ± 2.4 ml/sec; 7.35 ± 2.95 ml/sec vs 5.31 ± 1.91 ml/sec; p = 0.0004), whereas in lesions smaller than 3.5 ccm, no significant rise of the mean blood flow was detectable (5.06 ± 1.9 ml/sec vs 4.2 ± 1.54 ml/sec; p = 0.055). At follow up, a significant decay of AVM volume or even complete obliteration was found in 25 of 34 patients (73.5%). In these patients, the mean blood flow on the side of the lesion had diminished significantly (7.2 ± 3.29 ml/sec to 4.66 ± 1.63 ml/sec) and was not increased anymore in comparison with the contralateral ICA (4.00 ± 1.2 ml/sec; p = 0.11). These changes correlated with a significant reduction of the average AVM volume (7.88 ± 11.4 vs 0.5 ± 0.77 ccm p = 0.0026).

CONCLUSION
Based on our findings we can assume that the AVM angioarchitecture has a significant impact on the blood flow characteristics in the feeding artery. After successful therapy a significant reduction of the shunt volume after radiosurgery leads to normalization of the hemodynamics. Radiosurgery of nidal vessels is followed by a proliferation of the intima and reciprocally to a drop of the blood flow.

KEY WORDS: AVM, hemodynamics, MRA techniques

Poster 085
Computed Tomographic Angiography and Venography in Place of Catheter Angiography for Patients with Spontaneous Acute Intracerebral Hemorrhage

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PURPOSE
In hemorrhagic stroke patients without pre-existing hypertension or aged below 45 years, catheter angiography or digital subtraction angiography (DSA) remained the gold standard for investigation of any underlying vascular lesion. With the technology of multi-slice computed tomography (MDCT), we explored the effectiveness of using computed tomographic angiography and venography (CTAV) in place of DSA in patients with spontaneous acute intracerebral haemorrhage.

MATERIALS & METHODS
Setting and subjects: In a regional neurosurgical center in Hong Kong, we prospectively recruited 109 patients with nonhypertensive spontaneous intracerebral hemorrhage for this comparative study. Study instruments: All patients had CTAV in a single procedure using a MDCT with 64 detectors. They then would schedule to have catheter angiography the next day. Main outcome measures: Positive and negative predictive values in detecting vascular lesions causing the intracerebral haemorrhage.

RESULTS
Vascular pathologies causing hemorrhage were identified 37 (33%) patients, which included cerebral arteriovenous malformation in 22 patients. The positive predictive value and negative predictive value of CTAV for vascular pathologies causing hemorrhage were 97.3% and 100% respectively. Cohen’s Kappa coefficients were 0.98 (p<0.001) and 0.97 (p<0.001) for vascular lesions and cerebral arteriovenous malformation respectively. Cohen’s Kappa coefficient for cerebral arteriovenous malformation grading was 0.93 (p<0.001). There were 29 arterial feeder origins and 29 venous sinus/deep venous drainage systems identified from DSA, in which 28(97%) arterial feeder origins and 24(83%) venous sinus/deep venous drainage systems were identified concordantly from CTAV. Cohen’s Kappa coefficients for identifications of arterial feeder origins and venous sinus/deep drainage systems were 0.94 (p<0.001) and 0.78 (p<0.001) respectively.

CONCLUSION
Computed tomographic angiography and venography were able to screen vascular lesions causing spontaneous acute intracerebral hemorrhage with high diagnostic accuracy.

KEY WORDS: Intracerebral hemorrhage, angiography, computed tomography
RESULTS
Final analysis included 34 patients. CT angiography was more accurate for diagnosis of central than for peripheral CV with high sensitivity (82% and 92%), specificity (73% and 90%), accuracy, PPV and NPV for central vasospasm. For grading the severity of vasospasm CTA's sensitivity, specificity and accuracy were high for most central arteries. Reader’s recommendation of angioplasty according to CTA was significantly predictive of actual receipt of angioplasty but overestimated actual receipt of triple H treatment. The interobserver agreement for the treatment decision with medical therapy (triple H) or balloon angioplasty was excellent.

CONCLUSION
CT angiography is reliable for diagnosis of cerebral vasospasm after SAH especially for depicting central vasospasm. It is helpful in treatment decision making specifically regarding the need for balloon angioplasty.

KEY WORDS: Postaneurysmal subarachnoid hemorrhage, cerebral vasospasm, CT angiogram

Poster 087

Evaluation of Sensitivity of CT Angiogram Generated from the Dynamic Cerebral CT Perfusion to Diagnose Cerebral Aneurysms in Nontraumatic Subarachnoid Hemorrhage

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PURPOSE
The conventional CT angiogram (CTA) utilizing 140 kV and current of 300-380 mA has an established sensitivity in detecting cerebral aneurysms of 95% (0.91-0.97) for aneurysms > 3 mm, compared to the gold standard digital subtraction angiogram (DSA). We evaluated the sensitivity of cerebral CTA obtained from the CT perfusion acquisition (CTP/CTA) utilizing low voltage/ampere (80kV; 250 mA) in detecting cerebral aneurysms in patients with aneurysmal subarachnoid hemorrhage compared to DSA.

MATERIALS & METHODS
Between July 1, 2009 and September 30, 2010, a total of 87 patients were admitted to the neurovascular service in a level 1 trauma center with nontraumatic subarachnoid hemorrhage. All clinically stable patients who present with nontraumatic subarachnoid hemorrhage undergo CTP/CTA to obtain a baseline cerebral perfusion map before intervention. Three independent physicians; two board-certified radiologists (staff with 4 years experience in neuroradiology, and a neuroradiology fellow), and a radiology resident reviewed the DSA obtained within 2 days of the CTP/CTA and compared them to the CTP/CTA data. Dynamic CT perfusion was performed using a 128-slice (Definition AS+; Siemens Medical Solutions, Munich, Germany) with a technique of 80 kV, 250 mA and scan time of 40 seconds after the injection of 40 cc nonionic contrast agent followed by a saline chase with a flow rate of 8 cc/s. CT angiography images were obtained from the dynamic volume perfusion data. The sequence with the best arterial opacification was chosen for analysis at an independent 3D workstation vitrea enterprise suite (VES 1.1). Out of the 87 patients, 31 were excluded. Exclusion criteria were as follows: patients who did not have a DSA, underwent intervention before CTP/CTA, or had a nonaneurysmal nontraumatic SAH.

RESULTS
Fifty-six patients with 71 aneurysms were included in our study. Six of these aneurysms were present on DSA but were missed in the original CTP/CTA report. Two of the six missed aneurysms were identified by the reviewers on the CTP/CTA. The other four aneurysms were not identified by any of the three reviewers on the CTP/CTA. Three of the four aneurysms were obscured by adjacent atherosclerotic calcifications, ossified petroclinoid ligament, or bone. Three of the four missed aneurysms measured 2 mm and the fourth measured 3 mm on DSA. The overall sensitivity of CTP/CTA was 94%; however the sensitivity for aneurysms > 2 mm was 98.5%, and for aneurysms > 3 mm was 100%.

CONCLUSION
CT angiography images generated from the dynamic low voltage/ampere CT perfusion data (80 kV; 250 mA) is as sensitive as the conventional CTA utilizing 140 kV and current of 300-380 mA in detecting cerebral aneurysms in nontraumatic SAH. CT perfusion/CTA helps the radiologist to diagnose cerebral aneurysms in addition to providing functional information about cerebral blood flow and vasospasm as previously documented.

KEY WORDS: CTA, CT perfusion, cerebral aneurysms

Poster 088

Diagnostic Yield of Catheter Angiography in Patients with Isolated Nontraumatic Subdural Hemorrhage

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PURPOSE
To determine the yield of catheter angiography for the detection of causative vascular abnormalities in patients with isolated nontraumatic intracranial subdural hemorrhage (SDH).

MATERIALS & METHODS
We conducted a retrospective review of all patients who underwent catheter angiography at our institution for evaluation of nontraumatic SDH without associated intracerebral or subarachnoid hemorrhage over a period of 5 years. Noncontrast CT examinations were reviewed by two experienced neuroradiologists to determine, by consensus, the SDH location, maximum axial width and attenuation relative to the underlying brain parenchyma. Catheter angiograms were reviewed by experienced interventional neuroradiologists to determine the presence of an underlying vascular abnormality for the SDH. Medical records were reviewed for baseline clinical characteristics.
RESULTS
A total of 30 SDHs were identified in 25 patients included in our study. Thirteen patients were female (52%) and 12 male (48%). Mean patient age was 54.7 years (median 58 years, range 22-73 years). Twelve patients had a history of hypertension (48%), seven were receiving antiplatelet therapy (28%), and three had an international normalized ratio ≥1.5 (12%). Eighteen SDHs were left-sided (60%) and 12 right-sided (40%). Mean maximum axial SDH width was 10.2 mm (median 8.5 mm, range 2.5-23 mm). Compared to the underlying brain parenchyma, 15 SDHs were hyperdense (50%), seven isodense (23.3%), six heterogeneous (20%), and two hypodense (6.7%). Catheter angiography demonstrated an underlying vascular abnormality for the SDH in five patients (20%), three of whom were female (60%) and two male (40%). Three of these five patients had a history of hypertension (60%) and one was receiving antiplatelet therapy (20%). Three of the SDHs with an underlying vascular abnormality were left-sided (60%) and two right-sided (40%); three were hyperdense (60%) and two isodense (40%). The vascular abnormalities identified were two dural arteriovenous fistulas (dAVF, Figure 1), two ruptured aneurysms (a 10 mm left posterior communicating artery aneurysm and a 6 mm left paraclinoid internal carotid artery aneurysm) and a 1 mm right middle meningeal artery pseudoaneurysm in a patient who had undergone an ipsilateral craniotomy for brain tumor resection. One dAVF and the left posterior communicating artery aneurysm were treated surgically (40%), one dAVF and the left paraclinoid internal carotid artery aneurysm were treated endovascularly (40%), and the right middle meningeal artery pseudoaneurysm thrombosed spontaneously (20%).

CONCLUSION
Catheter angiography is a valuable tool in the evaluation of patients with isolated nontraumatic SDH, demonstrating an underlying vascular abnormality in 20% of patients.

KEY WORDS: Subdural hemorrhage, catheter angiography, aneurysm

Poster 088a
Vegetative State: May the Advanced MR Techniques (fMRI and Spectroscopy) be of Help in Prognosis?

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INTRODUCTION
Consciousness disorders are now considered as a broad spectrum of clinical entities ranging from coma, to vegetative state (VS) and minimally conscious state (MCS) and severe disease (SD), up to the recovery of independence. The differential diagnosis between the different states is difficult but is very important, also because of the different prognosis. Advanced MR technologies, such as fMRI and spectroscopy, are now available to throw more light on this problem.

AIM
Aim of our study was to analyze, by fMRI and spectroscopy, a cohort of 24 patients, suffering from different degrees of consciousness impairment, to assess the value of MR advanced technologies in the differential diagnosis and prognosis of these patients.

MATERIALS & METHODS
Patients. We enrolled 24 patients (age comprised between 17 and 58) with outcome of comas: 20 of them had polytrauma outcomes, 3 of them had cerebral anoxia, 1 of them had encephalitis outcome. Each patient underwent morphological, fMRI and H1-MRS spectroscopy analysis. A 3T Signa Excite system and an 8 channel phased array coil were used to acquire morphological sequences fMRI and H1-MRS spectroscopy. fMRI. Functional (Axial Single Shot, SS, EchoPlanar Image, EPI, Gradient Echo, GE), and morphological (isovolumetric 3D SPoiled GRass - Inversion Recovery, SPGR-IR) sequences were acquired. We used a block paradigm of the kind: 30 s stimulus vs 30 s rest, for a total length of 5 min. Three different paradigms were applied: 1) in the stimulus phase, the patient heard the voice of a relative telling an emotionally significant episode, vs silence; 2) in the stimulus phase, the patient heard the same voice telling the same episode as in point 1), but the voice was played in the reverse order, vs silence; 3) in the stimulus phase, the patient heard the same voice as in 1), whereas in the rest phase the patient heard the same reverse voice as in point 2). fMRI analysis was performed off-line by using BrainWave GE proprietary software. Briefly, the processing of this software is semi-automatic and consists in segmentation and coregistration of the morphologic sequence to the fMRI sequence, after the appropriate corrections (motion correction, smoothing, etc.). The final parametric maps were
calculated at a p<0.01 threshold and superimposed to the morphological coregistered segmented images. Spectroscopy (Single voxel, Point-Resolved Spectroscopy Sequence, PRESS). We analyzed the following metabolite ratios: ml/Cr, Cho/Cr, NAA/Cr, NAA/Cho. Resulting spectra were processed by SAGE Software (Spectral Analysis, GE Medical System). Particularly, we focused on NAA/Cho ratio, because it has been shown that a reduction of this ratio has a negative prognostic value. We compared the NAA/Cho values obtained in VS/MCS/SD patients with the corresponding values obtained in 16 healthy volunteers (age comprised between 25 and 57), by placing the voxel in the left frontal white matter. Normal NAA/Cho reference values were in the range of 2.0 ± 0.3.

RESULTS

\textit{fMRI}. When present, activations were located in the temporal lobes, mono or bilaterally depending on the characteristics of the cerebral lesions. Patients were divided in two groups: the ones showing clear-cut activations (15 patients, 65%) and the ones showing no activation (8 patients, 35%). \textit{H1-MRS spectroscopy}. Considering the NAA/Cho ratios, we divided patients in three groups: NAA/Cho ratios ≤ 1 (undoubtedly pathologic), NAA/Cho ratios in the range between 1.1 and 1.6 (moderately pathologic), and NAA/Cho ratios ≥ 1.7 (normal). Considering the NAA/Cho ratio of the 15 activated patients, five (33%) of them showed a NAA/Cho ratio ≤ 1, six (40%) of them showed a NAA/Cho ratio in the range between 1.1 and 1.6, and four (27%) of them showed a NAA/Cho ratio ≥ 1.7. Considering the NAA/Cho ratio of the 8 patients showing no activation, three (38%) of them showed a NAA/Cho ratio ≤ 1, five (62%) of them showed a NAA/Cho ratio in the range between 1.1 and 1.6, and no one (0%) showed a NAA/Cho ratio ≥ 1.7.

DISCUSSION

When taking into account the clinical course of our patients, we noted that the VS patients showing a clinical improvement in time (from VS to MCS / SD) all appertained to the activated group, whereas all the patients showing no clinical improvement appertained to the non activated group. Moreover, in the activated group, there was a loose correlation between the size of the activations and the NAA/Cho ratio values: the wider the activations the higher the NAA/Cho ratio values. Furthermore, when the follow-up of the patient was feasible, we observed that a favorable clinical evolution was associated with an increase in the size of the activated areas together with a normalization of the NAA/Cho ratio values, whereas an unfavorable clinical evolution was associated with a reduction in the size of the activated areas and a worsening of the aforesaid values. In the activated group (15 pts), only three patients (20%) showed no clinical improvement.

CONCLUSION

On the basis of the data at our disposal at present, it is possible to assert that the two advanced techniques (fMRI and H1-MRS Spectroscopy) we may represent a powerful diagnostic/prognostic support in patients suffering from VS/MCS/SD. Naturally, a higher number of patients have to be examined to confirm our hypotheses.

**Key Words:** fMRI, Spectroscopy, Vegetative State

Poster 089

Basal Ganglia: Network Anatomy, Functional Aspects and Clinical Considerations

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PURPOSE

The expanding and critical role of the basal ganglia in different neural networks has been the focus of recent investigations. The intricate contributions of these deep nuclei to the motor pathways as well as the less intuitive nonmotor loops now can be appreciated in greater detail. These neural pathways and their functional significance, however, have not been emphasized in the radiologic literature. Knowledge of these pathways is increasingly important in the interpretation of diffusion tensor imaging (DTI) and fMRI data as well as routine clinical MR imaging of the brain.

MATERIALS & METHODS

This exhibit will describe the fiber pathways connecting the basal ganglia to the body movement, oculomotor, prefrontal, and limbic neural loops/circuitry. The morphology and location of these pathways will be related to readily visible anatomical landmarks and the functional significance of these connections will be illustrated.

RESULTS

The key anatomical components of the motor loop include the primary motor, premotor, and somatosensory cortices, putamen, globus pallidus externa and interna, ventral lateral and ventral anterior thalamic nuclei, and substantia nigra. The oculomotor loop involves the frontal and supplementary eye fields, posterior parietal and prefrontal cortices, body of the caudate, globus pallidus interna, substantia nigra pars reticulata, and mediodorsal and ventral anterior thalamic nuclei. The prefrontal loop includes the dorsolateral prefrontal cortex, anterior caudate, globus pallidus interna, substantia nigra pars reticulata, and mediodorsal and ventral anterior thalamic nuclei. The limbic loop involves the amygdala, hippocampus, orbito-frontal, anterior cingulate, and temporal cortices, ventral striatum, ventral pallidum, and the mediodorsal nucleus.

CONCLUSION

The globus pallidus contributes to several important functional pathways that affect more than major body movements with which it has been conventionally associated. Knowledge of these neural networks will not only improve the interpretation of routine MR imaging of the brain, DTI and fMRI but also will influence the application of those techniques.

**Key Words:** Basal ganglia, network anatomy, functional aspects
Poster 090

Causes of Failed Stapes Surgery: Preoperative CT Findings with Surgical Confirmation

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PURPOSE
Stapes surgery usually is performed in the clinical setting of otosclerosis with the goal of hearing preservation. Revision stapes surgery is performed for unsuccessful primary surgery, delayed failure, and surgical complications, and confers a higher failure rate. The purpose of this review is to familiarize the reader with the CT findings of stapes surgery failure and the relevant preoperative contraindications to stapes surgery. The current limitations of standard CT for complication detection also are discussed.

MATERIALS & METHODS
We retrospectively reviewed the imaging and medical records of all patients undergoing stapes or stapes revision surgery at our institution between December 1999 and December 2009. All patients with high-resolution CT scans of the temporal bone were reviewed and correlated to clinical findings at otoscopy and surgery. Temporal bone CTs were assessed retrospectively by two reviewers, one with head and neck radiology expertise (BH). All imaging findings were correlated to operative findings. Examples of surgically confirmed causes of stapes surgery failure and preoperative findings that were contraindications to stapes surgery are highlighted.

RESULTS
A total of 340 patients who had undergone stapes surgery or revision surgery were identified from the department of neuro-otology clinical records. From this subset, 60/340 had temporal bone CTs available in PACS for review. Of these, 60, 16 patients (5 males and 11 females, 16-87 years of age, mean age of 56 years) had subsequent intraoperative reports. Examples of surgically confirmed causes of stapes surgery failure and preoperative findings that were contraindications to stapes surgery are highlighted.

CONCLUSION
CT evaluation in the setting of planned primary or revision stapes surgery is challenging for the radiologist. Inherent limitations of spatial resolution and beam-hardening artifact of the small metallic stapes piston prostheses remain problematic for correct piston localization and sizing, and granulation tissue and perilymph fistulae remain hard to diagnose. However, some cases of piston dislocation, ossicular chain disruption or necrosis, and overt vestibular penetration can be suggested and should be investigated routinely. This series additionally highlights important contraindications to stapes surgery: superior semicircular canal dehiscence, ossicular fixation, cholesteroloma, and tympanosclerosis.

KEY WORDS: Otosclerosis, stapes surgery, CT

Poster 091

Wegener’s Granulomatosis of the Sinonasal Cavity and Orbits

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PURPOSE
Wegener’s granulomatosis (WG) is characterized histologically by acute necrotizing granulomas and focal necrotizing vasculitis. The imaging appearances of WG within the sinonasal cavity and orbits have been well documented; however, there are particular distributions of involvement that are underappreciated. The purpose of this study was to evaluate the variable patterns of WG within the sinonasal cavity and orbits with particular emphasis on atypical manifestations.

MATERIALS & METHODS
Imaging studies and medical records of 11 consecutive patients with biopsy-proved WG referred from August 2009 to July 2010 were reviewed retrospectively.

RESULTS
Sinonasal mucosal thickening was demonstrated in 91%. Osseous destruction including the nasal septum was shown in 82%. Extensive sinonasal bone loss with an “empty central sinonasal cavity” was present in 45%. Sinonasal disease with contiguous intraorbital extension was found in 45%. Prominent nasolacrimal duct inflammatory changes were evident in 36%. Only one patient had an orbital mass without accompanying sinonasal disease.

CONCLUSION
The results correlate well with published case series where orbital involvement typically is associated with sinonasal disease. This study reconfirms that nasal septal perforation and sinonasal cavity soft tissue masses are very suggestive of WG. Less recognized distributions of WG were observed including extensive bony destruction with an empty central sinonasal cavity which could be mistaken for previous surgical intervention. Considerable granulomatous inflammation causing obstruction of the nasolacrimal drainage system has been poorly documented in the literature. In this series, two patients initially presenting with epiphoria were treated with dacrocystorhinostomies prior to their proper diagnosis. Finally, infiltrative subperiosteal orbital disease with extraocular muscle tethering can account for limitation of extraocular movements without a discrete granulomatous mass. This study emphasizes the highly variable patterns of WG of the
Poster 092

Variations in the Course of the Cervical Vagus Nerve on Thyroid Ultrasonography

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PURPOSE
The purpose of this study was to evaluate the incidence and type of variation in the course of the cervical vagus nerve (VN) on thyroid ultrasonography.

MATERIALS & METHODS
From August 2009 to September 2010, 163 consecutive patients were evaluated by ultrasound for the screening and characterization of thyroid nodules (mean age = 49.0 ± 14.4 years, M:F = 20:143). Two types of variation were defined as follows: (1) anterior variation, when the course of the VNs changed from the typical location to an anterior location in front of the common carotid artery (CCA); (2) medial variation when the course of the VNs changed from the typical location to a medial location to CCA (between CCA and thyroid gland). The incidence of each of the variation was studied.

RESULTS
Variation in the course of the VN occurred in 5.5% (18/326) of cases. The anterior variation was observed in 4.3% (14/326, R:L=4:10), and the medial variation was observed in 1.2% (4/326, R:L=3:1). For both variations, the VN was close to or nearly abutted the thyroid gland after it changed course.

CONCLUSION
Variation in the course of the cervical VN could be assessed by ultrasonography. Two variations were observed in 5.5% of cases. The anterior variation was more common than the medial variation.

KEY WORDS: Vagus nerve, variation, ultrasound
Poster 093

Radiologic Assessment of True Vocal Cord and Anterior Commissure Carcinomas and the Implications of Imaging Findings on the Use of Laser Resection for Treatment

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PURPOSE
To demonstrate the imaging findings of true vocal cord (TVC) and anterior commissure (AC) carcinomas and present how these findings can guide when treatment by laser resection is appropriate.

MATERIALS & METHODS
Computed tomography (CT) and magnetic resonance (MR) neck images acquired at two institutions within the last 10 years from patients with newly diagnosed carcinoma involving the TVC and/or the AC were compiled. As well, otolaryngology guidelines on the appropriate use of laser resection as treatment for these carcinomas were reviewed. Based on these guidelines and our imaging findings, several of the compiled cases were presented within this study to demonstrate how imaging plays a role in selecting an appropriate treatment modality.

RESULTS
True vocal cord cancers that involve the anterior commissure often are more difficult to treat with laser resection. Of those that are treatable, laser resection is controversial for lesions more advanced than early glottic cancer. T1(a and b) and T2 lesions are considered resectable by laser resection whereas laser resection of T3 lesions is performed only by highly experienced surgeons. T4 lesions generally are not considered resectable by laser. As well, recurrence rates rise after laser resection if the presenting cancer involves the anterior commissure. Thus it is important to preoperatively evaluate tumor stage and anatomical involvement radiographically, specifically for involvement of the anterior commissure. Fine contour abnormalities extending from the TVC to the AC or of the AC itself as well as carefully assessing thyroid cartilage integrity prove invaluable in determining tumor extent. In addition careful attention of contrast enhancement and attenuation differences within the TVC or AC guide assessment for spread. These findings exemplified by our presented studies, in specific for T2 lesions, ultimately helped the referring otolaryngologist decide whether tumor resection could be performed appropriately with laser resection. If not, patients would undergo conventional surgical management with or without chemoradiation.

CONCLUSION
Imaging of the true vocal cords as well as the anterior commissure for assessment of tumor spread is an integral component in the decision-making process by the referring otolaryngologist for whether a patient can undergo laser resection treatment of glottic carcinoma. Thus it is important as a radiologist to be able to recognize patterns of tumor invasion in this area which we have presented in the study.

Key Words: Anterior commissure, carcinoma, laser resection

Poster 094

Multimodality Imaging of the Parathyroid Gland in the Evaluation of Hyperparathyroidism

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PURPOSE
1. To discuss and show examples of the multimodality imaging work up of hyperparathyroidism (HPT), including nuclear medicine scintigraphy, dynamic CT, and ultrasound.
2. To describe the imaging findings of the various pathologic processes involving the parathyroid glands.
3. To illustrate how accurate localization can limit surgical extent with minimally invasive surgery.

MATERIALS & METHODS
In hyperparathyroidism (HPT), accurate localization of the parathyroid adenoma is important for definitive surgical treatment. The mainstay of imaging for parathyroid adenoma historically has been nuclear medicine scintigraphy. Various techniques exist for this exam, including early and delayed imaging with technetium-99m sestamibi, as well as our preferred exam of using subtraction dual isotope imaging with technetium-99m sestamibi and iodine-123. As well as sensitivity and specificity of this exam is quite good, especially when combing with SPECT or SPECT/CT, scintigraphy can fail to localize a parathyroid adenoma in certain cases such as an ectopic adenoma. With the improvements in multidetector CT over the past decade, a dynamic contrast-enhanced CT of the neck now can be performed and optimized for parathyroid imaging. This exam is particularly useful in patients with clinically suspected adenoma, but negative scintigraphy, often allowing for accurate localization in this subset of patients. Finally, in equivocal or negative scintigraphy and CT cases, ultrasound can be a useful technique for further characterization of a suspected adenoma as well as potentially allowing for percutaneous treatment in patients whom surgery is contraindicated.

RESULTS
Parathyroid surgery remains the preferred definitive treatment for primary HPT. With accurate preoperative localization, surgical exploration can be limited and minimally invasive techniques can be used. In addition, in patients with ectopic parathyroid glands, alternative surgical approaches can be planned. Finally, in patients with secondary or tertiary HPT in which multigland hyperplasia exists or in patients with multiple endocrine neoplasia (MEN) in which multiple adenomas can coexist, multimodality imaging can allow for accurate detection of multiple dysfunctional glands, limiting the need for repeat surgery. As each imaging modality has its own strengths and weaknesses for particular patient, a good understanding of nuclear medicine scintigraphy, dynamic CT, and ultrasound is needed.
Conclusion
The knowledge and ability to use multimodality parathyroid imaging with nuclear medicine scintigraphy, dynamic CT, and ultrasound when necessary for evaluation of HPT is critical to accurately localize pathology and limit the surgical extent required for definitive treatment.

Keywords: Parathyroid, nuclear medicine, CT

Poster 094a

Vegetative State: May the Advanced MR Techniques (fMRI and Spectroscopy) be of Help in Prognosis?

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Purpose
Consciousness disorders are now considered as a broad spectrum of clinical entities ranging from coma, to vegetative state (VS) and minimally conscious state (MCS) and severe disease (SD), up to the recovery of independence. The differential diagnosis between the different states is difficult but is very important, also because of the different prognosis. Advanced MR technologies, such as fMRI and spectroscopy, are now available to throw more light on this problem. Aim of our study was to analyze, by fMRI and spectroscopy, a cohort of 24 patients, suffering from different degrees of consciousness impairment, to assess the value of MR advanced technologies in the differential diagnosis and prognosis of these patients.

Materials & Methods
Patients. We enrolled 24 patients (age comprised between 17 and 58) with outcome of comas: 20 of them had polytrauma outcomes, three of them had cerebral anoxia, one of them had encephalitis outcome. Each patient underwent morphological, fMRI and H1-MRS spectroscopy analysis. A 3 T Signa Excite system and an 8 channel phased array coil were used to acquire morphological sequences (MRI and H1-MRS spectroscopy). fMRI. Functional [axial single shot (SS), echo planar image (EPI), gradient echo (GE)], and morphological (isovolumetric 3D spoiled gr - inversion recovery, SPGR-IR) sequences were acquired. We used a block paradigm of the kind: 30 s stimulus vs 30 s rest, for a total length of 5 min. Three different paradigms were applied: 1) in the stimulus phase, the patient heard the voice of a relative telling an emotionally significant episode, vs silence; 2) in the stimulus phase, the patient heard the same voice telling the same episode as in point 1), but the voice was played in the reverse order, vs silence; 3) in the stimulus phase, the patient heard the same voice as in 1), whereas in the rest phase the patient heard the same reverse voice as in point 2). fMRI analysis was performed off-line by using BrainWave GE proprietary software. Briefly, the processing of this software is semiautomatic and consists in segmentation and coregistration of the morphologic sequence to the fMRI sequence, after the appropriate corrections (motion correction, smoothing, etc.). The final parametric maps were calculated at a p<0.01 threshold and superimposed to the morphological coregistered segmented images. Spectroscopy [single voxel, point-resolved spectroscopy sequence (PRESS)]. We analyzed the following metabolite ratios: ml/Cr, Cho/Cr, NAA/Cr, NAA/Cho. Resulting spectra were processed by SAGE Software (Spectral Analysis, GE Medical System). Particularly, we focused on NAA/Cho ratio, because it has been showed that a reduction of this ratio has a negative prognostic value. We compared the NAA/Cho values obtained in VS/MCS/SD patients with the corresponding values obtained in 16 healthy volunteers (age comprised between 25 and 57), by placing the voxel in the left frontal white matter. Normal NAA/Cho reference values were in the range of 2.0 ± 0.3.

Results
fMRI. When present, activations were located in the temporal lobes, mono or bilaterally depending of the characteristics of the cerebral lesions. Patients were divided into two groups: the ones showing clear-cut activations (15 patients, 65%) and the ones showing no activation (8 patients, 35%). H1-MRS spectroscopy. Considering the NAA/Cho ratios, we divided patients into three groups: NAA/Cho ratios ≤ 1 (undoubtedly pathologic), NAA/Cho ratios in the range between 1.1 and 1.6 (moderately pathologic), and NAA/Cho ratios ≥ 1.7 (normal). Considering the NAA/Cho ratio of the 15 activated patients, five (33%) of them showed a NAA/Cho ratio ≤ 1, six (40%) of them showed a NAA/Cho ratio in the range between 1.1 and 1.6, and four (27%) of them showed a NAA/ Cho ratio ≥ 1.7. Considering the NAA/Cho ratio of the eight patients showing no activation, three (38%) of them showed a NAA/Cho ratio ≤ 1, five (62%) of them showed a NAA/Cho ratio in the range between 1.1 and 1.6, and no one (0%) showed a NAA/Cho ratio ≥ 1.7. Discussion. When taking into account the clinical course of our patients, we noted that the VS patients showing a clinical improvement in time (from VS to MCS/SD) all appertained to the activated group, whereas all the patients showing no clinical improvement appertained to the nonactivated group. Moreover, in the activated group, there was a loose correlation between the size of the activations and the NAA/Cho ratio values: the wider the activations the higher the NAA/Cho ratio values. Furthermore, when the follow up of the patient was feasible, we observed that a favorable clinical evolution was associated with an increase in the size of the activated areas together with a normalization of the NAA/Cho ratio values, whereas an unfavorable clinical evolution was associated with a reduction in the size of the activated areas and a worsening of the aforesaid values. In the activated group (15 patients), only three patients (20%) showed no clinical improvement.

Conclusion
On the basis of the data at our disposal at present, it is possible to assert that the two advanced techniques (fMRI and H1-MRS spectroscopy) we used may represent a powerful diagnostic/prognostic support in patients suffering from VS/MCS/SD. Naturally, a higher number of patients have to be examined to confirm our hypotheses.

Keywords: fMRI, spectroscopy, vegetative state
Poster 095

Retrospective Analysis of Factors Involved in Discrepancy between Attending and Preliminary Radiology Resident Interpretations of Computed Tomography of the Head and Neck

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PURPOSE
The primary purpose of this study was to determine the rates of discrepancy in radiology residents’ interpretations of after-hour Head & Neck CT imaging studies, and attempt to quantify any potential or realized effect on patient care. As a secondary objective, attempts were made to determine the impact of resident, study and patient variables on discrepancy rate in order to identify important repetitive patterns of misinterpretation for purposes of improved resident education.

MATERIALS & METHODS
Retrospective chart review of all head & neck imaging studies conducted at our university-affiliated health network from January 1, 2008 through December 31, 2009 revealed 761 patients with preliminary interpretations made by 56 different on-call residents. Preliminary resident interpretations were assessed for concordance with the interpretations of the final attending neuroradiologist by manual report comparison, and for all discrepant interpretations, electronic patient records were investigated for realized or potential impact on patient care. Discrepancies were deemed major in the presence of negative impact on patient care or clinical outcome, and were further subcategorized as undercall (failed recognition of abnormality), overcall (erroneous positive finding on a normal image) and miscall (misinterpretation of a positive finding). Cross-tabs and binomial logistic regression were employed to investigate impact of resident, study and patient variables on discrepancy rate. Generalized estimating equations were used to adjust for correlation between multiple interpretations within a resident.

RESULTS
The overall discrepancy rate for all included studies was 10.2%, with a minor disagreement rate of 9.1% and major disagreement rate of 1.2%. Of the discrepant reports, all major disagreements were undercalls (failed recognition of abnormality), overcall (erroneous positive finding on a normal image) and miscall (misinterpretation of a positive finding). Cross-tabs and binomial logistic regression were employed to investigate impact of resident, study and patient variables on discrepancy rate. Generalized estimating equations were used to adjust for correlation between multiple interpretations within a resident.

CONCLUSION
The observed discrepancy rates for CT head & neck studies were comparable to, although marginally larger than those of similar studies involving strictly head CT imaging studies. Our multivariate analyses suggest that clinical outcome is contingent to a far greater degree on patient and study characteristics than the level of interpreter training. Given the impact of these variables on the likelihood of discrepant interpretations, they should be considered appropriately during evaluation or remediation of radiology residents.

KEY WORDS: Resident, computed tomography, discrepancy

Table 1. Odds ratios for statistically significant predictors in univariate and multivariate logistic regression analysis for overall discrepancy rate. P-values are for Odds Ratio (OR) 95% confidence interval analysis.

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Odds Ratio</th>
<th>95% CI</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient age</td>
<td>1.09</td>
<td>1.05-1.13</td>
<td>0.03</td>
</tr>
<tr>
<td>Sex (Female)</td>
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<td>1.68-1.77</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Tumor (N)</td>
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<td>1.69-1.77</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Acute findings</td>
<td>1.58</td>
<td>1.54-1.63</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Chronic findings</td>
<td>1.43</td>
<td>1.39-1.47</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Postmenopausal status</td>
<td>1.43</td>
<td>1.39-1.47</td>
<td>&lt;0.001</td>
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</tbody>
</table>

Poster 096

Feasibility and Usefulness of Apparent Diffusion Coefficient at 3 T for Differentiating Benign from Malignant Tumors of the Head and Neck

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PURPOSE
Several reports have described studies of head and neck lesions using diffusion-weighted imaging (DWI) with a 1.5 T MR unit, but few have reported use of the 3 T unit. Although susceptibility artifacts can affect echo-planar DWI (EPI DWI) images more strongly at 3 T, it has come to be used instead of 1.5 T for the head and neck. Therefore, we must determine the feasibility and usefulness of EPI DWI at 3 T. This study was undertaken to evaluate the feasibility of DWI of head and neck tumors and to assess the usefulness of the apparent diffusion coefficient (ADC) for differentiating benign from malignant tumors at 3 T.

MATERIALS & METHODS
In total, 56 patients with head and neck tumors were examined. The tumor pathology included pleomorphic adenoma, schwannoma, Warthin tumor, inverted papilloma, oncocytoma, hemangioma, and meningioma as benign entities (n = 23), and squamous cell carcinoma, papillary carcinoma, spindle cell carcinoma, lymphoma, and melanoma as malignant entities (n = 33). The tumor locations included the pharynx, orbit, parotid gland, oral floor, thyroid, gingiva, deep cervix, lateral cervix, nasal, and parapharyngeal cavity. MR imag-
ing was performed using a 16-channel neurovascular coil on a 3 T MR scanner (Achieva; Philips Co.). Diffusion-weighted imaging was conducted with single-shot SE EPI DWI fat-suppressed with STIR. The ADC of benign and malignant tumors were calculated and compared.

**RESULTS**
Among 56 cases, three (5.3%) were not able to be evaluated on DWI because of susceptibility artifacts (denture or air). Those cases included tumors of gingiva ($n = 2$) and the nasal cavity ($n = 1$). In the remaining 53 cases, the DWI images and the ADC were sufficiently evaluated without remarkable artifacts. The ADC was $0.90 \pm 0.18 \times 10^{-3}$ mm$^2$/s in malignant tumors; it was $1.45 \pm 0.34 \times 10^{-3}$ mm$^2$/s in benign tumors. A significant difference was found between the two ($p < 0.005$). When the cut-off value of $1.14 \times 10^{-3}$ mm$^2$/s was used for differentiation, the sensitivity and specificity were, respectively, 78.9% and 92.6%.

**CONCLUSION**
The 3T MR imaging was overall feasible for evaluation of DWI and ADC of head and neck tumors, although 5.3% of cases were not possible for the evaluation because of susceptibility artifacts. Our results suggest that the ADC was useful to differentiate benign from malignant tumors of the head and neck at 3 T.

**KEY WORDS:** Diffusion-weighted imaging, 3 T MR imaging, head and neck tumor

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**Poster 097**

**Evaluation of Facial Artery on CT Angiography Using 64-Slice MDCT: Implications for Facial Plastic Surgery**

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**PURPOSE**
Accurate assessment of facial vascular anatomy enables the plastic surgeons to establish an appropriate surgical planning. Although anatomic variation of facial artery has been investigated classically in cadaveric specimens, less invasive in vivo assessment is necessary for preoperative evaluation. The purpose of our study is to evaluate the value of multi-slice CT angiography (CTA) in assessment of facial artery anatomical variations.

**MATERIALS & METHODS**
Among 109 consecutive cases of CTA of head and neck, total 30 cases with 59 facial arteries were included in this study. Remaining 79 cases were excluded due to severe dental metallic artifact, motion artifact, small field of view, or weak enhancement of common carotid artery. Thin-slab maximum intensity projection (MIP) and volume rendering were used for postprocessing of CTA. Visual evaluation was performed in both sides. The anatomical variations of the facial artery were classified into the following four groups; type 1: short course, terminate proximal to the superior labial artery, type 2: terminate distal to the superior labial artery near nasolabial fold, type 3: classic course, extends to later-
al nasal or angular branch, type 4: duplex with dominant lateral angular branch. The extent of inferior and superior labial artery also was evaluated separately.

**RESULTS**
Thirteen branches (22%) of the facial artery were classified as type 1, 29 branches (49%) were classified as type 2, and 15 branches (26%) extend beyond nasolabial fold and classified as type 3. Type 4, lateral angular branch as a main terminal branch of the facial artery was seen only in two branches (3%). Inferior labial artery was identified bilaterally in 12 cases (40%), unilaterally in 16 cases (53%), and identified in neither side in two cases (7%). Superior labial artery was identified bilaterally in 75% and unilaterally in 25% of cases.

**CONCLUSION**
Although the classic anatomy of facial artery extends to medial canthus region and become angular branch, this type of facial artery was seen only in 26%. Although visualization of small arterial branch may be limited due to venous injection, facial CTA has a potential imaging tool for preoperative planning of facial reconstructive surgeries.

**KEY WORDS:** CT angiography, facial artery, plastic surgery
**Poster 098**

Multispectral Quantitative Analysis of Salivary Gland Tumors: T1, T2 Relaxation Times and ADC Values

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**PURPOSE**

To evaluate the clinical utility of multispectral quantitative MR imaging parameters, specifically T1, T2 relaxation times and apparent diffusion coefficient (ADC) values, in identifying various pathologic types of salivary gland tumors.

**MATERIALS & METHODS**

Patients with salivary gland lesions were enrolled for this study. Prior to biopsy or surgical resection, MR imaging of the neck was performed. T1, T2 relaxation times and ADC values of the salivary gland lesions were measured and correlated with the results of subsequent pathologic examination. The differences in parameters among tumor types were evaluated by Kruskal-Wallis test. In cases of pleomorphic adenoma, the parameter differences between parotid gland and submandibular gland were tested by Mann-Whitney u test.

**RESULTS**

Eighteen patients with 13 parotid gland tumors (3 pleomorphic adenomas, 7 Warthin’s tumors, 1 basal cell adenoma, 1 carcinoma ex pleomorphic adenoma, and 1 mucoepidermoid carcinoma) and six submandibular gland tumors (4 pleomorphic adenomas, 1 adenoid cystic carcinoma, and 1 follicular lymphoma) were studied. There were no significant parameter differences between parotid and submandibular glands in patients with parotid and submandibular gland pleomorphic adenomas (T1: p = 0.72, T2: p = 0.72). Figure shows the distribution of T1, T2 relaxation times and ADC values among various pathologic types of salivary gland tumors. Significant differences were noted among three lesion types (pleomorphic adenoma, Warthin’s tumor, and primary salivary gland malignancy) in terms of T1 relaxation time and ADC value: T1 (1577.8 +/- 344.4 vs. 1046.5 +/- 217.5 vs. 1430.7 +/- 11.1 ms, p = 0.02) and ADC (1.75 +/- 0.34 vs. 1.31 +/- 0.09 x 10^-3 mm^2/s, p = 0.01). The relaxation times and ADC value of lymphoma (T1: 890.8 ms, T2: 85.9 ms, ADC: 0.93 x 10^-3 mm^2/s) tended to be lower than those of primary salivary gland tumors.

**CONCLUSION**

Pleomorphic adenomas in parotid and submandibular glands had similar parameter distributions. Pleomorphic adenoma, Warthin’s tumor, and malignant salivary gland neoplasms were distinguishable based on T1 relaxation times and ADC values. Multispectral quantitative MR imaging analysis may achieve more accurate diagnosis in patients with salivary gland tumors.

**KEY WORDS:** Salivary gland tumor, relaxation time, ADC value

**Poster 099**

Fat-Containing Masses of the Prestyloid Parapharyngeal Space: Unusual Case Series

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**PURPOSE**

Fat-containing tumors of the prestyloid parapharyngeal space are exceedingly uncommon. The purpose is to review the anatomy of the prestyloid parapharyngeal space and unusual congenital and developmental fat-containing prestyloid parapharyngeal masses. The cross-sectional imaging, endoscopic imaging and algorithm for imaging these masses are reviewed.

**MATERIALS & METHODS**

The parapharyngeal space is divided into two compartments based on its relationship to the tensor-vascular-styloid fascia. Differentiating prestyloid pathology from poststyloid pathology is critical in formulating a differential diagnosis and therapeutic plan. The parapharyngeal space is shaped as an inverted pyramid, extending from the base of the skull to the hyoid bone. Intrinsic tumors of the prestyloid parapharyngeal space represent <0.5% of all head and neck neoplasms. Approximately 70% of lesions in the prestyloid parapharyngeal space are benign and 30% malignant. The most common prestyloid parapharyngeal space masses are extrinsic masses with secondary extension into the prestyloid parapharyngeal space, ectopic salivary gland tumors and neurogenic tumors. Fat-containing prestyloid parapharyngeal space masses are rare and often transspatial in extent. Clinical symptoms from these masses include growing neck mass, oropharyngeal mass, unilateral Eustachian tube dysfunction, dysphagia, dyspnea, obstructive sleep apnea, cranial nerve deficits, Horner’s syndrome, pain, and trismus. A retrospective review of prestyloid parapharyngeal space masses was performed and unusual fat-containing cases were chosen for presentation.

**RESULTS**

Multiple unusual fat-containing prestyloid parapharyngeal masses are presented, including a heterotopic fat-containing pinna in a 4-month-old child, myxoid lipoblastoma, transspatial cervical lipoma extending into the parapharyngeal space, a prevertebral liposarcoma with extension into the...
parapharyngeal space, and a periparotid lipoma. The MR imaging of fat-containing lesions in the head and neck is often difficult secondary to suboptimal fat saturation. IDEAL (iterative decomposition of water and fat with echo asymmetry and least-squares estimation) MRI is presented as an alternative to fat-suppression techniques for head and neck imaging.

CONCLUSION
As complete excision is the mainstay of treatment for these lesions, imaging is crucial in guiding the surgical approach. As many of the fat-containing prestyloid parapharyngeal masses are transpatial, it is important to understand the range of pathology that may occur in this deep space of the neck.

KEY WORDS: Fat-containing masses, prestyloid parapharyngeal space, ideal MR imaging

Poster 100

MR Imaging Evaluation of the Temporomandibular Joint in Juvenile Rheumatoid Arthritis: A Retrospective Review

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PURPOSE
The purpose of this study was to evaluate the MR imaging findings of children with rheumatoid arthritis affecting the temporomandibular joint.

MATERIALS & METHODS
MR studies of the TMJ in 26 children (less than 18 years of age, mean: 11.3 years) with a clinical diagnosis of rheumatoid arthritis were reviewed retrospectively. All studies included oblique and sagittal T1 (TE = 14 ms; TR = 400 ms; 3 mm thick slices), T2* (TE = 9.6 ms; TR = 588 ms; 3 mm thick slices), proton density/T2 (TE = 18/110 ms; TR = 4000 ms), and coronal T1-weighted images (TE = 14 ms; TR = 700 ms; 3 mm thick slices). T1 and proton density/T2 images were repeated with the mouth open. Postcontrast sagittal and coronal T1 images were obtained in seven patients. All studies were done on either 1.5 T or 3.0 T units with dedicated surface coils. By consensus, two radiologists evaluated the studies for abnormal condyles, bone erosions, presence or absence of disks, effusions, contrast enhancement and pannus. Open mouth views were assessed for incomplete or abnormal translation.

RESULTS
Twenty-five joints (49%) had abnormal condyles. The disk was identifiable in 36 joints (71%). Erosion was seen in 19 joints (37%). Effusion was seen in 12 joints (24%). Enhancement was seen in 25 joints (50%). Fourteen joints were evaluated without the use of gadolinium. A pannus was found in 23 joints (49%). Abnormal translation was seen in 35 joints (71%).

CONCLUSION
Abnormal translation was seen most often in MR images of the TMJ in children with JRA.

KEY WORDS: Temporomandibular joint, juvenile rheumatoid arthritis, MR imaging

Poster 101

Use of Self-Expandable Stents in the Treatment of Acute Ischemic Stroke

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PURPOSE
Current thrombectomy devices (MERCI clot retriever and Penumbra System) may fail to restore flow of large intracranial vessels during acute ischemic strokes (AIS). We report our single-center experience with the use self-expandable stents (SES) in the treatment of AIS.

MATERIALS & METHODS
The stroke database of Baptist Cardiac and Vascular Institute in Miami was reviewed retrospectively from August of 2008 to September of 2010. All cases of AIS in which a SES was deployed as acute endovascular intervention were included in the analysis. Criteria for intervention were: neurologic symptoms due to AIS, a National Institute of Health Stroke Scale (NIHSS) ≥ 4 at presentation, stroke due to a large vessel occlusion and failure or contraindication to intra-arterial thrombolysis and/or mechanical thrombectomy. Good outcome was defined as a modified Rankin Scale (mRS) ≤ 2 on 1 month from hospital discharge.

RESULTS
Nineteen patients with AIS who underwent stenting were identified (Table). The mean NIHSS score on admission was 18 (range 6 to 28). All patients had complete occlusion (TIMI 0) of the affected vessel. Six enterprise (Codman Neurovascular/Cordis Corporation) and 13 wingspan stents (Boston Scientific) were deployed. Thirteen (69%) lesions achieved TIMI 3 flow (Figure), five (26%) were TIMI 2 flow and one (5%) TIMI 1 flow after stenting. No intraprocedural complications occurred. Symptomatic intracerebral hemorrhage occurred in three (16%) patients, two of whom died. Eight (42%) patients had a good outcome (mRS 0 n= 4, mRS 1 n=1, mRS 2 n=3). One patient lost follow up. Overall mortality was 26% (five patients).
Table. Patient characteristics.

<table>
<thead>
<tr>
<th>Age</th>
<th>Gender</th>
<th>Occlusion</th>
<th>NIHSS</th>
<th>Initial Therapy</th>
<th>Stent</th>
<th>Time of Intervention (hours)</th>
<th>TIMI</th>
<th>mRS</th>
</tr>
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<tr>
<td>1</td>
<td>91</td>
<td>F</td>
<td>L</td>
<td>M1</td>
<td>23</td>
<td>IV + IA + M Enterprise</td>
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<td>2</td>
<td>53</td>
<td>M</td>
<td>L</td>
<td>M1</td>
<td>20</td>
<td>IA + MERCI Enterprise</td>
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<td>3</td>
<td>79</td>
<td>M</td>
<td>L</td>
<td>M1</td>
<td>20</td>
<td>IA + M Enterprise</td>
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<td>M1</td>
<td>9</td>
<td>IA + M Enterprise</td>
<td>24*</td>
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<td>66</td>
<td>M</td>
<td>Basilar</td>
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<td>6</td>
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<td>M</td>
<td>L Carotid T</td>
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<td>26</td>
<td>IA + M Enterprise</td>
<td>9*</td>
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<td>7</td>
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<td>M</td>
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<td>Tandem RCA</td>
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<td>17</td>
<td>IV Wingspan</td>
<td>3.5</td>
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</tbody>
</table>

NIHSS = National Institutes of Health Stroke Scale, TIMI = thrombolysis in myocardial infarction, mRS = modified Rankin Scale, ICA = internal carotid artery, IV = intravenous, IA= intraarterial and M = microcatheter clot maceration. * Approximate time since last seen normal.

Figure. Right middle cerebral artery occlusion (Panel A) with successful recanalization (TIMI 3) after deployment of an Enterprise stent (Panel B).

CONCLUSION

The use of SES in AIS is safe and should be considered when conventional thrombolyis and thrombectomy approaches fail.

KEY WORDS: Thrombectomy, stent, ischemic stroke

Poster 102

Histologic Changes after Mechanical Thrombectomy Using Swine Stroke Model

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PURPOSE

Histologic change of arteries after mechanical thrombectomy for acute stroke therapy is yet to be determined. Mechanical thrombectomy devices were deployed on swine arteries, which were occluded by experimental thrombi, and then histologic evaluation was performed on those swine arteries.

MATERIALS & METHODS

A total of four swine were utilized for this study. Experimental thrombus was injected via a 6F guiding catheter into a superficial cervical artery (SCA) of swine, which is 1) similar diameter to human middle cerebral artery and 2) surgically easy to access and harvest. Mechanical thrombectomy was performed on each occluded SCA using Merci Retrieval System (Concentric Medical, Inc., CA). Thrombectomy was continued until recanalization (TIMI 2 or 3) was obtained or until the number of attempts reached to five times. Each SCA was harvested after the procedure and stained with H-E stain and immunohistochemical stain for endothelial cell (factor VIII).

RESULTS

TIMI 2 or 3 recanalization was obtained in five vessels of eight occluded vessels (62.5%). The average numbers of retrieve are 2.88. Angiographically, there was no arterial dissection or vessel perforation. Histologic analysis showed that intimal denudation was observed in all samples to a varying degree. In the half of samples of all, there was infiltration of inflammatory cells into subintimal layer.

CONCLUSION

Histologic analysis was performed on arteries after deployment of mechanical thrombectomy devices using swine stroke model. Various histologic changes were observed in the arteries; however, those were angiographically undetectable. This model may expand the possibility of preclinical evaluation of mechanical thrombectomy devices.

KEY WORDS: Mechanical thrombectomy, histology

Poster 103

Long-Term Angiographic Follow Up following Stenting for Chronic Total Occlusion Older than Three Months of the Proximal Subclavian Artery

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PURPOSE

The purpose of our retrospective study was to investigate success rate, safety and long-term angiographic outcome following stenting for chronic total occlusion (CTO) older than 3 months of the subclavian artery (SA).

MATERIALS & METHODS

Chronic total occlusion (CTO) was defined as total occlusion older than 3 months since initial documentation by conventional angiography, CT angiography or MR angiography. Among 12 patients who underwent stenting of subclavian artery lesions from Jan 2006 to Dec 2009, five patients (three male, mean age 71 years) had CTOs of the left SA and estimated occlusion length was about 40 mm. The five patients presented subclavian steal phenomenon and their brachial systolic blood pressure difference was 42 mmHg (median).
RESULTS
Successful recanalization was achieved in all five patients and the Palmaz stents were implanted. Left vertebral artery flowed antegrade after stenting and their brachial systolic blood pressure difference was reduced to 2 mmHg (median). No complications occurred except pseudoaneurysm at puncture site in one case. Angiography at 1 year after stenting demonstrated neither restenosis nor reocclusion, which was defined as diameter stenosis of more than 50%.

CONCLUSION
Stenting for CTO older than 3 months of the subclavian artery was feasible and safe. Long-term angiographic outcome was favorable.

KEY WORDS: Chronic total occlusion, subclavian artery, stenting

Poster 104

Prevalence of Extravertebral Cement Leakage after Vertebroplasty: Procedural Documentation versus CT Detection

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PURPOSE
Extravertebral leakage of cement is a common occurrence during vertebroplasty. Reported incidence of leakage varies widely across studies. This variation may be a result of the different imaging modalities used for leakage detection, with CT probably more sensitive than fluoroscopy or plain radiography. We compared the relative detection rates of extravertebral leakage noted intra-procedurally with that noted on post-procedure CT scanning in a cohort of patients undergoing vertebroplasty.

MATERIALS & METHODS
After approval by the local Institutional Review Board, we retrospectively identified 181 patients with 277 levels treated from our vertebroplasty database who had subsequently undergone a CT examination including the treated vertebrae. These CT exams were reviewed and four different categories of local cement leakage were recorded: paravertebral leakage, endplate leakage, epidural leakage, and prevertebral venous leakage. We also separately noted the presence of retrograde filling of cement along the needle tracks. The frequency of the different types of leakage were compared using the Pearson χ2 test with Fisher’s exact probability and were considered significant when p < 0.05.

RESULTS
Among 1255 patients in our entire database, 181 (14%) patients had undergone subsequent CT imaging to include the treated level(s). The subset of patients with CT imaging here did not significantly differ from the overall population of vertebroplasty patients in either age or gender. One hundred and forty-nine (82%, 95% CI 76-87%) vertebroplasty patients had evidence of some type of leakage on CT; of these, 52 (29%, 95% CI 23-36%) had more than one type of extravertebral leakage. Among these 149 patients with leakage noted on CT, only 62 (34%, 95% CI 28-42%) had leakage noted during the procedure (p = 0.01). The most common type of leakage was endplate leakage, found in 81 cases (45%, 95% CI 38-52%), followed by 64 cases of paravertebral leakage (35%, 95% CI 29-43%), 36 cases of epidural leakage (20%, 95% CI 15-26%), and 32 cases of prevertebral venous leakage (18%, 95% CI 13-24%). Retrograde filling of cement along the needle tracks was identified in 34% of cases and was associated significantly with paravertebral leakage (p = 0.02).

CONCLUSION
Cement leakage after vertebroplasty is common and significantly underestimated by operators during the procedure.

KEY WORDS: Vertebroplasty, CT, leakage

Poster 105

Angioarchitecture Determines Occlusion Rates following Gamma Knife Radiosurgery for Brain Arteriovenous Malformations

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PURPOSE
To test whether the angioarchitecture of brain arteriovenous malformations determines the obliteration rate following gamma knife radiosurgery.

MATERIALS & METHODS
Retrospective analysis of 117 consecutive patients (male/female: 61/56, age: 6-47 years, mean: 36 years) with brain arteriovenous malformations (BAVMs) who underwent radiosurgery between September 2005 and December 2009 at a single institution. The following angioarchitectural characteristics were reviewed by two experienced neuroradiologists in consensus by evaluating the digital subtraction angiogram (DSA) on the day of SRS: Enlargement of feeding arteries, flow-related aneurysms, shift of the arterial watershed, perinidal neoangiogenesis and intranidal aneurysms. The arteriovenous transit time was estimated by counting the number of DSA frames between first depiction of the nidus and first visualization of a vein. Concerning the venous analysis: Venous ectasias, circumscribed venous pouches, venous rerouting and the presence of a pseudophelebitic pattern (corkscrew-like dilated veins draining normal brain parenchyma in the late venous phase) were evaluated in patients who did NOT present with venous stenoses. The radiation plan was reviewed for nidus volume and eloquence of AVM location. A chart review was performed to determine clinical presentation and previous endovascular treatment. Outcome was dichotomized into complete vs incomplete obliteration and chi-square tests were performed, examining whether outcome status was associated with the described factors.
RESULTS
The presenting symptoms were hemorrhage in 72 patients, headaches in 15, seizures in 10, incidental in 5 and other in 15. The mean nidus volume was 3.74 cm³ (range 0.08-14.58 cm³). Embolization prior to SRS had been performed in 23 patients. The follow-up duration ranged from 6–48 months (mean 24 months). In the subsequent analysis, patients with a minimum follow up of 36 months (n = 39) and patients with confirmed complete obliteration prior to 36 months (n = 21) were included to avoid biasing our data with incomplete obliteration due to insufficient follow up. In this group of 60 patients 39 complete occlusions and 21 incomplete occlusions were present. There was no significant association between incomplete obliteration and flow-related or intranidal aneurysms, shift of the arterial watershed, angiogenesis, venous ectasias, eloquence of location, age, previous hemorrhage or embolization. Incomplete obliteration was associated with arterial enlargement (p = 0.023), high flow (0-1 frame between depiction of nidus and depiction the vein) (p = 0.001), venous pouches (p < 0.001), venous rerouting (p = 0.002), pseudophelebic pattern (0.054) and AVM size (p = 0.033).

CONCLUSION
In addition to larger AVM size, some angioarchitectonic factors that indicate high flow are associated with lower rate of AVM obliteration following SRS.

KEY WORDS: Angioarchitecture, arteriovenous malformation, radiosurgery

Poster 106
Safety and Outcome of Using Onyx for Endovascular Embolization of Dural Arteriovenous Fistulae: A Case Series of 39 Consecutive Patients

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PURPOSE
Onyx is a recently developed embolization agent with unique diffusion properties showing considerable promise in the treatment of vascular malformations. Preliminary reports suggest that Onyx is safe and efficacious in treating dural arteriovenous fistulae (dAVF), possibly as the primary treatment modality. This study examines the safety and outcome of 39 consecutive patients treated recently with Onyx at our institution.

MATERIALS & METHODS
We retrospectively identified every patient with a dAVF who was treated with Onyx embolization between 2006 and 2010. Their chart records, clinic notes, neuroimaging, and procedural notes, were reviewed. Results are compared to a pooled analysis of prior reports of Onyx-treated dAVFs and to other treatment modalities. IRB approval was obtained.

RESULTS
Thirty-nine patients (mean age 60 years, 54% acutely symptomatic) with 39 Onyx-treated dAVF (six Borden type I, eight type II, 17 type III, nine carotid-cavernous fistulae) were identified. Angiographic and clinical follow up (mean 6 months) was available for 85% and 90% of the patients, respectively. All six type I dAVF were either cured or left with minimal residual dAVF with resolution or near resolution of their symptoms, and thus requiring no further treatment. Among the 25 type II and type III dAVF, 85% had complete obliteration of cortical venous reflux, and the remainder only had mild residual cortical venous reflux; three of these subsequently were treated successfully with surgery or gamma-knife radiation. Of the nine treated carotid-cavernous fistulae (CCF), seven were angiographically cured and two were left with a mild residual fistula. Permanent complications occurred in four patients (10%, two in CCF patients) including one nonfatal stroke, one fatal stroke, and two cranial nerve palsies. Transient complications, including Onyx embolism with no subsequent permanent clinical sequelae, occurred in 15% of patients. Beyond the perioperative period, no patient had new hemorrhagic or ischemic neurologic events (total 19 patient-years of follow up).

CONCLUSION
This is one of the largest case series of Onyx-treated dAVF, and the largest to our knowledge of patients with angiographic and clinical follow up. The safety and efficacy of Onyx in treating dAVF at our institution is similar to prior reports. A pooled analysis of these findings combined with prior large observational studies of Onyx-treated dAVF is planned and will be compared to the reported safety and efficacy of other treatment modalities.

KEY WORDS: Dural arteriovenous fistula, Onyx, carotid cavernous fistula

Poster 107
Testing Flow Diverters in Giant Fusiform Aneurysms: A New Experimental Canine Model

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PURPOSE
Flow diverters (FD) are the latest most promising tool to treat giant and complex aneurysms. Currently available experimental aneurysm models do not reproduce potential clinical difficulties in treating these lesions with FDs.

MATERIALS & METHODS
Six large or giant canine fusiform aneurysms were created on the distal carotid artery in four animals. In four aneurysms, multiple arteries branched from aneurysms; in two aneurysms branches were clipped at the time of aneurysm construction. Aneurysms were treated with multiple telescoping prototype flow diverting stents (total of 15 FDs). Angiography was carried out prior to, immediately following, at 2 and immediately before sacrifice at 12 weeks.
Macroscopic photography of specimens was, followed by biopsies of selected regions of the tissue formed on the surface of FDs.

**RESULTS**
Flow diverter stents failed to completely occlude the aneurysms in all six cases, but aneurysms without branches had improved angiographic scores at 12 weeks as compared to those with patent branches. Technical or device-related difficulties occurred in four of six cases. Small defects in neointima formation on the surface of FDs were associated with residual aneurysms or patent arterial branches.

**CONCLUSION**
Large fusiform carotid aneurysms may reproduce many of the difficulties associated with the treatment of giant aneurysms and could be appropriate for the preclinical testing of FD stents.

**KEY WORDS:** Giant aneurysms, experimental aneurysm, flow diverter

**Poster 108**

*Age-Related Complications following Endovascular Treatment of Unruptured Intracranial Aneurysms*

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**PURPOSE**
Notwithstanding a plethora of studies focused on the safety of coil embolization in unruptured aneurysms, there remains a dearth of data evaluating the impact of advanced age on outcomes. The purpose of this study was to determine whether the incidence of procedural and postprocedural complications increases with age in patients undergoing elective, endovascular treatment for intracranial aneurysms.

**MATERIALS & METHODS**
IRB approval was obtained prior to initiation of this study. A retrospective review was performed of the medical record and imaging studies of all patients undergoing elective endovascular treatment of intracranial aneurysms between 2000 and 2010 at one institution. A retrospective cohort study was conducted in an attempt to identify risk factors for developing complications during or after coiling procedures. Complications were stratified into minor asymptomatic complication (temporary complication that resolved prior to dismissal), minor symptomatic (temporary complication resulting in decreased functionality that resolved prior to dismissal), major asymptomatic (permanent complication that did not resolve prior to dismissal), major symptomatic (permanent complication resulting in decreased functionality that did not resolve prior to dismissal). Along with obtaining information on intra and postprocedural complications and age, information on patient comorbidities and patient follow up also was obtained. T-tests and chi squared analysis was used to determine statistical significance.

**RESULTS**
Three hundred and fifty-five patients underwent 394 endovascular procedures treating 75 aneurysm recurrences and 319 new aneurysms during the time period studied. Of the 355 patients, 108 were above the age of 65 (30%). Total incidence of complications in the entire cohort was 27% (95% CI of 17.9%-26.1%), with the majority of these being minor asymptomatic. There was no significant difference in the rate of complications in the elderly (31%, (95% CI of 22.8%-39.2%)) as compared to the nonelderly (25%(95% CI of 20.5%-30.9%)), (p = 0.25). The overall incidence of major morbidity or mortality was 4.3%(95% CI of 2.2%-6.3%). Major symptomatic complications were more prevalent in the elderly than in the nonelderly (3% (95% CI of 1.0%-5.0%), in nonelderly vs 9% (95% CI of 3.9%-14.1%), elderly, p = 0.01). Major symptomatic complications included embolic events, stroke, hemiparesis and neurologic events.

**CONCLUSION**
While the overall complication rates were similar between the nonelderly and elderly, major, symptomatic complications increased in the elderly. Similar trends have been noted in carotid stenting studies. We hypothesize that elderly patients, given diminished vascular reserve, may suffer clinical consequences from any type of embolic complication, while the nonelderly may tolerate such events without symptoms, in any type of neurovascular procedure.

**KEY WORDS:** Unruptured, endovascular, aneurysm

**Poster 109**

*Endovascular Surgery with Coil Embolization of Spontaneous Dissecting Aneurysm of the Intracranial Vertebral Artery*

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**PURPOSE**
Pathogenesis and treatment of spontaneous dissecting aneurysm of the intracranial vertebral artery remain controversial. Spontaneous dissecting aneurysm of the intracranial vertebral artery is a rare cause of vertebrobasilar ischemic strokes. It has been associated with a 10% mortality rate in the acute phase. Death is the result of extensive intracranial dissection, brainstem infarction, or subarachnoid hemorrhage. We report 7 years experience at our institute in dealing with spontaneous dissecting aneurysm of the intracranial vertebral artery by endovascular surgery with coil embolization.

**MATERIALS & METHODS**
Twenty patients with spontaneous dissecting aneurysm of the intracranial vertebral artery in our institute from 2004 to 2010 were managed by endovascular surgery with coil embolization. Nineteen patients were treated with purely coil embolization, and one was managed by coil embolization with stenting assisted. All are followed with image studies.
RESULTS
There were 20 patients, including 8 men and 12 women, with a mean age of 49.9 years. (Youngest: 38 years old; eldest: 73 years old). Among 20 patients, 18 discharged with good results, but two were expired during hospitalization due to brain infarction and brainstem failure respectively. Among 18 successful patients, one got bilateral intracranial vertebral dissecting aneurysm but received only one side endovascular coil embolization, and three got PICA involvement. The mean number of coils is five. (Least: two coils with stent; most: 11 coils.) There were no significant periprocedural complications.

CONCLUSION
Endovascular surgery with coil embolization of spontaneous dissecting aneurysm of the intracranial vertebral artery is an effective and reliable method. Direct occlusion of dissecting segment of vertebral artery with preservation of the PICA leads to a good prognosis. To prevent the bleeding/rebleeding event to the unruptured/ruptured aneurysms and decrease the mortality rate of intracranial vertebral dissecting aneurysm, endovascular coil embolization should be performed as early as possible.

KEY WORDS: Intracranial vertebral dissecting aneurysm, endovascular surgery, coil embolization

Poster 110
Penetrating Head Injury: Diagnostic and Endovascular Treatment
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PURPOSE
Penetrating head injuries can be the result of numerous intentional or unintentional events, including missile wounds, stab wounds, and motor vehicle or occupational accidents (nails, screwdrivers). Stab wounds to the cranium typically are caused by a weapon with a small impact area andielded at low velocity. The most common wound is a knife injury, although bizarre craniocerebral-perforating injuries have been reported that were caused by nails, metal poles, ice picks, keys, pencils, chopsticks, and power drills. Objective: Demonstrate that endovascular treatment for vascular lesions caused by penetrating trauma is feasible, safe, durable and highly effective.

MATERIALS & METHODS
Between the years 2005 and 2010 we treated nine consecutive patients with vascular lesions secondary to penetrating wounds at our University Hospital: five gunshot wounds and four stab wounds, seven pseudoaneurysms, two arteriovenous fistulas. We utilized multidetector tomography on four of the patients diagnosing lesions in three of them and on the fourth one the splinters of the bullet blocked visualization of the pseudoaneurysms. Cerebral angiography of the six vessels with digital subtraction and endovascular treatment of the lesions was utilized on all patients. Follow-up cerebral angiography could be done on seven of the patients.

RESULTS
Two traumatic aneurysms and two arteriovenous fistulas were excluded immediately from circulation after stent graft placement without contrast material filling the aneurysm cavity. Four were excluded with coils and one with bare stent plus coils. We did not have complications such as vessel dissection, vessel perforation, or thromboembolism. The mean midterm follow up was 28 months. All patients showed exclusion of the pseudoaneurysms or the fistulas from the circulation on the angiographic follow ups.

CONCLUSION
Our experience demonstrates that endovascular treatment of intracranial traumatic aneurysms is feasible, safe, durable and highly effective. There were no reports of recurrence of the pseudoaneurysms or fistulas on follow-up angiography.

KEY WORDS: Penetrating, injury, head

Poster 111
Stent-Assisted Embolization of Acutely Ruptured Cerebral Aneurysms without Antiplatelet Premedication: A Single Center Experience
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PURPOSE
Use of stent-assisted embolization in acute subarachnoid hemorrhage (SAH) is limited due to the need for antiplatelet premedication. We review our experience and analyze the safety and efficacy of stent-assisted embolization of ruptured intracranial aneurysms during acute SAH without antiplatelet premedication.

MATERIALS & METHODS
Retrospective review of the medical charts and imaging was done in all the patients who were treated using stent-assisted embolization during the acute SAH period from July 1, 2003 to October 31, 2010. Results in 15 consecutive patients (3 men, 11 women; mean age, 50.2 years; range, 32-78 years) were evaluated. On admission 10 patients (66.6%) were in good condition (Hunt and Hess I-III) and five patients (33.3%) were in poor grade (Hunt and Hess IV-V). All the embolizations were performed maintaining a continuous flush of heparinized saline (6000 I.U./1000 ml) in the catheter system. The anticoagulation regimen included post-procedure intravenous heparin using the institutional heparin protocol followed by clopidogrel (75 mg) and aspirin (80 mg) starting the day following the procedure for 6 months. The mean length of the angiographic follow up was 10.5 months (range, 0-48 months).
RESULTS
Total of 17 aneurysms (11 wide-necked saccular aneurysms and six dissecting aneurysms) were treated using 20 intracranial stents (14 Neuroform and 6 Enterprise stents). The stent was deployed successfully in 90% of cases (18 of 20). The stent-assisted coil embolization was done in total of 11 saccular aneurysms while six dissecting aneurysms were treated with stent alone. There was complete occlusion in all the 11 saccular aneurysms and only two cases had minimal neck recanalization (grade 2 of Raymond classification) in the follow-up angiograms. The retreatment rate was 6.66% (1 of 15). The clinical outcome was good in 66.66% of patients (10 of 15). There was no case of intraprocedural stent thrombosis or delayed rebleed. There was one case of severe intracerebral hemorrhage and one case of delayed stent thrombosis, both related to heparin protocol violation.

CONCLUSION
Our results suggest that in the acutely ruptured complex intracranial aneurysms, if necessary, the use of the stent (with or without coils) for the treatment is feasible and is associated with low complication rate, even if antiplatelet premedication is not provided. We believe that the use of continuous heparinizied flush plays an important role in reducing the thromboembolic complications.

KEY WORDS: Stent, subarachnoid hemorrhage, complex aneurysm

Poster 112
Supernova Hemorrhage: A Previously Undescribed Complication of Arteriovenous Malformations following Gamma Knife Stereotactic Radiosurgery
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PURPOSE
Hemorrhage constitutes the most feared complication of cerebral arteriovenous malformations (AVMs) in both untreated patients and those treated with gamma knife radiosurgery (GKR). Radiosurgery does not immediately lead to AVM occlusion, requiring up to 2 years following treatment. Postobliteration hemorrhage is exceedingly rare; reported cases occurring months to years after radiosurgery and nidus occlusion typically are associated with residual or recurrent AVM. We report three cases of intracranial hemorrhage in patients with cerebral AVMs previously treated with radiosurgery in which no residual AVM was found on catheter angiography and discuss the potential pathophysiology of the hemorrhages.

MATERIALS & METHODS
Retrospective review of medical records and images was performed for three patients.

RESULTS
Patient A had a Spetzler-Martin grade 3 right frontal AVM for which he initially declined treatment. After subsequent intracerebral hemorrhage GKR was performed. Seventeen months post-treatment he presented with seizures and demonstrated subarachnoid hemorrhage and residual AVM nidus with patent venous outflow. Two days later conventional cerebral angiography was performed after clinical deterioration and showed no evidence of residual nidus or associated arteriovenous shunt. Patient B had a right parietal Spetzler-Martin grade 3 AVM that was treated with partial embolization, and the nidus appeared slightly smaller angiographically 11 months later. Gamma knife radiosurgery was performed 28 months after initial detection and embolization. Fifty-five months after treatment she presented with several days of severe headache and confusion and intraventricular hemorrhage on CT and MR imaging, with no clear source of bleeding. Conventional cerebral angiography showed no arteriovenous shunt and no other source of the intraventricular hemorrhage. Patient C had a Spetzler-Martin grade 5 left frontotemporal AVM that caused seizures in childhood prior to diagnosis. She underwent three courses of GKR at 0, 3, and 13 months after detection. Fifty-one months following her final treatment her AVM was now smaller. Angiogram at 57 months demonstrated a new large left deep draining venous varix with venous restriction. At 64 months she presented with a new, severe headache with acute onset. CT and angiography showed partial thrombosis of a large venous varix with concomitant downstream venous outflow restriction, but no definite associated intracranial hemorrhage.

CONCLUSION
Intracranial hemorrhage following GKR ablation of AVMs usually is associated with residual or recurrent AVM. We report two cases in which no residual AVM was found at the time of hemorrhage, suggesting a possible “supernova” hemorrhage at the time of complete venous outflow occlusion. We hypothesize that the intracranial hemorrhages experienced by patients A and B resulted from the progressive occlusion of nidal venous outflow, with rupture occurring secondary to an acute increase in pressure in residual AVM feeding arteries, nidal components and the proximal venous outflow. The progressive venous restriction and thrombosis demonstrated on sequential imaging in patients A and B support this hypothesis. Furthermore, the progressive venous restriction and thrombosis prior to complete AVM occlusion seen in Patient C illustrate the same concept, though one step prior to hemorrhage.

KEY WORDS: Arteriovenous malformation, gamma knife radiosurgery, hemorrhage

Poster 113
Follow up of Scalp Arteriovenous Malformations Treated with N-Butyl Cyanoacrylate and Onyx 18
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PURPOSE
Arteriovenous malformations (AVM) of the scalp are relatively rare vascular lesions that present either as a small subcutaneous scalp lump, or a large pulsatile mass with a propensity to massive hemorrhage (cirsoid aneurysm). On catheter angiography usually an arteriovenous fistula with a venous
aneurysm is demonstrated. Treatments include surgical excision, ligation of feeding vessels, transarterial or transvenous embolization, injection of a sclerosing agent into the nidus, and electrothrombolysis. To our knowledge, the use of liquid embolic agents has not been reported. We present our experience at IUMC with percutaneous and transarterial embolization of three scalp AVMs with N-butyl cyanoacrylate (NBCA) and Onyx 18 respectively.

**Materials & Methods**

We retrospectively identified all patients with arteriovenous malformations of the scalp who were treated with liquid embolics as the single treatment technique at our institution between January 2005 and December 2010. We documented age, gender, presenting symptoms, angioarchitecture of the lesion, post-treatment angiography results, and follow-up MRI/MRA and angiography results when available.

**Results**

Two female and one male patients were identified, who underwent three procedures for AVM of the scalp repair using NBCA and Onyx-18. The mean age was 49 ± 8 years. Three patients presented with a pulsatile mass in the scalp. Two patients underwent transarterial superselective catheterization of the arterial feeder from the external carotid artery and Onyx-18 was injected under continuous road-map guidance until complete resolution of the malformation and the cirsoid aneurysm was achieved. One patient underwent percutaneous embolization with direct puncture of the cirsoid aneurysm and NBCA injection under road map guidance. Post-treatment angiography in three patients demonstrated complete cure of the lesion. Follow-up angiography was available in two patients and follow-up MRI/MRA was available in one patient. None of the patients had any signs of recurrence in the follow-up examination. The pulsatile mass in the scalp also had resolved at the time of the clinic follow-up examination.

**Conclusion**

In our experience, the endovascular treatment of scalp arteriovenous malformations with cirsoid aneurysms with NBCA and Onyx-18 is feasible, safe, durable and highly effective.

**Key Words:** Cirsoid, fistula, vascular malformation

**Poster 115**

**Intra-Arterial Cone Beam CT Angiography for the Precise Anatomical Localization of Dural and Pial Arteriovenous Fistulas**

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**Purpose**

Cone beam CT angiography (CBCTA) provides enhanced vascular imaging for neurointerventional treatment planning, particularly of intravascular stents, thromboemboli, in-stent stenosis, and calcifications. In conjunction with traditional digital subtraction angiography (DSA) and 3D-DSA techniques, intra-arterial CBCTA offers superior contrast resolution to delineate the adjacent cross-sectional anatomy and soft tissue architecture. We evaluated this technique and its efficacy in delineating the subtle arteriovenous anatomy of dural/pial arteriovenous fistulas (AVFs) for treatment-planning purposes.
MATERIALS & METHODS
We performed a retrospective review of intracranial and spinal dural/pial arteriovenous fistulas that underwent diagnostic DSA and intra-arterial CBCTA procedures. Cone beam CT angiography scanning was performed with flat detector rotational angiography (Artis Zee Biplane, Siemens); 496 projection frames were acquired over a 200 degree arc (18 second rotation time, 80kV, 260mA). Planar and 3D reconstructions (overlapping 0.5 mm and 5 mm slice thickness) were evaluated on an independent workstation (Leonardo). We studied patient demographics, presentations, classification/anatomical localization of arteriovenous fistulas (AVFs), CBCTA technique, treatment, and complications. Neurointerventionalists/neurosurgeons involved in the diagnosis and treatment of these lesions graded any relevant improvement (0 or 1) in anatomical localization, treatment planning, or altered management derived from the CBCTA technique.

RESULTS
Eleven patients (10:1 male, mean age 62 years) underwent 12 CBCTA procedures. Intracranial AVFs were classified as dural Cognard type 1 (n=2), type 2b, type 3 (n=2), metameric dural/pial (n=2) and pial presenting with transient ischemic attack, headaches, pulsatile tinnitus, or intracranial hemorrhages (n=4). Spinal AVFs were limited to dural Anson-Spetzler type 1 (n=4) presenting with cervical subarachnoid hemorrhage, intramedullary hemorrhage, or progressive lower extremity weakness/paresthesias. Cone beam CT angiography techniques ranged with respect to intra-arterial diluted contrast (30-50%) injections in the CCA, ICA, ECA, VA, middle meningeal, intercostal and lumbar arteries; rates of 0.3-3.0 mL/sec and total volumes of 3.0-66 mL. A single CBCTA procedure was scanned using lower resolution and radiation dose with faster 8 second acquisition, but still providing accurate AVF localization. Significant improvement in anatomical mapping of AVFs was observed with CBCTA in 12/12 (arterial feeders, arteriovenous junction, venous drainers, or cross-sectional localization), corresponding with an improved treatment plan in 7/12, and altering management or treatment in 3/12. Subsequently, these lesions were treated with Onyx embolization (n=4), microsurgical clipping (n=5) and radiation (n=2) with one patient refusing treatment. Two postprocedural complications included intracranial hemorrhage and myocardial infarction, but no complications were encountered with the CBCTA technique.

CONCLUSION
We present a novel application of intra-arterial CBCTA as an adjunct to DSA for the precise anatomical localization of intracranial or spinal dural/pial AVFs. The impact of this technique allows for unparalleled cross-sectional mapping of arteriovenous pathology, assists in treatment planning most notably for microsurgical or radiation treatment, and can potentially alter patient management.

KEY WORDS: Arteriovenous fistula, cone beam CTA

Poster 116
Semipermeeable Stent for Flow Modification in the Management of Intracranial Aneurysms: Mexico City Experience with a New Aneurysm Occlusion Device

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PURPOSE
Initial experience with stent only therapy for intracranial aneurysms has raised concerns because of a high rate of delayed aneurysm rupture presumably due to increased wall tension during the period of progressive thrombosis. We present our experience with a flow diverting (FD) stent designed for immediate and complete aneurysm occlusion.

MATERIALS & METHODS
Between August 2010 and December 2010 patients with unruptured intracranial internal carotid artery aneurysms were treated according to an investigational protocol with a balloon mounted microporous membrane-covered stent (Excalibur™, Merlin Medical, Singapore). Unlike conventional FD stents, this novel aneurysm occlusion device (AOD) provides 60-70% surface area coverage regardless of stent diameter enabling higher rates of complete initial aneurysm occlusion. Patients were treated at a single center according to a prospective, single arm protocol approved by the national regulatory body and local institutional review board. If the parent artery harbored a stent of any kind the patient was excluded. No patients received preoperative antplatelet drugs or intraoperative heparin. All were given a loading dose of tirofiban and started on a 12-hour tirofiban infusion intraoperatively. Several hours prior to stopping tirofiban patients were loaded with Plavix and aspirin. Maintenance therapy with clopidogrel and aspirin was continued for a minimum of 3 months and aspirin indefinitely. Modified rankin score (mRS) and angiography were obtained at 1, 3, and 6 months.

RESULTS
Twenty-one patients (19 female) with 24 aneurysms (18 wide neck + 1 fusiform) were entered into the protocol. Patients ranged in age from 34 to 82 years. Aneurysm location was cavernous in five, ophthalmic in ten and supraclinoid in nine. Aneurysm size was < 12 mm in 17 and 12-24 mm in seven. Three aneurysms were previously coiled. Twenty-five stents were implanted in 19 patients. In two patients technical failure was due to stent dislodgment from balloon. Five patients required treatment with more than one stent because a single stent was not long enough to bridge the neck. In two patients multiple aneurysms (5) were treated with a single stent. There were 16 covered side-branches (13 ophthalmic, 1 posterior communicating, 1 meningeal,
and 1 anterior choroidal). Follow up ranged from 16 to 180 days (mean 78 days). There was one death due to parent artery perforation during guidecatheter positioning. There were no permanently disabling ischemic strokes. At last follow up mRS was 0-2 in 20 (95%) patients. There were no permanently disabling ischemic strokes. At last follow up mRS was 0-2 in 20 (95%) patients. There were five parent artery occlusions explained by clopidogrel noncompliance in one, omeprazole interactions in four, and inadequate stent apposition in two. Excepting three cases with parent artery occlusion all covered side branches remained patent. No patients developed parent artery stenosis ≥ 50% at 6 months. In 19 technical successes, immediate postprocedure 100% aneurysm occlusion occurred in 15, 90-99% in three, and 50-90% in one. At 1 month all 19 had 100% aneurysm occlusion.

**CONCLUSION**

Microporous membrane-covered stents enable high rates of complete initial aneurysm occlusion without the risk of delayed aneurysm rupture. Excellent stent apposition and effective antithrombosis are mandatory to ensure stent patency.

**KEY WORDS:** Intracranial aneurysm, endovascular flow diverter stent, Merlin MD

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**Poster 117**

**Automated Geometrical Characterization of the Carotid Siphon Based on 3D Rotational Angiogram**

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**PURPOSE**

To study the carotid siphon by automated geometric characterization based on high-resolution 3D rotational angiography.

**MATERIALS & METHODS**

Data of 83 3D rotational angiogram (Allura, Philips Healthcare) of patients treated endovascularly for intracranial aneurysms were used for this study. After segmentation of the arterial tree and central line computation of this anatomy, automatized detection of the carotid artery (from its exit point from the petrous canal to its terminal bifurcation) was realized. Each siphon was quoted by two separate readers according to a shape-based classification. Landmarks based on geometric properties of the center-line were used to delinate four segments (Figure: 1-inferior 2-posterior 3-anterior 4-superior) coinciding with clinical areas of interest on the siphon. For each of those segments the following data were calculated: 1. Lengths: (Euclidean distance and distance between ends) and corresponding arterial tortuosity (relative increment of a curve length deviating from a rectilinear line). 2. Arterial radius, osculating planes changes and bending energy. The whole carotid siphon length and corresponding arterial tortuosity also were calculated.

**RESULTS**

Conventional angiographic-based shape classification of carotid siphon resulted in substantial intraobserver and interobserver level of agreement (kappa test respectively 0.77 and 0.64 p=0.000). The automated-based geometric characterization was possible for each angiographic dataset and provided the following information regarding vascular tortuosity and radius of the main arterial curves of the siphon. The mean carotid siphon length was 61 mm +/-19 (range 33-106) and calculated tortuosity was 0.9+/-0.3 (range 0.3-1.7). Separate analysis was performed for each segments. Mean radius at posterior, anterior, and superior segments were respectively 4.4; 3.3, 5.4 mm. Plane changes according to coronal, sagital and axial planes were available for review; for the purpose of this study, osculating plane changes for the posterior and superior segments were compared according to the plane of anterior segment and were respectively 41 and 87 degrees. Subgroup analysis of each type of siphon defined according to the angiographic classification was performed but no significant correlation or differences with the automated geometric characterization parameters was found.

**CONCLUSION**

Angiographic classification of siphon showed good inter and intraobserver reliability. Nonetheless the subdivision in four types of siphon could not correlate to parameters provided by the geometric characterization. Multiple clinical hypotheses (development of intracranial vascular disease) or applications (stent design and endovascular use) would need further investigation and could benefit from the parameters offered by geometric-based definition of the siphon.

**KEY WORDS:** Carotid siphon, angiography, anatomy
Poster 118

Preliminary Results of Flow Diversion Device (Silk Stent) in the Treatment of Intracranial Aneurysms: A Focus on Technique-Related Artifacts Using a Multidetector 320 Row Scanner

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PURPOSE
The treatment of intracranial aneurysms has an approximate rate of 30% of recanalization. In the last years, many technical advances, such as balloon remodelling technique and stent-assisted coiling, have lead to improving results of the endovascular treatment. A new generation of stents has been introduced recently: the flow diversion devices. The aim of our work is to analyze the preliminary results after 1 year experience with a focus on the detection of stent artifacts with the use of multidetector CT (Aquilion ONE) for the early and late follow up.

MATERIALS & METHODS
Since April 2009 a series of 11 patients and a total of 12 intracranial aneurysms were treated endovascularly using Silk stent. Ten patients were female and one was male, ranging from 45 to 63 years of age. All of the aneurysms were broad neck: nine of them were located in the anterior circulation, two in the basilar artery and one in the vertebral artery. Seven patients were treated using one Silk stent, in one patient one Silk stent treated two aneurysms, while in four patients two Silk stents were required in a telescopic fashion. All patients had follow-up CT angiography (CTA) performed at 3 months and 1 year and then follow-up angiography at 6 months. The CTAs were obtained on a multidetector 320 row scanner, Aquilion ONE, (640 resolution) acquiring volumetric images.

RESULTS
The immediate short-term and 1 year follow-up data are presented here. The advantages, the limits and the clinical implications of the Silk stent technique also are illustrated. The detection of artifacts by the multidetector 320 row scanner in the follow up of aneurysms is reported. CT angiography using multidetector 320 scanner provided adequate visualization of the intracerebral circulation without artifacts at the stent level. Even in cases when two Silk stents were used the artifacts did not preclude the visualization of the artery. The MPR images enabled a satisfactory evaluation of the stent and its relationship with the parent artery.

CONCLUSION
In our preliminary experience, the multidetector 320 row scanner provides adequate results without evidence of artifacts from material of Silk stent in the follow up of patients treated for intracranial aneurysms. A prospective study is required to confirm these preliminary data.

KEY WORDS: Flow diverter, aneurysms, multidetector scanner

Poster 119

Endovascular Treatment of Wide-Necked Intracranial Aneurysms Using “Various Generations” of Neuroform Stents: Easier Navigation and Precise Placement with the Newest Generation of the Stent

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PURPOSE
Stent-assisted coiling has been a well established endovascular treatment for wide-necked aneurysms. The neuroform stent is a flexible nitinol self-expandable stent useful for neck reconstruction. The aim of this study was to establish the role of the stent in endovascular management of wide-necked cerebral aneurysms.

MATERIALS & METHODS
Between June 2003 and December 2010, 67 cases of neuroform stents were placed for treatment of wide-necked aneurysms. Postprocedure angiograms demonstrates flow directional changes with total occlusion of the aneurysm in most patients. In some cases there was minimal residual flow, which demonstrated total occlusion on the follow-up angiograms. Inclusion criteria included wide-necked aneurysms. Anatomical and clinical results and complications including distal thrombosis and stent thrombosis will be discussed. Types of stents include various generations of the stent including first generation Neuroform stent, Neuroform 2, Neuroform 2 trio, Neuroform 3 and the latest Neuroform EZ.

RESULTS
With the evolution and newer generations of the stent the navigation and precise positioning has improved significantly. The advantages and pitfalls of the new generation stent will be discussed. Technical considerations, complications and their management also will be discussed. Complete exclusion of the aneurysm was obtained in most of the cases.

CONCLUSION
The newer generations of the neuroform stent has aided in the navigation and precise deployment. Advantages and pitfalls and management of the pitfalls will be discussed.

KEY WORDS: Aneurysm, neuroform, wide neck

Poster 120

Safety of Intermediate Catheters: A Review of 489 Cases at Two High-Volume Centers

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PURPOSE
Compare and evaluate the two families of intermediate catheters with regards to distal access and safety.
Flow-Diverter Stents for the Endovascular Treatment of Intracranial Aneurysms: A Prospective Study in 97 Patients with 111 Aneurysms

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PURPOSE
Flow diverters (FDs) is a new approach to the endovascular treatment of intracranial aneurysms which uses a high density mesh stent to induce sac thrombosis. These devices have been designed for the treatment of complex shaped and large size aneurysms. So far published safety and efficacy data on this approach are limited. We report our 2-year experience with FDs in the treatment of cerebral aneurysms.

RESULTS
Overall rate of complication was 5.7%, none of which were directly attributable to the intermediate catheter. 14.8% of the complications related to aneurysm perforation, 18.5% to vessel perforation, while 18.5% related inadvertent embolizate embolization, 11.1% to coil prolapse, and 11.1% to dissection. The neuron family of catheters was advanced no farther than the cavernous internal carotid artery (ICA) in anterior circulation use (100%), whereas the DAC catheters frequently were advanced further to this point in 24.2% of the cases, as far as M3 branches. The complication rate among DAC is 12/131 (9.2%); the complication rate for neuron is 15/338 (4.4%). This difference is statistically significant (p = 0.049, chi-square test). The estimated odds ratio is 2.17, indicating that DAC cases in our sample are more than twice as likely as neuron cases to experience a complication. The 95% confidence interval for the true odds ratio is (0.99, 4.76).

CONCLUSION
The use of intermediate catheters to improve ease of access to target lesions appears relatively safe, with overall complication rates in line with historical numbers. However, the usage of the DAC family seems to confer a higher risk of complication relative to the neuron family, which may relate to the complexity of the cases in which they are employed. Further observation is necessary.

KEY WORDS: Intermediate catheters, distal access catheter, neuron catheter
Quantitative Assessment of Parenchymal Blood Volume in Tumor Embolization Using C-Arm CT Imaging: Initial Clinical Experience

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PURPOSE
C-arm CT measurement of cerebral blood volume (CBV) in ischemic stroke patients has already been reported. Our purpose was to evaluate the feasibility of assessing parenchymal blood volume (PBV) using C-arm CT in head and neck neoplasm during preoperative angiographic evaluation and embolization using poly-vinyl alcohol particles.

MATERIALS & METHODS
Nine patients diagnosed with head and neck tumor, underwent C-arm CT imaging (DynaCT, Axiom Artis zee, Siemens) using a 8-second 3D subtraction angiography protocol after intra-arterial contrast injection (10% contrast; 1.5cc/sec; 24-27 cc total, x-ray delay of 8-10 seconds after the mask and before the fill acquisition). Parenchymal blood volume maps (in ml/100g of tissue) then were computed by postprocessing using prototype software (Siemens AG, Forchheim, Germany). Four out of these nine patients had C-arm CT imaging before and after the embolization procedure. Parenchymal blood volume maps from these four patients were analyzed to infer quantitative assessment of tumor embolization and vascularity. The remaining five patients had one instance of C-arm CT imaging that was correlated with MR and CT images. Parenchymal blood volume maps also were compared qualitatively with the corresponding 2D angiographic images to assess tumor vascularity.

RESULTS
Quantitative analysis of PBV maps in four patients (2 carotid body tumors, 2 skull base tumors) showed a relative decrease in PBV values after embolization procedure (-63%, -79%, -46%, -42%, respectively) when compared with the preprocedural PBV maps. Parenchymal blood volume maps from the remainder of the patients were qualitatively comparable to the angiographic evaluation of tumor perfusion. Apart from computing the PBV maps, the same C-arm CT data also could be used to generate a fill reconstruction image (equivalent to contrast-enhanced C-arm CT) for soft-tissue evaluation. Because of the diversity of tumor type and small sample size, any inference from comparing the tumor PBV values across these cases could not be performed.

CONCLUSION
Parenchymal blood volume maps could be computed from routine C-arm CT imaging that provides functional information about the tumor perfusion in the angiography suite itself. This could be a valuable tool for quantitative and comparative assessment of the efficacy of tumor embolization. Heretofore, the extent of embolization procedures always has been assessed qualitatively from tumor blush on 2D angiographic images. Further work is required to determine the possible utility of this technique in studying tumor tissue vascularity, in guiding tumor biopsy of non-necrotic tissue, in tumor classification and localizing tumor zones for effective chemo-embolization therapy.

KEY WORDS: Parenchymal blood volume, C-arm CT imaging, tumor embolization
**Poster 123**

Management of Spinal Epidural Arteriovenous Fistulas

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**Purpose**
Spinal epidural arteriovenous fistulae (SEDAVF) are rare clinical entities, which can sometimes be symptomatic. Clinical progression and management of SEDAVF is not reported well in the literature.

**Materials & Methods**
We report a series of five consecutive cases treated at our center to analyze their diagnostic characteristics, clinical history, progression and treatment strategies in their management. We report a successful technique of percutaneous embolization of fistulas in a patient with failed previous attempts.

**Results**
All five patients were symptomatic; three patients presented with history of back pain, which progressed to myelopathic symptoms such as bilateral leg weakness or numbness, and two patients had symptoms of persistent back pain alone. Of the three patients who had myelopathic symptoms, two were treated successfully with transarterial embolizations with Onyx copolymer (ev3 Neurovascular, CA, USA). The third patient who had a prominent epidural venous pouch with numerous arterial feeders was embolized percutaneously with a flat detector CT-guided navigation (X per CT, Phillips Inc., The Netherlands) and real time fluoroscopic monitoring of the injected n-BCA glue (Trufill, Cordis Neurovascular Inc., FL, USA), after previous unsuccessful attempts with surgery and arterial embolizations. All three treated patients had complete angiographic remission of the fistulae and symptoms on follow up (mean 7.2 months). Of the two patients presenting with back pain alone, one patient was found to have a spontaneous thrombosis of the medullary vein before a scheduled percutaneous intervention and the other patient is being monitored closely.

**Conclusion**
The diagnosis and treatment of SEDAVF can be challenging due to their rare occurrence and intricate pathomechanics. Patients with mild symptoms of pain should be monitored closely. Patients with severe pain or progression of symptoms or myelopathic symptoms need to be treated at the earliest opportunity. Successful percutaneous embolization of fistulae can be performed when a sizeable venous pouch is present in association with numerous arterial feeders.

**Key Words:** Epidural arteriovenous fistula, percutaneous intervention, glue

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**Poster 124**

Percutaneous Management of Symptomatic Synovial Cystic Disease and Clinical Outcome

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**Purpose**
Synovial cysts are extradural lesions for which surgical microdecompression has been the traditional standard of care treatment. We describe different percutaneous treatment options and varying approaches which may be employed for the successful decompression of these cysts.

**Materials & Methods**
Five patients with symptomatic synovial cysts (Visual Analogue Scores between 4-8) were treated over the past 12 months by varying combinations of percutaneous techniques using CT for guidance. This allowed accurate guidance and subsequent rupture of the cysts. Three of the cases were performed using transfacetal transcapsular approaches, and two required additional interlaminar access and cyst fenestration to weaken the cyst wall prior to rupture. Long-term effectiveness can be judged by follow-up CT or MR.

**Results**
Percutaneous cyst rupture using these techniques resulted in marked symptomatic improvement. An average reduction of at least 60-70% in the VAS was achieved.

**Conclusion**
Percutaneous treatment of symptomatic synovial cyst, performed as outpatient procedures seems an effective alternative to surgery in a significant number of patients.

**Key Words:** Percutaneous management, synovial cyst

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**Poster 125**

Predictors and Outcomes of Merci Device Fracture during Mechanical Thrombectomy for Acute Ischemic Stroke

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**Purpose**
Merci retriever device fracture is one of procedure-related adverse events during mechanical thrombectomy for acute ischemic stroke. The purpose of this study was to describe the frequency and predictors of this complication in acute ischemic stroke patients after mechanical thrombectomy and its impact on clinical outcome.
Materials & Methods

We retrospectively analyzed acute ischemic stroke patients with large vessel intracranial occlusions treated by mechanical thrombectomy with Merci devices (Concentric Medical, Inc., Mountain View, CA) at the University of California, Los Angeles from August 2002 through August 2008. Digital subtraction angiograms and medical records were reviewed to identify the presence of device fracture. Univariate logistic regression analyses were performed to define the predictors of device fracture. The impact of device fracture on potential hemorrhage and clinical outcome at discharge were evaluated.

Results

Of 136 consecutive patients treated by mechanical thrombectomy, six (4.4%) experienced intraprocedural Merci devices fracture. In univariate analyses, internal carotid artery occlusion (OR 13.06; 95% CI 1.47 to 115.62, P = 0.01) was associated with device fracture. The fractured devices were ensnared successfully by a Merci device or microsnare (ev3, Inc, Irvine, CA) in three of six patients. Compared with patients with nonfractured devices, those with fractured devices had similar rates of thrombolysis and myocardial infarction (TIMI) grade II and III revascularization (66.7% versus 72.3%; p = 0.67), decreased rates of arterial occlusive lesion (AOL) grade III recanalization (0% versus 48.5%; p = 0.03) and longer mean procedure time (2.5 hours versus 1.8 hours; p = 0.03). In patients with fractured devices, no parenchymal hematomas were found. Hemorrhagic infarction and subarachnoid hemorrhage were found in three and two patients with fractured devices, respectively. There were no significant differences between patients with fractured devices and those with nonfractured devices for independence at discharge (modified Rankin Scale≤2, 0% versus 25%; p = 0.34) and in-hospital mortality (16.7% versus 23.4%; p > 0.99).

Conclusion

The complication of Merci retriever device fracture is relatively infrequent in acute ischemic stroke patients treated by mechanical thrombectomy. Target occlusion location in the internal carotid artery is an independent predictor of intraprocedural device fracture. This complication is not associated with parenchymal hematomas or poor clinical outcomes after thrombectomy.

Key Words: Acute stroke, mechanical thrombectomy, complication

Poster 126

Endovascular Treatment of Cerebral Venous Sinus Thrombosis in Children: A Case Series

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Purpose

Cerebral venous sinus thrombosis is a serious condition affecting 0.67 per 100,000 children per year. It has a 48% adverse outcome. The symptoms and signs are often non-specific and this can lead to a delay in diagnosis or it being missed altogether. The most common presenting features are headache (60%), seizures, reduced GCS or cranial nerve palsies. Coma and seizures at presentation are poor prognostic indicators. The diagnosis is made on CT, CTV, MR, MRV. The mainstay of treatment is heparin although this is not universal. The decision to proceed to endovascular treatment is guided by the multidisciplinary team involved in the patients care and should only be considered in the extreme cases where medical management has failed and the child is in poor clinical condition. There is very little published literature on the use of aggressive endovascular treatments in children with venous sinus thrombosis.

Materials & Methods

We present our experience of treating eight children ranging in age from 18 months to 16 years, with a diagnosis of cerebral venous sinus thrombosis. All had the diagnosis made by a neuroradiologist on CT, CTV, MR or MRV. The decision to proceed to endovascular therapy was made on discussion between the neuroradiologists and the clinicians. This was decided only upon discussion due to the very poor clinical state of the patients. Seven children were comatose, one child had signs of raised intracranial pressure with progressive cranial nerve palsies. Seven of the children already had been started on IV heparin and had shown no improvement. A variety of endovascular methods was used, local tPA, disruption of the clot with a microwire and catheter, balloon angioplasty and aspiration of the clot using the penumbra device.

Results

Seven children had good functional outcomes. One child died as a consequence of uncontrolled intracranial hypertension secondary to the venous sinus thrombosis.

Conclusion

Endovascular therapy appears to have a role in the treatment of venous sinus thrombosis in children when medical therapy has failed and the patient is in a poor clinical condition.

Key Words: Endovascular, venous sinus thrombosis

Poster 127

MR Imaging Biomarkers to Predict Fetal Development

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Purpose

Purpose of this study was to: i) perform multiparameter MR assessment of the gestational ages with biparietal-diameter (BPD), occipital-frontal-diameter (OFD), head-circumference (HC), femur-length (FL), humerus-length (HL), abdominal-circumference (AC) and ii) correlate these findings and the gestational ages with ultrasound measurements.
MATERIALS & METHODS
Seventy-two fetal MR images (gestational age=23±8 weeks) having correlative ultrasound report with biometrics and gestational ages reported within ±3 days of MRI were analyzed retrospectively. High-resolution multi-planar fetal MR protocol comprised of fast-imaging sequences to acquire whole body images of the fetus on 1.5T Siemens scanner. Biparietal-diameter and OFD were measured on transverse axial section of the fetal head which included the falk cerebri, cavum septum pellucidum and thalami. Biparietal-diameter was measured from the outer edge of the parietal bone to the inner edge parietal bone in relation to the anterior abdominal wall. Occipital-frontal-diameter was measured perpendicular to the BPD from the outer edge to the outer edge of the bones in the anterior-posterior plane. The longest transverse width of the cerebellum (TCD) was measured in the posterior fossa views. Abdominal-circumference was measured at the level of the liver and stomach. Humerus-length and FL were measured along the true long axis of diaphyseal shaft excluding the epiphysis. Radiologists were blinded to the ultrasound measurements reported on the ultrasound scan. Once the MRI measurements were reported, corresponding gestational ages were tabulated and correlated with the ultrasound ages using linear squares regression analysis. Student’s t-test was performed to determine any significant differences between the biometrics and gestational ages obtained from the two imaging modalities (p≤0.05).

RESULTS
Results showed an excellent correlation with insignificant differences between ultrasound and MRI-reported biometrics and gestational ages. All the MR biometric measurements correlated well with the ultrasound measurements (slope 0.97±0.03 and an R²=0.89±0.17). Gestational ages computed from the MR biometrics, also correlated well with the ultrasound ages (slope=0.99±0.01; R²=0.92±0.03). There was no significant difference between the biometrics (p-value=0.13±0.07) and the gestational ages (p-value=0.58±0.25) obtained from both the imaging modalities. Mean gestational age from MR was in excellent correlation with ultrasound mean gestational age (slope=1.05, R²=0.90, p-value=0.495). In addition, MRI was able to provide more information regarding the complex fetal anomalies.

CONCLUSION
Multiparameter assessment of fetal gestational ages was possible with rapid high-resolution MRI sequences. Our future goal is to include new MR biomarkers to demonstrate normal fetal proportions and to be able to predict fetal anomalies from biometric deviations at various gestational ages.

KEY WORDS: Biometry, MR imaging, fetal

Poster 128

Functional Connectivity Evaluation of Mesial Temporal Lobes in Epilepsy: Preliminary Studies

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PURPOSE
Functional MR imaging (fMRI) has increasingly supplanted the Wada test in presurgical evaluation of epilepsy, in particular for language lateralization. Clinical evaluation of mesial temporal lobe function in memory with fMRI has been more
difficult, and is particularly problematic in children who are unable to cooperate with the Wada. Functional connectivity MRI (fcMRI) — analysis technique based on task-free resting state fMRI recording — is an alternative approach for mapping functionally related areas of the brain. Potentially, it can be useful in assessing disruption of connectivity in certain disease states, including memory disruption in epileptic patients with hippocampal sclerosis. We have begun investigation of resting state fMRI for evaluation of mesial temporal lobe function.

**Materials & Methods**

Imaging was performed on a Siemens (Erlangen, Germany) 3 T (Trio) (EPIBOLD sequence, TE = 30ms, flip angle = 90°). Analysis was performed using 1000 Functional Connectomes Project scripts based on AFNI and FSL software packages. We retrospectively analyzed connectivity patterns in five healthy control subjects (ages 11 to 15 years) and compared to two patients (age 17 and 6 years) with memory disruption and epilepsy due to hippocampal sclerosis and three patients (ages 6, 13 and 20 years) with epilepsy without hippocampal sclerosis including one under propofol anesthesia. Resting state data were analyzed for connectivity with ventral precuneus and retrosplenial cortex.

**Results**

The figure shows connectivity patterns for ventral precuneus seed (MNI coordinates: 0, -60, 24) in one of the control subjects and in the patient. Robust connectivity with the ventral precuneus seed point was seen in fusiform gyri, parahippocampus and hippocampus in individual subjects. Connectivity pattern (A) was found to be bilateral and symmetric in control subjects (in agreement with the literature), and in the patients with epilepsy without hippocampal sclerosis. In contrast the epileptic patients with hippocampal sclerosis exhibited an asymmetric pattern (B) of connectivity with decrease in the hippocampal and parahippocampal regions ipsilateral to their sclerosis.

**Conclusion**

Epilepsy patients with hippocampal sclerosis revealed a deviation from typical connectivity pattern in controls with diminished connectivity on the side ipsilateral to seizure onset, also not seen in patients with extratemporal epilepsy. This connectivity in memory networks revealed with fcMRI analysis appears to be sufficiently robust, to be clinically applicable in assessment of both adult and pediatric subjects with epilepsy, warranting further study to correlate with Wada and neuropsychiatric testing.

**Key Words:** Functional connectivity, hippocampal sclerosis

**Poster 129**

Radiation Dose and Developmental Differences in Deep Gray Matter Nuclei Tissue in Healthy Children and Patients Treated with Brain Radiation

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**Purpose**

Whole-brain radiation therapy (RT) has improved survival among children with brain malignancies. However, RT can generate an array of adverse effects associated with a range of clinical pathologies, including neurocognitive deficits. The aim of this prospective study was to evaluate changes in deep gray matter integrity and related neuropsychologic performance among patients receiving brain radiation.

**Materials & Methods**

Nine pediatric patients (7 boys; mean age 11.8 ± 3.8 years) who received brain radiation were examined. The control group was comprised of nine healthy children (2 boys; 11.2 ± 1.8 years). The patients were examined at four visits: before or early in the course of RT, at 6, 15, and 27 months following completion of RT. Controls were examined at the same time intervals. Gray matter DTI data were acquired at 1.5 T with 15 noncollinear diffusion gradient directions (b = 1000 s/mm²). The following parameters were used: 24 axial slices (5 mm, no gap), 96*96 acquisition matrix, FOV 240 mm. Apparent diffusion coefficient (ADC), axial and radial diffusivities were calculated using “DTI Studio” in the following regions-of-interest: thalamus, globus pallidus, putamen, caudate head, and hippocampal head. Radiation dose to each individual region was calculated using Pinnacle software. Linear mixed effects models analysis was applied for statistical evaluations.

**Results**

The overall analysis revealed higher ADC and axial and radial diffusivities in patients than controls (p = 0.025, 0.005, and 0.017, respectively). In the individual regional analysis, the mean ADC was significantly higher in patients than in controls at all visits in the putamen and caudate, and the first and last visits in the hippocampal head (all p < 0.05). Among examined regions, the most prominent effects of radiation doses on diffusivity were detected at the 6 and 27 month follow ups, with no general pattern relating DTI measurements and regional radiation dose. Compared to healthy children, patients tended to perform better at all time points on neuropsychologic tests of dexterity, memory, and motor persistence and inhibition. All subjects improved their performance on these tests over time.

**Conclusion**

In normal development, mean diffusivity of deep gray matter decreases with age. In our study, a significant increase in the mean ADC calculated over time from five separate
Brain Metabolism in Autism and Relation to Disease Severity

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PURPOSE
There is strong evidence that autism is associated with abnormal brain development, but the nature of this aberrant neurodevelopment is not well characterized. Disorders of the amygdala, hippocampus and cerebellum play an important role in the characteristic cognitive and emotional dysfunction in patients with autism. The aim of this study is to evaluate the neurobiologic abnormalities in autistic children, using magnetic resonance spectroscopy (MRS) to evaluate the major brain metabolites in the left cerebellum (C) and left amygdala-hippocampus (AH) regions and to assess their relevance to the severity of the disease.

MATERIALS & METHODS
Twenty autistic children (17 males and 4 females, age ranging from 3 to 12 years old) were recruited from the genetics clinic and were enrolled in the study. They were seven mild, seven moderate and seven severe cases of children with autism rated according to the Childhood Autism Rating Scale (CARS). Seven healthy gender- and age-matched children served as controls. Patients and controls were subjected to detailed history taking, clinical examination and pedigree construction. Single voxel short echo MRS was performed for all autistic participants. Ratios of the major metabolites: N-acetyl aspartate (NAA), choline (Cho), creatine (Cr), and myoinositol (mI) were compared between the four groups.

RESULTS
The MRS results revealed that NAA/Cho in the C region, NAA/Cr in AH region were significantly lower (P = 0.009, 0.03), while Cho/Cr in the C region was significantly higher (P = 0.002) among patients compared to controls. The mean values of NAA/Cho and NAA/Cr in the C region were significantly lower among patients with moderate as compared to mild autism (P = 0.009, 0.001 respectively), and in severe as compared to mild autism (P = 0.02, 0.03 respectively). Meanwhile, the mean value of Cho/Cr in C region was significantly higher among patients with severe as compared to mild autism (P = 0.007) and mI/Cr in AH region was significantly higher among patients with severe as compared to mild autism (P = 0.007) and mI/Cr in AH region was significantly higher among patients with severe as compared to mild autism (P = 0.007). However, there were no significant differences in metabolites ratios between patients having moderate and those with severe autism. In the C region, the NAA/Cr ratio showed significant negative correlation, while Cho/Cr ratio showed significant positive correlation with the degree of severity of autism.

CONCLUSION
This study highlights changes of the major brain metabolites in autistic children which correlate with the severity of the disease. MR spectroscopy can be a helpful tool in the follow up and the understanding of the pathophysiology of autism which will lead to the development of new therapeutic approaches.

KEY WORDS: Autism, MRS, brain metabolites

Quantification of Optic Canal Stenosis Reversal after Hematopoietic Stem Cell Transplantation in Pediatric Patients with Osteopetrosis as Measured on CT and MR Imaging

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PURPOSE
Osteopetrosis is a rare but devastating inherited disorder of excessive bone formation due to osteoclastic dysfunction. Visual loss secondary to optic canal stenosis is a debilitating symptom, and often the initial presentation of osteopetrosis. Hematopoietic stem cell transplantation (HSCT) is the only known durable treatment of osteopetrosis, first reported to be successful in humans in 1980. Visual loss is noted to improve after HSCT but the mechanism remains unclear; the most common purported mechanism is reversal of optic canal stenosis with associated CN II decompression. However, the efficacy of HSCT in reversing optic canal stenosis is not well studied, with only one case report of a single patient described in the American Journal of Ophthalmology. We believe this is the largest case series that quantifies the change in optic canal diameter before and after HSCT.

MATERIALS & METHODS
At our institution, 24 patients with severe osteopetrosis were treated with HSCT in the past 33 years. Of these, Five patients with childhood onset of disease (mean age at HSCT: 0.75 years) had suitable cross-sectional neuroimaging studies available for each patient. The optic canal diameter also was measured in 17 age-matched control patients (mean age: 2.24 years). Comparisons of the optic canal diameters before and after HSCT were performed.
RESULTS
The mean optic canal diameter in the five osteopetrosis patients before HSCT was 1.93 ± 0.50 mm compared to 2.53 ± 0.54 mm, indicating a 31% increase after HSCT (p < 0.01). In the control population, the mean optic canal diameter was 3.86 ± 0.49 mm.

CONCLUSION
Optic canal diameters increased after HSCT in patients with osteopetrosis, but optic canal diameter measurements did not return to the average values measured in age-matched controls over the study interval. It remains uncertain if the optic canals of osteopetrosis patients will ever normalize after HSCT or remain smaller in diameter than those of unaffected patients. Follow up over several years may be necessary, but these data were unavailable for this study. Regardless, measurements of optic canal diameters prior to HSCT on cross-sectional neuroimaging studies of osteopetrosis patients will serve as a baseline for comparison on future studies after HSCT.

KEY WORDS: Optic canal, osteopetrosis

Poster 132
Adding to the Spectrum of Unusual Findings in a Rare Pediatric Neurocutaneous Syndrome: Head and Neck MR Angiography and MR Imaging in PHACE Syndrome

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PURPOSE
Head and neck vascular and structural abnormalities in PHACE are broad and our understanding regarding the phenotypic spectrum of the disease and frequency of different findings are largely derived from case series or case studies. Our goal was to systematically evaluate MR imaging (MRI) and MR angiography (MRA) head and neck images of children with PHACE syndrome to characterize the type and location of arteriopathy, to delineate associated intra and extracranial abnormalities and to estimate the prevalence of these findings.

MATERIALS & METHODS
After IRB approval was obtained from each of four participating institutions, MRI and MRA examinations of the head and neck in 20 patients meeting consensus diagnostic criteria for PHACE syndrome with at least one cerebrovascular or cardiovascular major criteria were reviewed and were reviewed for the presence of vascular, intracranial and extracranial abnormalities. All imaging was performed between March of 2000 and September of 2010. All studies were reviewed independently by two fellowship-trained pediatric neuroradiologists and one fellowship-trained pediatric vascular and interventional radiologist. Differences in interpretation were resolved by consensus.

RESULTS
Patient age at time of imaging ranged from 2 days to 4 years old. By study design, arteriopathy was observed in all patients. Tortuosity was the most common finding seen in 60% (12/20) of subjects and ectasia (30%) was the second most common finding. Interestingly, a characteristic focal tortuosity was seen at the junction of the cervical and petrous portions of the ICA in 30% (Figure). Neck findings included coarctation of the aorta in (35%), aberrant right subclavian artery in (25%), low common carotid artery bifurcation (20%), and ICA nonvisualization or long segment narrowing (20%). A focal notching/indentation of the cerebral peduncles was seen in 20%. Notable intra and extracranial findings included cerebellar hypoplasia (25%), internal auditory canal (IAC) hemangiomas (20%), orbital coloboma or staphylocoma (15%) and ischemic infarcts (15%) as have been noted previously in children with PHACE.

CONCLUSION
Our retrospective study of 20 children with PHACE syndrome revealed an incidence of common arterial and brain structural findings similar to that published in the literature with additional features including focal notching of the cerebral peduncles and focal tortuosity of the internal carotid arteries at the junction of the cervical and petrous segments as additional characteristic but not diagnostic features of PHACE syndrome.

KEY WORDS: PHACE, hemangioma, MR imaging
Poster 133

Agenesis of the Olfactory (CN I) and Abducens (CN VI) Nerves in WAGR Syndrome

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Purpose
To characterize the cranial nerve abnormalities associated with WAGR (Wilms tumor, aniridia, genitourinary abnormalities, mental retardation), a syndrome caused by heterozygous contiguous gene deletions in the chromosome 11p13 region.

Materials & Methods
MR imaging (MRI) of 21 patients (age 6-28 years) with clinical WAGR syndrome was performed at 3 T. Lower cranial nerves were assessed using axial 3D BFFE with ~0.3×0.3×0.8 mm resolution. Olfactory grooves were assessed using coronal 2D STIR and 3D FSE T2 with ~0.3×0.3×2.0 mm resolution. The deletions of the 11p chromosome were characterized by oligonucleotide array comparative genomic hybridization. Olfaction was assessed using the Smell Identification Test.

Results
Absence of cranial nerves was identified in seven patients. Unilateral absence of CN I was identified in one patient (Figure 1A, CN I present only on right - white arrow), who had moderate microsimia. Bilateral absence of CN I was identified in four patients, of whom two had anosmia and two could not have olfactory testing due to severe cognitive impairment. The olfactory fossae were variably developed in these five patients. Normal pubertal onset as well as normal gonadotropin and sex steroid levels excluded Kallmann syndrome. Unilateral absence of CN VI was identified in four patients (Figure 1B, CN VI present only on right - black arrow). Bilateral absence of CN VI was not identified. Clinical examination corroborated an absence of lateral gaze (Duane syndrome) in these cases. Despite the unilateral absence of CN VI, no asymmetry of the lateral rectus muscles was noted. Two patients had bilateral CN I absence together with a unilateral CN VI absence. All seven patients had de novo chromosome 11p13 deletions encompassing a shared 3.14 Mb region encompassing nine known genes in common, including PAX6, WT1, and PRG64.

Conclusion
Agenesis of CN I and CN VI is not uncommon in WAGR syndrome. The olfactory nerve agenesis in WAGR is not associated with hypogonadotropic gonadotropism, and therefore is distinct from Kallmann syndrome, associated with genes on Xp22 (KAL1), 8p11 (FGFR1), 3p21 (PROK2), and 20p13 (PROKR2). Duane syndrome, isolated agenesis of CN VI, is associated with genes on 8q13, 20q13 (SALL4), and 2q31 (CHN1). These cases of WAGR demonstrate a unique conjunction of CN I and CN VI agenesis and indicate the essential role of genes in the 11p13 region in the development of these cranial nerves.

Acknowledgment: This research was supported by the Intramural Research Program of the National Institutes of Health.

Key Words: Congenital, cranial nerves, development

Poster 134

Associations of Congenital Microcephaly with Simplified Gyral Pattern

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Purpose
Primary microcephalies are incompletely understood malformations that often are associated with developmental brain anomalies. It is known that some primary microcephalies show an abnormally simplified gyral pattern without thickening of the cerebral cortex; this group has been referred to as microcephaly with simplified gyral pattern (MSG). This study reviewed and analyzed a large number of MR imaging (MRI) scans of children with microcephaly to determine the frequency of associated morphologic findings including the gyral pattern and to assess whether these findings were associated with the severity of the microcephaly.

Materials & Methods
MR images of 119 patients with clinically diagnosed microcephaly were reviewed retrospectively (56 males and 57 females, ranging in age from 1 day to 30 years old). All
examinations in this study included at least one T1-weighted sagittal imaging sequence with section thickness of 5 mm or less, and one T2-weighted axial imaging sequence with sections of 5 mm or less. We focused on the degree of microcephaly and simplification of gyri. Degree of microcephaly was analyzed visually using midsagittal T1-weighted images to assess the craniofacial ratio (ratio of the area of the intracranial structures to the area of the face) and classified three grades; mild, moderate and extreme microcephaly. We evaluated simplification of gyri comparing the width of the gyri and the depth of the sulci on axial and sagittal images. The gyral pattern was classified as one of four grades; normal, mildly, moderately and severely simplified gyral pattern. Additionally, white matter volume, abnormalities of corpus callosum, size and structure of posterior fossa contents, and myelination were assessed on each MR images. Associations among the findings were evaluated using the Spearman correlation coefficient and the Fisher exact test.

RESULTS
Among seven patients with mild, 42 with moderate, and 70 with extreme microcephaly, more severe microcephaly was significantly correlated with greater simplification of gyration and greater diminution of white matter volume. The severity of callosal anomaly showed a lower, but still significant, correlation with the severity of microcephaly. Degree of hypoplasia of posterior fossa structures, delay in myelination, and abnormality of basal ganglia did not correlate with the degree of microcephaly.

CONCLUSION
A strong correlation was found between the degree of microcephaly, the volume of white matter, and the severity gyral pattern simplification. These associations should be considered when attempting to use neuroimaging characteristics to segregate and classify patients with microcephaly, as they may confound the classification.

KEY WORDS: Primary microcephaly, congenital microcephaly, simplified gyral pattern

Poster 135
Assessment of Tuberous Sclerosis Complex Tuber Types Using Diffusional Kurtosis Imaging

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PURPOSE
To quantitatively characterize the in vivo microstructure of tuber lesions (L) as compared to perilesion tissue (P) and normal-appearing contralateral perilesion tissue (CP) in three tuber types correlated to symptom severity (type C > B > A) in tuberous sclerosis complex (TSC) patients using metrics derived from diffusional kurtosis imaging (DKI).

MATERIALS & METHODS
Six TSC patients (2 w/refractory epilepsy, 2 w/history of seizures, 1 w/no seizures) ages 2.23 - 10.17 years, were recruited from the NYU Langone Medical Center. Whole brain T1-weighted magnetization-prepared rapid acquisition gradient-echo (MPRAGE), T2-weighted, fluid-attenuated inversion recovery (FLAIR) and DKI images were acquired at 3 T. Parametric maps for mean kurtosis (MK), axial kurtosis (K_{||}), radial kurtosis (K_{perpendicular}), fractional anisotropy (FA), mean diffusivity (MD), axial diffusivity (D_{||}) and radial diffusivity (D_{perpendicular}) were calculated using diffusional kurtosis estimator. Fluid-attenuated inversion recovery and MPRAGE images were registered to maps using ART2. Tuber types were identified as previously described. An oval region of interest (ROI) was drawn within the identified lesion on the registered FLAIR in one slice where there was normal-appearing tissue in the contralateral region. The same ROI was replicated over the perilesion region adjacent to the lesion boundary and over the contralateral region matching the perilesion location for control. All ROIs had the same shape and area; they were sampled from WM and applied to maps to obtain metric means.

RESULTS
In all tuber types, lesions are associated with a significant increase in diffusivity (indicated by MD most strongly in the radial direction) and a significant decrease in diffusional heterogeneity (indicated by MK). Lesion anisotropy (indicated by FA) is decreased significantly in types B and C. Mean diffusivity and MK are decreased significantly in both axial and radial directions in type C. Perilesion tissue does not differ significantly from normal contralateral tissue in all types. Compared to lesion, perilesion tissue diffusivity and heterogeneity differs significantly in types A and B but not in type C. This suggests perilesion tissue heterogeneity in type C is more similar to lesion tissue.

***p<0.001, **p<0.01, *p<0.05
1 way ANOVA, Bonferroni corrected
**Conclusion**

Degree of aberrant metric trends in the lesion and perilesion tissue generally increases from tuber types A to C corresponding to dominant types of increasing symptom severity. Given the very small cohort, interpretation of these results should be made with caution thus future analysis will include more subjects.

**Key Words:** DKI, TSC, diffusion

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**Poster 136**

Assessment of Dynamic Leakage on MR Perfusion Imaging in Patients with X-Linked Adrenoleukodystrophy before and after Bone Marrow Transplantation

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**Purpose**

The leading edge (LE) of contrast enhancement in cerebral X-linked adrenoleukodystrophy (ALD) is thought to relate to ongoing demyelination/inflammation with enhancement attributed to blood-brain barrier (BBB) disruption. For dynamic susceptibility contrast MR perfusion (DSC-MRP), contrast leakage into the extracellular space via a disrupted BBB has been well established, and thus presence or absence of dynamic leakage (DL) can serve as a marker of BBB integrity. The purpose of this study was to measure DL in various regions affected by ALD pre- and post-bone marrow transplant (BMT).

**Materials & Methods**

After IRB approval, DSC-MRP was performed using a 3 T unit in seven patients with posterior-type ALD prospectively <30 days prior to and 30-60 days post-BMT. Using coregistered postcontrast 3D T1-weighted images, region of interests (ROIs) were drawn by a staff neuroradiologist around the LE, centrally within visually affected parieto-occipital white matter (POWM), corpus callosal splenium (SpCC) and visually unaffected frontal white matter (FWM). Dynamic leakage was measured within each ROI and comparisons were made between pre- and post-BMT values. Dynamic leakage also was measured in seven control patients in similar locations (excluding LE, since not present). A separate ROI also was drawn around the visually abnormal region on the DL images and around the LE, and the mean areas of these two ROIs were recorded (cm$^2$).

**Results**

Dynamic leakage was absent/zero in seven control patients in all ROIs. Prior to BMT, DL was positive (>0.00) in the LE of all seven patients (range 0.01-0.02); specifically, DL was positive within POWM in one, SpCC in two, and absent/zero within visually unaffected FWM in all seven patients. Dynamic leakage was measured within each ROI and comparisons were made between pre- and post-BMT values. Dynamic leakage also was measured in seven control patients in similar locations (excluding LE, since not present). A separate ROI also was drawn around the visually abnormal region on the DL images and around the LE, and the mean areas of these two ROIs were recorded (cm$^2$). The mean was 3.2 cm$^2$, which highly correlated ($r=0.987$, $p<0.0001$). At follow up, the DL had visually nearly disappeared and was not measurable in all seven patients.

**Conclusion**

The LE of contrast enhancement in ALD involves BBB dysfunction, as evidenced by positive DL measurement pre-BMT on DSC-MRP. Following BMT, the resolution/reduction of DL associated with reduction in LE enhancement suggests improvement in BBB integrity. The slightly greater area of DL pre-BMT as compared to the LE suggests a small zone of milder BBB dysfunction or potentially reversible early injury.

**Key Words:** Leakage, adrenoleukodystrophy

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**Poster 137**

Time to Extinction of Contrast Enhancement Predicts Better Outcome after Hematopoietic Stem Cell Transplant in X-Linked Adrenoleukodystrophy

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**Purpose**

X-linked adrenoleukodystrophy (X-ALD) is the most common peroxosomal storage disease, leading to very long chain fatty acid (VLCFA) accumulation in the cells of the brain, adrenals, and testes. Patients typically present in childhood. When present, cerebral disease generally begins in typical locations, more commonly the corpus callosum, extending into the adjacent white matter. To date, the only curative treatment is hematopoetic stem cell transplantation (HSCT). MR imaging (MRI) staging with Loes scores has shown diagnostic and prognostic significance. In this study we correlate gadolinium contrast enhancement with Loes scores in post-HSCT X-ALD patients.

**Materials & Methods**

Eighty-six X-ALD patients were evaluated at the University of Minnesota Bone Marrow Transplant clinic extending from 2000-2010. All available MRI images were analyzed and assigned a Loes score based on the currently defined criteria, and a gadolinium enhancement score using a new formula unique to this study. Thirty-five patients had sufficient
MRI pre-HSCT (within 30 days), follow-up MRI within the first 60 days, 60-100 days post-HSCT, and 1 year. Patients were divided into groups based on time of extinguishment of enhancement. Group 1 was defined as absence of enhancement on the first post-HSCT study, group two extinguished by the 60-100 day MRI, and group 3 greater than 100 days or persistent enhancement.

RESULTS
Loes scores increased an average of 2.03 when enhancement was extinguished by the first post-HSCT MRI, 3.46 for days 60-100, and 3.69 for those extinguishing >100 days or longer. Total Loes score at 1 year post-HSCT showed significant difference between groups 1 and 2 (p<0.01), and between groups 1 and 3 (p=0.01), but not group 2 compared to 3 (p>0.05). Also, the delta Loes scores were not significant (p>0.05).

Figure 1: Average Loes scores for all patients in individual categories. The first bar indicates the average Loes scores for the pre-HSCT MRI. The second shows the average at approximately 1 year. The third bar indicates Pre-Post (delta) Loes score. Data were analyzed using pooled t-tests comparing groups. Group 1 n=15, Group 2 n=12, Group 3 n=8.

CONCLUSION
We believe that for most X-ALD patients, blood-brain barrier (BBB) disruption (and enhancement on MRI) is associated with active demyelination. Prolonged enhancement after HSCT allows more time for demyelination to progress, and this progression can be measured using the objective Loes scale. When enhancement extinguished on the first post-transplant study, patients did better than those when contrast persisted 2 months or longer.

KEY WORDS: Adrenoleukodystrophy, contrast, enhancement

Poster 138
MR Imaging Appearances in Two Cases of Infantile Refsum’s Disease
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PURPOSE
Infantile Refsum disease (IRD) is a rare peroxisomal disorder inherited in an autosomal recessive fashion. The predominant clinical features of IRD are visual impairment, chronic progressive polyneuropathy and cerebellar ataxia. Associated clinical problems include anosmia, sensorineural deafness, cardiomyopathy, skin rash, bone deformities and renal dysfunction. Magnetic resonance (MR) imaging of the brain has not been well documented in this disorder. The paucity of MR features in the literature reflects the rarity of IRD. We present two cases of IRD.

MATERIALS & METHODS
MR sequences included axial T2-weighted (TE 83.2/TR 3000), axial FLAIR (TE 109.6/TR 10000/T1 2200), T1-weighted volume (TE 4.6/TR 16.0), diffusion-weighted and postgadolinium T1-weighted imaging. Single voxel MR spectroscopy also was captured.

RESULTS
The first case demonstrated high T2 and low T1 signal in the corticospinal tracts of the ventral midbrain and pons, dentate nuclei, the middle cerebellar peduncles, anterior pons and medulla bilaterally. Moderate atrophy of the pons, middle cerebellar peduncles, dentate nuclei and cerebellar folia was present. Patchy enhancement was seen on postgadolinium images in the ventral pons and dentate nuclei. Supratentorial findings included delayed myelination, diffuse increased T2 signal in the centrum semiovale and corona radiata, and mild generalized atrophy. Diffusion imaging and MR spectroscopy were normal. The second case demonstrated high T2 signal in the pons, ventral aspect of the medulla and midbrain. Prominent involvement of the periorlionic regions bilaterally, with pre and postcentral gyral swelling also was present. Signal change included the postero-lateral margin of the thalami and the corticospinal tracts through the cerebral peduncle. The cerebellum was diffusely atrophic with T2 signal hyperintensity of the superior cerebellar peduncles. Postcontrast imaging showed enhancement along the path of the corticospinal tracts from the central pons superiorly to the corona radiate. Spectroscopy over the left basal ganglia was nonspecifically abnormal with reduction in NAA and mildly elevated choline and creatinine peaks. There was no lactate peak.

CONCLUSION
Infantile Refsum disease is an extremely rare disorder of peroxisomal function with extensive neuroimaging abnormalities. In both cases involvement of the ventral corticospinal tracts of the pons and midbrain was demonstrated and this may be an important diagnostic feature of this condition. The first case showed predominant involvement of the corticospinal tracts inferior to this, while the second case showed more supratentorial involvement. Diffusion-weighted imaging and MR spectroscopy were unremarkable. Enhancement was demonstrated in both cases as would be expected with active peroxisomal diseases.

KEY WORDS: Refsum’s
Primary Small Vessel Central Nervous System Vasculitis in a Young Female

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Purpose
Primary angiitis of the central nervous system in childhood (cPACNS) is a reversible, rare cause of severe neurologic impairment in the pediatric population. This entity is classified into different subtypes based on distinct radiologic, histopathologic and clinical features, each with different prognoses and treatments. We will discuss clinical and radiologic findings in a 9-year-old female with small vessel primary central nervous system vasculitis, who presented with anisocoria and panuveitis. MR imaging findings include a subependymal miliary pattern of enhancement that has, to our knowledge, not been described previously in association with cPACNS. We also will discuss briefly MRI and angiographic findings in other subtypes of this rare disorder.

Materials & Methods
The clinical data and laboratory findings including rheumatologic, microbiologic and biopsy specimens of a child treated for small vessel variant cPACNS were reviewed retrospectively. Imaging modalities reviewed included MR imaging of the brain and cervical, thoracic, and lumbar spine. Review of the relevant literature was performed.

Results
An 8-year-old otherwise healthy female presented to emergency department with anisocoria and nonreactive pupils. Fundoscopic examination revealed bilateral uveitis/choroiditis. Following MR images of brain and cervical spine demonstrated scattered foci of T2/FLAIR high signal abnormality in deep white matter, brain stem and cerebellar hemisphere with postcontrast enhancement and a distinctive subependymal and periventricular distribution suggestive of neurosarcoidosis, atypical lymphoma, Lyme disease, vasculitis or miliary tuberculosis. A multidisciplinary clinical approach ruled out infectious or rheumatologic etiologies, secondary central nervous system vasculitis, and disseminated lymphoma. Treatment with steroids was initiated for possible sarcoidosis with a good clinical response. However, upon discontinuation of therapy, the patient deteriorated and her symptoms recurred. A leptomeningeal and parenchymal biopsy showed small vessel variant cPACNS system.

Conclusion
Inflammatory central nervous system diseases in children comprise a wide spectrum of heterogeneous conditions, including primary angiitis of the central nervous system. Two subcategories of cPACNS include: angiography-positive cPACNS affecting large and medium-sized vessels, and angiography-negative cPACNS involving small-sized vessels, like the case we are presenting. These subcategories are different in clinical presentation, radiographic findings, prognosis, and treatment. The classic MRI findings in large and medium-sized vessels cPACNS are focal areas of acute ischemia in a vascular distribution. Conventional angiography and MR angiography demonstrates stenosis, tortuosity, beading, and occlusion of the proximal large and medium-sized vessels. Brain biopsy usually is not required due to the specificity of angiographic abnormalities in the pediatric population. Angiography-negative cPACNS, on the other hand, is a distinct clinical entity with different radiologic findings. MR imaging findings in angiography-negative cPACNS are typically multifocal and can involve both gray and white matter. Lesions are not restricted to the vascular territory of a large vessel. The paucity of diffusion restriction and presence of gadolinium enhancement suggest that lesions are inflammatory rather than ischemic. Leptomeningeal enhancement, if present, distinguishes cPACNS from demyelinating diseases. Conventional angiography is, by definition, negative in this subtype. The diagnosis of angiography-negative childhood primary angiitis of the central nervous system mandates an elective brain biopsy.

Materials & Methods
The clinical data and laboratory findings including rheumatologic, microbiologic and biopsy specimens of a child treated for small vessel variant cPACNS were reviewed retrospectively. Imaging modalities reviewed included MR imaging of the brain and cervical, thoracic, and lumbar spine. Review of the relevant literature was performed.

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Inflammatory central nervous system diseases in children comprise a wide spectrum of heterogeneous conditions, including primary angiitis of the central nervous system. Two subcategories of cPACNS include: angiography-positive cPACNS affecting large and medium-sized vessels, and angiography-negative cPACNS involving small-sized vessels, like the case we are presenting. These subcategories are different in clinical presentation, radiographic findings, prognosis, and treatment. The classic MRI findings in large and medium-sized vessels cPACNS are focal areas of acute ischemia in a vascular distribution. Conventional angiography and MR angiography demonstrates stenosis, tortuosity, beading, and occlusion of the proximal large and medium-sized vessels. Brain biopsy usually is not required due to the specificity of angiographic abnormalities in the pediatric population. Angiography-negative cPACNS, on the other hand, is a distinct clinical entity with different radiologic findings. MR imaging findings in angiography-negative cPACNS are typically multifocal and can involve both gray and white matter. Lesions are not restricted to the vascular territory of a large vessel. The paucity of diffusion restriction and presence of gadolinium enhancement suggest that lesions are inflammatory rather than ischemic. Leptomeningeal enhancement, if present, distinguishes cPACNS from demyelinating diseases. Conventional angiography is, by definition, negative in this subtype. The diagnosis of angiography-negative childhood primary angiitis of the central nervous system mandates an elective brain biopsy.

Key Words: Vasculitis, small vessel, CNS

Pediatric Demyelinating Disease on Susceptibility-Weighted Imaging

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Purpose
In adults with multiple sclerosis (MS), demyelinating lesions can be associated with hypointense signal on susceptibility-weighted imaging (SWI) (Haacke, et al, 2009). The purpose of this study was to assess the utility of SWI in identifying demyelinating lesions in the pediatric population and determine if the prevalence of SWI findings correlates with the type of disease (i.e., MS versus acute disseminated encephalomyelitis, ADEM), disability as measured by the Extended Disability Status Score (EDSS), or age.

Materials & Methods
Nine children were enrolled prospectively. Diagnosis was determined by a pediatric neurologist after 1 year of follow up. The neurologist was blinded to the imaging results. Five patients had MS and four had ADEM. MR images were reviewed using standard clinical software. Susceptibility-weighted imaging, T1 pre and postcontrast, and FLAIR images were coregistered using a semiautomated technique. Size, location, and enhancement of each FLAIR hyperintense lesion were documented. Each FLAIR lesion also was assessed for its SWI characteristics.

Results
Total FLAIR lesions identified ranged from five to 146, and the percentage of these lesions visible on SWI ranged from zero to 68 percent. When visible on SWI, the lesions appeared as amorphous hypointense lesions, linear hypointensities, or as a combination of these features (Figure). There was a trend (p=.06) between final diagnosis and the percentage of lesions visible on SWI. The median percentage of lesions detected on SWI for those with MS was 22% and for those with ADEM was 8%. Both age
(Spearman correlation=0.78, p=.0007) and EDSS (Spearman correlation=0.36, p=.028) were correlated with the percentage of lesions detected on SWI.

RESULTS

<table>
<thead>
<tr>
<th>Age at presentation</th>
<th>Age at time of MRI</th>
<th>EDSS</th>
<th>Final Diagnosis</th>
<th>FLAIR lesions</th>
<th>SWI lesions</th>
<th>Percentage visible on SWI (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>16</td>
<td>0</td>
<td>MS</td>
<td>22</td>
<td>4</td>
<td>18</td>
</tr>
<tr>
<td>15</td>
<td>18</td>
<td>0</td>
<td>MS</td>
<td>146</td>
<td>50</td>
<td>34</td>
</tr>
<tr>
<td>15</td>
<td>15</td>
<td>0</td>
<td>MS</td>
<td>20</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>17</td>
<td>20</td>
<td>0</td>
<td>MS</td>
<td>9</td>
<td>2</td>
<td>22</td>
</tr>
<tr>
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<td>16</td>
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<td>MS</td>
<td>90</td>
<td>22</td>
<td>24</td>
</tr>
<tr>
<td>4</td>
<td>14</td>
<td>0</td>
<td>ADEM</td>
<td>28</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>5</td>
<td>5</td>
<td>0</td>
<td>ADEM</td>
<td>5</td>
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<tr>
<td>5</td>
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<td>1</td>
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<td>12</td>
<td>1</td>
<td>8</td>
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<tr>
<td>17</td>
<td>17</td>
<td>6</td>
<td>ADEM</td>
<td>100</td>
<td>68</td>
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</table>

CONCLUSION

Susceptibility-weighted imaging can identify some demyelinating lesions in the pediatric population. The percentage of FLAIR lesions visible on SWI is correlated with age. Susceptibility-weighted imaging signal changes were present for all but one patient with MS, while only one of the patients with ADEM demonstrated significant findings on SWI. That particular ADEM patient was significantly older than the typical ADEM cohort. These findings suggest that SWI may offer additional information regarding the underlying pathophysiology of demyelinating diseases. A larger study is warranted to further evaluate its diagnostic and prognostic utility.

KEY WORDS: Multiple sclerosis, ADEM, susceptibility

Poster 141

Early Delayed Effects of Brain Radiation on Lobar Gray and White Matter Volumes of Pediatric Patients with Correlative Neuropsychologic Deficits

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PURPOSE

The aim of this longitudinal volumetric MR imaging (MRI) study was to evaluate changes in gray matter (GM) and white matter (WM) lobar volumes and neuropsychologic performance among children who received brain radiation, with the focus on early-delayed effects.

MATERIALS & METHODS

Thirteen pediatric patients who received brain radiation were examined at the initiation and 6 months after completion of radiation therapy. Control group consisted of 40 normally developing children. Lobar gray and white matter volumes were calculated from 3D-SPGR images acquired at 1.5 T. Linear mixed effects (LME) models analyses [with factors group, age at baseline (age0), visit number, and sex] were used to evaluate early delayed effects of radiation on lobar GM and WM volumes, controlling for total brain volume. All participants completed a neuropsychologic assessment at both visits, including measures of attention, executive function, memory, language, and visual and motor skills.

RESULTS

The table lists results of the overall LME analyses (p values for main effects and their interactions). In controls, no differences in lobar GM or WM volumes between the baseline and follow-up visits were detected. Lobar GM volumes of patients measured at baseline were nonsignificantly higher compared to controls and increased at the 6-month follow up within the frontal (6%) and temporal (6%) lobes. Lobar WM volumes at baseline did not differ between patients and controls. In patients significantly decreased WM volumes were demonstrated in the frontal, temporal and occipital lobes at the 6-months follow up (p<0.05; mean frontal lobar volumes are shown in the Figure). Neuropsychologic testing demonstrated significant impairment on visual selective attention, verbal working memory, verbal recall, and motor speed in patients (p<0.001 compared with controls). Children receiving radiation treatment at younger ages had the most significant deficits (group x age: p≤0.001).

<table>
<thead>
<tr>
<th>Group</th>
<th>Age0</th>
<th>Visit</th>
<th>Group*Visit</th>
<th>Age0*Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>GM</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frontal</td>
<td>NS</td>
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<td>&lt;0.0001</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Parietal</td>
<td>NS</td>
<td>&lt;0.0001</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Temporal</td>
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<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Occipital</td>
<td>NS</td>
<td>0.004</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>WM</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frontal</td>
<td>0.049</td>
<td>&lt;0.0001</td>
<td>NS</td>
<td>0.038</td>
</tr>
<tr>
<td>Parietal</td>
<td>0.036</td>
<td>0.039</td>
<td>0.009</td>
<td>NS</td>
</tr>
<tr>
<td>Temporal</td>
<td>NS</td>
<td>&lt;0.0001</td>
<td>0.018</td>
<td>NS</td>
</tr>
<tr>
<td>Occipital</td>
<td>NS</td>
<td>NS</td>
<td>0.02</td>
<td>NS</td>
</tr>
</tbody>
</table>
CONCLUSION
The current study demonstrates significant reductions in lobar WM and increases in lobar GM volumes of pediatric patients 6 months following radiation therapy. These results are in agreement with previous studies showing that radiation induces predominantly WM loss and patients receiving radiation therapy initiated at younger ages have the most significant deficits. The unexpected finding of gray matter volume increase needs further investigation.

KEY WORDS: MR imaging, radiation therapy, neuropsychologic testing

Poster 142
MR Perfusion at 3.0 T in X-Linked Adrenoleukodystrophy Pre and Posthematopoetic Cell Transplantation: A Preliminary Study

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PURPOSE
Dynamic susceptibility contrast MR perfusion (DSC-MRP) has become an important tool for diagnosis and understanding the physiology of cerebrovascular disease and neoplasms. To our knowledge, other than a preliminary meeting report, there is no literature utilizing MRP in posterior-type X-linked adrenoleukodystrophy (ALD). Thus, our goal was to determine MRP characteristics in ALD pre and posthematopoetic cell transplantation (HCT) in various regions of interest (ROIs), and to compare these values to controls.

MATERIALS & METHODS
After IRB approval, seven patients underwent DSC-MRP at 3.0 T <30 days pre-BMT and 30-60 days post-HCT. MR perfusion postprocessing was performed on a DynaSuite Neuro workstation (InVivo, Orlando, Florida). The pre/postcontrast MPRAGE T1-weighted imaging and FLAIR images were coregistered to the MRP maps, and the following ROIs measured: the total affected white matter (TAWM), centrally within the parietooccipital white matter (POWM), callosal splenium (SpICC), leading edge (LE) of contrast enhancement, and normal-appearing white matter (NAWM). Similar measurements were performed in seven controls. Relative measurements of rCBV, rCBF, rMTT, rTTP, and rPH (peak height) were calculated from these ROIs in ALD patients and controls, and compared using t-tests. Similar MRP measurements were performed post-HCT and compared to pre-HCT measurements and controls.

RESULTS
Normal-appearing white matter MRP values in ALD patients were not significantly different from NAWM in controls; within controls there was no significant difference between NAWM and either POWM or SpICC(all p>0.1). In ALD patients pre-HCT, rCBV was only minimally elevated in the TAWM and SpICC(mean 1.07-1.1), but was elevated significantly in the LE (mean 1.84), while being decreased in the POWM(mean 0.80); post-BMT, rCBV changed significantly only in the LE (mean 1.31, p<0.05). For rCBF, there were nearly normal values(near 1.00) in each ROI except for the LE (mean 1.75) pre-HCT; post-HCT, none of these ROIs changed significantly (all p>0.1). For MTT and TTP, the ROIs were quite variable, but the LE had decreased mean rMTT (-0.63sec) and rTTP (-0.83sec) pre-HCT as compared to NAWM; these improved post-HCT (-0.16sec and 0.10sec, respectively). The LE rPH was much higher pre-HCT(mean 1.92) as compared to POWM, SpICC, and total AWM (all about 1.0); this decreased slightly post-HCT (mean 1.57).

CONCLUSION
This preliminary study demonstrates that MRP findings in ALD are dynamic, being most prominent in the LE, suggesting blood-brain barrier dysfunction. The LE abnormalities appear to lessen after HCT. In addition, the low rCBV centrally within POWM both pre- and post-HCT may reflect irreversible injury.

KEY WORDS: Adrenoleukodystrophy, MR perfusion, hematopoetic cell transplantation
Poster 143

Vasogenic Edema Characterizes Acute Disseminated Encephalomyelitis in Children

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Pittsburgh, PA

PURPOSE
The aim of this study was to analyze the localized neuroimaging findings in children with acute disseminated encephalomyelitis (ADEM) and to evaluate the apparent diffusion coefficient (ADC) values in the pathologic brain during the acute phase of the disease.

MATERIALS & METHODS
Seventeen patients with ADEM were identified retrospectively. Patients meeting the diagnostic criteria for ADEM proposed by the International Pediatric Multiple Sclerosis Study Group were included in this study. MR imaging was performed in all patients at disease onset. MR images were evaluated for character and pattern of lesions by two expert neuroradiologists by consensus. All patients had ADC maps and 11/17 patients underwent contrast-enhanced MRIs at presentation.

RESULTS
Seventy percent (12/17) patients presented with vasogenic edema as demonstrated by the ADC map. Cytotoxic edema was observed in only one patient, four patients showed no change on diffusion-weighted imaging. Three of 11 (27%) patients showed enhancement in a scattered punctate fashion. 41.1% of patients presented with gray matter lesions the most common location being the bilateral frontal cortex. 82.4% of patients presented with white matter lesion, bilateral frontal subcortical location being the most common (41%), followed by the bilateral temporal lobes (35%) and the bilateral parietal lobes (23%). 64.7% of patients (11/17) displayed brainstem involvement. Optic tracts were involved in 53% (9/17) of patients. Sixty-six percent of the optic tract involvement was unilateral. Forty-one percent of patients (7/17) showed basal ganglia lesions. Thirty-five percent (6/17) of patients had a thalamic lesion of which 83.3% were bilateral. Twenty-three percent of patients had a lesion in the hypothalamus. Some of the atypical locations were mammillary bodies (one patient), corticospinal tracts (three patients) and corpus callosum (two patients). No patient had gray matter involvement in the cerebellum. Vasogenic edema was observed more frequently in association with white matter lesions (76% of patients) compared to gray matter lesions (71% of patients). Seventy-three percent of lesions in all locations were bilateral in location. Only optic tract involvement was unilateral in 66% of the affected patients.

CONCLUSION
Our study supports the hypothesis that the main pathophysiologic mechanism in ADEM is vasogenic edema, thus explaining in part the reversibility of the lesions. Children with ADEM are classically known to have varied imaging findings. Our study shows that though no location is spared from this multifocal distribution, the brainstem is the most common location followed in order by bilateral frontal white matter, bilateral basal ganglia, unilateral optic tract, bilateral temporal white matter, bilateral thalami, bilateral basal ganglia, bilateral parietal white matter, bilateral optic tracts and bilateral frontal gray matter. Involvement of the optic tract is emphasized as its clinical relevance has yet to be studied. Extensive knowledge of peculiar neuroimaging findings in children with ADEM may help in determining the diagnosis and understanding the pathophysiology of the disease.

KEY WORDS: Acute disseminated encephalomyelitis, vasogenic edema, demyelinating lesion

Poster 144

Chiari Malformation Correlates with Abnormal Cervical Spinal Canal Dimensions in Scoliotic Patients

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Madison, WI

PURPOSE
The association between Chiari malformations and scoliosis is well established. Recent studies also have suggested abnormal cervical spinal canal tapering in patients with Chiari malformation. We tested the hypothesis that, in patients evaluated for treatment of scoliosis, spinal canal dimensions differ between patients with and patients without an associated Chiari malformation.

MATERIALS & METHODS
We reviewed a registry of patients with known scoliosis and sorted patients into three groups: those with a Chiari malformation and syrinx, those with only a Chiari, and those with scoliosis and no Chiari or syrinx. We measured the AP diameter of the upper cervical spinal canal (C1-C4) on sagittal T2-weighted MR images of patients in all three groups using the same methods employed in the previous studies of the cervical spine. We then calculated the taper ratio, defined as the amount of narrowing of the AP diameter per cervical spine level. We made the same measurements in selected age- and gender-matched patients with MR studies read as normal. The differences between groups were tested with mean and measure of variability.

RESULTS
The taper ratio for scoliotic patients with Chiari malformation and syrinx was 0.9 mm per level. The scoliotic patients without a Chiari or syrinx malformation had smaller taper ratios. The control group had a taper ratio of 0.5 mm per level. The taper ratios averaged 0.9 (+/- 0.8) mm/level in those with both Chiari and syrinx versus 0.5 (+/- 0.4) mm/level in controls.

CONCLUSION
Scoliotic patients with a Chiari malformation and syrinx have abnormal tapering of the upper cervical spinal canal. This finding adds additional support to the theory that the Chiari malformation is related to a mesodermal developmental disorder.
KEY WORDS: Chiari, scoliosis, syrinx

Poster 145

Triangular Parietal Crossroads: Transient Structures of the Fetal Brain as Early Indicators of Cerebral Pathology

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PURPOSE

The integrity of transient structures of the fetal brain has been recognized as mandatory for normal fetal brain development. The so-called triangular crossroads have been described histologically as fiber-rich transient structures of the fetal brain with an abundant extracellular matrix content, situated lateral to the exit of the posterior limb of the internal capsule. Aim of this study was to characterize these structures on in vivo fetal MR images.

MATERIALS & METHODS

In vivo MRIs of 200 fetal brains between the 18th and 39th gestational week (GW) (median GW 27) were performed on a 1.5 T superconducting unit with a cardiac coil, using ultra-fast T2-weighted, T1-weighted, diffusion-weighted sequences and diffusion tensor imaging in three orthogonal section-planes. Fetuses were divided in two groups: one with normal brain development (n=100), and the second with pathologic brain development (n=100). In addition to the routine screening for normal or pathologic brain development, in each fetus the area lateral to the exit of the posterior or limb of the internal capsule also was assessed with respect to signal intensity, size and shape.

RESULTS

In fetuses with normal brain development we observed triangular-shaped areas with the basis of the triangle in the continuity of the posterior limb of the internal capsule, adjacent to the germinal matrix, and the tip oriented in the direction of the subplate. These zones appeared hyperintense to the subplate on T2-weighted images (Figure), and iso or hypointense on T1- and diffusion-weighted images. They developed and reached their maximum until GW 24, to fade eventually until the GW 28 and becoming isoointense with the adjacent structures at latest by the GW 30. The axial extent of the structures did not exceed 0.3 cm². In different pathologies, such as periventricular leukomalacia (n=6), metabolic diseases (n=1), or malformations (n=15) the triangles where larger as in normals, and/or showed CSF intensity, and/or persisted after the GW 28/30.

CONCLUSION

The transient MR features of the triangular crossroads may be explained with the high water content of the extracellular matrix, which gradually diminishes with ongoing cellular maturation, and thus then blurs with the surroundings. Increased signal-intensity/size or persistence probably reflects oxidative stress or impairment of fiber development in this region, due to a damage (or missing/incorrect formation) of the cells of origin. Normal triangular crossroads should not be misdiagnosed as ischemic lesions. Thus, this region seems to be an early indicator of the presence of cerebral pathology.

KEY WORDS: Crossroads, fetal MR imaging, cerebral pathology

Poster 146

Evolution of Brain MR Imaging Findings within the First Month after Coma Onset from Pediatric Cerebral Malaria

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PURPOSE

The pathogenesis of cerebral malaria (CM) remains elusive. Autopsy data have provided significant insights, but putative pathogenic mechanisms in survivors, who frequently suffer neurologic sequelae, are challenging to assess in malaria-endemic areas. An ongoing case series of brain MR images (MRIs) in pediatric CM reveals a complex heterogeneous set of findings at the time of admission to hospital. Here, we describe the evolution of brain MRI findings in the same patient population, describing findings on admission during the course of the acute illness, and 1 month later.

MATERIALS & METHODS

This prospective study was performed on consecutive children meeting the World Health Organization definition of CM (unarousable coma, asexual P. falciparum parasitemia and no other evident coma etiology) admitted to the Pediatric Research Ward at Queen Elizabeth Central Hospital in
Blantyre, Malawi. During two consecutive high transmission malaria seasons (2009/2010), 152 children with CM were enrolled, 120 of whom had malaria retinopathy. Institutional approval was obtained and parental consent was required to participate. All children were imaged on a GE 0.35 T Signa Ovation magnet on the day of admission and daily thereafter until they awoke or died. Follow-up scans were assessed at 1-month postdischarge. The following pulse sequences were used in 2009: Sag T1 FLAIR, Ax T2 FRFSE, Ax T2 FLAIR, Ax GRE, Cor T2 FRFSE, Ax EPI-DWI b=900, Ax PD, and +C Ax T1 sequences; and in 2010: Sag T1 FLAIR, Ax T2 FRFSE, Ax T1, Cor T2 FRFSE, Ax GRE, EPI-DWI b=200, EPI-DWI b=900, Sag 3D SPGR T1, Ax GRE (TE = 8.0, 11.5, 27.5, 31.0 & 47.0 ms) and +C Ax T1 sequences. Two radiologists, blinded to the retinopathy status of the patients, interpreted the acute and subsequent MRI studies together, and recorded the consensus findings using a semiquantitative scoring system.

RESULTS
Twenty-seven of the 120 children with retinopathy positive CM had more than one scan during the acute illness. Of the 120 patients 104 survived and 65 were able to be scanned 1 month later. In patients who were admitted shortly after the onset of coma, increased T2 signal in the basal ganglia was evident initially, and DWI abnormalities in the same area emerged over time. In patients with edema and high T2/high DWI signal changes in various regions on admission, the MRI findings either resolved rapidly (within 2 days), in conjunction with clinical recovery, or increased in severity, often in association with a fatal outcome. In 21 cases, the second and subsequent scans showed increased T2 signal in the corpor callosum and white matter. Frequently, the evolution of concomitant high T2 cortical signal and swelling was noted. An atypical finding was that high DWI signal usually underwent rapid and complete resolution without associated radiographic residua. At 1 month, generalized atrophy and/or persistent high T2 white matter signal abnormality were seen in 46/65 survivors scanned.

CONCLUSION
In acute pediatric CM, brain MRI findings evolve rapidly. As early as 1 month chronic changes indicative of brain injury, including diffuse cerebral atrophy often are evident.

KEY WORDS: Cerebral malaria, subacute, brain

Poster 147
Interparietal Occipital Fissure: A Normal Occipital Bone Ossification Pattern that Can Be Misdiagnosed as Fracture on Neonatal CT

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PURPOSE
This study was undertaken to determine the frequency, typical appearance, and natural history of an occipital bone ossification pattern, the interparietal occipital fissure, that can be mistaken for a fracture on CT in neonates. The interparietal occipital fissure was described briefly on radiography in a single patient with cleidocranial dysostosis in 1969. To our knowledge, there has been no other mention of this developmental variant in the radiology literature.

MATERIALS & METHODS
We retrospectively identified 214 consecutive patients from 0 to 90 days of age who had undergone head CT imaging between January 1, 2007 and September 30, 2009 using departmental electronic medical records. Common indications for CT examinations included: seizure, suspected intracranial hemorrhage, and infection. Patients with head trauma were included not excluded from review; however, there were no subjects with an occipital bone fracture. All CT examinations included axial 2.5 mm sections in bone windows that were reviewed by two radiologists with subspecialty training in pediatric neuroradiology. Four patients were excluded from review; therefore, a total of 210 patients were included in the final data set. Craniocephalic measurements of the interparietal occipital fissure were determined by counting the number of 2.5 mm slices in which the fissure was present, while transverse measurements of fissure width were made using electronic calipers. Twenty-two patients who demonstrated an intraparietal occipital fissure also had subsequent head CT performed at least 1 week after the index study.

RESULTS
Of the 210 patients included in our study (115 boys and 95 girls), 82% (n=173) demonstrated an interparietal occipital fissure. The mean age of our study population was 32.8 days (SD=27.5 d, range: 0-89 d) while the mean age of those with and without an interparietal fissure were 29.1 d (SD=25.8 d) and 50.4 d (SD=28.6 d), respectively. The mean craniocephalic length of the fissure was 8.4 mm (SD=4.2 mm, range: 2.5-22.5 mm); all fissures measured between 1 and 2 mm in width. In those 22 patients who demonstrated an interparietal occipital fissure and who had a follow-up CT examination, only three patients over 90 days old (Max: 179 days) still demonstrated this finding (two had evidence of interval partial ossification). The mean age at the time of follow up was 252.2 d (SD=208.4 d, range: 19-679 d).

CONCLUSION
Evaluation of neonatal calvarial fractures is complicated by variant sutures, fissures, and accessory ossicles. The interparietal occipital fissure represents one such variant that can be mistaken for a fracture by CT. This fissure can be identified as a midline lucency approximately 1-2 mm wide and extending caudally from the junction of the sagittal and lambdoid sutures between the superior portions of the paired interparietal portions of the occipital bone. The fissure does not extend into the supraoccipital segment of the occipital bone or to the foramen magnum, contrary to midline occipital bone fractures. The fissure is present in the majority of neonates, but fully ossifies between 3 and 6 months of age. Knowledge of this normal developmental occipital bone anatomy is required to avoid misdiagnosis.

KEY WORDS: Occipital bone, calvarium, anatomy
Open and Closed Neural Tube Defects: Posterior Fossa Measurements on Fetal MR Imaging

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Purpose
Differentiation between open and closed neural tube defects (ONTDs, CNTDs) on fetal MR imaging (MRI) is crucial due to differences in prognosis and counselling. This study aims to quantify posterior fossa abnormalities in dependency of the presence of ONTD or CNTD, and to provide further diagnostic and potentially prognostic parameters.

Materials & Methods
Orthogonal T2-weighted MR sequences, acquired during clinically indicated MR examinations (1.5 T) of fetuses without spinal dysraphism (n = 99; 17-39 GW), with ONTDs (n = 37; 19-34 GW) and CNTDs (n = 8; 19-32 GW), were used to measure the clivus-occupit angle (α) and the maximum transverse diameter of the posterior fossa (DMPF). For statistical comparison of fetuses with normal brain development with fetuses with spinal dysraphisms fetuses were age and sex matched.

Results
In fetuses without NTDs a significant positive correlation between gestational age and α (r = .952; p<.001) as well as DMPF (r = .601; p<.001) was found. No significant sex-specific differences concerning α or DMPF were found. In fetuses without spinal dysraphism α was significantly different from DMPF of fetuses with ONTDs (p<.001) but not with CNTDs (p = .327). α also was significantly different between fetuses with ONTDs and CNTDs (p = .029). Diameter of the posterior fossa of fetuses without spinal dysraphism was significantly different from DMPF of fetuses with ONTDs or CNTDs (both p<.001). Between fetuses with ONTDs and CNTDs no significant difference in DMPF was found (p = .618).

Conclusion
The morphology and size of the posterior fossa and especially the clivus-occupit angle (α) depends on the absence or presence of an ONTD or CNTD. In contrast to a published ultrasound study α does not remain constant during pregnancy but in our study correlates positively with gestational age. The clivus-occupit angle more than the maximum transverse diameter of the fetal posterior fossa may allow to differentiate between ONTDs and CNTDs and may aid in the evaluation of postnatal prognosis.

Key Words: Fetal MR imaging, neural tube defect, posterior fossa

Diagnostic Accuracy of Fetal MR Imaging for Cerebellar Abnormalities

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Purpose
To determine the sensitivity and specificity of fetal MR imaging (MRI) for cerebellar abnormalities using postnatal MRI as gold standard.

Materials & Methods
We identified patients imaged by fetal MRI and postnatal MRI. Fetal MRIs included single shot-fast spin-echo T2-weighted imaging. Postnatal MRI technique varied. Fetal and postnatal MRIs were reviewed in a blinded manner by two pediatric neuroradiologists. Cases with compressed cerebellum (e.g., hydrocephalus) were excluded. Cerebellar hemispheres were scored as normal or abnormal. Abnormal categories included small, abnormal morphology, and abnormal signal. Fetal MRI scores were compared with postnatal MR scores. Using postnatal MRI as the gold standard, we calculated sensitivity and specificity and 95% binomial confidence intervals. Two-tailed Fisher’s exact test also was performed for each category, using a significance level of p<0.05.

Results
A total of 98 fetal MR scans were compared against postnatal MRI. Mean GA at fetal MRI was 27.1 weeks (19.71 - 38.14 weeks). Age at postnatal MR ranged from 0 day - 4.7 years. Fourteen cases were excluded due to cerebellar compression or inability to evaluate the cerebellum. A total of 25 patients had a cerebellar abnormality on postnatal MRI, of which 16 were detected by fetal MRI. Mean GA for true positive cases and false negative cases was 27.6 weeks and 26 weeks, respectively. Overall sensitivity of fetal MRI for cerebellar abnormality was 64% (P=0.000, 95% binomial CI of 43%-82%) with 100% specificity (P=0.000, 95% binomial CI of 94-100%). Ten cases had small cerebellum on postnatal MRI; nine were detected by fetal MRI. There was one false positive case. Sensitivity of fetal MRI for small cerebellum was 90% (P=0.000, 95% binomial CI of 56-100%) with 99% specificity (P=0.000, 95% binomial CI of 93-100%). Twelve cases had abnormal morphology on postnatal MRI, and seven were detected by fetal MRI. There were no false positive cases. Abnormal morphology included dysplastic cerebellum, abnormal orientation of fissures and splayed hemispheres in Dandy Walker malformation, and polymicrogyria. Mean GA for cases detected by fetal MRI was 28.1 weeks, compared with 23.4 weeks for those not detected by fetal MRI. Sensitivity of fetal MRI for abnormal cerebellar morphology was 58% (P=0.000, 95% binomial CI of 28-85%) with 100% specificity (P=0.000, 95% binomial CI of 95-100%). Ten cases had abnormal T2 signal in the cerebellum on postnatal MRI, including calcification/hemorrhage, venous anomaly, and cerebellar cysts. Only three cases were detected by fetal MRI; there were no false positive cases. There was no difference in mean GA of false negative and true positive cases. Sensitivity of fetal MRI for
CONCLUSION
The sensitivity and specificity of fetal MRI is good for overall cerebellar abnormalities. Fetal MRI has higher sensitivity for detecting small cerebellum, compared with abnormal cerebellar morphology and is poor for cerebellar signal abnormalities. Knowledge of the diagnostic accuracy of fetal MRI for cerebellar abnormalities is important in accurate counseling of patients who undergo fetal MRI.

KEY WORDS: Fetal MR imaging, cerebellum, diagnostic accuracy

Poster 151
Nongated Isotropic 3D T2 Fast Recovery Fast Spin-Echo versus Cine Phase Contrast Imaging for Assessment of Cerebrospinal Fluid Flow

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PURPOSE
Nongated isotropic 3D T2 fast recovery fast spin-echo (FRFSE) is an alternative technique to cine phase contrast (PC) for cerebrospinal fluid (CSF) flow assessment. This study compares detection of CSF flow abnormalities in 3D T2 FRFSE versus PC and characterizes CSF dephasing patterns in normal patients (Figure 1) and patients with disordered CSF flow (Figure 2) on 3D T2 FRFSE.

RESULTS
For all readers, CSF flow abnormalities were detected only on 3D T2 FRFSE images in five of five Chiari cases and two of four aqueductal stenosis cases. PC and 3D T2 FRFSE were concordant for the remainder of cases. In no cases did information from the PC imaging change the interpretation rendered by 3D T2 FRFSE. On 3D T2 FRFSE, Chiari I malformations tended to exhibit dramatically decreased preoperative CSF dephasing across the fourth ventricle, which improved postoperatively. Three-dimensional T2 FRFSE was more useful than PC imaging in the assessment of these patients.

CONCLUSION
Nongated 3D T2 FRFSE simultaneously provides high-resolution, reformattable anatomical images with highly sensitive and useful CSF flow information in 5 minutes (versus 15 minutes for PC). Our clinical protocol for CSF flow imaging has been modified based on the results of this study to include the nongated 3D T2 FRFSE sequence.

KEY WORDS: Cerebrospinal fluid flow, phase contrast imaging, obstructive hydrocephalus

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PURPOSE
Cervical spine CT is a commonly ordered exam in children suffering cervical spine trauma. However, fractures of the cervical spine are an uncommon injury in children and it is unlikely that CT images will reveal ligamentous, soft tissue, and spinal cord injuries, which are more likely to occur. Although ionizing radiation is delivered to the patient, CT remains an exam favored by the emergency department (ED) and other clinicians due to the rapidity of the exam, eliminating the need for sedation that is required in many pediatric patients. The purpose of this study is to describe preliminary imaging findings and feasibility of diagnosing cervical spine injury using a “QUICK” cervical spine MR protocol instead of cervical spine CT, in non-sedated children suffering blunt trauma.

MATERIALS & METHODS
After IRB approval, single-shot T2 fat saturated, fast spin-echo (FSE) and short tau inversion recovery (STIR) images in sagittal and axial planes were added to standard cervical spine trauma protocols. Patients/parents were informed in writing that additional imaging sequences would be performed if the child could tolerate the examination without sedation or if sedation was not prolonged, and were given the option to opt out. Ten children aged 20 months-18 years with history of neck pain following trauma were examined. Six children were imaged while sedated without failure or prolonged sedation time; four children were examined without sedation. Images were reviewed by four blinded, board-certified physicians, three neuroradiologists and one pediatric neurosurgeon on a 3 point scale [1-nondiagnostic, 2-equally diagnostic as standard MR sequences] for diagnostic certainty, image quality, and artifacts. In order to determine feasibility of the QUICK cervical spine protocol, total imaging time, time of imaging sequence, motion artifacts, impact upon daily MR schedule (i.e., availability of add-on examination time, patient tolerance, and clinician acceptance of the examination) were tabulated.

RESULTS
Imaging findings of traumatic injury included ligamentous, muscular, and bone marrow edema, spinal cord contusion and prevertebral space hemorrhage. QUICK MR sequences, diagnostic certainty and image quality scores were diagnostic, (mean 2.52 and 2.22), and between observers were not significantly different (p=>0.05). QUICK sequences require 2-2.5 minutes each; average time needed to perform the entire QUICK cervical spine MR protocol is 4-7 minutes. Given this short examination time, patient tolerance of the examination is excellent in that the exam may be performed without sedation even in young children without motion artifacts that reduce diagnostic confidence. Further, adding patients to a busy MR schedule causes minimal impact and clinician acceptance of the imaging results is excellent. Clinician acceptance of the examination results is excellent; cervical spine CT is no longer part of routine pediatric trauma cervical spine imaging.

CONCLUSION
Preliminary use of QUICK cervical spine MR exam protocol in children is diagnostic of the presence and absence of cervical spine injury, with excellent inter-reader agreement. QUICK cervical spine MR exam is feasible in non-sedated children as exam time is short, there is minimal effect upon the MR patient schedule, and clinical acceptance is excellent.

KEY WORDS: Cervical spine, trauma, QUICK MR protocol

Poster 152a

Readout-segmented Echoplanar Technique for Diffusion-weighted Imaging of the Temporal Bone in Children at 3 Tesla

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PURPOSE
Diffusion-weighted imaging (DWI) as typically performed with single-shot echoplanar imaging (EPI) suffers from geometric distortion and amplitude artifacts resulting from susceptibility effects. The magnitudes of these effects are directly related to readout duration. The goal of this study is to demonstrate the potential utility of a readout segmented EPI technique for DWI in the temporal bone and nearby parenchyma.

MATERIALS & METHODS
Ten subjects underwent MR imaging in a 3T scanner (Siemens Magnetom Tim-Trio). DWI at the level of the temporal bone was performed using two different EPI sequences: 1. Standard: axial single-shot echo planar Diffusion Tensor Imaging (DTI; TR/TE (ms): 8320/88; flip angle: 90 degrees; bandwidth: 1396 hz/px; 1 acquisition; matrix: 128 x 128; voxel size (mm): 2 x 2 x 2; shots: 1; duration: 5:59 min). 35 image sets are acquired: 5 without diffusion weighting and 30 with non-collinear diffusion-weighting gradients (b value: 1000 sec/mm2). 2. Read-out segmented: axial EPI DTI (RESOLVE, Work-in-Progress Package, Siemens; TR/TE (ms): 4400/100; flip angle: 90 degrees; bandwidth: 1136 hz/px; 2 acquisitions; matrix: 110 x 110; voxel size (mm): 2 x 2 x 2; shots: 5; duration: 6:24 min). 7 image sets are acquired: 1 without diffusion weighting and 6 with non-collinear diffusion-weighting gradients (b value: 1000 sec/mm2).

RESULTS
Readout-segmented DTI consistently demonstrated decreased distortion relative to standard both within and adjacent to the mastoid temporal bone. In particular, mastoid
fluid was easily identified on the multi-shot images (B, arrowhead); furthermore, the extent of fluid closely approximated that seen at T2-weighted imaging (T2-images not shown). Single-shot DWI, by contrast, was non-diagnostic for fluid in the mastoid air cells. In addition, images obtained with the readout-segmented technique, in contrast to the single-shot images, allowed qualitative differentiation of cerebellar parenchyma near the mastoid from adjacent CSF and bone (A and B, arrows). Scan times were comparable using the two techniques.

**CONCLUSION**
The readout-segmented DTI technique presented here performed better in and around the mastoid temporal bone than our standard single-shot DTI in comparable scan time. These preliminary results suggest that segmented filling of k-space is not only a viable alternative to single-shot imaging but that such strategies may be advantageous in areas of the brain prone to susceptibility-related image distortion.

**RESULTS**
The “bimetal” jacket bullet was found to be strongly magnetic with a deflection of 60 degrees (Figure 1). Using a flat file the jacket was abraded to demonstrate a thin copper cladding over the thick steel jacket.

**CONCLUSION**
While there appears to be some dialog regarding the safety of imaging patient with imbedded bullets in the literature, physicians and technologists who act as gatekeepers for MR access need to be aware of the availability of steel clad bullets in the marketplace. Because they usually are less expensive to manufacture than full copper-clad ammo, market pressures on the availability and cost of copper may increase demand for this ammunition unless legislation bans their importation and availability.

**KEY WORDS:** Ballistics, MR imaging safety
**Poster 154**


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**Purpse**

Discrepancies between symptoms and traditional MR images often exist. However, functional MR imaging (fMRI) in cervical spinal cord meet many challenges. The association between the “lesions” and our proprioception is still not fully understood. Our goal is to answer these questions.

**Materials & Methods**

Preparation: Six right-handed normal volunteers and one patient with central cord syndrome underwent tactile fMRI. Stimulation protocol: Tactile stimulation was applied to the right hand dorsum in a block design and paced manually at 1Hz. MR imaging acquisition: MR images of the cervical spinal cord were obtained with a 3 T TrioTim Siemens unit. All data underwent the following procedures: slice timing, head motion correction, and smooth with 2 mm (FWHM) Gaussian kernel using SPM5. Functional MRI data then were analyzed and statistical t maps were generated for all subjects (uncorrected P < 0.05) and masked to retain only spinal cord tissue with the same mask used before the registration step. The mean signal intensity change during the task was computed for all activated voxels within the cervical spinal cord.

**Results**

Figure (left) shows greater activation in the dorsal cervical spinal cord at C7 level, compatible with the corresponded dermatome (C7-8 nerves) and sensory stimulus. Figure (right) shows greater BOLD signals and activation below the compressed spinal cord (C4/5) level in a patient with central cord syndrome and numbness over her left hand. Correspondingly, increased activation over left aspect of the cervical spinal cord, may be responsible for the symptom over the left hand. However, the activities in C1-2 level are both greater during resting and tactile periods, which may hint persistent function in our auto-regulation. Further work up is still necessary.

**Conclusion**

Tactile-related signal was detected in most subjects with relatively good spatial specificity. However, its amplitude significantly varied between different subjects. The correlation coefficients are relatively low (0.2–0.7, 0.28 in patient). Due to the small volume of spinal cord and motion artifacts from the respiration and swallowing, the reproducibility confronts great challenge. We used SPM programming to reduce cardiac-induced signal changes; most motion artifacts exist in XY plane and less effect on Z axis. Therefore, the clinical localization may be less interfered in the sagittal scanning. Functional MRI after the patient’s decompressive surgery should be followed but may confront susceptibility artifacts from metallic devices.

**Key Words:** fMRI, spinal cord, spinal cord injury

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**Poster 155**

**Findings of PET Using 18F-Fluorodeoxy Glucose and 11C-Methionine in Cases of Intramedullary Tumors of the Spinal Cord**

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**Purpose**

Findings of positron emission tomography (PET) using 18F-fluorodeoxy glucose (18F-FDG) and 11C-methionine (11C-Met) in cases of intramedullary tumors of the spinal cord are presented.

**Materials & Methods**

Positron emission tomography-CT was performed in seven patients (three males, four females) with intramedullary tumors of the spinal cord. Mean age at time of imaging was 37.0 years (range, 12-56 years). Underlying pathology was ependymoma (n = 4), anaplastic astrocytoma (n = 1), hemangioblastoma (n = 1), and cavernous angioma (n = 1). Positron emission tomography-CT using both 18F-FDG and 11C-methionine was performed in six patients, and PET-CT using 18F-FDG alone was performed in one case of ependymoma. Maximum standardized uptake value (SUV) was measured for each tumor and compared.

**Results**

Maximum standardized uptake value of 18F-FDG and 11C-methionine in the case of anaplastic astrocytoma were 7.4 and 2.7, respectively. However, SUVmax values for 18F-FDG and 11C-methionine were also relatively high in three of four ependymoma cases. SUVmax was low (2.0 and 1.4, respectively) in the case of hemangioblastoma. In the case of cavernous angioma, although SUVmax of 11C-methionine was low (1.8), SUVmax of 18F-FDG was relatively high (5.2).
CONCLUSION

In the diagnosis of intramedullary tumors of the spinal cord, the activity of $^{18}$F-FDG and $^{11}$C-methionine might be of great value. Both $^{18}$F-FDG and $^{11}$C-methionine are highly accumulated in anaplastic astrocytoma. However, care should be taken, as $^{18}$F-FDG and $^{11}$C-methionine may accumulate in ependymoma.

KEY WORDS: Spinal cord, neoplasm, PET

Poster 156

MEDLMEN: A Differential Diagnosis for Intradural, Extramedullary Spinal Masses

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PURPOSE

To illustrate and review the differential diagnosis for intradural, extramedullary spinal masses and discuss the distinguishing imaging features and clinical presentations.

MATERIALS & METHODS

This exhibit is based on a retrospective search for intradural, extramedullary spinal masses identified on MR imaging. Images of the representative entities will be presented and distinguishing imaging features, diagnostic imaging pearls, patient demographics, and prognosis will be discussed.

RESULTS

Our population had a variety of intradural, extramedullary spinal masses including, but not limited to, metastases, dermoid, ependymoma, and nerve sheath complex tumors. We developed the mnemonic medLMEN to help remember the differential diagnosis for intradural, extramedullary spinal masses with the last three entities being the most common.

CONCLUSION

Intradural, extramedullary spinal masses have a broad differential. The mnemonic medLMEN can help in remembering a location-based differential diagnosis that includes the majority of intradural, extramedullary pathologic processes. The differential diagnosis can be narrowed significantly by distinguishing these lesions by location, signal characteristics, and patient age.

KEY WORDS: Spinal mass, intradural, extramedullary

Poster 157

Absence of Usual MR Findings with Spinal Dural Fistulas: Do All Patients with Symptoms Need Vascular Imaging?

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PURPOSE

Delayed diagnosis is common with spinal dural fistulas. MR imaging plays an important role in the evaluation of this diagnosis and is thought to be a sensitive screening study prior to spinal angiography. Findings on MR include intramedullary T2 prolongation, abnormal enhancement on the cord, and prominent veins on T2-weighted imaging. However, cord T2 prolongation by itself is a nonspecific finding and can be seen in a wide variety of common diseases. We present a small series of cases from our institution of patients with angiographically proved spinal dural arteriovenous fistulas who did not demonstrate abnormal flow voids or enhancement on conventional MR imaging. In fact one of these patients was referred to us for biopsy of a presumed spinal cord tumor. These cases suggest that spinal dural arteriovenous fistula cannot be excluded when spinal cord T2 prolongation is encountered with the appropriate clinical history on the basis of conventional MR findings alone.

MATERIALS & METHODS

We identified three patients with angiographically proved spinal dural arteriovenous fistulas who did not have the typical MR imaging features of a spinal vascular malformation. All patients were male, ranging in age from 65 to 72 years, and presented with lower extremity weakness and paresthesias. All were evaluated consecutively by conventional MR imaging, MR angiography, and finally conventional angiography.

RESULTS

All three patients were symptomatic and had cord T2 prolongation without vascular flow voids or enhancement in the subarachnoid space. Abnormal vasculature, however, was subsequently demonstrated on MR angiography and then confirmed with conventional angiography.
CONCLUSION
Our experience suggests that a symptomatic patient with only cord signal abnormalities on routine MR may still have a spinal dural arteriovenous fistula. In this circumstance, more sensitive studies such as MRA or DSA may be necessary to establish the diagnosis of spinal dural fistula.

KEY WORDS: Dural, arteriovenous fistula, spine

Poster 158

Incidental Findings on Localizer Images of Lumbar Spine MR Imaging

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PURPOSE
The purpose of this study is to determine the prevalence of the different types of extraspinal incidental findings seen on localizer images of lumbar spine MR images and the possible clinical implications of such findings.

MATERIALS & METHODS
A 52-year-old male presented in 2010 to the ER for abdominal pain and the abdominal CT showed an 11 x 9 x 8 cm left renal mass, later histologically proved to be renal cell carcinoma with multiple metastases. Retrospectively, this left renal mass could be seen on the lumbar spine MR imaging (MRI) the patient had done in 2007, at which time the mass was only 4 x 3 x 4 cm. However, the mass was only obvious on the localizer images, was missed and was not reported. Both in-patients and out-patients, who had lumbar spine MRI at the McGill University Health Center (which includes three large tertiary hospitals), were included in the study. This study involves 206 lumbar spine MRIs that were carried out during the 6-month period between May and October 2010, which were reviewed retrospectively by the authors. We looked for findings on the localizer images outside the region of clinical interest excluding the vertebrae, intervertebral disks, neural structures, spinal canal and paraspinal soft tissue disease processes.

RESULTS
Of the 206 patients, 45% had extraspinal incidental localizer findings with 12% having more than one abnormality. Among the 92 patients with abnormal findings on localizer images, 30% of the diagnostic images were able to demonstrate all of the abnormalities found on the localizer images; however, an overwhelming 70% of the MRI sequences partially or completely missed the abnormalities seen on the localizer images. The most prevalent findings were renal abnormalities; in fact, 20% of all localizers demonstrated kidney lesions or cysts, 5% showed atrophic or aberrantly shaped kidneys and 8% demonstrated hydronephrosis. On the diagnostic images, the kidneys were cut off from the sides and only partially seen most (68%) of the time. Other abnormalities seen include: uterine or ovarian abnormalities (7.7%), enlarged bladder (3.9%), cul de sac fluid or pelvic cysts (3.9%), liver lesions (3.9%), pleural effusions (3.4%), hip abnormalities (3.4%), presacral fluid (1.9%), adrenal lesions (1.0%), subcutaneous lesions (1.0%), lung lesions (0.5%), AAA (0.5%), thoracic wall mass (0.5%), and spleen lesions (0.5%). Among the reports of the MRIs with abnormal localizer image findings, 34% reported all abnormalities found, 16% reported some and 50% reported none.

CONCLUSION
In total, 45% of our patients had extraspinal findings on their MRI lumbar spine localizer images, most of them being renal in etiology. Thus, we recommend considering include kidneys in the diagnostic images and not being cut off from the sides. In our institutions, only 34% of the reports documented all of the findings seen on the localizers. We believe that a careful examination of the localizers is warranted because of the multiple extraspinal findings that could be detected, though their clinical significance and impact still remain to be investigated.

KEY WORDS: Localizer, incidental findings, lumbar spine

Poster 159

Parametric Maps and Estimation of Therapy-Induced Changes of Spinal Bone Marrow an Imaging Biomarker for Metastases Diseases

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PURPOSE
Dynamic contrast-enhanced MR imaging (MRI) offers non-invasive characterization of the vascular microenvironment and has not been investigated fully in bone marrow diseases. In oncology practice, current clinical evaluations based on conventional MRI for diagnosis and assessments of treatment response are markedly limited, often depend on changes in tumor size and present with nonspecific lesions. Measuring changes in tumor hemodynamics would give insight into tumor heterogeneity and the derived parametric maps provide pathophysiologic status of metastases. Evaluation of blood pool localization and exchange of contrast agent between vascular bed and interstitium on a voxel-wise basis are of significant prognostic value and for their
predictive capability. We aimed to develop an imaging biomarker to facilitate the decision-making process and establish a robust technique to unravel the complexity of tumor vasculature that may aid in therapeutic management by employing the improved T1-weighted DCEMR algorithm.

**MATERIALS & METHODS**

Twenty-two spine bone marrow tumor patients aged 45-76 years (mean = 59 years) underwent MRI on 1.5 T GE scanner using 8-channel-CTL surface spinal coil. Lumbar spine study included axial T1-T2, and sagittal T1-T2, IR, DWI, followed by T1-weighted DCE and PCT1. Three DISPGR-T1-weighted DCEMRI were obtained phases-35, TR/TE= 4-5/1-2s, SThickness/FOV=5/36 mm with no-gap, FA=20, FOV=34-36 cm. We generated and evaluated spine bone marrow maps - blood volume and blood flow, uptake curve maps - up-slope and down-slope, enhancement maps - peak and relative map using in-house developed software. The perfusion indices, bone marrow blood volume (Figure a), baseT1 and postcontrast-T1 (Figures b and c). Analyzing tracer behavior on voxel to voxel basis, the effective change in T1 relaxation rate was determined by algorithm before converting MR signal intensities into bone marrow concentration time curve (BMTCT). MR signal was modeled in terms of T1-weighted effects of Gd-DTPA and precontrast medium steady state residue K was optimized to BMTCT.

**RESULTS**

The generated maps visually appreciate distinct regions fulfilling characteristics of hyper-vasculature and its heterogeneity when compared to tumor, normal and normally radiated regions. The BV maps distinguished pathologic, osteoporotic fractures and offers insight into discrimination between normal marrow and pathologically replaced marrow and accurately characterizes lesions as hyper or hypovascular even with susceptibility artifact, indicate a potential utility with spinal compression fractures.

**CONCLUSION**

We propose that this robust noninvasive T1-weighted DCEMRI technique improves accuracy of perfusion metrics and enables visual appreciation that could characterize marrow heterogeneity and differentiate between different conditions that affect marrow pathophysiologically.

**KEY WORDS:** Algorithm, DCE-MR, spine bone marrow
CONCLUSION
This work demonstrates the feasibility of direct quantitative imaging of myelin in situ, without the potential confounds of disease-induced alterations in myelin-associated water relaxation rates.

KEY WORDS: Myelin imaging, UTE MR imaging

Poster 161

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PURPOSE
Early diagnosis and prompt initiation of adequate treatment are essential for clinical outcome in infective spondylodiskitis. Thus, MR techniques that could help in the accurate and early detection of infective spondylodiskitis, even diskitis are valuable. Diffusion-weighted imaging (DWI) is based on the random motion of water protons and is used successfully as an important diagnostic tool in the evaluation of different brain disorders. With its ability to detect altered water proton mobility, it also may be useful for the evaluation of spinal disorders including infection, inflammation, infarction, neoplasm, or degenerative changes, may disturb normal tissue architecture and cause ultimate shifting of water molecules between tissue compartments secondary to disruption of cellular structure and membranes permeability or both. We evaluated the patients with infective spondylodiskitis or diskitis with DWI using apparent diffusion coefficient (ADC) analysis to enhance early detection.

MATERIALS & METHODS
A retrospective analysis was performed of patients who were diagnosed with infective spondylodiskitis/diskitis and had undergone DWI. Regions of interest were drawn in the affected intervertebral disks for ADC calculation. Care was taken to avoid inclusion of vertebral bodies in any region of interest. Apparent diffusion coefficient values were measured and compared with healthy controls and degenerative disk disease groups.

RESULTS
The infected disks showed hyperintense signal change on DWI and lower ADC values in comparison with the normal-appearing disks, but higher ADC values in comparison with the degenerative disks.

CONCLUSION
Our preliminary results suggest that the detection and quantification of ADC abnormalities is a supplementary tool to conventional MR imaging. It is hoped that infective spondylodiskitis will be recognized earlier, and appropriate management instituted in a timely fashion.

KEY WORDS: Diffusion-weighted MR imaging, apparent diffusion coefficient mapping, infective spondylodiskitis

Poster 162
Solitary Fibrous Tumors of the Cervical Spine

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Solitary fibrous tumors are rare tumors of the spine infrequently reported. We present two unusual cases, one intradural and one extradural in location with the neuroimaging findings and the correlative histopathology. Interestingly, both cases demonstrate avid tumor enhancement and hyperintense T2 signal. These findings are nonspecific and can mimic other tumors. This presentation will address the neuroimaging findings for such rare cases to allow the reader to consider solitary fibrous tumor in their differential diagnosis of spinal tumors.

KEY WORDS: spine neoplasm

Poster 163
New Compression Fractures after Prophylactic Percutaneous Vertebroplasty

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PURPOSE
Previous studies have shown that 41% to 67% of subsequent fractures after percutaneous vertebroplasty (PV) occur at the level adjacent to the augmented vertebra. Kobayashi, et al previously described that prophylactic treatment for unfractured adjacent vertebrae can decrease the incidence of subsequent fractures. The purpose of this study was to investigate the incidence of subsequent fractures at and adjacent to the prophylactically treated vertebrae.
MATERIALS & METHODS
This study included 116 patients (96 women and 20 men; mean age, 76.2 years; range, 47-95 years) with osteoporotic compression fractures who received prophylactic PV for at least one unfractured vertebra adjacent to the fractured vertebra(e). A total of 180 unfractured vertebrae adjacent to fractured vertebrae were treated prophylactically. The locations and numbers of the prophylactically treated vertebrae were as follows: T6 (n = 2), T8 (n = 2), T9 (n = 2), T10 (n = 18), T11 (n = 40), T12 (n = 32), L1 (n = 41), L2 (n = 23), L3 (n = 15), L4 (n = 3), and L5 (n = 2). One hundred and seven vertebrae were superior to the fractured vertebra, 53 vertebrae were inferior to the fractured vertebra and 20 vertebrae were in between them. The mean number of prophylactically treated fractured vertebrae per session was 1.6 (range, 1-3). Since we limited the maximum cement volume up to 30 gm (1 pack) at 1 session, we could not treat all adjacent vertebrae in cases with multiple unhealed fractures. For this reason, a total of 91 unfractured vertebrae adjacent to fractured vertebrae were not treated prophylactically. The incidence of subsequent fractures at and adjacent to the prophylactically treated vertebrae was investigated. The patients were followed with physical examinations and radiographs at 1 day, 3 and 12 months after PV. They were allowed to visit us if back pain relapsed. MR imaging was performed on as-needed basis.

RESULTS
In 180 prophylactically treated vertebrae, only one (0.6%) had subsequent fracture around the injected cement within 12 months. Meanwhile, 14 (15.4%) of 91 nonprophylactically treated vertebrae had fracture in adjacent vertebra within 12 months. Thus, there was a statistically significant difference ($P < 0.001$) in the incidence of subsequent fractures in adjacent vertebrae between those treated and those not treated prophylactically. Subsequent fractures within 12 months occurred at 8 of the 157 vertebrae adjacent to prophylactically treated vertebrae (5.1%), and at four of the 74 vertebrae adjacent to nonprophylactically treated vertebrae (5.4%); thus, there was no statistically significant difference ($P = 1$).

CONCLUSION
Prophylactic treatment in unfractured adjacent vertebrae can prevent subsequent fractures in these vertebrae after PV. There was no increased risk of subsequent fractures after prophylactic PV.

KEY WORDS: Prophylactic percutaneous vertebroplasty, subsequent fracture

Poster 164
Discharge Disposition following Vertebroplasty

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PURPOSE
The aim of this study was to determine discharge disposition for inpatients treated with vertebroplasty for painful, vertebral compression fractures, and to compare discharge disposition to premorbid status.

MATERIALS & METHODS
We performed a retrospective review of inpatients who underwent consultation for consideration of spinal augmentation for treatment of painful, vertebral compression fractures. We gathered data concerning patients’ demographics, living arrangement prior to hospitalization, disposition at the time of discharge, quantitative pain levels before and after vertebroplasty, qualitative pain levels at the time of hospital admission and discharge, and length of hospital stay prior to and following vertebroplasty.

RESULTS
Ninety inpatients underwent vertebroplasty, 73 (81%) of whom had been living independently at home before hospitalization. Of these 73 patients, 31 (42%) returned home after discharge, 9 (12%) returned home with home health care assistance, and 32 (44%) were sent to skilled nursing facilities. Six (7%) of the 90 patients resided in assisted-living centers prior to hospitalization; all of these patients were discharged to either assisted-living or skilled-nursing facilities. Eight (9%) of the 90 patients resided at skilled-nursing centers prior to hospitalization, and all eight returned to nursing centers after their hospital stay. Discharge disposition was not significantly associated with either preoperative pain levels at rest or with activity ($p = .76$ and $p = .23$, respectively) or with postoperative pain levels at rest or with activity ($p = .08$ and $p = .25$, respectively).

CONCLUSION
This study demonstrates that patients undergoing vertebroplasty as inpatients often are discharged to rehabilitation centers rather than home, irrespective of their status prior to hospitalization or their pre and postoperative pain levels. These findings suggest that simple care of fracture-related back pain may fail to encompass the complex medical and nursing requirements for elderly, osteoporotic patients treated with vertebroplasty.

KEY WORDS: Vertebroplasty, discharge disposition

Poster 165
Clinical Significance of Repeat Vertebroplasty for Recurrent Pain at Cemented Vertebra with Fluid Sign

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PURPOSE
The aims of this study was to determine the association between recurrent pain and fluid sign following percutaneous vertebroplasty (PV) and to assess the clinical significance of retreatment for cemented vertebrae with fluid sign.

MATERIALS & METHODS
Institutional review board approval and informed consent were obtained for this study. Five hundred forty-five patients (478 women, 42 men; mean age, 78.5 years; range, 58-96 years) and 1214 vertebral bodies were treated from January 2008 to December 2009. All patients underwent preoperative magnetic resonance imaging (MRI) with contrast enhance-
ment and computed tomography (CT). Almost all patients showed good response after initial PV. Sixty-one patients developed recurrent pain following successful PV within a year. Of them, 57 revealed subsequent fracture in the adjacent or distant vertebra from the treated vertebra. Another four patients who complained of recurrent pain demonstrated only fluid sign at the bone-cement interface without obvious compression fracture.

**RESULTS**

In all these four patients, large cavity formation (cleft) in the vertebral body was noted and there was destruction of posterior wall of the vertebra in preoperative MRI and CT. Definite mismatch was noted in fluid cleft size on STIR images and ill-enhanced area around the enhanced area of fat-suppressed contrast-enhanced images on preoperative MRI. These mismatch areas were considered to be necrotic debris which was thought to be responsible for development of fluid in the treated vertebra.

**CONCLUSION**

Fluid sign in the treated body represents unhealed bone-cement interface and cement instability. The existence of a large cleft (vacuum or fluid filled) in the treated vertebrae and destruction of vertebral posterior wall may be important factors influencing instability of injected cement.

**KEY WORDS:** Vertebroplasty, retreatment, fluid sign

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**Poster 166**

Large Intravertebral Cleft Is a Favorable Predictor of Pain Relief in Percutaneous Vertebroplasty for Osteoporotic Compression Fractures

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**PURPOSE**

The purpose of this study was to investigate the relationships between preprocedural intravertebral clefts and short-term pain relief in patients with osteoporotic compression fractures after percutaneous vertebroplasty (PVP).

**MATERIALS & METHODS**

The present study was approved by the institutional review board, and written informed consent was obtained from all patients. A retrospective review of preprocedural radiologic images of 134 patients with painful osteoporotic compression fracture was performed. The following factors were analyzed on preprocedural magnetic resonance imaging (MRI) and computed tomography (CT): size of the intravertebral cleft, anatomical location of the fractured vertebral body (FVB), contrast enhancement of the FVB on MRI and degree of protrusion of the FVB into the spinal canal. Excellent pain relief was defined as a visual analogue scale (VAS) pain score of 0 or one at 3 months after PVP. Statistical analyses were conducted to evaluate the relationship between the imaging factors described above and pain relief using Pearson’s Chi-squared test. Multivariate logistic regression analysis also was performed.

**RESULTS**

Excellent pain relief was obtained in 50 of 74 (67.6%) patients with intravertebral cleft larger than half the height of the FVB (large cleft), while excellent pain relief was obtained in 14 of 60 (23.3%) patients with intravertebral cleft less than half the height of the FVB (small cleft). A large cleft was a significant key factor in the excellent pain relief group after 3 months (P < 0.05). Further, ≥ 40% of the spinal canal occupied by bony fragments of the FVB was related to incomplete pain relief (P < 0.05). Other factors were not significant (P > 0.05).

**CONCLUSION**

A large intravertebral cleft was a favorable short-term outcome predictor in patients with osteoporotic compression fractures after PVP, while severe protrusion of the FVB causing lumbar spinal canal stenosis had a negative effect on pain relief.

**KEY WORDS:** Vertebroplasty, intravertebral cleft, favorable predictor

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**Poster 167**

Prediction of Vacuum Phenomenon in Vertebral Compression Fractures: Dynamic Contrast-Enhanced MR Imaging Study

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**PURPOSE**

The nonhealing cleft may be responsible for persistent pain and progressive vertebral collapse after acute injury. If localized kyphosis increased, there is risk of neuropathy appearing as a complication. Even after receiving vertebroplasty, it was reported to be at increased risk for subsequent cemented vertebral refraction and new adjacent vertebral fractures.

**CONCLUSION**

A large intravertebral cleft was a favorable short-term outcome predictor in patients with osteoporotic compression fractures after PVP, while severe protrusion of the FVB causing lumbar spinal canal stenosis had a negative effect on pain relief.

**KEY WORDS:** Vertebroplasty, intravertebral cleft, favorable predictor
Dynamic contrast-enhanced magnetic resonance imaging (DCE-MRI) has been used for the evaluation of bone marrow perfusion. However, there are few reports on the evaluation of osteoporotic VCF and intraosseous cleft formation. We investigate the relationship between intraosseous clefts and bone marrow perfusion using DCE-MRI in patients with osteoporotic VCF before vertebroplasty.

**Materials & Methods**
Forty subjects referred for evaluation of VCF underwent DCE-MRI. Bone marrow perfusion, as measured using the DCE-MRI time-intensity curve from a noninjured vertebra was developed using two distinct parameters including peak enhancement ratio (PER) and enhancement slope. The ratios of the well and the poorly enhanced zone of each injured vertebra were calculated. Multiple logistic regression analysis was used to evaluate the relationships between baseline clinical factors, parameters of DCE-MRI and presence or absence of intraosseous clefts.

**Results**
Twenty-nine injured vertebrae (72%) had intraosseous clefts. Lower PER of the noninjured vertebrae was associated with higher poorly enhanced zone ratio of the injured vertebra (γ = -0.362, p = 0.017). Multivariate logistic regression analysis identified only lower PER (hazard ratio, 0.000; 95% confidence interval, 0.000-0.096; p = 0.009) was associated with the presence of intraosseous clefts. A PER value less than 0.57 had a sensitivity of 80% and specificity of 90% for predicting intraosseous clefts (Figure 1).

**Conclusion**
In patients with osteoporotic VCF before vertebroplasty, decreased bone marrow perfusion, as measured by DCE-MRI, was associated with intraosseous cleft formation.

**Key Words:** DCE-MR imaging, vacuum phenomenon, vertebral compression fractures

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**Poster 168**
**Flexion and Extension MR Imaging of the Functional Cervical Spinal Unit after Cervical Arthroplasty**

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**Purpose**
Conventional radiographs after cervical arthroplasty allow the assessment of the osseous structures, the implant and signs of instability but not of the disks and nerve roots. The purpose of this study was to assess the feasibility of flexion-extension MR imaging (MRI) of the cervical spine after cervical arthroplasty at 3 T.

**Materials & Methods**
Ten subjects (mean age 55 ± 11 years, 3 female) with clinical indications for cervical arthroplasty and proved nerve root compression were examined before and after cervical arthroplasty. All examinations were performed on an open-bore 3 T MRI (Verio, Siemens, Germany). Supine position was used for neutral position imaging. Extension and flexion were maintained by cushions. Saggital 3D T2-weighted sequences were acquired for each position. Range of motion (ROM) for the entire spine and each spinal unit was calculated. Nerve root and cord compression in the different positions were evaluated. MR examinations were compared with conventional radiographs.

**Results**
Mean range of motion was 24 ± 4.3 degrees. The nerve roots and cord could be identified in all subjects before and after surgery. Increased nerve root compression in extension compared to neutral position was observed in seven patients and in one patient in flexion. Spinal cord compression was observed in two patients in extension. There was a significant correlation for ROM between MRI and plain radiographs.

**Conclusion**
Open-bore 3 T MRI scanners allow true flexion-extension imaging of the cervical functional spinal unit after cervical arthroplasty with excellent correlation to conventional radiographs. It demonstrates the functional aspect of degenerative spinal disease.

**Key Words:** Functional MR imaging, cervical spine, arthroplasty
**Poster 169**

Sacroiliac Joints Vacuum Phenomenon: CT Diagnosis and Significance

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**Purpose**
Vacuum phenomenon is found commonly in sacroiliac joints, and the literature suggests it may be a source of back pain. We investigated 1) the prevalence of sacroiliac joints vacuum phenomenon (SJVP), 2) the rate at which it is reported on abdominopelvic and lumbosacral spine computed tomography (CT) images, and 3) the literature supporting its relationship with symptomatic back pain.

**Materials & Methods**
CT images of the pelvis and lumbar spine from January to February 2009 were reviewed retrospectively. Six hundred and fifty-two patients were studied during this period. Axial thin section images were reviewed under default lung and bone window setting. The age, sex, symptoms and radiologist reports were assessed from the electronic medical record (EMR).

**Results**
The prevalence of SJVP on CT imaging was 34%, with higher rates found in female patients (41%, p < 0.001) and the older age group (39%, p < 0.05). Eight-five percent of the SJVP were present bilaterally. Among the 223 patients with SJVP, only 17% were reported. There were no statistically significant differences between reporting rates for body radiologists and neuroradiologists. Back pain was more frequent (p < 0.05) in patients with SJVP (9%) than without SJVP (5%). The difference in prevalence of SJVP in patients with back pain (49%) and patients without back pain (33%) was statistically significant (p < 0.05).

**Conclusion**
Sacroiliac joints vacuum phenomenon is a prevalent condition with higher rates among older and female individuals. The phenomenon is underreported on CT images and is a potential area where a practice quality improvement (PQI) initiative could be implemented. Although our sample was biased and patient histories were incomplete, we found a statistically significant difference in the prevalence of SJVP between patients with and without back pain. The medical literature on the subject suggests this finding may be worth reporting until further clarification of its significance with a larger scale prospective study.

**Key Words:** Vacuum phenomenon, sacroiliac joint, computed tomography

**Poster 170**

Digital Subtraction Myelography in the Evaluation of Cerebrospinal Fluid Leaks: Preliminary Results in 20 Patients with Spontaneous Intracranial Hypotension

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**Purpose**
Review our technique and experience in performing digital subtraction myelography (DSM) and present our preliminary results with the use of DSM in the evaluation of cerebrospinal fluid (CSF) leaks in patients with diagnosis of spontaneous intracranial hypotension (SIH).

**Materials & Methods**
We retrospectively reviewed 20 consecutive patients who underwent DSM for the evaluation of CSF leaks at our institution from 11/09 to 11/10. All patients had clinical symptoms compatible with SIH as well as epidural fluid collections which were identified on either MR myelogram or CT myelogram. We analyze and present our technical success rate, leak identification rate and postprocedural complications.

**Results**
The procedure demonstrates high technical feasibility. The majority of the patients underwent DSM under conscious sedation and a small fraction of the patients had the procedure performed under general anesthesia. The diagnostic accuracy of the exam is highly dependent on the image quality and the patient’s ability to maintain suspended respiration. There were no major complications. The rate of minor complications approaches 20% and included headaches, muscle spasms and short-lasting seizures.
CONCLUSION
Digital subtraction myelography is a minimally invasive technique that has the potential of accurately identifying the level of CSF leak in patients with persistent SIH symptoms in which a leak has not been identified by other imaging modalities. Potential complications can be decreased with adequate patient selection and preprocedural planning.

KEY WORDS: Myelography, leak, digital
Tale of Two Procedures: Trends in Cerebral Angiogram and Myelography Volumes from the National Inpatient Sample, 1997-2008

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PURPOSE
Neuroradiology fellowship directors have noted substantial decreases in invasive procedure volumes, especially in the era of noninvasive vascular imaging, with potentially detrimental effects on resident and fellow training opportunities. The aim of this study was to use a large national administrative database in order to determine trends in the utilization of inpatient, conventional cerebral angiograms and contrast myelograms from 1997 through 2008.

MATERIALS & METHODS
The Nationwide Inpatient Sample (NIS) database was utilized to identify hospitalizations with International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) procedure codes for contrast myelograms (87.21) and contrast cerebral arteriograms (88.41). Appropriate weights from the NIS database were applied for national estimates. Numerous demographic and hospital variables were examined including patient age, hospital teaching status and hospital location (metropolitan vs nonmetropolitan). Multiple linear regression analyses were used to assess utilization trends.

RESULTS
Between 1997 and 2008, over 1.13 million cerebral angiograms have been performed in the United States on an inpatient basis. From 1997 to 2008, there was a 145% increase in the number of hospital discharges for patients who had received a cerebral angiogram, with a year-to-year increase averaging 3.8%. The majority of the angiograms (94%) were performed at hospitals located in metropolitan areas and approximately 64% were performed at teaching hospitals. The number of angiograms performed at teaching hospitals increased 77% over the 12-year period with a year-to-year increase of approximately 6% (p<0.001). Conversely, angiograms performed at nonteaching hospitals only increased 3% over the same time period. In contradiction to angiograms, there has been a steady decrease in the number of inpatient contrast myelograms performed in the United States, diminishing from 27,582 in 1997 to 7,086 in 2008, which represents a 74% decrease over that time. Similar to cerebral angiograms, the majority of myelograms were performed at hospitals located in a metropolitan area. The percentage of myelograms performed at teaching hospitals was equal to those performed at nonteaching hospitals. The number of myelograms performed at teaching hospitals decreased by approximately 68% from 1997 to 2008, with a statistically similar decrease of 80% observed at nonteaching hospitals (p=0.24).

CONCLUSION
Even in the era of rapid growth of noninvasive vascular imaging, the numbers of conventional cerebral angiograms has increased steadily, especially at teaching hospitals. In contrast, the volume of myelograms has decreased steadily. These findings suggest that numbers of conventional angiograms may still be sufficient for training neuroradiology fellows.

KEY WORDS: Angiogram, myelogram, national inpatient sample
**ePoster 002**

**Susceptibility-Weighted Imaging in the Diagnosis of the Cortical Vein Reflux or Venous Infarction Caused by Dural Arteriovenous Fistula**

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**PURPOSE**
Susceptibility-weighted imaging (SWI) is reported as useful diagnostic sequence for various intracranial diseases. We evaluate cortical venous reflux or venous infarction caused by dural arteriovenous fistula (dAVF) using SWI.

**MATERIALS & METHODS**
From 2007 to 2010, 24 dAVFs were diagnosed in our institution with angiography. Susceptibility-weighted imaging and conventional MRI were performed for patients with cortical venous reflux caused by dAVFs. Clinical and neuroradiologic features were investigated retrospectively.

**RESULTS**
Susceptibility-weighted imaging gave the information of cortical venous reflux for all cases. Susceptibility-weighted imaging showed the extended cortical veins were well recognized and according to congestive cortical veins demonstrated by angiography. These veins were shown more attractively in SWI than conventional MR imaging. However venous structures nearby skull base representing superior ophthalmic vein and sphenoparietal sinus were invisible in SWI. There are four cases of manifestation with venous infarction. Susceptibility-weighted imaging of these area showed strong low signal intensity but white matter near the dilated veins showed high signal intensity. This signal change was invisible in conventional MR imaging. In angiography these veins demonstrated venous congestion, therefore, it is suggested that these findings showed a rise of oxy-hemoglobin.

**CONCLUSION**
In evaluation and prediction of dAVF, accompanied especially with cortical reflux and venous infarction, SWI appears to be more sensitive than conventional MR imaging and can be a useful tool for dAVFs.

**KEY WORDS:** Susceptibility-weighted imaging, dural AVF, MR imaging

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**ePoster 003**

**Comparison of Gadofosveset Trisodium Steady-State MR Angiography with First Pass and 3D Time of Flight MR Angiography in the Follow Up of Coiled Cerebral Aneurysms**

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**PURPOSE**
The purpose of this study is to compare three MR angiographic techniques; 3D time of flight (TOF) MR angiography (MRA), first pass contrast-enhanced MRA, and steady-state contrast-enhanced MRA. The first pass and steady-state MRA techniques are performed with Gadofosveset trisodium (Vasovist). Our hypothesis is that steady state MRA is the optimal technique for detection and measurement of residual aneurysm remnants based on improved image resolution.

**MATERIALS & METHODS**
This was an ethics committee approved study. Eight consecutive patients with 14 coiled aneurysms underwent routine surveillance including the three MRA techniques. Two blinded independent expert interventional neuroradiologists evaluated the MRA techniques based on three questions. 1) Is there satisfactory vessel conspicuity? 2) What size is the coiled aneurysm remnant? 3) Do you recommend retreatment or follow up? The test characteristics of the three MRA techniques were evaluated using the steady-state MRA as the standard.

**RESULTS**
Satisfactory conspicuity of the perianeurysmal vascular anatomy was present in 12 (86%) TOF MRAs, 14 (100%) first pass MRAs, and 14 (100%) steady-state MRAs. Five residual aneurysm remnants greater than 2 mm were described on the steady-state MRAs. Of these, four were identified on TOF MRA (sensitivity 80%, specificity 89%), and five were demonstrated on steady-state MRA (sensitivity 100%, specificity 100%). The one aneurysm remnant not seen on TOF MRA measured 5 mm on the first pass and steady-state MRAs.

**CONCLUSION**
First pass and steady-state contrast-enhanced MRA techniques were superior to 3D TOF MRA in the follow up of coiled cerebral aneurysms. Although there was no statistically significant difference between first pass and steady-state contrast-enhanced MRAs for detecting residual aneurysm remnants, the tendency of the first pass MRA was to slightly underestimate the aneurysm remnant size.

**KEY WORDS:** Aneurysm, MRA, vasovist
High-Resolution MR Imaging of Cerebral Vasculopathy: Initial Experience

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PURPOSE
Digital subtraction angiography (DSA), MR angiography (MRA), and CT angiography (CTA) all have been used to characterize intracranial vascular abnormalities. However, all of these techniques characterize the intravascular space, rather than the vessel wall. While ultrasound can characterize vessel wall lesions, the presence of the skull impedes accurate imaging of the intracranial vasculature. Endovascular probes are available, but are not advanced easily into the deep cerebral vasculature. The development of high spatial resolution MRA (HRMR) techniques to improve our understanding of the blood vessel walls of the intracranial circulation may yield benefits in patient selection for varying medical, surgical and interventional therapies. We present a survey of cases demonstrating the utility of HRMR in cases of cerebral vasculopathy.

MATERIALS & METHODS
All studies using a recently developed HRMR protocol at the Cleveland Clinic were reviewed by two staff neuroradiologists and categorized according to vascular findings, pathologic states, and technical limitations. Illustrative cases were selected to highlight potential diagnostic applications of this technique, as applied in a busy clinical setting.

RESULTS
Forty-six HRMR examinations were reviewed for 42 patients, of whom four had follow-up HRMR imaging. Patients included 17 males and 25 females, with ages ranging between 14 to 82 years (mean 48.5 SD 16.83). Positive findings for presumed vasculitis included vessel wall enhancement with wall thickening, +/- vessel luminal narrowing, and was identified in 18 studies (43%). Two patients had vessel narrowing/occlusion without significant wall enhancement. Aneurysms were identified in 11 studies (26%), and dissection was identified in three patients. Another study had fibromuscular dysplasia, another had moyamoya disease. Remaining six studies were negative for vascular wall abnormalities. Internal carotid was affected in 14 patients (four aneurysms, two dissections and eight vasculitis changes). Middle cerebral in 18 patients (four aneurysms, 11 vasculitis, two stenosis without enhancement and one dissection). Anterior cerebral artery was affected in six patients (five vasculitis and one dissection). Posterior cerebral in four patients (was stenotic with enhancing wall in one patient, stenotic in a patient with presumed vasculitis of other vessels, isolated stenosis in one study and stenotic in a patient with dissection). Anterior communicating was affected in four patients (aneurysms in three patients and vasculitis in one study). Posterior communicating had enhanced wall and stenosis in one vasculitis patient and superficial temporal in two patients. Twenty-one patients showed vascular wall enhancement (18 studies of presumed vasculitis, two aneurysms, and one dissection). Thirteen patients showed luminal vessel narrowing (two isolated stenoses, and one patient with dissection, and 10/18 of the presumed vasculitis group). Three of 18 of the presumed vasculitis group showed vessel wall thickening.

CONCLUSION
High spatial resolution MRA techniques are a novel method of evaluating vascular wall abnormalities. Increasing experience with the technique will allow better understanding of normal findings and pathologic states. High spatial resolution MRA can afford excellent discrimination of vessel wall thickening and enhancement, which may be helpful in diagnosis as well as monitoring treatment response. More research is needed to better understand the role HRMR can play in the evaluation of cerebrovascular disease.

Key Words: High-resolution MR, cerebral vasculitis, post-contrast

Cerebellar Dural Arteriovenous Fistula Mimicking a Hypervascular Tumor on MR Imaging

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PURPOSE
We report a case of cerebellar dural arteriovenous fistula (DAVF) presented with subacute progressive neurologic dysfunctions, with MR findings mimic a hypervascular tumor. The lesion was successfully treated with combined endovascular embolization and neurosurgical resection. Pathology confirms the lesion was a vascular lesion instead of a tumor.

MATERIALS & METHODS
A 62-year-old man presented with 1 week of progressive headache, vertigo, slurred speech, loss of balance, and vomiting. Non-contrast head CT scan showed a large right cerebellar lesion with mass effect. MR imaging (MRI) brain with gadolinium and MR angiography (MRA) of the circle of Willis demonstrated a hypervascular lesion with right occipital artery contribution. Diagnostic subtraction angiography demonstrated a DAVF in the middle line of the cerebellum, which was supplied by the middle meningeal artery of the right external carotid artery (ECA) and the posterior meningeal artery. It had retrograde leptomeningeal venous drainage (RLVD), which drained into the right transverse sinus and the Vein of Galen via dilated cerebellar cortical veins. The fistula was obliterated with n-Butyl Cyanoacrylate (n-BCA) via transarterial approach. As the diagnosis of a tumor could not be excluded, the lesion then was resected. The patient recovered well from surgery, and was neurologically intact on discharge and at 6-week clinic follow-up visit. Pathologic studies demonstrated angiomatic collections of vessels with thickened walls in the leptomeninges and cerebellar parenchyma, and gliosis in the white matter parenchyma. No tumor was identified.
RESULTS
Preoperative noncontrast head CT scan showed a large heterogeneous hypoattenuating lesion in right cerebellum with edema and mass effect. There was no intracranial hemorrhage. MR imaging of the brain with contrast revealed a 4.5 x 3 cm mass in the right posterior inferior aspect of the cerebellum. It was an ill-defined T2 hyperintense lesion with multiple signal voids in the inferior margin of the lesion. The lesion had hypointense signal on T1-weighted images with diffuse peripheral enhancement on gadolinium-enhanced T1-weighted images. There was moderate surrounding edema, producing mass effect on the 4th ventricle, left cerebellar hemisphere and midbrain. There was no diffusion restriction.

CONCLUSION
Intracranial dural fistula with RLVD has an aggressive natural history with high risk of intracranial hemorrhage, rapid progression of nonhemorrhagic neurologic deterioration, and death. Early recognition of the disease and disconnection of the shunting can reverse the disease course. Characteristics of MR imaging included low T1 signals, high T2 signals with signal voids, diffuse peripheral contrast enhancement, white matter edema and a topographic involvement of the cerebellum (posteroinferior cerebellar hemisphere). However, those findings may be difficult to differentiate from neoplasm. Our case demonstrates that DAVF with possible RVLD should be included in the differential diagnosis when MR imaging demonstrates the above features, and a diagnostic cerebral angiography is warranted. Prompt surgical and/or endovascular treatment is effective to reverse clinical symptoms.

KEY WORDS: Dural arteriovenous fistula, MR imaging, cerebellum

ePoster 006
Classification of Persistent Primitive Trigeminal Artery on MR Angiography: An Analysis of 20 Cases
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PURPOSE
The purpose of this study is to demonstrate persistent primitive trigeminal artery (PPTA) on MR imaging (MRI) and MR angiography (MRA) while emphasizing its anatomical vascular relationships and to reclassify these variations for a comprehensive understanding based on the embryologic types of the posterior communicating artery (P-com) and the relationship with the basilar artery (BA).

MATERIALS & METHODS
Of the total 8629 patients who underwent MRI and MRA from Jan 2008 to Nov 2010 in our hospital, we analyzed the MRA of 20 patients with a PPTA. All 3D TOF MRA (1.5 T or 3 T) and three TFCA were evaluated retrospectively with special attention given in order to define the relationship of the PPTA, BA, and P-com and to determine the original site of the PPTA from the ICA, the size of the PPTA (larger than M1 or smaller than M1 - assuming your readers will know what M1 refers to as well as its size), as well as its course (intrasellar or parasellar). Clinical configurations and associated abnormal vascular lesions also were described. From these data, all PPTA variations were compared to its previously reported classification.

RESULTS
Twenty (13 women and 7 men, 43 ~ 76 years of age, mean age 60.2 years) of the 8629 patients had a PPTA (2.3%). Five patients with focal neurologic symptoms showed acute cerebral infarction in the right corona radiata, acute infarction on the anteromedial side of the pons, medulla, and chronic infarction in basal ganglia and temporal lobe. A patient with visual disturbance had a meningioma involving the cavernous sinus. Five patients had aneurysms (25%) in the ICA and MCA, the ipsilateral or contralateral side to the PPTA origin. There were five types of PPTA: type 1, PPTA inserted in the BA with adult type PCAs (n = 10); type 2, PPTA inserted in the BA with fetal type PCAs (n = 2); type 3, PPTA inserted in the BA and terminating in the ipsilateral PCA with contralateral fetal type PCA (n = 1); type 4, PPTA inserted in the BA and terminating in the contralateral PCA with ipsilateral fetal type PCA (n = 4); and type 5, PPTA terminating in the AICA with no interposition of the BA (n = 3). Severe hypoplasia of the proximal BA was found in 10 patients. Fourteen of our 10 study patients (70%) showed the parasellar course (a lateral type) of PPTA, while six (30%) had the intrasellar course (a medial type) of PPTA.

CONCLUSION
Three-dimensional TOF MRA can be used for identifying of PPTA and making a classification indirectly in daily practice. There were five types of PPTA in our study and the incidence of PPTA with type I was greater than that of other types of PPTA.

KEY WORDS: Persistent primitive trigeminal artery, MR angiography, classification

ePoster 007
Atypical Presentation of Posterior Reversible Encephalopathy in Two Patients with Sepsis
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PURPOSE
Reversible posterior encephalopathy syndrome (PRES) is characterized by a wide array of nonspecific neurologic symptoms and has distinctive radiologic appearance that usually manifests as abnormal signal in the bilateral posterior or white matter and occasionally in the gray matter in the parietal, temporal and occipital lobes, compatible with vasogenic edema. We report atypical presentation of this syndrome with uncommon involvement of the superior frontal and cerebellar hemispheres in two nonhypertensive patients with septic shock and respiratory failure.
MATERIALS & METHODS
The clinical data of two patients were reviewed retrospectively. Magnetic resonance images were obtained within 2 hours of the seizure onset and at 3-5 weeks follow up. Review of the relevant literature was performed.

RESULTS
Each patient presented with septicemia and respiratory failure. After initial improvement of the symptoms the mental status of both patients suddenly declined and they developed focal motor seizures. Their blood pressures were elevated mildly. MR imaging (MRI) studies demonstrated foci of bilateral abnormal hyperintense T2 and FLAIR signal involving the subcortical and deep white matter in the posterior and paramedian parietal, inferior occipital and inferior temporal lobes. Additionally the superior frontal lobes and bilateral cerebellar hemispheres showed similar signal abnormalities. Follow-up MRI in 5 and 3 weeks demonstrated resolution of the abnormal findings on MRI. During the past decade PRES has been associated with hypertension, preeclampsia/eclampsia, and autoimmune diseases such as SLE, Wegener’s, polyarthritis nodosa, scleroderma. In the younger population there are known associations with poststreptococcal glomerulonephritis and Henoch-Schonlein Purpura. Reversible posterior encephalopathy syndrome associated with infection/sepsis/shock was first reported in 25 patients by Bartynski, et al (2006). Eighty-four per cent of those patients had G+ organisms cultured from their blood like the cases in our study. The Bartynski study demonstrated greater vasogenic edema in normotenive patients than in hypertensive patients. Recent studies demonstrate that in 40% of patient with PRES secondary to infection/sepsis/shock and overall in 25% of all patients with PRES, the blood pressure is within the normal range, in contrast to the earliest reported cases of PRES.

CONCLUSION
Up until recently the most popular pathophysiologic theory for PRES is severe hypertension with failed autoregulation that causes injury to the capillary bed resulting in hyperfusion and brain edema. However, the presence of mild hypertension or the absence of hypertension in patients with infection/sepsis/shock beckons another theory which considers immune mediated endothelial injury/dysfunction and vasoconstriction as the primary insult, resulting in hyperfusion, ischemia and ultimately vasogenic edema. Perhaps intermittent episodes of hypertension occur in sepsis, but are difficult to recognize because of confounding factors such as pain. Further investigations will be necessary to bring clarity and confirm the mechanism of this clinico-neuroradiologic entity.

KEY WORDS: Atypical, posterior reversible encephalopathy, sepsis

ePoster 008
Oculopneumoplethysmography and MR Angiography for the Detection of Carotid Artery Stenosis

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PURPOSE
Oculopneumoplethysmography (OPG) is a noninvasive investigation, initially conceived in the 1970s, which uses measurement of ocular systolic pressures via vacuum pressure applied to the sclera in order to make determinations regarding the presence or absence of hemodynamically significant carotid artery system stenoses. The purpose of this study was to assess the accuracy of OPG for the diagnosis of carotid artery stenosis both as a stand-alone test and in conjunction with carotid system MR angiography (MRA).

MATERIALS & METHODS
This retrospective study reviewed patients who had undergone OPG and digital subtraction angiography (DSA) (90 patients, 174 vessels) in close temporal proximity to determine the accuracy of OPG with DSA as the reference standard. Three carotid artery stenosis thresholds (≥ 50%, ≥ 70%, ≥ 80%) were analyzed. The accuracy of the combination of OPG and MRA was analyzed in a subset of patients (54 patients, 94 vessels) who underwent OPG, MRA and DSA. In an attempt to standardize MRA interpretation and ensure that a numeric percentage carotid stenosis was recorded for all vessels, all MRAs were reviewed independently by an experienced neuroradiologist (J.T.W.) blinded to the results of both the OPG and DSA.

RESULTS
The sensitivity and negative predictive value of OPG increased with higher degree stenoses and for lesions ≥ 80% these values were 85.3% and 94.2% respectively. Specificity and positive predictive values were lower at all thresholds and were 72.9% and 49.3% respectively at the ≥ 80% stenosis threshold. For MRA alone, specificity and NPV were high (92.3% and 92.1% at the 70% and 80% stenosis thresholds respectively) but PPV was only moderate (63.2% for the highest grade group), suggesting a significant number of false positive results. When OPG and MRA were concordant, the sensitivity and specificity for ≥ 80% stenoses were 91.0% and 97.8% respectively. PPV and NPV were 91.0% and 97.8% respectively when these tests were in agreement.

CONCLUSION
Oculopneumoplethysmography appears to be an accurate rule-out test for hemodynamically significant carotid artery stenosis. Oculopneumoplethysmography augments the accuracy of MRA for detection of carotid artery disease and when these two tests are negative, disease appears to be effectively excluded. The data suggest that OPG in conjunction with MRA is particularly useful in reducing the number of false-positive results as compared to MRA alone.

KEY WORDS: Carotid artery stenosis, oculopneumoplethysmography, MR angiography
 Automated Trajectory Analysis in Deep Penetrating Head Injury

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PURPOSE
Traumatic brain injury (TBI), in particular penetrating head injury, is the signature injury of recent military conflicts in Iraq and Afghanistan. Currently, there is no consistent reporting or effective data management of penetrating head injuries (PHI). We created and validated a novel semiautomatic trajectory imaging analysis software for penetrating head injuries that estimates the volume and anatomical structures of expected tissue damage. Trajectory imaging analysis of penetrating head injury provides rapidly needed clinical information that establishes prognostic indicators in the acute trauma clinical care setting.

MATERIALS & METHODS
We randomly selected penetrating head injuries from the Vietnam Head Injury Study (VHIS) registry and analyzed the injuries using software designed to map the trajectory of head penetrating projectiles using noncontrast enhanced head CT. A cylindrical injury probability zone was produced by recording entrance wound and terminal fragment locations in 91 CT scans. In addition to this volume of potentially damaged tissue based on locations and fragment size, specific anatomical regions, intersected by the probability injury zone, were automatically generated using the Analysis of Brain Lesion (ABLE) software with the Automated Anatomical Labeling (AAL) atlas. Comparison of this simplified path was made with manual tracings of encephalomalacia to demonstrate potential use of automated systems in lieu of more resource-intensive processing. Additionally, comparison of a radiologist versus a nonradiologist on trajectory estimates was performed. Kappa analysis and Dice similarity coefficients were used for quantitative comparison of anatomical regions and volume estimation. Lastly, an overlay of all manual tracings of PHI was computed to show spared areas of the brain in this population.

RESULTS
We determined the percentage of AAL structures intersected by the calculated trajectory cylinder of probable injury, by analyzing the overlap of the spatially normalized lesion image with the AAL atlas image in MNI space. Preliminary results demonstrate high specificity of the anatomical regions identified with our semiautomated trajectory cylinder and manual tracings of tissue damage. Initial comparison of radiologist versus nonradiologist estimates demonstrated that semiautomation with less skilled operator may be possible with training and certain limitations. Overlay of all manual tracings support a concept previously called zona fatalis; a central area of the brain where damage is associated closely with death by exception.

CONCLUSION
We believe that these preliminary results demonstrate the potential for semiautomation of preliminary zone of central nervous system (CNS) tissue injury caused by penetrating projectile. There is overlap with manually traced regions from a prior study. We hypothesize that chronic zones of injury also may reflect long-term effects of interrelated neural pathways, ballistic dynamics and probable tumbling effects of blast fragments at the time of injury. We believe that these efforts may lead to future predictive modeling for long-term clinical effects of initial trajectory assessments.

KEY WORDS: Trauma, TBI, brain

Hippocampal Injury in Mild Traumatic Brain Injury: A Diffusion Tensor Imaging Study

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PURPOSE
Axonal injury in the hippocampus has been reported in an animal model of traumatic brain injury (TBI) and patients with moderate to severe TBI have suggestively lower hippocampal volumes than mTBI patients. Diffusion tensor imaging (DTI) can detect TBI-related damage and diffuse axonal injury. Our aim was to detect the presence, if any, of microstructural injury in the hippocampi of patients with mTBI and healthy controls using DTI.

MATERIALS & METHODS
We studied 36 consecutive patients with mild TBI (13 women, 23 men; mean age, 36 years; range, 19-59 years) who met the following criteria: 1) mild closed head injury; 2) no known history or imaging indication of CNS disease unrelated to trauma; 3) patient aged 18 years or older. 4) no presence of micro-bleeds on T2*-weighted gradient-echo (GRE) images. Mild head trauma was classified according to the definition developed by the Mild Traumatic Brain Injury Interdisciplinary Special Interest Group of the American Congress of Rehabilitation Medicine, reviewed by Esselman et al. The MRI scans were performed on a 1.5 T imager (Siemens Vision). The MRI protocol included T2-TSE, T2-FLAIR, T2*-GRE, and DTI. Diffusion tensor imaging was acquired with a single-shot echo-planar imaging with b values of 0 and 1000 seconds/mm2. Diffusion tensor images were acquired in six noncollinear directions. A dual spin echo was used to minimize distortions due to eddy currents. Mean diffusivity (MD) and fractional anisotropy (FA) maps were generated using in-house software (ref my paper on J Neurosurgery). The maps were evaluated using a region of interest (ROIs) approach. Regions of interest were placed bilaterally in the head and body of the hippocampus on two consecutive slices. Mean diffusivity and FA values of each brain region were compared between patients and controls by using a t test.
RESULTS
Compared to healthy controls, mTBI patients showed significantly higher MD levels in the head (0.64 vs 0.56 x 10^-3mm^2s^-1; p < 0.0001) and body (0.60 vs 0.57 x 10^-3mm^2s^-1; p = 0.02) of the hippocampi and significantly lower FA in the head (0.2 vs 0.26; p < 0.0001) of the hippocampi.

CONCLUSION
Diffusion tensor imaging measurement of the hippocampi in mTBI patients suggests the presence of subtle structural damage. This damage might contribute to neuropsychologic impairment and postconcussive symptoms.

KEY WORDS: Hippocampal injury, diffusion tensor imaging

ePoster 011
Metabolic Dysfunction in the Basal Ganglia and Thalamus of Mild Traumatic Brain Injury Patients with Corresponding Perfusion Abnormality

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PURPOSE
Many Americans sustain a mild traumatic brain injury (mTBI) annually, resulting in long-term cognitive, physical, and behavioral problems. We hypothesize that adult mTBI subjects (n = 6) with persistent (90-700 days postinjury) neurocognitive deficits with prolonged cerebral metabolic alteration, specifically decreased NAA in the deep gray structures, seen on 3D magnetic resonance spectroscopic imaging (MRSI) will have abnormal perfusion-weighted MRI (PW-MRI). Mild traumatic brain injury is a common cause of chronic debilitating symptoms. Management of mTBI is hindered by vague symptoms and nonspecific imaging findings. MR spectroscopic imaging and PW-MRI may aid in diagnosis and treatment.

MATERIALS & METHODS
Three-dimensional MRSI (PRESS TR/TE = 1700/144 msec, voxel size 1cm^3) and perfusion-weighted MRI (PW-MRI; TR/TE = 14/00/32 msec) were acquired at 3 T. LCmodel was used to semi-quantitatively measure the mean N-acetylaspartate/creatinine (NAA/Cr), NAA/choline (NAA/Cho), and Cho/Cr ratio for each lobar and hemisphere region. Spectra from mTBI subjects were compared to control ratios of age-matched healthy subjects (n = 6). Perfusion-weighted MRI source data were processed to create relative cerebral blood flow (CBF) and cerebral blood volume (CBV) maps. In mTBI subjects, CBF and CBV values were compared between voxels with normal metabolite ratios and those with abnormal metabolite ratios. Statistical significance was measured using independent samples t-test.

RESULTS
In mild TBI subjects, voxels in the left basal ganglia which showed abnormally low Cho/Cr due to decreased Cr, showed significantly higher (p < 0.05) CBF (mTBI 210.8 ± 86.68), CBV (mTBI 12 ± 5.16), and significantly lower MTT (mTBI 3.32 ± 0.02) compared to normal voxels (67.6 ± 38.76, 5.64 ± 2.51, and 5.15 ± 1.01, respectively). In the left thalamus of mTBI subjects, voxels with abnormally high NAA/Cr due to decreased Cr levels showed significantly higher (p < 0.05) CBF (233.7 ± 26.05) and CBV (14.9 ± 3.22) compared to normal voxels (83.4 ± 58.82 and 6.79 ± 3.98, respectively).

CONCLUSION
MR spectroscopy imaging and PW-MRI are valuable tools which can identify abnormalities in mTBI patients that are otherwise not identified on other imaging modalities. These changes may identify underlying pathophysiologic changes associated with long-term cognitive deficits.

KEY WORDS: Mild traumatic brain injury, MR spectroscopic imaging, perfusion-weighted MR imaging

ePoster 012
Evaluation of a Novel Readout-Segmented Approach to Diffusion-Weighted MR at 3 T Utilizing a 32-Channel Head Coil

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PURPOSE
To evaluate a readout-segmented echo planar imaging (rs-EPI) approach to diffusion-weighted (DWI) brain MR imaging (MRI) with a navigator-based phase correction and reacquisition versus single-shot EPI (ss-EPI) DWI with a focus on possibilities with the former sequence relative to the greater signal-to-noise ratio (SNR) afforded by utilization of a 32-channel head coil.

MATERIALS & METHODS
Thirteen subjects (10 volunteers and three stroke patients to date) were evaluated with ss- and rs-EPI DWI at 3 T. Both sequences first were performed utilizing a 12-channel head coil, a parallel imaging factor (IPAT) of 2, a constant field of view (220x220 mm^2), 192x192 matrix size, and the minimum allowed TE (rs-EPI: TE 63 ms, 9 readout segments (ROS), 1 scan average (NSA); ss-EPI: TE 76 ms, NSA 4). Additional SNR available with the 32-channel coil was exploited to either 1) increase the parallel imaging factor while maintaining in-plane resolution (IPAT=3, 192x192 matrix; rs-EPI: TE 58 ms, NSA=2, ROS=7 versus ss-EPI: TE 76 ms, NSA=4) or alternatively to 2) increase in-plane spatial resolution (256x256 matrix, IPAT=2; rs-EPI: TE 68 ms, NSA=1, ROS=13 versus ss-EPI: TE 109 ms, NSA=2) versus the 12-channel scans. Signal-to-noise ratio and artifact point distortion from susceptibility artifacts were quantified, and a blinded neuroradiologist ranked the scans...
in terms of spatial resolution, susceptibility artifacts, image blur, and overall preference (the latter being decided among all 12- and 32-channel scans). Additional sequences performed in stroke patients utilizing the above 12-channel protocol were assessed similarly.

**RESULTS**

Signal-to-noise ratio was not significantly different between the low-resolution (IPAT=3) 32-channel scans (9.6±1.4 ss-EPI versus 8.0±1.3 rs-EPI). Signal-to-noise ratio was statistically lower (p<10^-4) with the high-resolution scans (IPAT=2), but among them greater with rs-EPI (p<0.002; 5.5±0.6 rs-EPI versus 4.7±0.5 ss-EPI). Severity of artifactual pontine distortion was greatest with the ss-EPI sequences (10-17%), the high-resolution rs-EPI sequence having significantly less distortion (p < 0.02; 4.4±3.3%), and the low-resolution rs-EPI having even less (p< 0.05; 2.3±1.8%). The assessment of the blinded reader in terms of susceptibility artifact agreed with the quantitative distortion assessment. In every case, image blurriness was ranked: low-resolution ss-EPI > high-resolution ss-EPI > low-resolution rs-EPI > high resolution rs-EPI. When asked for the choice of the top two sequences from among the 32-channel scans, in every instance the blinded reader selected the two 32-channel rs-EPI scans. The reader expressed a similar preference for rs-EPI DWI in patient scans.

**CONCLUSION**

Substantial image quality improvements are possible with rs- versus ss-EPI DWI regardless of the head coil, 12- or 32-channel, utilized. Acquisition with the latter allows for implementation of greater IPAT factors or acquisition of scans at a higher resolution without significant SNR or acquisition time penalty. In this situation, rs-EPI presents further advantages in that higher resolution can be achieved by increasing the number of readout segments without increasing echo-spacing (i.e., the principle determinant of susceptibility artifacts) or TE (i.e., an important determinant of SNR) to the degree necessary with ss-EPI.

**KEY WORDS:** DWI, readout-segmented EPI, 3 T MR imaging

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**ePoster 013**

**Limbic System: The Emotional Nervous System**

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**PURPOSE**

Limbic system is the seat of memories and emotions. It has a very complex anatomy and connections. Here, we attempt to present a simplistic approach to the anatomy and also discuss the various pathologies that may affect the important parts of the limbic system.

**MATERIALS & METHODS**

From our extensive database of cases from neuroradiology departments of adult and children's hospitals, cases that depict anatomy and various pathologies of the limbic system are selected and presented in our poster in an organized fashion.

**RESULTS**


**CONCLUSION**

The limbic system, so-called the primitive or the visceral brain, is a complex structure. Understanding the anatomy, afferent and efferent connections, and pathologies of this pathway is interesting and helpful in explaining the imaging approach to the limbic system.

**KEY WORDS:** MR imaging, limbic system, hypothalamus

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**ePoster 014**

**Thickening of the Pituitary Stalk in Adults**

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**PURPOSE**

The purpose of this exhibit is: To demonstrate the normal MR imaging (MRI) pattern of the pituitary stalk. To describe the imaging aspects and associated brain findings of diseases associated with a thickened pituitary stalk. To correlate imaging findings with the diagnosis.

**MATERIALS & METHODS**

We reviewed more than 500 MR exams. Pituitary stalk thickening was defined as a diameter superior to 3 mm at the level of the optic chiasma. We differentiated focal nodular, focal nonnodular and diffuse thickening of the pituitary stalk.

**RESULTS**

Focal thickening was seen in cases of metastasis, inflammatory and congenital diseases while diffuse thickening was seen in primary tumors, inflammatory and infectious conditions. Each disease had associated brain anomalies which helped for differential diagnosis.
**CONCLUSION**

A wide variety of conditions is responsible for pituitary stalk thickening. We reviewed 500 MRI exams in adult patients. We reported conditions associated with a thickened pituitary stalk, their imaging aspects and associated brain findings. Neoplasia was the most common etiology followed by inflammatory, infectious and congenital malformation.

**KEY WORDS:** Thickening, stalk, infundibulum

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**ePoster 015**

**Are Region of Interest Measurements an Accurate Way to Determine Enhancement on Routine Brain MR Imaging?**

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**PURPOSE**

Presence or absence of enhancement on magnetic resonance imaging (MRI) studies often is of diagnostic importance. In computed tomography Hounsfield units allow accurate determination of enhancement. In MRI subtle or diffuse enhancement, as well as enhancement in areas with inherent T1 shortening can be difficult to detect. The purpose of our study was to evaluate the accuracy of region of interest (ROI) measurements in determining enhancement on routine brain MRI.

**MATERIALS & METHODS**

We randomly selected 20 patients (10 scanned on a 1.5 T system and 10 scanned on a 3 T system) and measured ROI in water (globe or ventricle), and in the right frontal white matter (WM). Exclusion criteria were: motion artifact and lesions in the area of measurements. Measurements were taken on pregadolinium axial and sagittal T1 fast spin-echo (FSE) and on postgadolinium axial T1 FSE with fat saturation and on coronal T1 FSE. Region of interest size was between 0.6 and 1 cm$^2$.

**RESULTS**

On axial sequences at 1.5 T lowest/highest water ROI was 81/128 pregadolinium and 98/186 postgadolinium. For brain at 1.5 T these measurements were 287/437 pregadolinium and 309/575 postgadolinium. At 3 T lowest and highest water ROI on axial sequences was 112/449 precontrast and 72/372 postcontrast. For brain at 3 T these values were 221/727 pregadolinium and 160/758 postgadolinium. Average difference between pre and postgadolinium water was 27.9 (range -15 to 70) at 1.5 T and 58.2 (range -123 to -2) at 3 T. Postcontrast images showed lower values than precontrast in 1/10 cases at 1.5 T and 10/10 cases at 3 T. Average difference between pre and postgadolinium WM was 60.1 (range -53 to 172) at 1.5 T and 58.5 (range -102 to 31) at 3 T. Postcontrast images showed lower values than precontrast in 2/10 cases at 1.5 T and 9/10 cases at 3 T (Figure A). Longer TR and shorter TE tended to increase ROI values, but were not the only factor accounting for these differences (data not shown).

**CONCLUSION**

On routine brain imaging ROI measurements are not a reliable indicator if contrast enhancement is present or not, especially if the question is subtle enhancement. Areas of subtle enhancement may have a lower ROI value on postcontrast images compared to precontrast images (Figure B). The variations of ROI measurements are influenced partially by choice of TE and TR; however, this alone does not explain the observed variability.

**KEY WORDS:** Enhancement, Region of interest, MR imaging

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**ePoster 016**

**Reversible Splenial Lesion in the Corpus Callosum due to Rapid Withdrawal of Carbamazepine in Two Patients after Neurosurgical Decompression for Trigeminal Neuralgia**

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**PURPOSE**

Reversible splenial lesions (RSLs) of the corpus callosum have been described in various clinical conditions, and some are attributed to the action of antiepileptic drugs such as carbamazepine. Carbamazepine provides good pain relief for trigeminal neuralgia and commonly is formulated in medications. However, when preparing for surgical treatment, carbamazepine should be discontinued or replaced with a suitable alternative. Here, we reported the cases of two patients who developed RSLs following surgical treatment of trigeminal neuralgia.

**MATERIALS & METHODS**

Two patients (a 36-year-old male and a 35-year-old female) who presented with recurrent trigeminal neuralgia were included. The patients had exhibited no seizures. They had...
been prescribed carbamazepine 600 ~ 1200 mg/day before neurosurgical decompression of the trigeminal nerve. In one patient, carbamazepine was discontinued 1 day before the surgery, and it was stopped on the morning of the day of the surgery in another patient. The neuralgia was eliminated completely after the surgery, and carbamazepine was not reinstituted in two patients. The postoperative MR imaging was performed 2 days and a week in two patients, respectively. MR imaging (MRI) sequences included T1-weighted imaging, FLAIR imaging, T2-weighted imaging, diffusion-weighted imaging, and MR spectroscopy. The follow-up MR imaging was performed 3 weeks after the initial MR examinations.

**RESULTS**

In both patients, the initial postoperative MR imaging revealed an isolated oval-shaped abnormal signal on the mid-portion of the splenium of the corpus callosum that showed low intensity on T1-weigthed imaging and high intensity on T2-weighted imaging, fluid-attenuated inversion recovery, and diffusion-weighted imaging. The apparent diffusion coefficient was reduced on the lesion. MR spectroscopy of the lesion revealed no abnormal findings indicating neuroaxonal damage or demyelination. Another MRI of the brain 3 weeks after the initial examinations showed complete resolution of the splenial lesion in two patients.

**CONCLUSION**

Rapid withdrawal of carbamazepine in preparation for surgical treatment can result in RSLs in nonepileptic patients with trigeminal neuralgia. This finding is transient and represents a clinicoradiologic syndrome with an excellent prognosis. We should consider this phenomenon in the perioperative period of trigeminal neuralgia to avoid invasive diagnostic and therapeutic methods.

**KEY WORDS:** Carbamazepine, trigeminal neuralgia, reversible splenial lesion

**ePoster 017**

**Quantitative Susceptibility Mapping: A Novel Approach for Characterizing White Matter Lesions with MR Imaging**

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**PURPOSE**

Quantitative susceptibility mapping (QSM) is a newly developed MR imaging (MRI) technique for quantifying local susceptibility effects in brain tissue. The magnetic susceptibility of each voxel is estimated from phase data acquired during susceptibility-weighted MR imaging. Quantitative susceptibility mapping distinguishes diamagnetic from paramagnetic effects and generates a unique tissue contrast, distinct from T1-, T2- and T2*- and diffusion-weighted MR imaging. This exhibit reviews our initial experience characterizing white matter lesions with QSM.

**MATERIALS & METHODS**

Data Acquisition. The study was IRB approved and HIPAA compliant. Eleven patients with hyperintense T2/FLAIR white matter lesions were evaluated using QSM. MR imaging was performed on a 3T GE scanner with an 8-channel birdcage head coil. A multiecho spoiled gradient-echo sequence with 7 TEs was utilized; uniform TE spacing = 5ms and TR = 42.1ms; flip angle = 5 degrees; bandwidth = 62.5kHz; FOV = 22cm; slice thickness = 3mm (ZIP2 to an effective thickness of 1.5 mm); acquisition matrix size = 320 x 224; image acquisition time = 2:33 min. Data Analysis. Susceptibility maps were generated using a morphology-enabled dipole inversion (MEDI) technique. The MR sequences were coregistered into MNI space using FLIRT. Regions of interest (ROI) were drawn around T2-hyperintense white matter lesions by a neuroradiologist using AFNI. An ROI of similar size was placed in normal-appearing white matter (NAWM). Histograms of voxel values within each ROI were reviewed, and the mean and standard deviation of voxel values were determined. Data were binned, according to pathology, which was determined by reviewing the patient’s electronic medical record and other available imaging studies.

**RESULTS**

Quantitative susceptibility mapping defines the susceptibility of water as equal to zero. Negative QSM values indicate relatively diamagnetic tissue and positive values indicate relatively paramagnetic tissue, with respect to water. Normal myelinated white matter is strongly diamagnetic and therefore negative on QSM. We hypothesized that disruption of the normal white matter architecture, in conditions such as gliosis, chronic infarction or tumor infiltration, would cause increased tissue susceptibility and higher QSM values, due to loss of diamagnetic effects. We also hypothesized that conditions which consist primarily of cytotoxic or vasogenic edema, less appreciable changes in QSM values would occur, given that water has a theoretic QSM value equal to
zero. The mean and standard deviation of white matter QSM values for each patient, grouped by underlying pathology, is listed in Table 1.

### Table 1: 

<table>
<thead>
<tr>
<th>Pathology of white matter lesion</th>
<th>Anatomical location</th>
<th>Mean ± Std (Mean ± Std)</th>
<th>(NAWMS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Posterior reversible encephalopathy</td>
<td>Bilateral parietal subcortical white matter</td>
<td>-20.1 ± 28.0</td>
<td>-30.1 ± 28.0</td>
</tr>
<tr>
<td>Arteriovenous malformations</td>
<td>Right frontal-parietal deep white matter</td>
<td>-22.0 ± 25.3</td>
<td>-26.5 ± 25.3</td>
</tr>
<tr>
<td>Malignant edema</td>
<td>Left frontal-parietal subcortical white matter</td>
<td>-3.5 ± 12.4</td>
<td>-3.5 ± 12.4</td>
</tr>
<tr>
<td>Tumors</td>
<td>Right frontal-superior subcortical white matter</td>
<td>8.7 ± 19.2</td>
<td>8.7 ± 19.2</td>
</tr>
</tbody>
</table>

### RESULTS

Quad-grams were found to give the best performances and were used in this study. In the 10-fold cross-validation analysis, the average accuracies for dynamic language model classifier and the naïve Bayes classifier were 88.5% with 95% CI of 2.5% for 437 reports of "sellar/suprasellar mass", "suprasellar mass" or "colloid cyst". These reports were independently manually classified by radiologists. When compared to the manual classification, the prediction model produced an accuracy of 88.2% with 95% CI of 2.1% for 959 reports that contain keywords “sellar mass”, “suprasellar mass” or “colloid cyst”. These reports were independently manually classified by radiologists. Its ability to perform retrospective research. Utilization of such a tool could dramatically improve radiologists’ ability to perform retrospective research.

### CONCLUSION

Automated classification of brain imaging reports using machine-learning techniques can effectively facilitate the identification of suitable cases for retrospective research. Utilization of such a tool could dramatically improve radiologists’ ability to perform retrospective research.

### KEY WORDS: 

Radiology report classification, data mining, machine learning
is limited. Whether or not BG undergoes degeneration, and whether or not this change is associated with pallidal hyperintensity and cognitive performance currently is unknown in cirrhotic patients.

**Materials & Methods**
The volumes of subcortical nuclei of 28 chronic liver disease patients and 28 control patients were compared. Using 3D T1-weighted MR images, the volume and shape of each nucleus was automatically analyzed via the functional MRI (fMRI) of the Brain Software Library. Correlations between the subcortical volume and other clinical variables, including the pallidal signal intensity, were assessed by multiple regression analysis.

**Results**
Child B and Child C liver disease patients displayed significantly smaller bilateral putamen volumes than control patients (Figure 1), and Child C patients also demonstrated smaller left caudate nucleus and left amygdala volumes than control patients. Pallidal hyperintensity correlated with the BG volume decrease, which was linearly related to worse cognitive performance. The nonuniform distributed shape abnormalities in the striatum further support the ascending spiral interconnecting theory of the striatum.

**Conclusion**
These findings strongly suggest that atrophy in the BG develops according to the severity of the liver cirrhosis. The manganese deposition increases the risk of deep gray matter atrophy. These findings uphold the value of additional psychomotor research associated with liver cirrhosis.

**Key Words:** Basal ganglia, liver cirrhosis, shape analysis

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**ePoster 020**

**Voxel-Based Assessment of Gray Matter Volumes in Chronic Carbon Monoxide Intoxication**

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**Purpose**
Patients with carbon monoxide (CO) intoxication may or may not develop delayed neuropsychiatric syndrome (DNS). The association between morphologic differences and their clinical neuropsychologic deficits in chronic stage is still unknown. However, smaller differences in brain structure may be overlooked in conventional imaging study. Voxel-based morphometry (VBM) is a fully automated method of analysis which allows for unbiased exploration of gray matter density changes. The aim of the study is to evaluate the structure and cognition deficits in CO intoxication with or without DNS using VBM analysis.

**Materials & Methods**
Magnetic resonance imaging and neuropsychologic tests were conducted on 12 patients with DNS, 11 patients without DNS, and 15 age-, sex-, and education-matched healthy subjects. Patients were followed after CO intoxication for a mean of 24.22 ± 15.37 months (range, 6-45 months). We investigated differences in gray matter volume (GMV) between subgroups using VBM to determine which structural abnormalities existed, and then correlated these with the diminished cognitive functioning.

**Results**
The patient groups performed worse neuropsychologic subtest results than healthy controllers (P<0.05) with the worst tendency in DNS group. All patients showed extensively reduced regional GMV in bilateral frontal and parietal lobes mainly, and some in left thalamus, bilateral basal ganglia, bilateral temporal, and left occipital lobes. The DNS group revealed further volume atrophy in bilateral thalami, frontal, parietal, right occipital lobes, and bilateral cerebella, compared with no DNS group. The DNS group revealed more perceptual organization deficits than no DNS group. This correlated with reduced GMV in bilateral superior parietal lobule, bilateral thalamus, and right uvula (P<0.05) (Figure 1).
Figure 1. Locations and plots of significant clusters where a relationship exists between picture completion performance and GM volume detected from group analysis between with or without DNS, while controlling for age, education, gender, and TIV. The linear relationships between the four significant GM clusters [(a) right thalamus, (c) left thalamus, (d) right superior parietal lobule, (f) left superior parietal lobule] and picture completion performance are plotted. The cluster of GM abnormalities located on bilateral thalami (b) and superior parietal lobules (e) are overlaid on the T1 MNI template.

CONCLUSION
In chronic stage after CO intoxication, the patients with DNS experienced worse outcome cognitively and morphologically than patients without DNS. Voxel-based structural deficits in selective brain structures help to characterize a subgroup of patients who exhibited poor clinical performance after CO intoxication.

KEY WORDS: Carbon monoxide intoxication, delayed neuropsychiatric syndrome, voxel-based morphometry

ePoster 021
Compressed Sensing Applied to Dynamic Contrast-Enhanced MR Permeability Imaging

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PURPOSE
To demonstrate the feasibility of applying compressed sensing (CS) to dynamic contrast-enhanced (DCE) MR permeability imaging. Compressed sensing has the potential to overcome limitations in both spatial and temporal resolution that currently hinder DCE acquisitions. Compressed sensing DCE may enable scanning of entire mass lesions with higher spatial resolution to improve diagnostic accuracy of brain tumors, multiple sclerosis, and other intracranial lesions. We present an exploratory study investigating the impact of CS artifacts on DCE permeability imaging.

MATERIALS & METHODS
K-space data from a standard clinical DCE MR brain sequence were acquired and undersampled offline to simulate an accelerated CS scan. Undersampling factors (R) ranging between 1.25 and 2.50 were investigated; images were reconstructed with sparsity constraints along the three spatial directions and in the temporal domain. A neuroradiology fellow compared images from the fully sampled DCE MRI (Figure 1) with those reconstructed from undersampled data (Figure 2).

RESULTS
Negligible aliasing artifacts were observed at all acceleration factors considered. Image blurring worsened with data reduction (Figure 2); however, image quality was deemed to be acceptable for clinical purposes at undersampling factors less than or equal to 2.5.

CONCLUSION
The CS reconstruction preserves adequate image quality at acceleration factors up to 2.5; higher factors should be possible when undersampling is implemented during acquisition rather than retrospectively. This is likely to allow for enhanced spatial and temporal resolution compared to current DCE acquisition techniques. Further studies are needed to evaluate the postprocessing of CS DCE images and determine whether MR permeability metrics such as K-trans can be reliably determined.

KEY WORDS: MR permeability, compressed sensing
Clinical Utility of Functional MR Imaging in Surgical Planning for Patients with Intracranial Tumors

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PURPOSE
Studies have shown that functional magnetic resonance imaging (fMRI) activation patterns are consistent with the cortical responses seen during intraoperative brain mapping. However, more research is needed to better characterize the true clinical utility of preoperative fMRI, especially as an adjunct to preop risk assessment and surgical planning. This is particularly important in determining the extent to which fMRI can be used as a predictive model of surgical morbidity and mortality.

MATERIALS & METHODS
Seventeen hundred and twenty-seven adult patients undergoing resection of an intracranial mass between 2001 and 2009 at the University of Wisconsin were identified via retrospective review of neurosurgical case logs. Two hundred and seventy-eight patients were included in the study with the following inclusion criteria: pathologic diagnosis of glial or metastatic tumor, supratentorial cortical location, and first-time diagnosis of intracranial mass. Exclusion criteria included all tumors not of glial or metastatic origin, sellar, infratentorial, ventricular or subcortical location, and/or recurrent tumor. In addition to all pertinent demographic data, information regarding patient morbidity (motor and language deficits) and mortality was reviewed. Out of 278 patients, 160 patients did not receive preoperative fMRI and 118 patients received preoperative fMRI.

RESULTS
Preliminary analyses of patients who underwent preop fMRI showed significant relationship between motor and language LAD (Lesion to Activation Distance) and existence of either pre or postoperative motor (p < 0.001) and language deficits (p = 0.009) (see Figure). Increasing age was associated with motor and language deficits (p = 0.02 and p = 0.04 respectively). Right-handedness related with language deficits (p = 0.05). Survival analysis revealed that pre - and postoperative deficits, grade, tumor location, as well as LAD predict mortality. Further analyses of patients who did not receive fMRI is in progress to characterize these relationships.

CONCLUSION
In patients who had preop fMRI, motor deficits increased linearly as distance from tumor to primary sensorimotor cortex (SMC) decreased. Language deficits increased exponentially as distance from tumor to language areas decreased below 1 cm (see Figure). Postoperative mortality analysis shows an interaction effect between motor or language LAD and mortality predictors (grade, tumor location). These findings are directly applicable to preoperative neurosurgical risk assessment and planning. Further analysis with patients who did not receive fMRI is underway to determine the role of fMRI in clinical diagnostic and preop assessment of patients with intracranial tumors.

KEY WORDS: fMRI, brain tumor, motor deficits

Perfusion MR Characteristics Predict External vs Internal Carotid Artery Vascular Supply to Meningiomas

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PURPOSE
To determine if the percentage signal recovery, as measured by dynamic susceptibility-weighted, contrast-enhanced (DSC) perfusion MR imaging (MRI) can be utilized to distinguish internal carotid artery (ICA) versus external carotid artery (ECA) vascular supply to meningiomas.

MATERIALS & METHODS
Twenty patients with preangiographic DSC perfusion MRI, digital subtraction catheter angiography, and surgically confirmed histology of meningioma were enrolled in this study. Digital subtraction angiographic results were used to categorize tumor vascular supply into carotid branch derivations: ICA (n = 5), ECA (n = 9), or dual (n = 6). A blinded analysis was performed of T2*-weighted susceptibility signal intensity-time curves generated on a voxel-by-voxel basis from region of interest outlining the entire tumor volume. Percentage signal recovery (PSR) was determined using FuncTool (GE) program where the end signal intensity values were expressed as percentage of the initial T2* signal.
intensity prior to the arrival of gadolinium contrast agent. Statistical analysis using the student’s independent sample t-test was used to determine group difference between ICA and ECA supplied meningiomas.

**RESULTS**

Meningiomas with ICA-derived vascular supply had a significantly higher mean PSR (54%, ± 6%) than meningiomas with ECA-derived vascular supply (37%, ± 4%), p< 0.05.

**CONCLUSION**

The results of our study suggest that DSC perfusion MRI may be used to noninvasively determine the derivation of meningioma vascular supply. Since it is only those patients with ECA branch vascular supply that undergo embolic intervention prior to surgery, DSC perfusion MRI could aid in identifying which patients would benefit from undergoing an invasive angiographic procedure for potential embolization.

**KEY WORDS**: Meningioma, vascular, perfusion

ePoster 024

**Advantages of High b-Value Diffusion-Weighted Imaging to Diagnose Pseudo-Response in Patients with Recurrent Glioblastoma after Bevacizumab Treatment: Case Report**

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**PURPOSE**

The diagnosis of pseudo-response after bevacizumab treatment is difficult. Because diffusion-weighted imaging (DWI) is associated with cell density, it may facilitate the differentiation between true- and pseudo-responses. Furthermore, as high b-value DWI is even more sensitive to diffusion, it has been reported to be diagnostically useful in various clinical settings.

**MATERIALS & METHODS**

A 42-year-old woman with glioblastoma, received radical surgery followed by radiotherapy with concomitant and adjuvant chemotherapy with temozolomide. Upon tumor recurrence she was treated with 10 mg/kg of bevacizumab every 2 weeks. Conventional T1-weighted images acquired after the injection of 0.2 ml/kg gadolinium showed a marked decrease in the enhanced lesion. On T2-weighted images we noted a marked decrease in the high intensity area, a decrease in the mass effect, and improvement in the midline shift. Diffusion-weighted imaging at b-1,000 sec/mm2 showed an increase in the high intensity area although the change was faint. On the other hand, on b-4,000 DWI there was an obvious increase in the high-intensity area. Despite the repeat delivery of bevacizumab, tumor progression was observed at conventional MR imaging (MRI) at the site of and around the area of high-intensity visualized at DWI-4000.

**RESULTS**

Diffusion-weighted imaging, now accepted as a cancer biomarker, and calculation of the apparent diffusion coefficient (ADC) may help to differentiate between pseudo and true responses. Tumor cell density decreases if treatment is effective. On the other hand, ineffective treatment or tumor recurrence results in increased tumor cell density and the high cell density area becomes larger due to an increase in the tumor size. High b-value-based DWI has been found to be useful for the diagnosis of acute infarction, degenerative diseases, for glioma grading, and for the differentiation between glioblastoma and malignant lymphoma. Studies on multi-component diffusion in brain tissue demonstrated that the slow component is more sensitive at high than regular b-value DWI, suggesting that the ADC based on higher b-values reflects changes in tumor cellularity more accurately.

**CONCLUSION**

High b-value DWI reflects cell density more accurately than regular b-value DWI. Our findings suggest that in patients with recurrent glioblastoma, high b-value-based DWI is useful for the differentiation between pseudo and true responses to treatment with bevacizumab.

ePoster 025

**Role of Perfusion CT in Adult Glioma Grading**

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**PURPOSE**

Perfusion computed tomography (CT) can provide additional information about tumor vascularity and angiogenesis for characterizing brain tumors. The aim of our study is to evaluate the usefulness of various perfusion CT (PCT) parameters in diagnosing adult gliomas.

**MATERIALS & METHODS**

Perfusion computed tomography was performed in 59 glioma patients, 16 low-grade gliomas (LGG) and 43 high-grade gliomas (HGG). Normalized ratios of the PCT parameters [normalized cerebral blood flow (nCBF), normalized cerebral blood volume (nCBV), normalized mean transit time (nMTT)] were used for final analysis. All parameters were obtained from tumor region (nCBFt, nCBVt, and nMTTt) and peritumoral region (nCBFp, nCBVp, and nMTTp).
RESULTS
Mean nCBFt and nCBVt in HGG were 4.38±3.12 and 3.35±2.00, and significantly higher than LGG (1.14±0.53, P<0.0001 and 1.01±0.33, P<0.0001). Meanwhile, mean nCBFp and nCBVp in HGG (0.93±0.36 and 0.97±0.24) were significantly lower than LGG (1.55±0.95, P<0.005 and 2.1±0.42, P<0.01). Mean nCBFp and nCBVt in the LGG were higher in oligodendrogliomas (1.24±0.61 and 1.06±0.28) than astrocytomas (0.72±0.61 and 0.78±0.50). The nCBFt in anaplastic oligodendrogliomas (AO; 4.40±2.53) was significantly higher than anaplastic astrocytomas (AA; 1.60±2.04, P<0.05). However, nCBVp and nCBFp in AO (0.97±0.15 and 0.91±0.16) were significantly lower than AA (1.19±0.19 and 1.8±0.37, P<0.05).

CONCLUSION
Perfusion CT provides useful information for preoperative diagnosis and valuable complementary information about tumor hemodynamics. Using statistical analyses both the tumor region data and peritumoral region resulted significantly for diagnosis in glioma grading and predicting the histology.

KEY WORDS: Perfusion CT, adult gliomas, peritumoral area

Intraventricular Meningioma: Analysis of 42 Cases

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PURPOSE
Meningioma, the most common nonglial tumor, accounts for approximately one fourth of all primary intracranial neoplasms. However, an intraventricular location is rare (< 7% of meningiomas).

MATERIALS & METHODS
We retrospectively reviewed the clinicopathologic and imaging findings on CT (32/42) and MR (37/42) of 42 pathologically confirmed cases of intraventricular meningioma (IVM) collected from 1984-2009.

RESULTS
All 42 tumors were surgically confirmed as intraventricular. The most common location was the lateral ventricle atrium: left (18/42) and right (12/42). Two cases were in the 3rd ventricle and one in the 4th. The age range was 8 to 80 years, mean 39.9 years. The female-to-male ratio was (27/15).

Intraventricular meningioma are usually vibrantly enhancing round to lobulated intraventricular masses. On T1-weighted MR imaging (MRI), IVM appeared isointense (18/37) or hypo-intense to gray matter; and, on T2-weighted images hyper- (29/37), (4/37), iso- (4/37) hypo-intense to gray matter. Most had homogeneous signal, while (7/37) were heterogeneous - most evident on T2-weighted images. All 36 meningiomas were vibrantly enhancing on MR with contrast (1 patient had only noncontrast MR). MR imaging showed areas of periventricular parenchymal edema in 29/36 cases. Hydrocephalus produced by lateral ventricular meningioma was localized to the ipsilateral trigone and temporal horn (dilatation of posterior and inferior horn). However, four cases had bitemporal hydrocephalus; three were located in left atrium and one in right atrium. Catheter angiography, available for 25 cases, demonstrated the classic appearance - a hypervascular mass with increasing blush throughout the arterial phase, persisting well into the late venous phase, and with slow washout. Tumors in the atrium often were (8/18) supplied by both anterior and lateral posterior choroidal arteries. Two patients had calcifications visible on scout or plain film.

CONCLUSION
Although uncommon, meningiomas represent an important differential diagnosis for intraventricular masses. Intraventricular meningioma are usually vibrantly enhancing round to lobulated intraventricular masses in the atrium. Most patients had intermittent or vague symptoms for 2 years or less before diagnosis, and some were incidental findings. The meningothelial and fibrous subtypes were the most common and psammotous IVM were densely calcified and visible on plain radiography in 2/5 cases.

KEY WORDS: Intraventricular meningioma, pathology, MR imaging

Usefulness of High b-Value Diffusion-Weighted Imaging at 3 T for Evaluating Creutzfeldt-Jakob Disease: Comparative Study Using Healthy Volunteers

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PURPOSE
Theoretically, higher b-value (b = 3000 s/mm2) diffusion-weighted imaging (DWI) yields better contrast because it reflects tissue diffusivity better and is less subject to the T2 shine-through effect. Using five healthy volunteers, we investigated changes in the gray-white matter contrast on
high-b-value DWI at 3 T. We also assessed whether this technique is useful for the detection of lesions attributable to Creutzfeldt-Jakob disease (CJD).

**Materials & Methods**

Five healthy male volunteers (age range 26 - 45 years; mean 35 years) underwent DWI at b = 1000, 2000, 3000, 4000, and 5000 s/mm² on a 3 T MR imaging (MRI) unit. On DW images acquired at the level of the basal ganglia, one radiologist performed region-of-interest (ROI) measurements of the signal intensity (SI) of five gray matter structures, the anterior cingulate and middle frontal gyrus, and the insula, caudate head, and putamen. The gray-to-white matter contrast ratio (GWCR) was calculated using the formula GWCR = SIGM/SIWM, where SIGM and SIWM are the SI of the gray matter and frontal white matter, respectively. Two women with sporadic CJD (age range 65 - 75 years, mean 69 years) underwent conventional MRI and DWI at b = 1000 and 3000 s/mm². In 12 regions of the brain, two neuroradiologists consensually interpreted the degree of SI on DW images; in their qualitative evaluation of the images they used a 4-point score where grade 3 = definite lesion visualization, grade 2 = probable, grade 1 = possible, and grade 0 = no visualization. Interobserver agreement was assessed by k statistics.

**Results**

As the b value increased, GWCR decreased in all evaluated gray matter structures. On images acquired at b = 3000 s/mm², GWCR was less than 1.0 in four of five structures. Of 24 brain regions (2 CJD patients), six were recorded as grade 3, four as grade 2, six as grade 1, and eight as grade 0 on DWI at b = 1000 s/mm². At b = 3000 s/mm², 17 were of grade 3 and seven structures of grade 0. Interobserver agreement was fair for DWI at b = 1000 s/mm² (k = 0.23) and excellent at b = 3000 s/mm² (k = 0.92).

**Conclusion**

At 3 T DWI, the gray-to-white matter contrast in most gray matter structures reverses at b = 3000 s/mm². In the evaluation of CJD lesions at 3 T DWI, b = 3000 s/mm² appears to be more useful than b = 1000 s/mm².

**Key Words:** Diffusion-weighted imaging, Creutzfeldt-Jakob disease, 3T MR imaging

ePoster 028

**MR Spectroscopy Imaging of Inhibitory Neurotransmission in Chronic Pelvic Pain**

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**Purpose**

Endometriosis is the most common condition identified in women with chronic pelvic pain. Like most other chronic pain disorders, there is little correlation between the presence or severity of endometriosis and the severity of pain symptoms. One hypothesis to explain this apparent discrepancy is upregulation of the central pain processing pathways. However, there are few studies studying brain metabolite changes in chronic pelvic pain. The purpose of this study was to assess for decreases in of γ-aminobutyric acid (GABA), the major inhibitory neurotransmitter in the central nervous system (CNS), (as measured by magnetic resonance spectroscopy imaging) in a number of brain regions implicated in pain processing in chronic pelvic pain subjects compared to healthy controls.

**Materials & Methods**

The participants in this study were eight female subjects (aged 26 - 35 years, mean age 29.1 years) with a history of surgically-confirmed endometriosis and symptoms of chronic pelvic pain and nine female healthy controls (aged 22-52 years, mean age 31.4 years). MR imaging examinations were performed on a Philips Achieva 3 T MRI (Best, Netherlands). Subjects underwent conventional MR point-resolved spectroscopy (PRESS); the MR spectral editing technique, MEGA-PRESS, was used to measure GABA relative to NAA. Voxels were placed in brain regions which have been implicated in pain processing in other neuroimaging studies including the anterior insula, posterior insula and the anterior cingulate cortex. LCModel was used to calculate creatine, choline, N-acetylaspartate (NAA), myo-inositol and Glx concentrations. Determination of GABA/NAA ratio as well as GABA concentrations were carried out in Matlab (The Mathworks, Natick, MA) using in-house software. GABA concentrations were quantified in institutional units (i.u.) as the ratio between the GABA integral and the NAA integral multiplied by the NAA concentration calculated in LCModel. Differences in GABA measurements between the different brain regions were analyzed using unpaired t-tests (p < 0.05).

**Results**

There was a significantly lower GABA/NAA ratio in the posterior insula in chronic pelvic pain subjects (0.212 ± 0.025) compared to healthy controls (0.244 ± 0.032; p = 0.04). There was a trend towards significantly lower GABA concentration in the posterior insula in chronic pelvic pain subjects (1.409 i.u. ± 0.201) compared to healthy controls (1.645 i.u. ± 0.262; p = 0.06). There were no significant differences in the GABA/NAA ratios or GABA concentration in the anterior insula or the anterior cingulate cortex.

**Conclusion**

Diminished inhibitory neurotransmission resulting from lower concentrations of GABA within the posterior insula may play a role in the pathophysiology of chronic pelvic pain.

**Key Words:** MR spectroscopy, chronic pain
**ePoster 029**

Analysis of Language and Memory Lateralization by Functional MR Imaging and WADA Test in Epilepsy and Effect of Gender on Postoperative Seizure Improvement

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**PURPOSE**

The intracarotid sodium amobarbital procedure (ISAP or WADA test) lateralizes cerebral functions to the cerebral hemispheres preoperatively. Functional magnetic resonance imaging (fMRI) is used increasingly to analyze preoperative language lateralization. In this study, concordance of fMRI with WADA was examined in patients with medically intractable seizures. The relationship of the distance between the epileptic focus to functional activation area with patients’ postoperative deficits in language also is analyzed.

**MATERIALS & METHODS**

This study includes 17 patients with preoperative fMRI and WADA (n = 17 for language tests, n = 9 for memory, age range: 12-49 years). The images were analyzed using established fMRI paradigms for language and memory (Moritz/Haughton 2003). Activation of Broca’s and Wernicke’s areas were measured in three dimensions. A threshold-dependent lateralization index (LI) was calculated for language areas: LI = [(L-R)/(L+R)] * ½. LI>0.25 is considered left-hemisphere dominant, 0.25< LI < .25 considered bilateral, and LI<.25 considered right dominant. An experienced technologist’s interpretation of memory lateralization was utilized for analysis. Standard neuropsychiatry WADA test procedures were used for comparison. The shortest distance between a language area to the border of surgical focus (LAD) was measured (<10 mm, 10-20 mm, or >20 mm) and compared with postoperative language deficits. The effect of gender on postoperative seizure improvement also was analyzed. Improvement (binary decision) was based on postoperative neurologic assessment at 6 months and/or reduction in seizure medication dose at 6 months. Chi square tests, Fisher’s exact test, ANOVA, and Student’s t-test were performed for statistical analysis.

**RESULTS**

Concordance between fMRI and WADA is 82.4% (p = 0.88) for language dominance and 66% (p= 0.64) for memory. No correlation was found between LAD and postop language or memory deficit (p-value = 0.46 for language; p = 0.37 for memory). Females demonstrated increased postoperative seizure improvement (Fisher’s p-value = 0.009; female = 12; male = 7). Gender groups had no significant difference in terms of age, handedness, preoperative seizure types, or location of surgical focus.

**CONCLUSION**

Language concordance between fMRI and WADA is similar to that reported in prior studies (Binder, et al, 2006; Swanson, et al, 2007). Targets for future studies include further examination of the concordance of fMRI with WADA for memory paradigms and further correlation of LAD with language/memory deficits. However, this study clearly demonstrates fMRI as a useful preoperative adjunct to WADA for language lateralization in patients with medially intractable seizures.

**KEY WORDS:** WADA, language, memory

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**ePoster 030**

White Matter Involvement in Sporadic Creutzfeldt-Jakob Disease

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**PURPOSE**

To explore diffusion tensor imaging (DTI) metrics changes in the gray and white matter of sporadic Creutzfeldt-Jakob disease (sCJD) and possibly identify a specific pattern of subcortical white matter (WM) involvement.

**MATERIALS & METHODS**

Twenty-six sCJD patients [F:M 12:14; mean age 62(9) years] matching the 2007 UCSF sCJD criteria, and nine healthy controls [F:M 4:5; mean age 62(16) years] seen at the Memory and Aging Center of UCSF were studied with the same 1.5 T GE MRI. Diffusion tensor imaging parameters: Axial T1-weighted 3D FSPGR volume imaging (TE/TR 6/27, voxel 0.94x0.94x3, matrix 256x192, FOV of 75) and DTI scan with 15 directions (3mm slice thickness, TR/TE 9000/69, b=1000s/mm² and one b=0s/mm² reference image) were acquired on a 1.5T. The mean diffusivity (MD), axial diffusion (DA) radial diffusion (DR) and fractional anisotropy (FA) maps were calculated in-house software after eddy-current correction. We performed cortical gray matter and white matter segmentation with Freesurfer 4.5 image analysis suite; with the same tool we performed a parcelization respectively of the cortex and subcortical white matter into 34 regions of interest (ROIs) for each hemisphere (Desikan-Kyliyan atlas). The DTI maps were coregistered to the T1 space by using an affine alignment (FLIRT) followed by a nonlinear alignment (FNIRT) of the FA map to the T1 volume. The fidelity of the registration was confirmed by visual inspection. The average of the DTI parameters in the total white matter mask and the average of MD and FA in each gray and white matter ROI were calculated. We performed the Van der Waerden version of the Krustal-Wallis nonparametric test to compare the differences between the two groups for the DTI parameters in each ROI.

**RESULTS**

In the total white matter we observed statistically significant reduction of MD (p=0.0015), DA (p=0.0002), DR (p=0.0163) in the sCJD patients versus controls. In most of the white matter ROIs the average MD was significantly lower (P<0.01) in sCJD compared to the controls with an almost symmetric pattern of involvement; the average FA was significantly lower in sCJD (P<0.05) compared to the controls bilaterally in the entorhinal and posterior right posterior cingulate, in the left rostral middle frontal insula,
parahippocampi, in the right lateralorbitofrontal, medial orbitofrontal, caudal anteriorcingulate, rostral anteriorcingulate, middle temporal and temporal pole WM. No FA changes were found in the occipital and parietal WM ROIs. In the cortical ROIs we observed a statistically significant MD reduction (p<0.01) bilaterally in the isthmuscingulate, parahippocampal, bankssts, fusiform, inferiortemporal, midletemporal, inferiorparietal, precuneus, supramarginal, in the left postcentral, left superiorparietal, left cuneus, in the right posteriorcingulate and in right lateraloccipital. No significant MD differences (p<0.01) were observed in the frontal lobe. In the deep nuclei we observed statistically significant reduction of MD (p<0.01) bilaterally in the caudate, thalamus, putamen and in the left pallidum.

CONCLUSION
In this study we show a significant global involvement of the white matter in sCJD. We hypothesize that this could be mainly the expression of primary changes of the disease, and not due to secondary degeneration of WM.

KEY WORDS: Diffusion tensor imaging, sporadic Creutzfeldt-Jakob disease

ePoster 031
Decreased White Matter Integrity in Acute Carbon Monoxide Intoxication
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PURPOSE
Human toxicity often is overlooked in carbon monoxide (CO) intoxication because CO is tasteless and odorless and its clinical symptoms and signs are nonspecific. It may develop hypoxic brain damage which predominates in the cerebral cortex, cerebral white matter and basal ganglia. The aim of the study is to evaluate the integrity of white matter after acute CO intoxication and the relationship with clinical comorbid conditions by diffusion tensor imaging (DTI).

MATERIALS & METHODS
Diffusion tensor imaging scan was conducted on 20 patients with acute CO intoxication and 20 sex- and age-matched healthy volunteers. Tract-based spatial statistics was used for voxelwise analysis of whole brain white matter DTI measures. The diffusion measures were correlated with Glasgow coma scale, capillary blood pH value, white-blood cell count, serum carboxyhemoglobin, potassium, and creatinine (Cr) level when these patients arrived at the emergency room.

RESULTS
Regions characterized by low fractional anisotropy (FA) and high radial diffusivity (RD) included corpus callosum, external capsule, corona radiata, superior longitudinal fasciculus, and inferior longitudinal fasciculus, indicating demyelinating process. Greater diffusion abnormalities in sections of inferior longitudinal fasciculus were associated with decreased capillary blood pH value. Lower FA measures in corpus callosum fiber tracts were correlated with elevated serum Cr level, indicated rhabdomyolysis.

Figure 1. The relationship revealed linear correlation (p < 0.05) between mean FA (b), mean RD (c) and capillary blood pH value, located on corpus callosum (splenium), which ROI drawn on the mean FA skeleton (a). The relationship revealed linear correlation (p < 0.05) between mean FA (e), mean RD (f) and capillary blood pH value, located on right ILF/IFO, which ROI drawn on the mean FA skeleton (d). ILF=inferior longitudinal fasciculus; IFO inferior frontocipital fasciculus.

CONCLUSION
The findings indicate that acute CO intoxication will develop demyelination in selective white matter tracts. Worse clinical condition may predict the severity of white matter damage which can assist the guidance of clinical management.

KEY WORDS: Carbon monoxide intoxication, diffusion tensor imaging, tract-based spatial statistics

ePoster 032
Assessing the Chronic Neuropsychologic Sequelae of HIV-Negative Cryptococcal Meningitis Using Diffusion Tensor Imaging
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PURPOSE
The high rate of neuropsychologic sequelae in cryptococcal meningitis (CM) survivors indicates that initial antifungal therapy is far from being satisfactory. This prospective cross-sectional study applied diffusion tensor imaging (DTI) on HIV-negative CM patients to determine if microstructural changes in brain tissue are associated with subsequent cognitive symptoms.

MATERIALS & METHODS
Fifteen patients with HIV-negative CM and 15 sex- and age-matched healthy volunteers were evaluated and compared. All underwent complete medical and neurologic examinations, and neuropsychologic testing. Brain DTI was obtained to derive the fractional anisotropy (FA) and apparent diffu-
sion coefficient (ADC) of several brain regions. Correlations among DTI parameters, neuropsychologic rating scores, and cryptococcal-antigen titer in CSF were analyzed.

RESULTS
Significant ADC values increased and FA values decreased in HIV-negative CM patients in multiple selected regions of interest, including the genu of the corpus callosum and the frontal, parietal, orbito-frontal, and periventricular white matter and lentiform nucleus (Figure 1). Higher CSF cryptococcal-antigen titer on admission was associated with poorer DTI parameters ($r = -0.666$, $p = 0.018$), which were linearly related to worse cognitive performance during follow up.

CONCLUSION
The decline in brain DTI parameters in the associated brain areas indicate an HIV-negative CM microstructural pathology that is related to neuropsychologic consequences.

KEY WORDS: Diffusion tensor image, cryptococcal meningitis, cognition

ePoster 033
Effect of Fiber Orientation Distribution Function Reconstruction on Probabilistic Tractography

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PURPOSE
In neurodegenerative diseases conventional magnetic resonance imaging (MRI) identifies areas of injury, but poorly measures the degree of injury. Diffusion tensor imaging (DTI) is an advanced MRI technique that holds promise to identify fiber tracks in the CNS. However, conventional tractography fails in lesions and with crossing fiber tracks. High angular resolution diffusion imaging, combined with reconstruction of the diffusion probability density function (PDF), allows tracking algorithms to potentially work through lesions and crossing fibers. The persistent angular structure (PAS) reconstruction has demonstrated more precision as compared to other PDF reconstruction methods, but rarely has been used due to its computational cost. Recent advances have reduced this cost, so we investigate this method as a basis for probabilistic tractography. We present our initial results of probabilistic tracking with the PAS and compare with probabilistic tracking using spherical deconvolution (SD).

MATERIALS & METHODS
Probabilistic tractography with each of the two probability distribution functions was performed using HARDI scans from 17 healthy controls and 10 multiple sclerosis patients. Three tracking problems were presented to each algorithm: tracking across the splenium corporis callosi, finding the corticospinal tract from the midpons to the motor cortex and tracking from the left to right hand motor areas. Identical tissue, seed and target masks were used for each test. Finally, we performed our comparison of the tracking results qualitatively, by tracking efficiency and by tracking consistency.

RESULTS
Probabilistic tractography with SD was more efficient in attempts per track in two of the three cases, and was faster on average than with PAS. However, PAS reconstruction produced lower dispersion tracks as measured with the Hausdorff distance.

CONCLUSION
Probabilistic tractography using a PDF generated via persistent angular structure was able to generate tracks across the splenium, following the corticospinal tract from the peduncle to the cortex, and in 23 out of 27 cases from the left to the right hand motor area. We demonstrate the ability of probabilistic tractography with PAS to find a path through the dense crossing fibers of the superior longitudinal fasciculus as well as through multiple sclerosis lesions.

KEY WORDS: Tractography, diffusion imaging

ePoster 034
Brain Oxygen Metabolism Changes in Multiple Sclerosis Measured with T2-Relaxation-Under-Spin-Tagging MR Imaging

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PURPOSE
PET study has shown cerebral hypometabolism with significantly decreased oxygen metabolic rate in both gray matter and white matter in MS. The current study was to determine whether oxygen metabolic abnormalities can be detected using a newly developed T2-relaxation-under-spin-tagging (TRUST) MRI, which is measuring the venous sinus blood oxygenation (Yv).

MATERIALS & METHODS
Twenty-three patients with clinically definite relapsing-remitting MS (eight males and 15 females; mean age, 38.3 years; range, 22 to 53 years) and 16 healthy volunteers (seven males and nine females; mean age, 35.2 years; range, 20 to 59 years) were recruited. The mean disease duration for the patient group was $68.4 \pm 59.6$ months and the mean EDSS score was 1.7 (range 0 - 5.0). MR imaging was performed on a 3.0 T whole body MR scanner. A complete sequence for TRUST MRI includes labeled and control scans acquired at different eTEs for different T2-weightings:
RESULTS

The T2 of the superior sagittal sinus blood was found to be significantly higher in patient group (mean/SD: 59.6/4.8%) compared to controls (mean/SD: 59.5/8.2ms) (P = 0.007). Correspondingly, Yv, which is converted from venous blood T2, was also significantly higher in patient than control group (mean/SD: 64.2/5.1% vs 59.6/4.8%, respectively) (P = 0.007). We found significant positive correlation between Yv and lesion volume (r = 0.44, P = 0.03), indicating that patient with more lesions has higher Yv and lower oxygen consumption. There was a significant difference of brain parenchyma fraction (BPF) between patients and controls (P = 0.04), suggesting there is general brain atrophy in MS patients. However, we did not find any correlation between Yv and atrophic measures including BPF.

CONCLUSION

Using TRUST MRI, this study defines for the first time the significantly higher oxygenation level of the venous sinus blood (Yv) in MS, most likely as a result of considerably reduced oxygen consumption or utilization. Our results are consistent with the findings of the prior PET study (1), suggesting that significant underutilization of oxygen in MS might reflect the diffuse neuronal cells inactive state due to diffuse nature of the disease rather than neuronal tissue loss. The study may raise important questions regarding oxygen metabolism in MS as a component of neurodegeneration that leads to progressive and global neuronal cells dysfunction.

KEY WORDS: Multiple sclerosis, oxygen metabolism, MR imaging

Clinical Correlates of Brain Atrophy in Multiple Sclerosis

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PURPOSE

Our study aimed to calculate total brain, gray matter (GM), and white matter (WM) volumes and to investigate the association between brain volumes and measures of clinical impairment in patients with multiple sclerosis (MS). We sought to investigate whether the Multiple Sclerosis Severity Score (MSSS) improves the association compared to the widely used Expanded Disability Status Score (EDSS), which is hampered by several limitations such as its noncontinuous scoring.

MATERIALS & METHODS

Eighty-two patients with MS meeting the revised McDonald criteria were enrolled prospectively in the study. Forty (M/F = 11/29) patients (mean age: 43.4 years, mean disease duration: 5.2 years and mean EDSS: 1.8) had relapsing-remitting (RR) course, 27 (M/F = 9/18) patients (mean age: 54.0 years, mean disease duration: 24.4 years, and mean EDSS: 1.5) had a benign course, and 15 (M/F = 8/7) patients (mean age: 54.93 years, mean disease duration: 9.47 years, and mean EDSS: 4.0) had a primary progressive (PP) course. For comparison, 38 age- and gender-matched healthy controls (M/F = 17/21) were recruited (mean age: 49.2 years). For all subjects, normalized brain volume (NBV), GM, and WM volumes (GMV and WMV) were measured on 3D magnetization prepared rapid gradient-echo (MPRAGE) images acquired on a 3 T imager using structural image evaluation, using normalization, of atrophy (SIENAX). The MSSS was calculated by comparing the EDSS with the disease duration.

RESULTS

Compared to controls, NBV and GMV but not WMV were decreased significantly in each subgroup of MS patients (P value ranging from 0.02 to <0.001). Normalized brain volume and GMV showed a poor but significant association with EDSS and MSSS (p = 0.02 for both) and a moderate significant association in the subgroup of benign MS patients (p = 0.007 for both). There was no significant difference between EDSS and MSSS in terms of the strength of their correlation with brain volume (p > 0.8).

CONCLUSION

As expected, all subgroups of MS patients showed significant decrease of NBV compared to healthy controls. The separate evaluation of GMV and WMV showed that the decrease of NBV is mainly driven by the decrease of GMV supporting the ever-growing evidence of neurodegeneration in MS patients. Expanded Disability Status Score and MSSS were associated equally with brain volume measures suggesting that, in cross-sectional studies, MSSS does not improve the strength of clinical-MRI correlations. Longitudinal studies, including measures of cognitive impairment are needed to further investigate the clinical correlates of brain atrophy.

KEY WORDS: Multiple sclerosis, demyelinating
Spectrum of MR Findings of Acute Wernicke Encephalopathy: Does Atypical Findings Show at Nonalcoholic Patients, Always?

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PURPOSE
The purpose of our study was to show spectrum of MR findings of Wernicke encephalopathy in patients with and without history of alcohol abuse.

MATERIALS & METHODS
We retrospectively evaluated MR imaging findings of 20 consecutive patients [M:F = 11/9, mean age: 53.7 (50–63) years] with Wernicke encephalopathy. Six patients had history of alcohol abuse and 14 patients had depression or had been receiving total parenteral nutrition (TPN) due to various causes including cancer. Clinical manifestation and MR findings were analyzed in alcoholics and nonalcoholics with consensus; location of lesions, enhancement pattern, diffusion characteristics on DWI, etc. Treatment and outcome also were documented.

RESULTS
Fifty percent (10/20) showed changes in consciousness, 40% (8/20) had ocular symptom, and 35% (7/20) had ataxia. Involved area of MRI brain imaging was at thalamus (19/20), mamillary bodies (18/20), periaqueduct area (20/20), medulla (10/20), cerebellar peduncle (2/20), and cortex (6/20). Six patients (30%) alcoholics and 14 patients (70%) nonalcoholics had cortical involvement. On diffusion-weighted imaging (DWI), two patients had diffuse high signal intensity along cortex of both frontal lobes. Contrast enhancement in the periaqueduct area (5/20), mamillary bodies (5/18), medial thalami (2/18), cortex (2/18) was observed. Four patients (65%) alcoholics and three patients (20%) nonalcoholics had thiamine medication and improved clinical manifestation. Four patients showed stupor to comatose mentality and cortical involvement at the same time. Six patients are alert mentality as well as no cortical involvement.

CONCLUSION
Wernicke encephalopathy is characterized by a quite distinct pattern of MR alterations, which include symmetric high signal intensities in the thalami, mamillary bodies, tectal plate, and periaqueduct area. Cortical involvement of patients with Wernicke encephalopathy is not uncommon and this finding may not be an indicator distinguishing between alcoholics and nonalcoholics. Also atypical MR findings, especially cortical involvement may be more related to clinical severity than to alcohol use.

KEY WORDS: Wernicke encephalopathy, MR imaging

Cerebral Edema in Cirrhotic Patients with and without Spontaneous Portosystemic Shunt: A Voxel-Based Morphometry Study

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PURPOSE
Hepatic encephalopathy (HE) is a well-known complication after the transjugular-intrahepatic-portosystemic shunt. Cerebral edema occurs immediately after procedure due to neurotoxins bypassing the liver. Liver cirrhosis and portal hypertension may develop the spontaneous portosystemic shunt (PSS). However, the role of spontaneous PSS to the brain is still unclear. The purpose of this study is to evaluate the structural change in cirrhotic patients with and without spontaneous PSS by using voxel-based morphometry (VBM).

MATERIALS & METHODS
Total 41 cirrhotic patients and 22 age/gender-comparable healthy controls were enrolled in this study as the group with spontaneous PSS (n=25), the group without spontaneous PSS (n=16), and the group of healthy controls. Voxel-based morphometry was conducted to investigate the differences in gray matter volume between these groups and to determine which structural abnormalities existed.

RESULTS
Cirrhotic patients with spontaneous PSS showed volume reduction in bilateral basal ganglia after comparing with the group without PSS and healthy controls (Figure 1a). However, the volume of bilateral thalami, parahippocampi, and insular and cingulate cortices were significantly greater in the cirrhotic patients with PSS. Furthermore, the group with PSS revealed more volume increase in bilateral thalami, parahippocampi and cingulate cortices than the group without PSS (Figure 1b).

(Figure 1) Superimposed images of the brain with statistical t map depicting the volume difference between groups: (a)
Normal controls and cirrhotic patients without PSS had greater volume in bilateral basal ganglion than patients with PSS. Portosystemic shunt with neurotoxin deposition in basal ganglion may lead to tissue damage and atrophy. No significant volume difference between the normal group and the group without PSS. (b) The size of bilateral thalami, hippocampi, parahippocampi, and insular and cingulate cortices were significantly greater in the group with PSS, in comparison not only with normal controls but also with the group without PSS. The spontaneous PSS increases the risk of cerebral edema.

CONCLUSION
Except volume reduction in basal ganglia, cirrhotic patients with spontaneous PSS revealed significant volume increase in selective gray matter indicating cerebral edema. Our results supplement relevant information and bedside assessments on cirrhotic patients with repeated HE.

KEY WORDS: Portosystemic shunt, liver cirrhosis, voxel-based morphometry

Alteration of Brain Water Diffusivity in Cirrhotic Patients with and without Spontaneous Portosystemic Shunt: a Tract-Based Spatial Statistics Study

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PURPOSE
Spontaneous portosystemic shunt (PSS) is a well-known complication of liver cirrhosis and portal hypertension. However, its impact to brain water diffusivity still is not well delineated. The purpose of this study is to evaluate the white matter diffusivity with diffusion tensor imaging (DTI) by tract-based spatial statistics (TBSS) method in cirrhotic patients with and without PSS and correlating to portal vein flow, shunt severity and lab data.

MATERIALS & METHODS
Diffusion tensor imaging data were collected from 25 cirrhotic patients with spontaneous PSS, 16 cirrhotic patients without PSS, and 22 age/gender comparable healthy controls. Four DTI parameters, fractional anisotropy (FA), first eigenvalue (FEV), radial diffusivity (RD) and apparent diffusion coefficient (ADC) were compared among the three groups by analyzing DTI data using TBSS. Portal vein flow was measured by Doppler ultrasound. Shunt severity was defined after review of CTA or MRA of liver.

RESULTS
Cirrhotic patient with PSS showed decreased FA, increased RD (Figure 1) and increase ADC after comparing with cirrhotic patients free of PSS and health controls. No significant difference of FEV among the three groups. Also, no significant difference of FA, RD (Figure 1) and ADC between cirrhotic patients free of PSS and health controls. Lower portal vein flow, lower albumin level, higher ammonia level and increase severity of spontaneous PSS correlated with lower FA.

CONCLUSION
Cirrhotic patients with spontaneous portosystemic shunt showed significant increase of brain water diffusivity and association with poor clinical profile. Portosystemic shunt blood flow bypassing liver has edematogenic effect to brain may explain that no significant DTI parameter difference between cirrhotic patients without spontaneous PSS and control group. In addition, TBSS is a promising method in examining the white matter degeneration in cirrhotic patient with spontaneous portosystemic shunts.

KEY WORDS: Portosystemic shunt, DTI

Can FDG-PET Quantitative Three-Dimensional Stereotactic Surface Display Z-Scores Predict Progression from Mild Cognitive Impairment to Dementia?

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PURPOSE
Recent studies utilizing subjective visual analysis or software that is not available commercially have found that the risk for progression from mild cognitive impairment (MCI) to Alzheimer disease (AD) might be predicted by the degree and distribution of cerebral hypometabolism with FDG PET.
We investigated the ability of automated quantitative commercially available software to predict progression from MCI to AD.

**MATERIALS & METHODS**

Eighteen patients enrolled in the Mayo Alzheimer Disease Research Center (ADRC) between 2002 and 2004 were determined to have MCI based on clinical assessment of a behavioral neurologist and standardized ADRC neuropsychologic assessment including the Mattis dementia rating scale; this clinical assessment was repeated annually. Each patient was administered 370 MBq F-18 FDG underwent a brain PET scan with 2D-acquisition of 10 minutes for emission and transmission. Images were processed with CortexID software (GE Medical) on an advantage workstation to yield three-dimensional stereotactic surface projection (3D-SSP) images and z-score maps which report the standard deviation of cerebral metabolism. Z-scores were recorded for the following cortical regions: posterior cingulate, medial parietal, parietal association, temporal association, frontal association, and medial frontal cortices. Average association, average cerebral, global, and the single highest regional score for a given patient also were recorded. Sensitivity, specificity, and accuracy of z-score prediction of progression were determined for each of these regions at z-score thresholds of 1.00, 1.25, 1.50, 1.75, 2.00, and 2.25.

**RESULTS**

Twelve patients (5 men, 7 women, average age 73.9 years and education 15.3 years) progressed to dementia (average follow-up 3.7 years, 11 developed AD and 1 developed dementia with Lewy Bodies). 6 patients did not progress (3 men, 3 women, average age 66.5 years and education 15.7 years) during an average follow up of 3.2 years. The highest sensitivity to predict progression of any region was found for the posterior cingulate, medial parietal, and parietal association cortices at the lowest threshold (0.67 for each), but the associated specificities were poor (0.17, 0.33, and 0.50, respectively). The highest accuracy achieved for a region was only 0.61 for the temporal association cortex at threshold of 1.25 and the parietal association cortex at a threshold of 1.00. When only the single highest z-score of any patient was considered regardless of location, the accuracy was higher (0.75 at the 1.5 and 1.75 thresholds), but there was no threshold at which both the sensitivity and specificity surpassed 0.50. For each z-score value investigated, there was considerable overlap in the range of values between the two groups. For example, the z-scores of the posterior cingulate ranged between 0.28 and 1.95 for the group that progressed compared to 0.875 to 2.145 in the group that did not progress.

**CONCLUSION**

The degree and distribution of cerebral hypometabolism as determined by quantitative z-scores was not predictive of progression of MCI to AD. Although it is possible our sample size was not large enough to detect small differences between the groups, we demonstrate that there can be considerable overlap between these groups, likely limiting utility on a patient-by-patient basis.

**KEY WORDS:** Mild cognitive impairment, Alzheimer dementia, FDG PET

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**ePoster 040**

**MR Permeability in Normal-Appearing White Matter and White Matter Lesions of Patients with Multiple Sclerosis**

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**PURPOSE**

Our objective is to correlate the presence and severity of abnormal vascular permeability metrics in cerebral white matter with the diagnosis of multiple sclerosis (MS) and presence of T2 hyperintense lesions. Advanced imaging analysis software (iCAD) was used to evaluate microvascular derangements of cerebral white matter in multiple sclerosis. The goal of the imaging analysis in this study was to evaluate blood-brain barrier (BBB) and vascular inflammatory abnormalities using dynamic contrast-enhanced (DCE) MR permeability imaging in normal cerebral white matter and cerebral white matter affected by MS.

**MATERIALS & METHODS**

We performed a retrospective review of five patients, diagnosed with definite clinical MS and five patients with no diagnosis of MS who underwent imaging for unrelated indications. The patients underwent DCE MR imaging (MRI) permeability imaging. Data were postprocessed on the iCAD platform, a semiautomated imaging analysis suite. Vascular permeability (k-trans) was measured in regions of interest (ROIs) placed over normal-appearing cerebral white matter in the splenium of the corpus callosum and frontal lobe white matter in both MS patients and control group subjects. K-trans measurements also were obtained in MS lesions by placing an ROI over the MS plaque. We then compared and correlated k-trans values between MS lesions and normal-appearing white matter of MS and non-MS patients.

**RESULTS**

MR DCE permeability metrics demonstrated increased k-trans in normal-appearing white matter of MS patients when compared to control group subjects, who demonstrated k-trans values of 0. Increased permeability also was revealed within MS lesions.
CONCLUSION
Vascular inflammatory changes with associated subtle permeability changes related to early BBB violation can be detected in normal-appearing white matter as well as in white matter lesions of in multiple sclerosis patients. Dynamic contrast-enhanced CE permeability analysis may be useful in diagnosis and treatment response evaluation of MS.

KEY WORDS: Multiple sclerosis, MR permeability

Thresholded CT Perfusion Maps Can Accurately Determine Infarct Core when Diffusion-Weighted Imaging Is Unavailable, and Have Similar Specificity in Identifying Patients Unlikely to Benefit from Thrombolysis

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PURPOSE
The presence of a large (>70 ml) admission diffusion-weighted imaging (DWI) lesion in acute stroke patients with a proximal vessel occlusion is an established marker for poor outcome, and hence considered to be a contraindication for endovascular therapy. Our aim was to establish the accuracy of CT perfusion (CTP) cerebral blood volume (CBV) and cerebral blood flow (CBF) maps for estimating infarct core and for determining patients likely to have a poor outcome regardless of treatment, compared to a DWI reference standard.

MATERIALS & METHODS
We analyzed the admission CTP and DWI of 62 stroke patients presenting with a large vessel occlusion on CTA. Infarct core was segmented manually on the admission DWI. We applied 85% and 70% reduction thresholds to CBF and CBV maps respectively, and subsequently determined lesion volumes both by manual segmentation and by visual estimation using the ABC/2 method. Linear regression was used to compare resulting lesion volumes, and Bland Altman plots were used to assess variability. ROC curve analysis was conducted to evaluate the test characteristics of each set of volumes in prediction of clinical outcome, with modified Rankin score (mRS) < 2 considered good and > 2 considered poor outcome.

RESULTS
There was strong correlation between the thresholded CTP and DWI lesion volumes (R2=0.87, coef=1.11 for CBF; R2=0.82, coef=1.05 for CBV, all p<0.001); as well as between the segmented and ABC/2 estimated lesion volumes (R2=0.81, coef=1.03 for DWI; R2=0.883, coef=1.003 for CBF; R2= 0.946, coef=1.11 for CBV, all p<0.001). Bland Altman analyses showed that CBF lesions tended to minimally overestimate, whereas the CBV lesions tended to more substantially underestimate, the DWI lesion volumes; the CBF lesion volumes also had nominally less variability than did the CBV lesion volumes (Avg. dif.=1.6 ml, STDV=±13.97 ml for CBF; and Avg. dif.=13 ml, STDV=±16 ml for CBV). ROC curve analysis showed that there was no significant difference between CBV and CBF, or CBV and DWI, for overall prediction of clinical outcome (AUC=0.84 for DWI, AUC=0.74 for CBF, and AUC=0.74 for CBV, p=0.9 for CBV vs. CBF, and p=0.06 for CBV vs. DWI), although there was a significant difference between DWI and CBF (p=0.017 for DWI vs. CBF).

CONCLUSION
All parameters were highly specific for poor outcome, but at different volume thresholds (see scatterplots).

KEY WORDS: CT perfusion, DWI, infarct volume
Evaluation of the Evolution and Relevance of in vivo MR Imaging Blood-Brain Barrier Permeability Measurements in a Rat Model of Ischemic Stroke

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PURPOSE
To evaluate the predictive value of blood-brain barrier (BBB) permeability measurements extracted from perfusion-weighted MR imaging for hemorrhagic transformation in stroke.

MATERIALS & METHODS
Spontaneously hypertensive rats and Wistar rats with unilateral, 2h-hour filament occlusion of the right MCA underwent imaging during occlusion, post-reperfusion at 4 hours and 24 hours. Blood-brain barrier permeability was imaged by dynamic contrast enhancement imaging technique and quantified by Patlak analysis. Cresyl-violet staining was used to detect and characterize hemorrhage on histology in sacrificed rats at 24 hours, immediately following the last imaging study. Permeability changes were evaluated at baseline, after reperfusion and at 24 hours, in animals with or without macroscopic hemorrhage. Receiver-operating characteristic (ROC) analysis was performed to determine the most accurate permeability threshold to predict hemorrhagic transformation.

RESULTS
In animals that showed macroscopic hemorrhage at 24 hours, BBB permeability values in the whole infarcted hemisphere were 0.28 ± 0.02, 0.51 ± 0.19, and 0.42 ± 0.09 ml/min·100 ml (± ± σ) during occlusion, 4-hour post-reperfusion and 24-hour post-reperfusion, respectively. Blood-brain barrier permeability values on the contralateral hemisphere in the same animals were 0.27 ± 0.04, 0.36 ± 0.16, and 0.26 ± 0.11 ml/min·100 ml, respectively. In animals without a macroscopic hemorrhage at 24 hours, BBB permeability values in the infarcted hemisphere were: 0.27 ± 0.06, 0.49 ± 0.24, 0.45 ± 0.18 ml/min·100 ml. The predictive value of BBB permeability in terms of macroscopic hemorrhage at 24 hours was characterized on the ROC analysis by an area under the curve of 0.679. Combining BBB permeability with reperfusion information mildly increased the area under the curve to 0.761. Overall, the negative predictive value of BBB permeability measurements was significant, while the positive predictive value was limited. For instance, for a BBB permeability threshold of e.g., 0.35 ml/min·100 ml positive and negative predictive values were 6.4% and 97.6% respectively.

CONCLUSION
Altered BBB permeability is a necessary but not sufficient condition to cause hemorrhagic transformation in rats with an infarct. Further research is needed to identify the additional risk factors that need to be present, in combination with an increased BBB permeability, to perfectly predict hemorrhagic transformation in the setting of stroke.

KEY WORDS: Ischemic stroke, hemorrhagic transformation, blood-brain barrier permeability

Correlation of CT Perfusion Occipital Blood Flow Asymmetries with Asymmetric Posterior Communicating Arteries in Stroke Patients

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PURPOSE
The University of Colorado Denver stroke program has used CT perfusion (CTP) and CTA (CT angiography) for stroke alert patients for over 5 years. During this time we identified multiple cases of subjective occipital perfusion asymmetry that coincided with asymmetries between the posterior communicating artery diameters. To further evaluate, we measured the posterior communicating artery (PCA) distribution mean transit time (MTT), time to peak (TTP) and cerebral blood flow (CBF) and compared these parameters to the ratios of the diameters of the first segments (DP1) of the posterior cerebral arteries and the diameter of posterior communicating arteries (DPcom).

MATERIALS & METHODS
The study was granted IRB-exempt status by the hospital. Stroke patients were evaluated with dynamic CTP and CTA. Only patients without evidence of posterior circulation embolic events were included. Thirty-five patients from the time period of 1/2005-7/2006 have been analyzed thus far. Patients were segmented into those with and without perceived asymmetries in the occipital lobe perfusion parameters (TTP, MTT and CBF) using manufacturer’s standard software. Thirteen patients had perceived asymmetries in occipital perfusion parameters. Images were reanalyzed with an independent deconvolution-based software package (Vitrea). We measured voxel means and standard deviations for each left and right PCA territory perfusion parameter using uniform regions of interest (ROIs). We measured DP1 and DPcom using standard PACs software tools (McKesson) and calculated DP1/DPcom. Left-right differences in the same perfusion parameters were calculated and plotted against left-right P1/Pcom differences and the data fit by linear regression.

RESULTS
Current results demonstrate positive correlations between increasing difference in TTP and MTT and increasing P1/Pcom ratios, i.e., the greater the difference in P1/Pcom between occipital lobes, the greater the difference in the perfusion parameters. Cerebral blood flow demonstrated a similar but negative correlation, as expected.
CONCLUSION
These results demonstrate that posterior circulation perfusion asymmetry correlates with asymmetric occipital supply differences (persistent fetal circulation) and are consistent with our previously-presented hypothesis (ASNR 2008) that the posterior circulation perfuses slightly more slowly than the anterior circulation.

KEY WORDS: Perfusion, PCA, anatomy

Pulse-Wave Synchronized Arterial Spin-Labeling MR Imaging on Moyamoya Disease Compared with SPECT Imaging

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PURPOSE
Standard arterial spin-labeling magnetic resonance imaging (ASL-MRI) and pulse-wave synchronized ASL-MRI (Pews-ASL-MRI) were compared with single photon emission computed tomography (SPECT) imaging on moyamoya disease (MMD).

MATERIALS & METHODS
Cerebral blood flow (CBF) examinations using ASL-MRI on 3 T MRI and SPECT images with iodine-123-N-isopropyl-p-iodoamphetamine at resting (rest-IMP) and after acetazolamide challenge (ACZ-IMP) were performed on 16 MMD patients. The CBF values determined by ASL-MRI(ASL-value), Pews-ASL-MRI (Pews-ASL-value), rest-IMP (rest-IMP-value), and ACZ-IMP (ACZ-IMP-value) of cerebral hemispheres (36 sides) were measured with normalized CBF maps created from data of those four perfusion imaging methods. Cerebrovascular reactivity (CVR) also was calculated. The ASL-value and Pews-ASL-value were compared with the rest-IMP-value, ACZ-IMP-value, and CVR.

RESULTS
The ASL-value, Pews-ASL-value, rest-IMP-value, ACZ-IMP-value (mL/100g/min) were 25.6 ± 11.9, 23.7 ± 13.3, 32.7 ± 6.9, and 42.4 ± 10.7, respectively. CVR (%) were 33.1 ± 41.5. Significant relationships were observed between ASL-value versus ACZ-IMP-value (correlation coefficient: r = 0.807, p < 0.01), ASL-MRI vs CVR (r = 0.702, p < 0.01), Pews-ASL-MRI versus rest-IMP-value (r = 0.544, p < 0.01).

CONCLUSION
Significant relationships of ASL-MRI vs. ACZ-IMP and Pews-ASL-MRI vs. rest-IMP might suggest that they could speculate not only apparently but also potentially dangerous zone for ischemia.

KEY WORDS: Cerebrovascular disease, moyamoya disease, arterial spin-labeling

CT Perfusion as a Prognostic Marker for the Development of Stroke in Transient Ischemic Attack Patients with Nonsignificant Carotid Artery Stenosis

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PURPOSE
Stroke is a leading cause of long-term, acquired adult disability. Identifying its predictors is critical in shaping the management of patients who are at risk. Patients with nonsignificant carotid stenosis and poor cerebral perfusion, however, may have a higher stroke risk than patients with normal cerebral perfusion. CT perfusion may therefore play a role in stroke prevention by acting as a stratifying factor in determining whether a symptomatic patient with nonsignificant internal carotid artery stenosis could benefit from more aggressive nonsurgical management. We hypothesize that in patients with nonsignificant stenosis (0 - 59%), cerebral blood flow, blood volume, and mean transit time as measured by CT perfusion during a transient ischemic attack (TIA) would be decreased in subjects more likely to have a stroke or TIA within 3 months, 6 months, and 1 year intervals.

MATERIALS & METHODS
A prospective study was performed to evaluate the risk of stroke or recurrent TIA in symptomatic patients using CT perfusion. Difference in outcome between groups with differing cerebral perfusion scans was analyzed using nonparametric ANOVA statistical models. Patients who presented to a tertiary care emergency room with a TIA were studied. Subjects received a cerebral CT scan, CT angiogram, and CT perfusion, all blindly analyzed by a neuroradiologist for the degree of ICA stenosis, and size of perfusion (blood volume, blood flow, and mean transit time) defects. The perfusion abnormality was measured applying the ASPECTS method to MCA territory defects. Stroke risk factors were collected and an ABCD2 score was calculated to determine a subject’s baseline stroke risk. Subjects were classified into two groups by degree of stenosis: significant (>60 - 99%) and nonsignificant (0 - 59%). Three months, 6 months, and 1 year following initial assessment, each subject was contacted for a secondary assessment of neurologic status for the primary outcome, a subsequent stroke or for the secondary outcome, a TIA event.
**RESULTS**  
Thirty-five patients consented to participate; however, five were lost to follow up and one was excluded for subsequent diagnosis of hemiplegic migraine for a total of 29 eligible patients. There is no correlation between the presence or size of CT perfusion defect and occurrence of stroke or recurrence of TIA at 3, 6 or 12 months. CT perfusion may show that high ASPECTS can be correlated with low likelihood of stroke or TIA 3 months postinitial TIA event.

**CONCLUSION**  
There have been few studies to differentiate between how aggressively one should manage those with nonsignificant carotid artery stenosis (0 - 59%). In our study, CT perfusion parameters including blood flow, blood volume, and mean transit time during a TIA event were not shown to be an effective indicator of stroke or TIA within 3 months. Conversely, a high ASPECTS score on CT perfusion does show a low likelihood of stroke or TIA in 3 months postinitial TIA.

**KEY WORDS:** Stroke, perfusion, carotid artery stenosis

**ePoster 046**

Comparison of Three Functional MR Imaging Paradigms for Identifying Brain Language Areas

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**PURPOSE**

Localization of language areas prior to brain surgery is critical in minimizing morbidity. Although a wide variety of language paradigms have been described previously, significant challenges remain in generating consistent and reliable results. The aim of this study is to compare three different language paradigms.

**MATERIALS & METHODS**

Seventeen healthy right-handed volunteers (11 women, 6 men) ranging in age from 22 to 45 years, with no history of neurologic or psychiatric symptoms were included in the study. All examinations were conducted with a 3T MRI scanner and an 8-channel head coil. Following the acquisition of high-resolution T1-weighted anatomical reference images, functional imaging was completed by gradient-echo EPI sequence. Three different semantic functional MR imaging (fMRI) paradigms including verb generation task-1 (VGT-1), verb generation task-2 (VGT-2) and a semantic fluency task (SFT) were used in each subject for the localization of the language areas. Verb generation task-1 and SFT had passive baseline conditions with true rests. Baseline conditions at VGT-2 observed to be useful in reduction of activations for detecting and lateralizing receptive language area. Extensive activations and deactivations also were observed on default networks during VGT-1 and SFT in addition to these language areas.

**RESULTS**

During VGT-1, on group analyses, bilateral activations in inferior frontal regions (Brodmann area 44, 45), superior temporal regions (Brodmann area 22) and left inferior parietal lobule (Brodmann area 39, 40) were obtained. Activations in the left inferior frontal region and superior temporal region were more robust in comparison with right side. Activation of the superior temporal gyrus, inferior frontal gyrus and inferior parietal lobule was observed only in left side, while no activation pattern was seen on the right side with VGT-2. The SFT task produced activations in the inferior frontal gyrus and inferior parietal lobule together with a small area in bilateral superior temporal gyrus (receptive language area). Extensive activations and deactivations also were observed on default networks during VGT-1 and SFT in addition to these language areas.

**CONCLUSION**

Many different types of fMRI language tasks have been used as verb generation tasks, semantic decision tasks, phonological tasks, and passive listening or sentence-reading tasks. Although, some authors suggested that using active baselines in sentence-generation tasks may obscure the activity in language areas, our results show that the VGT-2 task with active rest condition produced more specific activations at all target language areas. Activations of VGT-1 were spatially wider and may cause confusion during the clinical use in the assessment of language lateralization and critical localization. Semantic fluency task did not provide sufficient activations for detecting and lateralizing receptive language area, and extensive deactivation was observed. In conclusion, extensive activations and deactivations on default network that may not be relevant for the purpose of language mapping were observed with VGT-1 and SFT. Active baseline conditions at VGT-2 observed to be useful in reduction of activations and deactivations on default networks.

**KEY WORDS:** fMRI, language, lateralization

**ePoster 047**

Impaired Small-World Efficiency in Functional Networks in Liver Cirrhosis Patients

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**PURPOSE**

Hepatic encephalopathy (HE) is one of the major complications of liver cirrhosis and a complex neurophysiologic syndrome. It will be acts of confusion, personality changes, conscious changes and ups and downs of the neurologic manifestations. Network efficiency was defined using a “small-world” network model that quantifies the effectiveness of information transfer within brain networks. Our purpose of this study is to investigate abnormalities of neuronal connectivity among widely distributed brain regions in patients with liver cirrhosis.
MATERIALS & METHODS
The subject group comprised 37 patients with liver cirrhosis (53±8 years) and 34 normal healthy subjects (53±9 years). The patients were divided into noHE (n=19), MHE (n=9) and overtHE (n=9). The functional images were obtained using an EPI sequence with the following parameters: 33 axial slices, and TR= 2s on a GE 3T scanner. Each subject was scanned in a resting state for 10 min. All resting data underwent the following preprocess procedure: slice timing, head motion correction, spatial normalization with re-sampling to 2x2x2 mm and smooth with 6mm (FWHM) Gaussian kernel using SPM5. Resting-state fMRI Data Analysis Toolkit (REST), was used for removing the linear trend of time courses and for temporally band-pass filtering (0.01-0.08 Hz). Prior to the correlation analysis, a linear regression was performed to remove the effects of nine nuisance covariates: the WM signal; the CSF signal; and six head motion parameters. Regional mean time series were estimated for each individual by averaging the fMRI time series over all voxels in each of 90 regions utilizing AAL model. We then obtained the inter-regional correlation matrix Rij (i, j=1, 2,...N, here N=90) by calculating Pearson’s correlation coefficients across subjects between every pair of regions. We applied a cost threshold value (0<C<1) and correlation threshold value (0<R<1) to construct the functional brain networks. This allows us to examine the relative and absolute network efficiency in each group. The absolute and relative network efficiency measurements quantify distinct aspects of topological network organization. To determine whether the network topology in liver cirrhosis was correlated with the degree of severity, we performed a linear regression analysis of each network parameter against the severity of liver cirrhosis.

RESULTS
Graph theoretical analysis revealed that the local efficiency curves of functional connectivity networks were intermediate compared with those of the matched regular and random networks over a wide range of network costs and correlation threshold. The liver cirrhosis patients exhibited significantly decreased integrated absolute local efficiency [t(2) = -2.01, P=.048] and integrated relative local efficiency [t(2) = -2.747 P=.008] in the functional connectivity networks with increasing the severity of liver cirrhosis.

CONCLUSION
In this study, we used resting-state functional MRI measurements to demonstrate that human brain functional networks exhibit economical small-world properties as characterized by high local efficiency at a relatively low wiring cost. More importantly, we showed that the network efficiency had significant decrements with increased severity in liver cirrhosis, with the most prominent changes in specific brain regions, including the medical prefrontal cortex and temporal association areas.

KEY WORDS: Resting fMRI, brain connectivity, liver cirrhosis

ePoster 048
Factors Influencing Successful Recanalization after IV-rtPA Treatment in Acute Ischemic Stroke: The Successful Recanalization Score

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PURPOSE
We determined the incidence and significant predictors of successful recanalization, defined as angiographic recanalization and a good clinical outcome, after IV-rtPA in acute ischemic stroke. A successful recanalization score was devised and tested.

MATERIALS & METHODS
One hundred twenty-six consecutive patients with anterior circulation ischemic stroke receiving IV-rtPA were reviewed retrospectively. This study was approved by the institutional review board and all patients provided informed consent. Imaging included a baseline noncontrast CT (NCCT) and CT angiography (CTA). Recanalization was assessed on a 24-hour CTA. Clinical outcome was determined by a 90 day Modified Rankin Score (mRS). Successful recanalization was defined as angiographic recanalization (TIMI score>=2) with a good clinical outcome (mRS <=3). Logistic regression analysis determined predictors of successful recanalization and the successful recanalization score (SRS) was devised and tested using Akaike’s information criteria (AIC).

RESULTS
Mean age was 72.8 ± 12.1 years (male 64/126, 51%). Successful recanalization occurred in 37% (46/126) of all patients. Patients with successful recanalization had fewer neurologic deficits (p = 0.001) and higher ASPECT scores (p = 0.005) than those without successful recanalization. Admission NIHSS score (p = 0.026) and the site of vessel occlusion (p = 0.016) were significant predictors of successful recanalization. Distal occlusions were more likely to have a better outcome [OR 2.9, 95%CI (1.357 - 6.385); p = 0.005]. The SRS performed better for predicting successful recanalization compared with either NIHSS or occlusion location alone (AIC 146.9; R2 12.5%; p<0.0001).

CONCLUSION
Milder baseline stroke deficit, distal vessel occlusion and the successful recanalization score are significant predictors of successful recanalization.

KEY WORDS: Acute stroke, recanalization, thrombolysis
Rate of Hematoma Expansion in Primary Intracerebral Hemorrhage Predicts Mortality and Clinical Outcome: A Prospective Study

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PURPOSE
Intracerebral hemorrhage (ICH) results in high mortality and morbidity for patients. Our previous retrospective study has shown that ICH patients with a higher rate of hematoma expansion had a higher mortality rate compared to patients with a lower rate of hematoma expansion. We performed a prospective study to validate the predictive value of the rate of hematoma expansion.

MATERIALS & METHODS
We prospectively collected all patients with primary ICH who presented to the emergency department over 1.5 years. A total of 160 patients received baseline noncontrast CT (NCCT) within 24 hours of admission and underwent follow-up NCCT within 48 hours. The ICH volume and the intraventricular extension were calculated on the CT images. Patient’s clinical and demographic information were obtained at admission. In-hospital mortality, and modified Rankin Scale (mRS) at 3 months were recorded. All variables were analyzed using univariate analysis to find potential predictors. An ordinal multivariate logistic regression analysis was performed to determine independent predictors of in-hospital mortality and poor clinical outcome.

RESULTS
Independent factors associated with in-hospital mortality from ICH were initial ICH volume (p<0.0001), rate of ICH expansion (p = 0.0022), and blood glucose level (p = 0.01). Rate of ICH expansion was an independent predictor of in-hospital mortality (odds ratio: 5.6, 95% CI 1.9 to 16.7, p = 0.0022). Factors independently associated with the 3-month clinical outcome were mean arterial blood pressure of patients (p = 0.024), presence of intraventricular extension (p = 0.0081), initial ICH volume (p = 0.0071), and rate of ICH expansion (p = 0.0011). Rate of ICH expansion was an independent predictor of the 3-month clinical outcome (odds ratio: 11.2, 95% CI 2.6 to 47.6, p = 0.0011) (Figure1)

CONCLUSION
The rate of hematoma expansion is an independent predictor of in-hospital mortality and poor clinical outcome in primary ICH, and thus, may guide clinicians’ patient selection for aggressive treatment.

KEY WORDS: Intracerebral hemorrhage, mortality, stroke

Spot Sign Score Identifies Rapid Bleeding in Spontaneous Intracerebral Hemorrhage

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PURPOSE
To determine whether spot sign score correlates with rate of hematoma expansion and whether rate of expansion predicts in-hospital mortality and clinical outcome in spontaneous intracerebral hemorrhage (ICH).

MATERIALS & METHODS
The study included 367 consecutive patients presenting to the emergency department (ED) from January 1, 2000 to December 31, 2008 with nontraumatic ICH. All received noncontrast head CT (NCCT) and multidetector CT angiography (MDCTA) on presentation to the ED and a follow-up NCCT within 48 hours. Imaging was used to determine the hematoma location and volume, rate of expansion, and spot sign score. Primary outcome measures included in-hospital mortality and modified Rankin Scale at discharge. Regression analysis was performed to correlate spot sign score and rate of hematoma expansion.

RESULTS
Intracerebral hemorrhage expansion was identified in 194 of 367 patients (53%). In a multivariate analysis, rate of ICH expansion predicted mortality (Hazard Ratio 1.1, CI 1.08-1.12, p<0.0001). Patients who expired had an average rate of ICH expansion of 2.8 ml/hr compared to 0.2 ml/hr in survivors. Spot sign score on presentation to the ED correlated with the rate of hematoma expansion.
CONCLUSION

Rate of hematoma expansion predicts outcome in spontaneous ICH. Spot sign score on presentation correlates with rate of expansion, supporting the hypothesis that high spot sign scores reflect active bleeding in acute ICH.

KEY WORDS: Intracerebral hemorrhage, stroke, computed tomography

ePoster 051

Time Alone Is Not Brain

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PURPOSE

“Time is brain” has been the guiding principle in the management of acute ischemic stroke (AIS). However there are patients who present with small infarct volumes several hours after stroke onset suggesting significant variability. Our goal was to evaluate whether a correlation existed between time since stroke onset and baseline infarct size.

MATERIALS & METHODS

We analyzed 98 anterior circulation AIS patients who presented to our ED in 2008, were imaged by MR imaging (MRI) within 24 hours of onset, and who had definite times of stroke onset, or were discovered within 30 minutes of last seen well. We calculated infarct volumes on diffusion-weighted imaging (DWI)/apparent diffusion coefficient (ADC) images using dedicated software.

RESULTS

We found no significant correlation between infarct volumes and stroke onset time (r = -0.07, P = 0.48). The proportion of patients with infarct volume >100 cc within 3 hours of onset (2/20, 10.0%) was similar to the proportion with >100 cc volume after 3 hours of onset (8/78, 10.3%; P = 0.70). Moreover, when dividing the patients into four groups based on time (0-3 hours, 3-6 hours, 6-9 hours, > 9 hours), the results were again similar (10.0%, 12.5%, 4.3%, and 14.3%, respectively). There was no significant difference in the proportion of patients with large infarct volumes as the time from stroke onset increased (P = 0.74) (Figure). When looking at only those patients with proximal artery occlusions (ICA or M1 segment), we again found no correlation (r = 0.15, P = 0.39), and no difference in the proportion of patients who had large strokes when analyzed using the 2 time classes (P = 0.97) or the 4 time classes (P = 0.42).

CONCLUSION

In a broad population of anterior circulation AIS, there is no correlation between infarct volume and time since stroke onset. A longer time from onset did not result in a greater proportion of strokes >100 cc. Our findings suggest that time alone is not brain, and that additional factors that impact infarct size should be considered in treatment decision making.

KEY WORDS: Acute ischemic stroke, infarct size, diffusion-weighted imaging

ePoster 052

Automated Assessment of Leptomeningeal Collateralization in Acute Middle Cerebral Artery Stroke: Proof of Concept

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PURPOSE

Collateral status in acute ischemic stroke significantly correlates with clinical outcome but so far there is no standardized method of collateral rating based on CT angiography (CTA). User independent automated collateral rating would be valuable for fast decision making in acute stroke management and data acquisition in stroke trials. The purpose of this
study is proof of concept that reliable automated collateral assessment can be obtained in acute stroke CTA images using automated image analysis software.

**Materials & Methods**

Collaterals were rated in CTA maximum projections (MIP) images of 35 acute stroke cases with proximal middle cerebral artery occlusion. In consensus, two raters scored abundance of collaterals in the ischemic hemisphere compared to the unaffected contralateral side using the following scoring scheme: 0- virtually absent; 1- less than the contralateral unaffected side; 2- equal or more than the contralateral unaffected side. For automated scoring of collateral vessels, CTA MIP images were skull stripped, coregistered to MNI-152 standard space and thresholded (70-370HU) to define vessel-specific voxels (Analyze 10.0, AnalyzeDirect). A template of the right and left hemisphere with masking of the saggital and transversal sinus was used to calculate the relative abundance of vessels per hemisphere: \[\text{mean vessel-HU} \times \text{vessel-volume}\] (FSL4.1, FMRIB). The collateral index (CI) was calculated as the ratio of relative vessel-abundance in the ischemic hemisphere to the unaffected side. Optimal cut-off values of CI for predicting collateral scores (CS) were determined by CART (Classification and Regression Trees, TIBCO Spotfire S+ 8.1). Agreement between rater-based and automated CS was assessed by weighted kappa (SAS 9.2).

**Results**

The correlation between CI and CS was significant (Spearman 0.742). Collateral index range was 0.61 to 1.23 with optimal cut-offs at 0.74 and 0.97 for classification of CI into CS. Agreement between CI and predicted CS was significant (kappa = 0.661).

<table>
<thead>
<tr>
<th>CI cut-off</th>
<th>median</th>
<th>st.dev.</th>
<th>range</th>
<th>N</th>
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<tbody>
<tr>
<td>CS 0</td>
<td>0.71</td>
<td>0.059</td>
<td>0.13</td>
<td>4</td>
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<tr>
<td>CS 1</td>
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<td>0.090</td>
<td>0.35</td>
<td>25</td>
</tr>
<tr>
<td>CS 2</td>
<td>1.06</td>
<td>0.095</td>
<td>0.28</td>
<td>6</td>
</tr>
</tbody>
</table>

**Conclusion**

Proof of concept for automated assessment of collateral vessels is presented: software-based collateral index in acute stroke CTA images highly correlated with reference collateral scores. The collateral index can be classified to generate rater-based collateral scores. The results encourage further development of software for automated collateral scoring in acute stroke imaging.

**Key Words:** Collaterals, stroke, software

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**Effect of Altering Temporal Acquisition Intervals on the Quantitative Measurement and Qualitative Interpretation of Whole Brain CT Perfusion Imaging**

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**Purpose**

Perfusion imaging of whole brain z-axis coverage can be achieved using shuttle mode acquisition. The radiation dose can be reduced by increasing the time intervals of dynamic image acquisition. We assessed the effect of altering temporal resolution on calculated perfusion parameters and qualitative interpretations of whole brain perfusion maps.

**Materials & Methods**

The perfusion data of eight patients presenting with stroke symptoms between July 2009 and March 2010 were acquired at 1.5 second intervals. By using data obtained at every other or every third time point, longer acquisition intervals of 3.0 and 4.5 second respectively were simulated from the source data. Quantitative measurement of penumbra and normal cortex were compared between 1.5 versus 3.0 and 1.5 versus 4.5 second data sets. In addition, the perfusion maps of these data sets were assessed by three neuroradiologists independently for presence and size of defect, quality of the maps, and congruity of final interpretation.

**Results**

The mean relative cerebral blood flow (rCBF) values of the penumbra were overestimated at both 3.0 (p<0.0001) and 4.5 (p<0.0001) second acquisition interval as compared to 1.5 second. There is significant difference (p<0.0005) between the mean rCBF values obtained from penumbra and healthy tissues at 1.5 second acquisition interval but not at 3.0 and 4.5 second. In terms of qualitative interpretations, however, there was no difference in detection of defect comparing 1.5 versus 3.0 second and 1.5 versus 4.5 second, with excellent reader agreement. The size of defect is underestimated on the 3.0 and 4.5 second maps for three out of eight patients based on rCBF and MTT, but no difference was detected using time to peak (TTP). The quality of the 4.5 second maps was significantly lower compared to 1.5, but not 3.0 compared to 1.5.
CONCLUSION
Although there was no difference in the qualitative detection of defect comparing 1.5 second to 3.0 and 4.5 second intervals and assessment of defect size on TTP maps, there was significant difference in quantitative measurement and quantitative assessment of defect size on CBV and MTT maps.

KEY WORDS: Perfusion, stroke, shuttle

ePoster 054
Diffusion Tensor Imaging of the Corpus Callosum in Multiple Sclerosis Patients: Differences between Enhancing and Nonenhancing Cohorts
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PURPOSE
To analyze the differences in diffusion tensor imaging (DTI) derived metrics of the corpus callosum (CC) in relapsing remitting and secondary progressive multiple sclerosis patients with enhancing and nonenhancing lesions.

MATERIALS & METHODS
The study was approved by the IRB. Diffusion tensor images of 32 patients with relapsing remitting MS (RRMS) and 14 patients with secondary progressive MS (SPMS) were analyzed retrospectively on a GE Advantage workstation to generate fractional anisotropy (FA) and mean diffusivity (MD) maps. Fractional anisotropy and MD values were calculated by freehand regions of interest at the level of genu, midbody and splenium of corpus callosum by two neuroradiologists who were blinded to clinical information. The conventional images also were reviewed to enable generation of four groups: I - RRMS with no lesion enhancement. II - RRMS with enhancing lesions. III - SPMS with no lesion enhancement. IV - SPMS with enhancing lesions. Differences in FA and MD between groups I and II, and between III and IV were studied using the unequal variance independent samples t-test. Differences were evaluated in all three regions of the corpus callosum.

RESULTS
Significant differences were seen in mean FA values in all three regions of the CC between groups III and IV by reader I (p = 0.004, 0.01 and 0.005 for genu, body and splenium) and in the genu and splenium of CC by reader II (p = 0.04, 0.001 respectively). All three regions of the CC demonstrated lower FA values in group IV (enhancing SPMS) compared to group III. No significant differences in MD values were seen between groups III and IV in all CC regions by both readers. Also, none of the regions in the CC showed significant differences in MD and FA values between groups I and II (for both readers).

CONCLUSION
Fractional anisotropy of SPMS patients with enhancing lesions appears to be significantly lower than that seen in SPMS patients with no actively enhancing foci, suggesting that there may be more white matter damage in the former. Hence we may be able to use FA as a marker for disease activity and possibly for follow up. We presently are studying longitudinal FA changes prospectively in SPMS patients and its correlation with clinical outcome measures to better understand pathophysiology of SPMS.

KEY WORDS: Diffusion tensor imaging, multiple sclerosis, corpus callosum

ePoster 055
Brain MR Imaging and 25-Hydroxyvitamin D
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PURPOSE
Vitamin D is active in the healthy function of the human brain; low levels may be associated with poor cognitive function in the elderly. A recent study showed an association between low levels of serum 25-Hydroxyvitamin D and MR imaging (MRI) evidence of large vessel infarction and white matter hyperintensities (WMH) in patients over the age of 65 years. Less than 10ng/mL vitamin D is considered deficient, 10-20 ng/mL is insufficient. The purpose of this pilot study is to evaluate the relationship between serum vitamin D levels and the MRI appearance of the brain in nonelderly adult subjects.

MATERIALS & METHODS
Under IRB approval 56 patients who had a serum vitamin D level drawn and a standard MRI of the brain within 3 months of each other were identified. Patients’ age ranged from 31-69 years, 14 from each decade. Retrospective analysis includes 25-Hydroxyvitamin D, clinical factors and qualitative and volumetric study of routine brain MRI. Clinical characteristics included possible confounding factors such as age, hypertension, migraine, trauma, multiple sclerosis, cigarette and alcohol use in addition to standard profile. The MRI studies were evaluated by two senior neuroradiologists for infarction, atrophy, perivascular spaces, WMH (typical punctate and confluent; location- juxtacortical, cortical and periventricular) and a general impression. Statistical methods: Spearman correlation coefficient was computed to assess the relationship between vitamin D level and WMH; a Chi-square test or a Fisher’s exact test was used to assess the association between hypertension and presence of WMH.

RESULTS
Seven patients were excluded because of insufficient MRI studies or overwhelming pathology. Twenty-five patients had WMH, 24 had no WMH, the average vitamin D levels were 34 and 33 ng/mL respectively. One patient had MRI evidence of a cortical infarction and a vitamin D level of 11.
Three patients had lacunar infarcts with vitamin D levels of 9, 19 and 11ng/mL. Among age 51–60 patients (n = 13), low serum vitamin D was marginally statistically correlated with punctate central WMH (Spearman correlation coefficient: -0.53, p = 0.064); Among patients 51 and older (n = 26), low serum vitamin D was marginally statistically correlated with juxtacortical punctate WMH (Spearman correlation coefficient: -0.35, p = 0.084); Hypertensive patients have significantly more central punctate WMH, p = 0.0005; juxtacortical punctate WMH, p = 0.0035; periventricular confluent WMH, p = 0.0038; and marginally more periventricular punctate WMH present than nonhypertensives, p = 0.0760.

CONCLUSION
In this pilot study low serum vitamin D marginally correlated with juxtacortical and central punctate white matter hyperintensities among patients >51 years old. Four patients with low vitamin D had infarcts. Further study of the role of vitamin D in the healthy brain and in the prevention of disease in adult patients is indicated. The possibility of reversing or delaying WMH in patients with low vitamin D should be investigated.

KEY WORDS: MR imaging - brain, vitamin D

ePoster 056
Naming Impairment and Gray Matter Loss in the Conversion from Mild Cognitive Impairment to Alzheimer Disease

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PURPOSE
Our goal was to assess the correlation between regional gray matter (GM) volume loss and naming ability measured using the Boston Naming test in amnestic mild cognitive impairment (MCI) patients with conversion to Alzheimer disease (AD).

MATERIALS & METHODS
The 30-item Boston Naming test (BNT) was administered to 35 subjects (21 males, mean age 72.3 years) participating in the AD Neuroimaging Initiative with documented MCI-to-AD conversion, 12 months before the diagnosis of AD. The sample was divided into two groups, 21 subjects with BNT score below or equal to the median (low BNT) and 14 subjects with BNT score above the median (high BNT). Brain MR images (MRIs) obtained 1 year before the diagnosis of conversion from MCI to AD and at the time of the conversion were available for each patient. The Clinical Dementia Rating scale was used to assess disease severity. Voxel-based morphometry with SPM5 was used for MR image postprocessing. Comparison between longitudinal imaging data was conducted using paired t-tests and results were considered significant when the p-value was less than 0.05 with false discovery rate correction for multiple comparisons.

RESULTS
There were no significant differences in demographics or disease severity between the two groups. Low BNT subjects showed significant GM volume loss in the bilateral frontal and parietal lobes during the 12 months preceding the diagnosis of AD. There were no significant changes in GM volume in the high BNT group during the 12 months preceding the conversion to AD.

CONCLUSION
Patients with MCI-AD conversion and naming deficit undergo faster GM atrophy than patients without naming deficit. The accelerated progression of neocortical frontal and parietal atrophy in MCI-AD converters presenting with naming dysfunction has potential important implications for therapeutic approaches and prognosis in AD.

KEY WORDS: Alzheimer disease, mild cognitive impairment, MR imaging

ePoster 057
Atypical Brain Stem Variant of Posterior Reversible Encephalopathy Syndrome

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PURPOSE
Posterior reversible encephalopathy syndrome (PRES) is characterized by clinical symptoms associated with imaging features of the typical presence of bilateral and symmetric vasogenic edema in the parietal and occipital lobes. Posterior reversible encephalopathy syndrome rarely presents with predominant involvement of the brain stem and medulla oblongata (variant). So, the purpose of this study was to investigate the differences between typical PRES and variant type.

MATERIALS & METHODS
We retrospectively evaluated MR imaging (MRI) and clinical findings of 44 patients (mean age: 40 and 59 years, male = 20, female = 24) with PRES. These patients were divided into two groups. In group I, 28 patients had typical distribution of lesions without brain stem involvement. In group II, 16 patients had brain stem involvement of lesions. We assessed the MR imaging features, clinical data, and patients’ outcome.

RESULTS
Mean systolic blood pressure (BP) was 164.25 ± 34 (range: 110-210) in group I and 185.37 ± 30 (range: 140-250) in group II. Systolic BP was higher in group II (p = 0.047) but others were not significantly different between the two groups; age, sex, predisposing factor, symptom, and prognosis. Follow-up MR was performed in 25 patients (group I n = 14, group II n = 11). Twenty-three of these patients had reversibility of lesion on follow up (group I: 13/14, group II: 10/11). Seven patients had sequela. In group I, three patients
had sequela (2: encephalomalacia, 1: diffuse brain atrophy) and in group II, four patients had sequela (3: encephalomalacia, 1: death). However, there is no significant difference in the two groups. Except for death, four of six patients who had sequela on follow-up imaging, had hemorrhage or no reversibility of lesion. Five patients had involvement of brain stem only. These patients were recovered completely without sequela and lesions disappeared on follow-up imaging.

**Conclusion**
Systolic BP has an influence on involvement of brain stem but involvement of brain stem does not have an influence on the prognosis of the patient. It seems that the influencing factor to prognosis is not distribution of lesion but reversibility of lesion and hemorrhage.

**Key Words:** Hypertension, encephalopathy

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**ePoster 058**

**Differentiating Tumefactive Demyelinating Lesions and Primary Central Nervous System Lymphoma Using Quantitative Apparent Diffusion Coefficient Analysis**

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**Purpose**
Acute mass-like demyelinating lesions of the brain, referred to as tumefactive demyelinating lesions (TDLs), can pose a considerable diagnostic challenge as they can simulate aggressive tumors on imaging. Due to their frequent multi-focal involvement, TDLs can mimic primary central nervous system lymphoma (PCNSL), and invasive biopsy often is required to make a diagnosis. Surgical biopsy, however, may not always provide a definitive answer since corticosteroid therapy, which is given frequently to patients with suspected TDLs or PCNSL prior to biopsy, can confound histopathologic analysis leading to inconclusive results. The purpose of our study was to determine whether diffusion-weighted imaging, which can provide an indirect assessment of tissue cellularity and extracellular mobility, can differentiate TDLs, a hypocellular process, from PCNSL, a hypercellular neoplasm.

**Materials & Methods**
Since 2002, 24 patients presented with newly diagnosed TDLs (10 male, 14 female; mean age: 35 years, range: 16-53 years) confirmed either pathologically (n = 12) or clinically (n = 12) based on history, imaging findings, cerebrospinal fluid (CSF) analysis, and follow-up evaluation at our institution. For a comparison cohort, the pretreatment MR imaging (MRI) scans of 28 immunocompetent patients (14 male, 14 female; mean age: 64 years, range: 30-91 years) with PCNSL initially diagnosed by surgical biopsy during that same time period were randomly selected from our institutional tumor database. Apparent diffusion coefficient (ADC) maps were constructed from diffusion-weighted images obtained with b-values of 0 and 1000 s/mm utilizing the FuncTool application of an AW Workstation (GE Healthcare; Waukesha, WI). Lesions then were manually segmented from the ADC maps using coregistered contrast-enhanced T1-weighted images as well as T2-weighted and fluid attenuated inversion recovery images to exclude adjacent edema and fluid within the ventricular system. Mean, minimum, and maximum lesion ADC values for each patient were normalized to bulk free fluid ADC, measured within the lateral ventricles. Normalized relative ADC (rADC) values subsequently were compared between TDL and PCNSL patients with a two-tailed Welch’s t test; results were declared significant if p < 0.05. A threshold analysis was conducted after excluding any partial or complete rim of reduced diffusion during TDL segmentation.

**Results**
Mean, minimum, and maximum rADC were 0.435±0.133, 0.241±0.072, and 0.669±0.207 (mean ± standard deviation) for TDL patients and 0.315±0.074, 0.143±0.079, and 0.650±0.178 for PCNSL patients. A statistically significant difference was found for mean and minimum rADC (p = 0.0004 and p < 0.0001, respectively) while maximum rADC was statistically indistinguishable (p = 0.719). After excluding partial or complete rims of reduced diffusion (seen in 14 of 24 cases), all TDL but only five of 28 PCNSL patients had minimum ADC greater than 0.192.

**Conclusion**
Mean and minimum rADC values successfully differentiated TDL and PCNSL patients with a promising threshold value for minimum rADC. Maximum rADC values were indistinguishable, likely from partial volume averaging with adjacent edema or ventricular CSF, which demonstrate facilitated diffusion at lesion boundaries. In combination with clinical evaluation and conventional imaging findings, diffusion MRI characteristics can support a more confident diagnosis of TDLs and potentially prevent unnecessary brain biopsies to exclude PCNSL.

**Key words:** Tumefactive, demyelinating, diffusion

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**ePoster 059**

**Association between Linear Measurements of Corpus Callosum, Gait and Balance in the Elderly**

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**Purpose**
Computer generated measurements of corpus callosum have been linked to gait impairment in the elderly. However, these measurements are difficult to use in routine clinical practice. The purpose of this study was to evaluate the relationship between linear measurements of corpus callosum thickness with gait and balance in elderly individuals.

**Materials & Methods**
Two hundred seventy-seven community-dwelling elderly subjects of Nutrition, Aging and Memory in Elderly (NAME) study had neurologic, neuropsychologic examina-
tions and brain MR imaging. Gait function was assessed using Tinetti gait (0-12), and balance (0-16) scores. Midsagittal reformats of 3D T1-weighted magnetization prepared rapid acquisition gradient-echo images were used to measure the corpus callosum thickness on a clinical PACS workstation. Thickness of the genu, anterior one third, mid-body, posterior one third and splenium as well total anterior-posterior length of corpus callosum were determined. Simple and partial correlation (after adjustments for age and mini-mental status examination score) were assessed between thicknesses of different portions of corpus callosum and Tinetti scores. A p value of <0.01 was considered significant.

RESULTS
There was significant correlation between genu thickness and gait and balance scores (p<0.001) that persisted after adjustment for age. The splenium thickness significantly correlated with gait (p<0.001) scores and was associated with both gait and balance scores after adjustment for age. After adjustment for MMSE, the genu thickness was only related with balance scores but splenium thickness remained associated with both gait and balance scores.

CONCLUSION
The independent association between linear measurements of the genu and splenium thickness with gait and balance scores indicates that atrophy of these portions of corpus callosum is a marker of gait impairment in the elderly. This simple measurement may be helpful in assessing patients with gait impairment.

KEY WORDS: Gait, MR imaging, corpus callosum

Effect of Motion and Eddy-Current Correction on the Reproducibility of Corticospinal Diffusion Tensor Tractography in Normal Subjects and Stroke Patients

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PURPOSE
In this study, we first establish the reproducibility of corticospinal diffusion tensor tractography (DTT) in healthy subjects and stroke patients with unilateral hemiparesis. The intra-rater, inter-rater, intra-session, and inter-session reproducibility of DTT derived indices [fiber numbers, fractional anisotropy (FA), apparent diffusion coefficient (ADC), and three eigenvalues] are measured. The second part of this study is to assess the effect of motion and eddy-current correction on the reproducibility of corticospinal DTT derived indices in both healthy subjects and stroke patients. The results of this study may be applied in the longitudinal follow up of the therapy effects on stroke patients.

MATERIALS & METHODS
Institutional review board approval and written informed consent were obtained prior to examination. Ten normal subjects (mean age 25.8 ± 6.8 years) and 15 patients (mean age 49.6 ± 9.1 years) with chronic stroke were enrolled. Two DTT scans of the 10 healthy subjects were obtained in one session and the third scan was obtained 1 week later on a 3 T MR scanner. Three scans of the 15 patients were obtained on 3 separate days. Bilateral corticospinal tracts in each scan of all healthy subjects and stroke patients were reconstructed twice: one time with motion/eddy-current correction and the other without. Three methods were used to compare the bias of DTT derived indices with and without correction: repeated ANOVA, ICC based on linear mixed models, and Bland-Altman plot.

RESULTS
In all DTT derived indices, the FA has the highest ICC test-retest reproducibility (0.86-0.91), while the ADC has the lowest one (0.74-0.80). With repeated ANOVA, the differences of the DTT indices between with and without correction have p-values all above 0.05 in both normal subjects and stroke patients.

CONCLUSION
Retrospective motion and eddy-current correction method do not show statistical significant effect on the measured values and reproducibility of corticospinal DTT derived indices in both cooperative normal subjects and stroke patients using 3 T clinical diffusion-weighting schemes.

KEY WORDS: Eddy-current correction, motion correction, diffusion tensor tractography

Characterization of Glial Cell Intratumoral Functional MR Imaging Resting-State Networks Using Graph Theoretical Analysis: A Preliminary Investigation

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PURPOSE
Previous studies have demonstrated that graph-theoretical analysis of structural tissue-architecture associated with prostate and tongue tumors can provide prognostic information. To date, no studies have investigated the application of similar graph theoretical analysis methods applied to resting-state functional magnetic resonance imaging (RS-fMRI) BOLD signal from tumors, such as brain glial cell malignancies. The purpose of this study, therefore, was to determine if graph theory network metrics can be used to characterize glial cell tumors using RS-fMRI signal extracted from the lesion using a voxel-wise approach. We hypothesized that some network metrics might vary according to glial tumor type.

MATERIALS & METHODS
Four patients with brain tumors were scanned in a 1.5 T GE scanner using an 8-channel head coil (GE Medical Systems, Milwaukee, WI, USA) for collection of structural anatomi-
cal (3D SPGR) MRI and RS-fMRI BOLD data as part of routine presurgical fMRI motor and language mapping evaluation. In order to evaluate network metrics within each patient’s tumor, a region of interest was drawn manually around the lesions and remaining brain masked out. Data from each voxel within the tumor was used to generate a binarized adjacency matrix from which graph theory metrics (clustering coefficient, characteristic path length, local efficiency; global efficiency; and small-worldness) were computed.

**RESULTS**
Patients included a 69-year-old female with right frontoparietal glioblastoma multiforme (GBM), 42-year-old female with left temporal astrocytoma, 37-year-old male with left frontal oligodendroglioma, and 45-year-old male with right frontal oligodendroglioma. Comparison of network metrics between astrocytomas and oligodendrogliomas demonstrated similar values for clustering coefficient (p>.05), characteristic path length (p>.05), local efficiency (p>.05), and global efficiency (p>.05), with a trend for significance for small worldness (p = 0.06).

**CONCLUSION**
Intratumoral graph theory network metrics can be computed from RS-fMRI BOLD signal, and may vary by tumor type. Most network metrics were similar between tumor types; however, the astrocytomas demonstrated lower small-worldness than the lower grade gliomas, indicating a more random pattern of internodal connectivity. Further characterization of network characteristics of glial tumors could lead potentially to novel functional imaging markers with which to study disease progression, guide therapy and predict outcomes.

**KEY WORDS:** Graph theoretical analysis, resting-state fMRI

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**ePoster 062**

**Combining Connectivity Maps to Predict Routes of Progression in Malignant Gliomas: A Prospective and Retrospective Analysis**

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**PURPOSE**
To determine the predictive value of diffusion tensor imaging (DTI) in the progression of malignant gliomas.

**MATERIALS & METHODS**
We prospectively identified seven patients with pathologically confirmed malignant gliomas and retrospectively identified nine more patients with malignant gliomas from an institutional database. Diffusion tensor imaging was acquired before chemoradiation therapy in all 16 patients. Using DTI&FiberTools, a Monte Carlo simulation and multiple iterations were performed to generate probabilistic maps that displayed the probability of connectivity between two locations. For each patient, a region of interest (ROI) was drawn around the tumor in three dimensions, and two suspected progression pathways were determined: 1) the longest fiber tract extending from the tumor and 2) the fiber tract with the maximal local connectivity surrounding the tumor. These predicted pathways then were compared to the actual site of progressive disease on follow-up MR imagings (MRIs) obtained every 2 months. Progressive disease was defined using revised response assessment criteria as greater than 25% increase in enhancing disease, new enhancing disease, or significant increase in nonenhancing disease (in patients receiving antiangiogenic therapy).

**RESULTS**
All 16 patients had progressive disease in at least one of the two predicted pathways. The longest fiber tract correctly predicted 14/16 sites of progression. The maximal connectivity fiber tract correctly predicted X/Y sites of progression. In five of 16 cases, the tumor grew in more than one direction. The mean time to progression was ZZ months (range, A-B months).

Maximal fiber length. (A) Connectivity map demonstrates the longest fibers (arrow) extending anteriorly in the periatrial region. Contrast T1-weighted imaging (B) 10 months later reveals progressive disease (arrow) in the same location that is new from pretreatment scan (not shown).

**CONCLUSION**
These results indicate that probabilistic maps may have a role in predicting sites of future tumor progression. This is consistent with other studies that demonstrate a relationship between DTI and tumor progression. Further work is necessary to determine the role of DTI in treatment planning, particularly developing individualized image-modulated radiation therapy plans.

**KEY WORDS:** Malignant glioma, diffusion tensor imaging, tractography
Diffusion Tensor Metrics of Epidermoids

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PURPOSE
To establish normative values of various parameters on diffusion tensor imaging (DTI) like fractional anisotropy (FA), apparent diffusion coefficient (ADC) and the different tensor metrics in the evaluation of epidermoid tumors.

MATERIALS & METHODS
MR imaging of 34 cases of epidermoid tumors [28 histopathologically proved, six diagnosed based on classical imaging features on conventional MR imaging (MRI) which included DTI sequence in addition to the conventional MRI sequences was evaluated retrospectively]. Region of interest (ROI)-based measurements of the FA and ADC values and linear (CL), planar (CP) and spherical (CS) anisotropy values and mode values of epidermoid tumors were performed. Mean values for each parameter were calculated. In addition, the t-test was applied to mean values of CL and CP to see if the difference was statistically significant.

RESULTS
The mean FA, ADC, CP, CS, CL and diffusion mode values with standard deviation and minimum and maximum values are summarized in the table.

<table>
<thead>
<tr>
<th>Metric</th>
<th>Mean</th>
<th>ADC</th>
<th>Planar</th>
<th>Spherical</th>
<th>Linear</th>
<th>Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.466</td>
<td>0.831</td>
<td>0.495</td>
<td>0.422</td>
<td>0.073</td>
<td>-0.663</td>
</tr>
<tr>
<td>Std. Deviation</td>
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<td>0.126</td>
<td>0.124</td>
<td>0.031</td>
<td>0.264</td>
</tr>
<tr>
<td>Range</td>
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<td>0.699</td>
<td>0.631</td>
<td>0.592</td>
<td>0.151</td>
<td>1.104*</td>
</tr>
<tr>
<td>Minimum</td>
<td>0.255</td>
<td>0.462</td>
<td>0.164</td>
<td>0.156</td>
<td>0.022</td>
<td>-0.962</td>
</tr>
<tr>
<td>Maximum</td>
<td>0.630</td>
<td>1.161</td>
<td>0.795</td>
<td>0.748</td>
<td>0.174</td>
<td>0.142</td>
</tr>
</tbody>
</table>

The unit of ADC is 10^-3 mm²/sec. FA and other DTI metrics are dimensionless. *Only one patient had mode value greater than zero. Remainder of the cases had negative mode values. Also, there was a statistically significant difference between mean planar and linear anisotropy values (p < 0.001).

CONCLUSION
Diffusion tensor imaging and diffusion tensor metrics are superior to routine diffusion-weighted sequence in imaging epidermoids. Quantification of DTI can provide objective accurate parameters for evaluation of intracranial epidermoids. The FA and CP values within this tumor are high and mode values are mostly negative. This is probably due to structured orientation of keratinous material oriented along a plane. Thus, DTI and diffusion tensor metrics afford information about cytoarchitectural organization of intracranial epidermoids.

KEY WORDS: Epidermoid, diffusion tensor imaging, diffusion tensor metrics

Comparison of Functional MR Imaging and Transcranial Magnetic Stimulation for Primary Motor Cortex Localization

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PURPOSE
Transcranial magnetic stimulation (TMS) is an imaged-guided technique for motor cortex localization and can be used to provide complementary information to functional MR imaging (fMRI) or magnetoencephalography (MEG). During TMS, a current is passed through a hand-held coil creating a brief magnetic pulse. The magnetic field passes the skull painlessly and induces a focal electrical field within cortex causing neuronal depolarization and contraction of contralateral muscles. We compared TMS and fMRI localization of primary motor cortex in healthy adults.

MATERIALS & METHODS
Following IRB approval, 10 subjects underwent 3 T MRI fMRI using a thumb abdution task. A structural scan was transmitted to a neuronavigational system to provide stereo-tactic guidance for TMS application. Next, single-pulse TMS was performed to identify the site leading to the most robust contraction of the contralateral abductor pollicis brevis muscle. This site was labeled on the structural scan within the neuronavigational system. The investigator applying TMS was blinded to the fMRI activation. Finally, TMS- and fMRI derived center of gravity (CoG) maps were created based on the weighted motor evoked potential (MEP) amplitudes obtained along a 7 x 7 grid (points 1 cm apart along the scalp centered at the site of maximal muscle contraction). The fMRI motor activation sites (highest z-value) were coregistered with the TMS activation sites (extrapolation of the TMS site on the scalp along a perpendicular trajectory down to the closest underlying cortical surface).

RESULTS
Using a 1 sample t-test with a cut-off distance of 10 mm for detecting a difference in techniques, we determined that TMS and fMRI are not statistically different (p value = 0.16). However, the TMS sites were systematically more inferior-laterally located along the motor strip than the fMRI sites. Subjects in which the TMS CoG map provided a well defined point of activation tended to correlate more closely with the fMRI activation site.
Figure - TMS green, fMRI pink, anatomical hand knob in blue.

CONCLUSION
Like other investigators (Lotze, 2003), we found a systematic difference between TMS and fMRI. This may be due to factors including orientation of the TMS coil to the cortical surface and limitations of our method for extrapolating TMS scalp sites to cortex not reflecting individual variability in cortical geometry. Despite these limitations, TMS may be a useful clinical mapping technique providing crucial complementary information about the functional relevance of an activation site.

KEY WORDS: Functional imaging, transcranial magnetic stimulation

Pulsed Arterial Spin Labeling Time-Series Data Can Be Used to Accurately Compute Graph Theory Metrics of Global Distributed Brain Connectivity

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PURPOSE
Graph theory network analysis methods applied to resting-state functional magnetic resonance imaging (RS-fMRI) blood oxygen level dependent (BOLD) data have begun to shed light upon changes in the central nervous system (CNS) at the level of whole-brain distributed network connectivity that appear to underlie a variety of neurodegenerative and psychiatric disorders. Using RS-fMRI for graph theoretical analysis requires collection of rapid whole brain time-series data to identify low frequency statistical interdependences between brain regions or voxels. Pulsed arterial spin labeling (PASL) perfusion MRI generates similar whole brain time-series data (tag and control pairs) at repetition times (TR) of 3-6 seconds, compared to a typical TR of 2 seconds for RS-fMRI. Little is known about the accuracy of graph theory network metrics computed using PASL data. The purpose of this study was to determine if graph theory methods can be applied accurately to PASL time-series data. We hypothesized that PASL data would yield similar network metrics, as compared to RS-BOLD data.

MATERIALS & METHODS
An institutional ethics committee approved this study. Thirty-one normal control subjects were scanned in a 1.5 T GE scanner using an 8-channel head coil (GE Medical Systems, Milwaukee, WI, USA) for collection of structural anatomical (3D SPGR) MRI and RS-fMRI BOLD, and PASL perfusion data. The PASL tag and control time series was combined in a variety of ways for graph analysis: the full time series; tag images only; control images only; tag + control; tag - control; and control - tag. All data were motion-corrected and normalized to a standard template using SPM. A binarized adjacency matrix for each imaging time series across subjects was generated at a network cost of 0.3 from which common graph theory network metrics (clustering coefficient, characteristic path length, local efficiency, global efficiency, and small worldness) were computed. One-way between group analysis of variance with post-hoc analyses were conducted to explore the impact of each sequence (RS-fMRI and PASL) on computed network metrics.

RESULTS
There were no statistically significant differences between graph network metrics computed from RS-fMRI and PASL time-series data for clustering coefficient \[ F (6,210) = 1.671, p = .129 \] or characteristic path length \[ F (6,210) = 1.811, p = .098 \]. There was, however, a main effect of time-series data type for local efficiency \[ F (6,210) = 2.559, p = .021 \], global efficiency \[ F (6,210) = 2.969, p = .008 \], and small-worldness \[ F (6,210) = 9.209, p < .0005 \]. Post-hoc analyses revealed differences for some of the PASL time-series data as compared to RS-fMRI, but not for the full time-series PASL and tag only time-series data.

CONCLUSION
Accurate graph metrics can be computed from time-series data generated from standard clinical PASL MRI. This allows for a single perfusion study to also provide graph theory network connectivity metrics without requiring a separate time-consuming RS-fMRI acquisition. Translation and broad clinical implementation of graph theoretical analysis techniques to clinical PASL perfusion MRI data may lead to the discovery of novel functional imaging markers that improve the ability to diagnose disease and predict outcomes associated with central nervous system dysfunction.

KEY WORDS: Graph theoretical analysis, resting-state fMRI

Pattern of Susceptibility-Weighted Imaging in Central Nervous System Toxoplasmosis Infection in a Series of AIDS Patients

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PURPOSE
The diagnostic role of MR imaging (MRI) in evaluating patients with central nervous system (CNS) toxoplasmosis (CNST) has been well established, but the incidence of susceptibility imaging (SWI)-related abnormalities on MRI has not been explored yet in CNST; notably, SWI is more
sensitive in detecting small deposits of hemorrhage and/or iron. Thus, we explored the utility of SWI for initial and follow-up MRI in patients with clinically confirmed CNST.

**MATERIALS & METHODS**

We retrospectively reviewed 11 patients (8 males, 3 females) MRIs with clinically confirmed CNST (based on treatment response). Five of the 11 had follow-up MRI within 30-60 days. The majority of lesions followed by MRI were evaluated using a 3.0 T magnet (34/36). A senior radiology resident and staff neuroradiologist jointly reviewed the MRIs, recording the number of lesions, locations, and size on FLAIR, diffusion-weighted imaging (DWI), contrast-enhanced (CE) T1-weighted imaging and SWI. For the five patients with available follow-up imaging, the number, imaging pattern, and evolving appearance were recorded.

**RESULTS**

Mean time to follow-up MRI was 77 days. A total of 272 lesions were seen, with 37 lesions followed on MRI in five patients. Of the 37 lesions total initially, 37 were positive on FLAIR, 11 on SWI, 28 on DWI, and 17 having CE. Twenty-seven of 37 FLAIR-positive lesions became SWI-positive on subsequent MRI, regardless of CE or reduced diffusion. Of 28 DWI-positive lesions, 10 were initially SWI-positive, while 21 were SWI-positive at follow up. Of 17 CE-positive lesions, seven were initially SWI-positive, with 13 SWI-positive at follow up. Notably, of the 37 FLAIR-positive lesions, 11 were SWI-positive initially, and 27 were SWI-positive at follow up (p=0.054). There was poor agreement between the presence on DWI (p=0.888) or CE with SWI (p=0.1168) on the initial exams, and within the five patients with follow up. The majority of CE-positive lesions (n=17) were CE-positive on follow up (n=13) in those same locations.

**CONCLUSION**

Although the vast majority of lesions were FLAIR-hyperintense, the most informative finding was the eventual development of SWI-positive lesions in the majority of FLAIR-positive lesions (approximately three quarters). This is regardless of whether or not these lesions enhance or demonstrate restricted diffusion. In addition, once a lesion is positive on SWI, it remains so. Most apparent is the dynamic nature of these lesions; thus, there is poor correlation between the initial presence of abnormalities on SWI, DWI, and CE. We presume these represent microhemorrhages initially, but could represent microcalcification chronically related to inflammation.

**KEY WORDS:** Toxoplasmosis, susceptibility-weighted imaging

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**ePoster 067**

**Intra and Interobserver Variability in Measurements of High-Grade Gliomas**

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**PURPOSE**

Bidimensional tumor measurements indicating a >25% increase in tumor size generally are accepted as indicating tumor progression by neuro-oncologists. We assessed intra and interobserver variability of such measurements.

**MATERIALS & METHODS**

Ten patients with contrast-enhancing, biopsy-proved glioblastoma multiforme underwent MR imaging (MRI) in three orthogonal planes on two occasions 1 month apart. Nine readers measured tumor diameters in each plane on anonymized digital images. Seven of these readers repeated measurements 6 weeks later. Products of tumor measurements were calculated and determinations of tumor progression (defined as >25% increase in area) were made. We performed a univariable analysis to compare the difference of the product of each plane between two readings of each reader and also calculated the consistency of determination of rate of progression on each reading based on those measurements. We also tested the homogeneity of any pair of two different readers by determining simple Kappa coefficients for the first and second readings by the same reader and across different readers. The simple Kappa coefficients were estimated for each pair readers (p< 0.05 for all tests). The SAS statistical package V9.2 (SAS Institute, Inc., Cary, NC) was used for all data managements and analyses.

**RESULTS**

The paired t-test between the first and second readings for each reader showed that four of seven readers were found to have a statistically significant difference between readings in at least one imaging plane. Assessment of consistency of disease progression judgments between first and second readings showed that, on average, each reader was consistent only 63% of the time (range: 40%-80%). The Kappa coefficient for agreement of a reader with himself with regards to progression/lack of progression on different readings was relatively low, at 0.23. When assessing rate of agreement for any set of two readers, we found the chance for disagreement was higher than the chance of agreement in 26% of the pairs. Pairwise Kappa correlation coefficients showing likelihood
that two readers would agree with one another regarding progression or lack of progression was very low, at 0.05 (i.e., essentially only a 50% chance of agreement).

**Conclusion**

Intra and interobserver variability for determining tumor progression was very low, indicating that manual measurements by individual readers are relatively unreliable.

**Key Words:** Neoplasm, variability, measurements

ePoster 068

**Differentiation at 3 T High b-Value Diffusion (b = 3000 s/mm²) MR Imaging between Tumor Recurrence and Radiation Injury in Treated Gliomas**

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**Purpose**

Theoretically, higher b-value diffusion-weighted imaging (DWI) improves contrast because its reflects tissue diffusivity better and is less subject to the T2 shine-through effect. The purpose of this study was to assess whether DWI at $b = 3000$ s/mm² is more useful for discriminating glioma recurrence from radiation injury than DWI at $b = 1000$ s/mm² at 3 T.

**Materials & Methods**

We retrospectively reviewed conventional follow-up MR images, DW images acquired at $b = 1000$ and $3000$ s/mm², and apparent diffusion coefficient (ADC) maps that were obtained starting 1 month after the completion of radiation treatment in patients with histologically proved gliomas. All MR studies were performed on 3 T units. We studied 11 patients with areas of abnormally enhancing tissues. The final diagnosis was established histologically, or by the patients’ clinical course and a combination of imaging studies. Visual assessments recorded on a 5-point scale and quantitative assessments based on the DWI signal intensity (SI) ratio (tumor SI/normal SI), and ADC values were compared on DW images acquired at $b = 1000$ and $3000$ s/mm².

**Results**

Of the 11 patients, six suffered tumor recurrence; five manifested radiation injury. At visual assessments, hyperintensity was more conspicuous in patients with tumor recurrence, and hypointensity was stronger in the presence of radiation injury on DW images acquired at $b = 3000$ than $b = 1000$ s/mm². Quantitative assessments showed that at both b-values the mean SI ratio was significantly higher in patients with tumor recurrence than radiation injury. The difference between the SI ratio of tumor recurrence and radiation injury was larger at $b = 3000$ than at $b = 1000$ s/mm². At $b = 3000$ s/mm² the mean ADC value was significantly lower in the presence of tumor recurrence than radiation injury. On the other hand, there was no significant difference in the mean ADC value at $b = 1000$ s/mm².

**Conclusion**

At 3 T, DWI at $b = 3000$ s/mm² may be more useful than at $b = 1000$ s/mm² for the discrimination between glioma recurrence and radiation injury.

**Key Words:** Diffusion-weighted imaging, glioma, recurrence

ePoster 069

**New Patterns of MR Perfusion Images in High-Grade Glioma Patients Treated with Bevacizumab**

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**Purpose**

The purpose of this study is to identify new MR imaging (MRI) brain perfusion patterns in patients with high-grade brain tumors treated with bevacizumab (Avastin®), an inhibitor of neoangiogenesis.

**Materials & Methods**

Thirteen patients diagnosed with high-grade gliomas were studied by 3 T MRI (Siemens scanner Erlangen, Germany). The protocol consisted of the following sequences; axial T1-weighted spin-echo imaging, axial T2-weighted fast spin-echo imaging, 3D FLAIR, axial DTI, axial T2-weighted gradient-echo imaging, perfusion, axial T1-weighted postgadolinium imaging (0.2mmol/kg of body weight) and a 3D T1-weighted gradient-echo postgadolinium imaging. The criteria used in the evaluation of tumor progression comprised the analysis of edema using FLAIR sequences and the perfusion of lesions using rCBV and T1-weighted postgadolinium images.

**Results**

Of the thirteen patients, (10 men and 3 women, mean age of 49.8 years: range 22-68 years), ten were diagnosed with glioblastoma, one high grade anaplastic ependymoma, one anaplastic pleomorphic xantho-astrocytoma and one with gliomatosis cerebri. MR imaging showed tumor hypoperfusion and progression of disease in six patients (46.2%). Seven patients (53.8%) presented hyperperfusion of their tumors with progression occurring in six patients (85.7%), and one (14.3%) presented stable disease.

**Conclusion**

Treatment with bevacizumab (Avastin®) alters the process of angiogenesis which may result in hypoperfusion in patients with disease progression. This new pattern must imperatively be known in order to avoid erroneous interpretation of imagery results in the follow up of these patients.

**Key Words:** Avastin, glioma
Glutamine and Glutamate Concentrations in Recurrent High-Grade Gliomas

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PURPOSE
The glutamatergic system plays an important role in the growth and invasion of glioma cells. By releasing toxic levels of glutamate, high-grade gliomas may invade healthy brain tissue. Increased glutamine (and myo-inositol) concentrations in normal-appearing white matter contralateral to untreated GBM, suggestive of tumor infiltration was reported recently. The aim of this study was to assess glutamate and glutamine concentrations in patients previously treated for high-grade gliomas.

MATERIALS & METHODS
Ten patients (mean age 42.8 years, range 22.8-67.3 years, 9 men) treated with surgery, chemotherapy, and radiation for high-grade gliomas (GBM, N=7; anaplastic astrocytoma/oligodendroglioma, N=3) were examined with clinical MRI and single voxel ¹H MRS (STEAM; TR/TE/TM=2s/20ms/10ms; NS=160-224; typical VOI=2x2x2 ml) at 3 T. Spectra were collected in the T2-hyperintense lesion(s) suspect for tumor and in a contralateral control region. Time permitted, spectra also were collected in a region adjacent to the lesion. LCModel was applied to evaluate metabolite concentrations, corrected for CSF (institutional units, i.u.). Linear mixed effects (LME) model analyses were used for statistical evaluations.

RESULTS
In all patients, tumor progression was confirmed (clinically or at surgery). The figure displays mean metabolite concentrations in the lesions (14 ROIs), adjacent regions (5 ROIs), and control regions (11 ROIs). Spectra collected in the lesions showed elevated mean concentration of glutamine (Gln) (lesions, p=0.057 and adjacent regions, p=0.006 vs control regions) and lower concentration of glutamate (Glu) (lesions, p<0.0001 and adjacent regions, p=0.012 vs control regions). N-acetylaspartate (NAA) and creatine (Cr) concentrations in the lesions were lower compared to control regions (both p<0.0001). There was no difference in mean choline (Cho) and myo-inositol (Ins) concentrations between the lesions and control regions. For individual concentrations, Cramér-Rao lower bounds were within 20% for Gln concentration in all lesions (but not in all control regions) and for Glu concentration in the control regions (but not in all lesions).

CONCLUSION
While the MRS findings based on Cho, Ins, and NAA concentrations were nonspecific for tumor progression, all patients had a high Gln and low Glu concentration in the lesion and had tumor progression. Previous MRS studies reported elevated Glu+Gln concentrations in high-grade gliomas, meningiomas, and oligodendrogliomas. Presence of tumors results in alterations of glutamine metabolism, as glutamine is the main source of nitrogen for tumor cells. Increase in glutamine transport thus may have contributed to the observed increase in glutamine concentration.

Acknowledgement: Supported by the James S. McDonnell Foundation and grants MZ0IKEM2005 and 1M0002375201.

KEY WORDS: High-grade gliomas, ¹H MRS, glutamine

Correlation of Perfusion Permeability Estimates with Genes Related to Angiogenesis Regulation in Glioblastoma

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PURPOSE
The integration of imaging and genomic data is critical for a better understanding of gliomas, particularly considering the increasing focus on utilization of various imaging biomarkers for patient survival and treatment response. The purpose of this study was to correlate permeability surface area-product (PS) measured using perfusion CT (PCT) with the Gene Ontology biologic process pathways for positive and negative regulation of angiogenesis in glioblastoma.

MATERIALS & METHODS
Fifteen patients with WHO grade IV gliomas underwent pretreatment PCT using 64-slice CT scanner and PS maps were generated using perfusion CT 3.0 (Advantage Windows, GE, Milwaukee, WI) software. Tumor specimens were analyzed by The Cancer Genome Atlas (TCGA) project and genomic data was obtained retrospectively from TCGA. The Agilent gene expression microarrays from the TCGA were interrogated for correlation between PS estimates and gene expression across the entire genome. There were 18233 named genes represented by 56821 probes. Of these 3184 genes...
(17.4%) were found to have a significant Pearson’s correlation coefficient at $p<0.05$ with the expression of at least one probe (5365 total probes). Given our interest in PS estimates we considered the Gene Ontology biologic process pathways for angiogenesis regulation only.

**RESULTS**

We observed expression levels for 54 (195 probes) genes in the positive regulation of angiogenesis pathway (GO:0045766), of which 10 genes (18.5%) had significant correlation with permeability ($p<0.05$). The maximum absolute correlation coefficient with associated $p$-value is given for each of these genes: VASH2 Vasohibin 2 ($-0.74$, $p=0.002$), CCR3 Chemokine (C-C motif) receptor 3 ($-0.56$, $p=0.030$), TNRFSF1A Tumor necrosis factor receptor superfamily, member 1A ($0.68$, $p=0.006$), HIF1A Hypoxia inducible factor 1 alpha ($0.66$, $p=0.008$), CX3CL1 chemokine (C-X3-C motif) ligand 1 ($0.60$, $p=0.017$), KDR VEGFR-2 ($0.58$, $p=0.024$), GATA4 GATA binding protein 4 ($0.58$, $p=0.024$), ITGB2 Integrin alpha 2 ($0.58$, $p=0.025$), RUNX1 Runx-related transcription factor 1 ($0.54$, $p=0.042$), FGF2 Fibroblast growth factor 2 ($0.53$, $p=0.042$). In the negative regulation of angiogenesis pathway (GO:0005923), we observed expression levels for 41 genes (145 probes) of which eight genes (19.5%) had significant correlation with permeability ($p<0.05$). The maximum absolute correlation coefficient with associated $p$-value is given for each of these genes: AMOT Angiomotin ($-0.62$, $p=0.015$), CX3CR1 Chemokine (C-X3-C motif) receptor 1 ($-0.61$, $p=0.016$), NF1 Neurofibromin 1 ($-0.55$, $p=0.034$), PTPRM Protein tyrosine phosphatase, receptor type, M ($0.83$, $p=1.2E-4$), CDH5 (0.58, $p=0.024$), ADAMTS1 (0.55, 0.035), KLK3 (0.54, $p=0.037$), PML (-0.54, 0.038).

**CONCLUSION**

Our preliminary results show correlation of PS estimates with genes related to angiogenesis. Genes known to promote angiogenesis such as TNRFSF1A, HIF1A, KDR, FGF2 showed a statistically significant positive correlation where as genes known for inhibition of angiogenesis such as VASH2 and AMOT showed significant inverse correlation. These studies indicate that further investigation with a larger study number is warranted, and that correlation of imaging/perfusion parameters such as PS estimates obtained in vivo with genomic profile of gliomas potentially could lead to their use as imaging biomarkers.

**KEY WORDS:** CT perfusion, TCGA, genomic analysis

**ePoster 072**

**Erdheim-Chester Disease of the Central Nervous System**

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**PURPOSE**

Erdheim-Chester disease is a rare, non-Langerhans cell histiocytosis which can involve the central nervous system. The demographics and imaging findings in 11 patients with this disease are reviewed. We present manifestations which have not been described previously and findings on advanced imaging techniques.

**Materials & Methods**

CT, MR and PET/CT studies of the brain, maxillofacial region, and spine were reviewed in 11 patients with Erdheim-Chester disease. The studies were evaluated for disease presence in the following locations: intra-axial and extra-axial intracranial compartments, skull, pituitary gland, orbit, paranasal sinuses, and the spine. In addition, one patient was studied with MR spectroscopy and MR perfusion; several patients were evaluated with diffusion tensor imaging.

**RESULTS**

Eight out of the 11 patients had disease of the central nervous system. The most common location of involvement was the pons and brachium pontis, followed by the hypothalamus and pituitary gland. PET/CT demonstrated FDG avidity of all lesions, including within the spine. Newly described findings include a stellate appearance of a supratentorial extra-axial lesion and right lateral ventricular ependymal enhancement with extension to the lentiform nucleus. MR spectroscopy of an extra-axial lesion demonstrated a lack of normal brain metabolites with a possible lipid peak. The dynamic susceptibility sequence of this lesion showed a relative lack of blood flow compared to white matter, despite the enhancement on the dynamic contrast-enhanced image and T1-postcontrast images. Diffusion tensor imaging of a pontine lesion showed no fiber tract disruption.

**CONCLUSION**

Erdheim-Chester disease has variable imaging appearances in the central nervous system. Neuroradiologists should be aware of these findings to avoid mistaking them for other disease processes. Further study will be necessary to define the significance of findings on advanced imaging techniques.

**KEY WORDS:** Erdheim-Chester disease

**ePoster 073**

**Diffusion Tensor Imaging and MR Perfusion-Weighted Imaging in Differentiating between Intracranial Dural Metastases and Meningiomas**

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**PURPOSE**

It can be a diagnostic dilemma, to preoperatively differentiate between intracranial dural-based metastases and meningiomas, on conventional MR images. The purpose of this study was to evaluate the utility of diffusion tensor imaging (DTI) and dynamic susceptibility-weighted contrast-enhanced MR perfusion imaging (DSC-PWI) with regard to this differentiation.
**Materials & Methods**

Retrospectively, 21 patients with histology-confirmed meningiomas and 18 cases of intracranial dural-based metastases were enrolled in this study. The studies had been done on a 1.5 T and 3 T GE scanner with precontrast DTI protocol that included TR/TE = 12000/101.7 ms, FOV = 24 x 24 cm2. Matrix = 128 x 128, thickness = 3 mm and gap=0 mm in 3 T scanner (or thickness = 5 mm with gap=1 mm in 1.5 T) using 25 noncollinear gradient directions with a b-value of 1000 sec/mm2. Dynamic susceptibility-weighted contrast-enhanced-PWI was performed as axial single-shot, gradient-echo, echo-planar imaging sequence (TR/TE =1500/50 milliseconds; flip angle, 80°; FOV = 24x 24cm2; matrix = 96 x 128; thickness = 3 mm and no gap) obtained during the first pass of a bolus of gadoveresetamide. The mean trace apparent diffusion coefficient (trace ADC), minimum ADC, mean fractional anisotropy (FA), maximal FA and maximal relative cerebral blood volume (rCBV) ratio were calculated for all lesions. For statistical evaluation we used Mann-Whitney U test and the receiver operating characteristic (ROC) analysis to determine the lesion separating threshold.

**Results**

The mean FA and maximal FA values of meningiomas (0.25±0.066 and 0.375±0.085, respectively) were significantly higher than for intracranial dural-based metastases (0.126±0.024 and 0.161±0.036, respectively), p<0.001. There was no significant difference in mean ADC, minimal ADC values and maximal rCBV ratio between these two types of tumors (p>0.05). The maximal FA showed a slightly higher sensitivity while the specificity was the same for both maximal FA and mean FA in distinguishing intracranial dural-based metastases from meningiomas (Table 1).

**Table 1: Statistical analysis of imaging parameters in differentiating between meningiomas and intracranial dural-based metastases.**

<table>
<thead>
<tr>
<th>Index</th>
<th>meningiomas (Mean±SD)</th>
<th>intracranial (Mean±SD)</th>
<th>p value</th>
<th>Area under curve</th>
<th>Cutoff value</th>
<th>Sensitivity</th>
<th>Specificity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean FA</td>
<td>0.256±0.066</td>
<td>0.126±0.024</td>
<td>0.001</td>
<td>0.94</td>
<td>0.157</td>
<td>0.96</td>
<td>0.889</td>
</tr>
<tr>
<td>Maximal FA</td>
<td>0.375±0.085</td>
<td>0.161±0.036</td>
<td>0.001</td>
<td>0.98</td>
<td>0.213</td>
<td>0.982</td>
<td>0.889</td>
</tr>
<tr>
<td>Mean ADC</td>
<td>0.836±0.024</td>
<td>0.92±0.283</td>
<td>0.133</td>
<td>0.343</td>
<td>0.825</td>
<td>0.509</td>
<td>0.333</td>
</tr>
<tr>
<td>Minimal ADC</td>
<td>0.722±0.123</td>
<td>0.78±0.23</td>
<td>0.874</td>
<td>0.483</td>
<td>0.714</td>
<td>0.526</td>
<td>0.444</td>
</tr>
<tr>
<td>Maximal rCBV</td>
<td>7.39±6.56</td>
<td>5.01±3.27</td>
<td>0.617</td>
<td>0.503</td>
<td>4.97</td>
<td>0.513</td>
<td>0.478</td>
</tr>
</tbody>
</table>

**Conclusion**

The results suggest that mean and maximal FA values can be helpful adjuvant imaging parameters to differentiate between intracranial meningiomas and dural-based metastases.

**Key Words:** Meningioma, metastases, diffusion tensor imaging

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**ePoster 074**

**Perfusion MR Imaging in Differentiating High-Grade from Low-Grade Gliomas**

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**Purpose**

To correlate perfusion MR imaging with histologic grade of cerebral gliomas.

**Materials & Methods**

Relative cerebral blood volume (rCBV) maps were determined in 22 patients with pathologically proved gliomas (11 glioblastomas, 8 anaplastic gliomas and 2 low-grade gliomas) by dynamic contrast-enhanced T2*-weighted MR imaging. MR examination was completed with conventional T1- and T2-weighted imaging. The rCBV maps were calculated with an independent workstation by fitting a gamma-variate function to the contrast material concentration versus time curve. Relative CBV ratios obtained between tumor and normal white matter were compared between glioblastomas, anaplastic gliomas and low-grade gliomas by means of receiver operating characteristic (ROC) analysis.

**Results**

Mean rCBV ratios were 4.85 (± 1) for glioblastomas, 3.87 (± 0.7) for anaplastic gliomas and 1.65 (± 1.6) for low-grade gliomas. Receiver operating characteristic analysis demonstrates significant differences between glioblastomas and anaplastic gliomas (p<0.05), between anaplastic gliomas and low-grade gliomas (p<0.05) and between glioblastomas and low-grade gliomas (p<0.01). The rCBV ratio cutoff value between high-grade gliomas and low-grade gliomas was 2.52 with a sensitivity and specificity of 100% and 75% respectively.

**Conclusion**

Perfusion MR imaging is a reliable technique for differentiating high-grade from low-grade gliomas.

**Key Words:** Glioma, perfusion, low-grade/high-grade

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**ePoster 075**

**Short-Term MR Imaging Characteristics and Response to MR Image-Guided Laser Ablation Therapy**

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**Purpose**

MR imaging (MRI)-assisted laser thermal ablation is still in its early stages of development. It is an alternative minimal-invasive surgical option in patients who either have “non-operative” tumors or who are at poor surgical risk. We would like to report our initial observations of the MRI in patients who have undergone laser ablation therapy.
MATERIALS & METHODS

Three patients with primary neoplasms of the brain with three different histologies (anaplastic ependymoma, PNET, and glioblastoma multiforme) are reported. Using standard navigation techniques and a Medtronic StealthStation® neuronavigation system, a laser probe is placed strategically within the tumor bed. With the patients awake in the MRI suite, a 15-W 980-nm diode laser is inserted into the planned target in the tumor. On a GE Excite 1.5 T MRI, MR-based thermal imaging is accomplished using 2D fast RF-spoiled gradient echo (SPGR) images with sequential multiphase and extended dynamic range (echo time - 20 ms, repetition time 37.5 ms, flip angle - 30 degrees, bandwidth - 10kHz). During laser ablation, the temperature of the tumor core and surrounding brain is measured by the MRI thermometry software. The brain-tumor interface temperature is limited to 50º C in order to avoid damage to nearby normal structures. Sequential MRI follow-up studies were performed at approximately the following post-thermal ablation intervals: 3 days, 1 week, 1 month, 2 months, and 3 months. The lesion size and edema were measured in three dimensions and were compared based upon composite volume measurements.

RESULTS

We have made the following postablation imaging observations: 1. The volume of the central tumor mass 24 hours postablation increases in size, peaking at 3 days to 1 week. 2. The central tumor mass remains stable for 2 to 3 months. In the two lesions with three-month follow up (anaplastic ependymoma and PNET), the decrease in size of the enhancing tumor mass is dramatic. The third lesion does not yet have 3 month follow up but has followed the previously described pattern in every other way at 2 months. 3. Postablation, perifocal edema increases dramatically but begins to decrease within 2 months. 4. The immediate postablation scans show ring-like peripheral enhancement with a central nonenhancing “ghost” that has maintained this morphology throughout the follow-up period. 5. Both the intensity of enhancement and the thickness of the enhancing ring decrease immediately post-thermal ablation and subtly decrease progressively with time. 6. In all three of our cases, we have observed persistent enhancement at 2 to 3 months. With the short-term follow up that we have at this time, we have interpreted our findings as favorable with respect to tumor therapy.

CONCLUSION

Initial three-month observation of imaging findings in patients who have undergone MRI-guided laser ablation therapy has a favorable imaging trend. Our initial imaging results within 3 months of follow up in three different histologies suggest that from a morphologic perspective this technique offers favorable outcomes. Long-term follow-up studies are warranted.

KEY WORDS: Laser, thermal, ablation

Radiology Imaging Findings in Gliosarcoma: A Retrospective Analysis

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PURPOSE

Gliosarcomas are rare tumors with poor prognosis composed of intermingled malignant glial and sarcoma elements with an estimated incidence of 1.8-8.0% of all malignant astrocytic neoplasms. We aim to review the imaging findings in eight patients with gliosarcoma that were treated in our center between 2002 and 2010. This study, to the best of our knowledge, is the largest describing the imaging manifestations of this rare tumor.

MATERIALS & METHODS

Five females and three males with ages ranging from 19 to 66 years (median age: 51 years) diagnosed with gliosarcoma underwent brain MRI and four had CT. Two radiologists reviewed all images retrospectively.

RESULTS

All lesions were located supratentorially. Five were in the parietal lobes. The other three were at occipital lobe, temporal lobe and occipitoparietal lobes. Tumors were iso or hyperdense on CT with calcifications in all three cases. Cystic component and hemorrhage could be identified in one case. MR imaging showed variable appearance on both T1- and T2-weighted images. In general, the tumors had a tendency for hypointense signal on T1 and hyperintense signal on T2. Six tumors showed intense ring-like enhancement and two heterogeneous enhancement of mainly a solid tumor. Associated dural and/or ependymal involvement was present in all cases and moderate to severe edema was evident in seven. Interestingly, three cases had a pre-existing lesion at the same site at least two of which were benign appearing. Two other female patients had associated small meningiomas.
CONCLUSION
Although our study revealed no unique radiologic features for gliosarcoma, it is important to note that they all demonstrated either dural or ependymal involvement or both. Calcification, hemorrhage or cystic component are described with a tendency for ring-enhancement pattern. Interestingly pre-existing benign-looking lesions and associated remotely located small meningiomas also are described.

KEY WORDS: Gliosarcoma, MR imaging

**ePoster 077**
**Multivariate Analysis of Morphologic and Diffusion MR Imaging Correlates of 1p and 19q Codeletion in a Large Cohort of Oligodendrogial Tumors**

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**PURPOSE**
The codeletion of chromosomes 1p and 19q in oligodendrogial tumors is associated with a favorable clinical outcome. Our goal was to identify the best MR imaging (MRI) predictors of 1p/19q status in a large series of oligodendrogial tumors.

**MATERIALS & METHODS**
Consecutive subjects were included who had 1) a diagnosis of previously untreated oligodendrogial tumor, 2) 1p and 19q chromosomal analysis from tumor specimen, and 3) an available preoperative MRI. While blinded to 1p19q status, images were evaluated for morphologic features, including: location, bilaterality, overall degree of circumscription, sharp/indistinct border on T1-weighted and T2-weighted, smooth/irregular contour on T2-weighted, homogeneity on T1-weighted and T2-weighted, paramagnetic susceptibility effect, necrosis/cystic change, and contrast enhancement. Mean, maximum, and minimum ADC values were also obtained from a representative image of each tumor. The correlation of 1p/19q codeletion status with these imaging features, tumor type, and tumor grade (grade 2=low, grade 3 and 4=high) was assessed.

**RESULTS**
One hundred sixty-six patients met criteria. Median interval between date of MRI and pathologic sampling was 3.5 days. Eighty-two percent of oligodendrogliomas and 50% of oligoastrocytomas were 1p19q codeleted. In univariate analysis, several features strongly correlated with codeletion. Tumors centered in the frontal and parietal lobes were more likely to be codeleted relative to tumors in the insular and temporal lobes (p=.0023). Morphologically ill-defined tumors were more likely to be codeleted, as ~70% of tumors which lacked either an at least partially circumscribed margin, or sharp T1-weighted or T2-weighted border were codeleted, compared to only ~16% of tumors which demonstrated at least one of these features (p<.0001). Tumors with lower mean/maximum ADC values also were more likely to be codeleted (p=.001). From a multivariable logistic regression model, the most significant predictors were mean ADC (p=0.007), circumscription (p=0.02) and tumor histopathology (p=0.01). The discriminatory power from this model was high (C-statistic of 0.865).
**CONCLUSION**

1p/19q codeletion is strongly predicted by frontal/parietal location, lack of tumor margin circumscription, lower mean ADC values, and tumor histopathology. In select patients, imaging correlates of a genetic subtype of oligodendroglial tumors which is associated with improved clinical outcome could potentially obviate the need for chromosomal analysis.

**KEY WORDS:** Oligodendroglioma, oligoastrocytoma, 1p19q

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**ePoster 078**

**Superior Longitudinal Fasciculus and Arcuate Fasciculus Tumor Involvement Analysis by T2 FLAIR versus Diffusion Tensor Imaging at 3 T**

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**PURPOSE**

The involvement of the superior longitudinal fasciculus (SLF) and the arcuate fasciculus (AF) by a tumor can be critical when determining how a tumor will be resected and if postoperative language deficits might result. The white matter anatomy at 3 T utilizing T2 FLAIR technique has been underappreciated. The difference of the compactness of the fiber tracts likely plays a large role in the ability of T2-weighted techniques to visualize white matter tracts. Diffusion tensor imaging (DTI) has a well-established role in displaying the superior longitudinal fasciculus and the arcuate fasciculus. We hypothesized that T2 FLAIR will demonstrate the position of the SLF and the AF robustly in the presence of brain tumors.

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**MATERIALS & METHODS**

Our imaging database was searched for cases of brain tumor mapping that were performed at 3 T (Achieva, Philips Healthcare, Best, Netherlands). The MRI exams consisted of a 3D volumetric high-resolution T2 FLAIR sequence (0.43 mm x 0.43 mm x 0.6 mm) and high-resolution DTI images (2 mm x 2 mm x 2 mm, 16 directions of gradient sampling). There were 32 subjects (19 male, 13 female, 14-74 years) enrolled in this retrospective study. The T2-FLAIR volumetric images were reconstructed in the axial and coronal planes. The DTI images had fractional anisotropy (FA) maps calculated and then color coded in the standard red, green, and blue fashion to denote major fiber tract orientation. The color FA maps were evaluated in axial, sagittal and coronal planes. Tractograms of the AF were created on the Philips Extended Work Space (turning angle threshold = 27, FA lower limit = .15). The amount of involvement of the SLF was analyzed by the color FA maps and the T2 FLAIR images. The amount of involvement of the AF was evaluated by AF tractogram versus T2 FLAIR images. The scale used to analyze the involvement was: 0 = none, 1 = touch, 2 = moderate to marked abutment but not deviation or invasion, 3 = extensive abutment with deviation or invasion. A correlation coefficient was used to compare the involvement of the SLF or the AF as determined by the DTI techniques versus T2 FLAIR.

**RESULTS**

There was a correlation of 0.98 when comparing T2 FLAIR and color FA maps for determining SLF involvement by tumors. A correlation of 0.60 was present comparing the T2 FLAIR analysis and tractography analysis of AF involvement.

**CONCLUSION**

We detected a marked correlation between utilizing volumetric T2 FLAIR images and color FA maps in determining SLF involvement by tumors. This indicates that T2 FLAIR can greatly help a radiologist demarcate the SLF and this can be vitally important for surgical planning. There was a moderate correlation between T2 FLAIR analysis and tractography analysis of AF involvement. The only modest correlation of T2 FLAIR to AF tumor involvement is expected since the AF subcomponent of the SLF is not seen distinctly and the position can be approximated on only T2 FLAIR.

**KEY WORDS:** Superior longitudinal fasciculus, arcuate fasciculus
Persistent Diffusion Restriction Indicative of Treatment Necrosis in Glioblastoma Multiforme Evaluated with FDG PET

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PURPOSE
To demonstrate geographic lesions characterized by diffusion restriction in patients with treated glioblastoma multiforme (GBM) that are metabolically inactive and likely represent treatment necrosis rather than viable tumor.

MATERIALS & METHODS
FDG PET was performed in GBM patients on treatment protocols when progression vs radiation necrosis was not firmly established by MR imaging (MRI) alone. Retrospective review identified five patients in which FDG PET evaluated the development of new diffusion restriction. MR imaging, including apparent diffusion coefficient (ADC), computed from 15 direction B-1000 DTI, hypoperfusion (CBF and CBF from DSC-MRI following preinjection to eliminate permeability effects), and FDG PET were evaluated. Clinical and imaging outcomes were reviewed.

RESULTS
In all 5 cases a region of diffusion restriction in the deep white matter was identified. All shared MRI features (Figure 1) including relatively homogeneous markedly decreased ADC (A), a ragged margin of thin peripheral enhancement (B), hypoperfusion (C) with CBV and CBF less than that of white matter (WM) and not distinguishable from the noise level. In each case FDG uptake (D) was less than that of WM and not differentiable from noise. On follow up of 5-17 months (mean 10 months) (E) these lesions did not develop high perfusion, nodular enhancement, or metabolic uptake or other signs of conversion to viable tumor. Progression occurred at sites distinct from the region of diffusion restriction. Furthermore, unlike the transient diffusion restriction seen in stroke, the diffusion restriction in these cases persisted without apparent change for months.

CONCLUSION
Diffusion restriction associated with GBM has been associated with increased cellularity and increased metabolic activity indicative of viable tumor. Hence, the development of diffusion restriction can be interpreted as an ominous finding, indicating progression, recurrence, or transformation to high grade. The series of patients in this report indicate that radiation/treatment necrosis can result in regions of marked and persistent diffusion restriction which can be differentiated from viable tumor by concomitant hypoperfusion and lack of FDG uptake. Interestingly, the persistence of the diffusion restriction for months distinguishes it from the cytotoxic edema identified in acute infarcts. Although it may be that this pattern of necrosis is unique to specific therapies, such as antiangiogenic agents, this has to be determined yet. Nevertheless, radiologists need to be aware that the development of diffusion restriction in the setting of GBM can represent necrosis and not necessarily viable tumor.

KEY WORDS: Progression, angiogenesis, perfusion

Dynamic Contrast-Enhanced MR Imaging Correlates of Histologic Features in Glioblastoma Multiforme

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PURPOSE
Glioblastoma multiforme (GBM) are characterized by vascular proliferation, necrosis and mitotic activity. Dynamic contrast-enhanced MRI (DCE-MRI) provides a noninvasive method for characterizing the tumor microvascular environment. It was hypothesized that DCE-MRI parameters would correlate with histologic microvascular features in GBM.

MATERIALS & METHODS
Twenty-eight patients with subsequently histologically proved GBM underwent preoperative T1-weighted DCE-MRI. Parametric maps of Ktrans (contrast transfer coefficient), ve (measure of extravascular extracellular space), vp (measure of plasma volume per unit of tissue) and EnF (enhancing fraction) were generated. Surgical specimens were assessed semiquantitatively for the presence of necrosis, mitotic activity, histologic patterns, and tumor vascularity. Image analysis using CD34 immunostaining was used to quantify endothelial surface area (ESA), vascular surface area (WSA) and vascular profile count (VPC). The relationships between individual MRI parameters and histopathologic features were examined.

RESULTS
Significant relationships were identified between ve and mitotic activity (Figure 1), p<0.012, and ve and the presence of prominent fibrillarity, p<0.007; VPC/mm2 correlated with vp, p<0.042 and with EnF, p<0.036 (Figure 2); Ktrans correlated with the presence of frank necrosis (p<0.005) and EnF showed a nonsignificant trend with decrease in relation to necrotic volume.
CONCLUSION
As expected, a correlation was identified between vp and a histologic marker of vascularity (VPC). Interestingly, ve was identified as a potential correlate of mitotic activity in GBM. This was an unexpected finding and may reflect cell density dependent growth inhibition. Further work is warranted to examine this in more depth.

KEY WORDS: DCE-MR imaging, histopathology, glioblastoma multiforme

ePoster 081
Predicting Recurrent Tumor Versus Radiation Necrosis Using Advanced MR Imaging

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PURPOSE
A common problem in the care of brain tumor patients is new enhancing abnormalities adjacent or distant to the site of the resection. The current study focuses on the assessment of advanced MR imaging (MRI) biomarkers as a means to differentiate tumor from radiation necrosis.

MATERIALS & METHODS
Brain cancer patients at our institution who have a new enhancing lesion after treatment undergo an advanced MRI protocol, which consists of conventional MRI with T2, T2 FLAIR, diffusion tensor, and pre and postcontrast T1-weighted imaging. Additionally, multivoxel 1H spectroscopy and perfusion imaging (both dynamic contrast-enhanced (DCE) and spin echo dynamic susceptibility-enhanced (DSC) imaging) is performed. Patients receiving subsequent biopsy or surgery within 20 days of imaging were assessed retrospectively and the performance characteristics of conventional, perfusion, and spectroscopic imaging data for predicting tumor versus treatment-related necrosis were calculated. Pathology results were graded on a 5 point scale with the clinically important cut-off of significant residual/ recurrent tumor used to calculate performance. Patients subsequently were followed clinically.

RESULTS
Of the 110 patients imaged, 41 patients received biopsy or surgery for clinical indication. After exclusion for timing of tissue sampling, nonglial cell primary tumor, untreated tumors and treatment regimen, 14 cases were selected for further analysis with a spectrum of pathology findings. All patients selected had WHO grade 3 or 4 brain tumors and received treatment with temozolomide, resection and radiation, which ended 76-1504 days before imaging. Four patients also received bevacizumab. All patients except four were followed for greater than 6 months. Conventional MR imaging with comparison to prior studies and reference to clinical history, by two expert neuroradiologists with greater than 20-years experience each, yielded a sensitivity and specificity (Se/Sp) of 0.67 and 0.60, respectively. The best performing advanced MRI measures were maximum Ktrans of greater than 0.025 min\(^{-1}\) (Se/Sp 1.00/0.60) and average plasma volume fraction (vp) of enhancing lesion greater than 0.013 (Se/Sp 0.78/1.00) for tumor. Maximum vp of greater than 0.015 and choline to NAA ratios of less than 2.8 also performed well (Se/Sp 0.78 /0.80 for both).

CONCLUSION
It is often difficult to discern necrosis related to tumor from radiation-induced necrosis, but this determination can be critical in subsequent management. In this cohort of patients, DCE measures of Ktrans and vp were found to be most valuable in making this determination. This further improved with exclusion of patients treated with bevacizumab. Interestingly, significant elevation of the choline to NAA ratio, previously reported as a high-grade tumor marker, was a better predictor of necrosis. This could be from altered tumor biology after treatment. Other previously reported values for tumor performed poorly, such as DSC negative enhancement integral, DCE positive enhancement integral, choline to creatine ratio, lipid levels, and apparent diffusion restriction. Multiparametric combinations of the advanced MRI measures may further improve sensitivity and specificity and such analyses are ongoing. Further research in this area is needed to help guide clinical treatment decisions and avoid unnecessary biopsies with the potential for undersampling.

KEY WORDS: Necrosis, glioma, perfusion
ePoster 082

Post-Mortem Alterations in Fractional Anisotropy and Mean Diffusivity in Fixed Cerebral Hemispheres

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PURPOSE

The purpose of this work was to investigate the post-mortem changes in diffusion tensor properties throughout fixed human cerebral hemispheres [as measured with MR imaging (MRI)] over time.

MATERIALS & METHODS

Four hemispheres were placed in formaldehyde solution and were imaged with DTI, twice within 48 hours postmortem and approximately once per week thereafter, until 1 month postmortem. One brain donor had also undergone MRI 1 year prior to death, so antemortem DTI data were available for this subject. All post-mortem imaging was conducted at room temperature using the same clinical 3 T Philips Achieva MRI scanner (Best, Netherlands) using the following scan parameters: resolution = 1.8 x 1.8 x 2.0 mm^3, TE = 53 ms, TR = 35.5 s, b = 0, 1000, 2000, 3000, 4000, 5000, 6000 s/mm^2, 15 diffusion directions, scan time = 55 min. All diffusion-weighted volumes from a given hemisphere were registered to the same T2-weighted volume. Mean diffusivity (MD) and fractional anisotropy (FA) were calculated for each imaging session and the changes in these quantities over time were observed.

RESULTS

For the hemisphere that had been imaged both antemortem and postmortem, voxelwise comparison showed 92% reduction in white matter MD and 78% reduction in gray matter MD just 22 hours after death (the time of the first post-mortem scan) compared to 1 year antemortem. There was little correlation between ante-mortem and post-mortem MD values. Conversely, FA values were not altered substantially in the first 22 hours after death. Ante-mortem and post-mortem FA values gathered from all brain voxels were highly correlated (r = 0.78, p = 1.0e-12). Following the first post-mortem scan of each hemisphere, FA in the major white matter tracts decreased by approximately 30% over a timespan of 1 week (Figure). Over the next 3 to 4 weeks, FA measurements stabilized somewhat and remained lower than the initial post-mortem FA. The noise of the FA measurements increased in the later scan sessions. Results were similar for major white matter tracts in all four hemispheres.

CONCLUSION

Post-mortem DTI should be conducted as soon as possible after death, preferably within 24 hours, in order to obtain FA values that are most similar to those that would have been measured in vivo just before death and, thus, are most likely to be related to histologic data. For MD, there does not appear to be a strong relationship between ante-mortem and post-mortem values.

KEY WORDS: Postmortem, diffusion, MR imaging

ePoster 083

Translation of Post-Mortem Volume Measurements of Subcortical Gray Matter to in vivo Studies

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PURPOSE

The purpose of this work was to determine the relationship between the volume of subcortical gray matter structures measured with MR volumetry in vivo and postmortem.

MATERIALS & METHODS

High-resolution anatomical images of six elderly humans (mean = 88.9 years, st.dev. = 1.31) were collected in vivo and postmortem. For the post-mortem acquisition, a brain hemisphere from each subject was imaged. The cerebellum and brainstem were removed and the hemisphere was stored in a container filled with formaldehyde solution. For the segmentation of the eight subcortical gray matter regions 18 manually segmented T1-weighted image volumes (http://www.cma.mgh.harvard.edu/ibsr) were used. Each of the 18 image volumes was registered to the in vivo and post-mortem data using nonrigid registration (ART). The output transformation that maps each of the 18 image volumes to each subject’s data was applied to the labeled volumes using nearest neighbor interpolation. The final segmentation of each region was obtained by combining all 18 labeled volumes using a vote-rule based on maximum frequency. Further improvement of the results was obtained by the use
of gradient maps for the anatomical images and two-class gray/white matter segmentation obtained by FSL. The volume of each segmented region was normalized to the intracranial volume. Post-mortem volumes were plotted as a function of the in vivo volumes. Finally, the shape differences between in vivo and post-mortem data were obtained using the SPHARM-PDM UNC Toolbox.

**RESULTS**
A linear relationship was demonstrated between the normalized post-mortem and in vivo volumes of the subcortical gray matter regions, described by: \( y = 0.8791x + 0.0086 \), \( p<10^{-10} \) (Figure 1). Shape analysis provided additional evidence on the contraction of the surface of these structures.

![Figure 1: Postmortem vs. in-vivo normalized volumes of subcortical gray matter regions.](image)

**CONCLUSION**
The observed shrinking of the subcortical gray matter regions may be due to a reduction in water content of brain tissue after death. The present investigation facilitates translation of post-mortem MR volumetric measurements to in vivo studies.

**KEY WORDS:** Segmentation, volumetry

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**ePoster 084**

*Effects of Age, Gender, and Hemispheric Location on T2 Hypointensity in the Pulvinar at 3 T*

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**PURPOSE**
The signal changes of the pulvinar with aging have not been established, though pulvinar hypointensity may be recognized frequently on T2 and diffusion-weighted images. Previous studies have reported the signal loss on T2-weighted imaging with aging in the globus pallidus, red nucleus, substantia nigra, and dentate nucleus, presumably due to the increase of iron deposition. The purpose of this study was to evaluate the effect of age, gender, and hemispheric location on T2 hypointensity in pulvinar.

**MATERIALS & METHODS**
The imaging database was searched for subjects with unremarkable brain 3 T MR findings. One-hundred forty-three subjects (F=91, M=52, 8-91 years old) were enrolled in this retrospective study. MR images were analyzed with regard to signal intensity of the pulvinar relative to the thalamus and cerebral white matter on FLAIR images, respectively. The multivariate linear regression was used to study the age effect on the signal ratio of pulvinar to thalamus or white matter with adjustment for the hemispheric effect for male and female groups respectively.

**RESULTS**
In the male group, the slopes of the regression lines were -0.00358 (\( p<0.0001 \)) and -0.00437 (\( p<0.0001 \)) for the ratio of pulvinar to thalamus and white matter, respectively. In the female group, the slopes were -0.00152 (\( p>0.0001 \)) and -0.00157 (\( p=0.0002 \)) for the ratio of pulvinar to thalamus and white matter, respectively. The male subjects had more rapid decrease of signal ratio with age than the female ones, with \( p=0.0002 \) or 0.0006 for the ratio of pulvinar to thalamus or white matter, respectively. The right pulvinar had lower signal ratios than the left one in both male and female subjects.

![Signal ratio of pulvinar to thalamus versus age](image)

**CONCLUSION**
We detected a significant association between pulvinar signal on T2-FLAIR images and age, a linear signal decrease with age. The signal changes also are asymmetric and gender related. We speculate that T2 hypointensity in the pulvinar may be reflective of increased iron deposition.

**KEY WORDS:** Pulvinar, T2 hypointensity
ePoster 085

Significant Differences in MR Perfusion in Lupus Patients Compared to Healthy Controls

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PURPOSE
Systemic lupus erythematosus (SLE) is an autoimmune disorder with an annual incidence of 2.0-7.6 per 100,000. Neuropsychiatric systemic lupus erythematosus (NPSLE) occurs in 25-70% of patients with SLE and is associated with increased morbidity and mortality. The clinical manifestations of NPSLE include: headache, stroke or stroke-like symptoms, psychosis, seizures and cognitive dysfunction among others. Although clinical assessment is the cornerstone of the NPSLE diagnosis, this diagnosis can be difficult to make and is frequently presumptive. Our objective with this study was to search for a perfusion parameter that could be used as a diagnostic marker for NPSLE patients so that we could make inroads in terms of diagnosis and therapy.

MATERIALS & METHODS
Eighteen SLE patients with no neurologic symptoms (17 females, 1 male, mean age 42.7±14.3 years), 19 NPSLE (19 females, mean age 43.3±11.6 years), and 19 healthy controls (HC) (19 females, mean age 44.5±14.3 years). All subjects had conventional 3 T MR imaging (MRI) of the brain. Perfusion measurements (CBF, CBV, and MTT) were obtained using Phillips T2* perfusion tool software. Perfusion was generated from an arterial input function (AIF) obtained using the right middle cerebral artery. The ratio of CBF, CBV, and MTT of eight different brain regions were compared between the three cohorts by two-sample t-test or Wilcoxon rank-sum test when appropriate (lack of normality). A probability (p) value of 0.05 or smaller was considered significant for all hypothesis tests.

RESULTS
Several significant differences were seen between the HCs and the SLE patients in terms of relative cerebral blood flow in the following areas: right posterior thalamus (p = 0.03), right hypothalamus (p = 0.042), and posterior cingulate gyrus (p = 0.048), and the left parahippocampal gyrus (p = 0.048). Additionally, there was also a statistically significant difference between CBV in the left hypothalamus region (p = 0.048). Healthy controls and NPSLE patients showed a significant difference in the CBV of the posterior cingulate gyrus (p = 0.045). Testing for equality of variances revealed significant differences in the CBV between the SLE and NPSLE patients (p = 0.001) as well as between HC and NPSLE (p<0.0001). Overall, the NPSLE patients had higher variability than the other two cohorts. In terms of the CBF the healthy controls and the NPSLE had significantly different variability (p = 0.03) and the NPSLE patients has higher variance than the HC group.

CONCLUSION
Several statistically significant differences in perfusion patterns were found in patients with lupus with and without neuropsychiatric symptoms compared to HCs. Differences in CBF were seen in SLE patients compared to HC patients, this may be in part due to vascular changes secondary to SLE. Interestingly, no statistically significant difference in CBF was seen between the NPSLE and HC patients. One of the most significant findings was that the perfusion parameters for the NPSLE patients showed increased variability compared to the HC and SLE patients, and maybe this is why we and others have found it difficult to find a specific/singular perfusion target in which to help diagnose neuropsychiatric lupus.

KEY WORDS: MR imaging perfusion, neuropsychiatric lupus, systemic lupus erythematosus

ePoster 086

Diagnostic Yield of Head CT for Headache in the Low Risk Patient

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PURPOSE
Headache is a common patient complaint, accounting for up to 4.5% of emergency department (ED) visits. It remains one of the most common primary chief complaints associated with computed tomography (CT) imaging in the ED accounting for 7.5% of CT-associated ED visits in 2007. Excessive imaging has come under scrutiny in recent years due to mounting concern about the risks of radiation exposure and rising health-care costs. Prior studies have examined the role of head CT for the evaluation of headaches in the ED setting. However, methodologic concerns have limited their value. Our goal was to reassess the diagnostic value of emergency head CT in the work-up patients with isolated chief complaint of headache utilizing contemporary CT equipment and protocols.

MATERIALS & METHODS
The study group was composed of ED patients presenting to a metropolitan tertiary care center from September 2010 to November 2010. All patients presenting with a chief complaint of “headache” who subsequently received an enhanced head CT were included in the study. Patients were identified through a search of the radiology information system (RIS). Of 714 reviewed studies, 557 were excluded if there was any additional history other than “headache.” Of the 157 remaining, confirmation of the history was accomplished by review of the electronic medical record. Based on this review, patients were excluded if risk factors existed for acute intracranial pathology. These included, but were not limited to: head/neck trauma, altered mental status, recent head/neck surgery, anticoagulation therapy, atrial fibrillation, and malignancy, prior intracranial bleed, known aneurysm, uncontrolled HTN or clinical diagnosis of stroke. After exclusion criteria were applied, a total of 46 patients were included in the study. Findings were categorized as “normal” (no abnormalities), “incidental” (findings do not explain patient’s symptoms), or “abnormal” (findings do explain patient’s symptoms). Calculations were performed using Microsoft Excel.
RESULTS
Of the patients in the study, 65.3% were female. Age range was 18-77 years (mean, 39.4 years). No scans demonstrated findings that explained the patients’ symptoms. Sixty-three percent of the studies were normal. Incidental findings were present in 37% of patients. Incidental findings included sinus mucosal disease, diffuse brain atrophy, chronic small vessel disease, chronic lacunar infarcts or large vessel distribution infarcts, subarachnoid cyst, and calcified meningioma. Zero studies were diagnostic of the patients’ symptoms.

CONCLUSION
This study demonstrates the low diagnostic value of unenhanced head CT for the evaluation of headaches in the low risk patient. Radiation exposure is significant. Unenhanced head CTs average 75 mGy (CTDIvol) per scan based on ACR/ASNR reference standards. With an estimated 1.215 million ED visits involving head CT for headache evaluation, a significant dose reduction and cost savings potentially could be achieved through more judicious use of CT. Given the findings in this study, patients may be better served by a careful clinical history, appropriate neurologic exam, and, if indicated, MR imaging of the brain.

KEY WORDS: Headache

**ePoster 087**

Factors Determining the Clinical Significance of an “Empty” Sella Turcica

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PURPOSE
The “empty” sella turcica is characterized by intrasellar herniation of the subarachnoid space, resulting in a flattening of the pituitary gland, with or without enlargement of the bony sella turcica. This appearance on MR imaging (MRI) often represents an incidental finding as the result of an anatomical defect in the diaphragm sella, but also may be a sign of chronically elevated intracranial pressure in the setting of idiopathic intracranial hypertension (IIH), a potentially treatable condition that can result in insidious vision loss. The purpose of this study was to evaluate clinical and MR imaging (MRI) factors that may help determine whether the finding of an “empty” sella is incidental or requires further evaluation.

MATERIALS & METHODS
Forty-five patients with clinically documented IIH, and 92 patients with the term “empty sella” reported on a brain MRI examination (but without history of pituitary abnormality/surgery, clinical diagnosis of IIH, or intracranial abnormality on MR imaging) were enrolled retrospectively in this IRB-approved study. MR images for both the IIH and incidental “empty” sella groups were evaluated for maximum anterior-posterior (AP) and cranial-caudal (CC) sella turcica dimensions, AP diaphragm sella dimension, AP position of the pituitary infundibulum along the diaphragm sella, flattening and height of the pituitary gland, scalp soft tissue thickness at the C2/3 level. Both groups also were evaluated for presence or absence of orbital findings suggestive of IIH (posterior scleral flattening, optic nerve sheath dilatation, prelaminar optic nerve protrusion, and optic nerve vertical tortuosity). Age, gender, presenting clinical symptoms, and MR imaging measurements were compared between the two groups. Sellar and pituitary dimensions also were correlated with patient age in each group.

RESULTS
The mean age of the IIH group (36.1 years; SD=11.7), was significantly younger (P < 0.05) than that of the incidental “empty” sella group (54.3 years; SD = 14.3). Patients in the IIH group were significantly more likely to have presenting symptoms of headache (93% versus 33%) or visual complaints (62% versus 28%; both P < 0.05). Nearly all the IIH patients (96%) demonstrated an “empty” sella appearance. There were no significant differences between the two groups in measures of AP and CC dimensions of the sella turcica, AP diaphragm sella dimension, infundibular position, or degree of pituitary flattening. The IIH group demonstrated significantly greater mean scalp thickness (9.0 mm versus 6.4 mm; P < 0.05) and neck soft tissue thickness (19.5 mm versus 13.8 mm; P < 0.05). While the vast majority of the IIH group (93%) had one or more orbital findings to suggest IIH, the incidental “empty” sella group rarely had any of these findings (14%). There was a modest age-related correlation with diaphragm sella width (r = 0.53) in the IIH group, but not the incidental “empty” sella group (r = 0.13).

CONCLUSION
Using a combination of clinical factors and imaging characteristics the significance of the MR imaging finding of an “empty” sella can be determined with a high degree of confidence.

KEY WORDS: Empty sella, idiopathic intracranial hypertension, sella turcica

**ePoster 088**

Quantitative Assessment of Extracranial Venous Drainage and Cerebral Perfusion in Multiple Sclerosis Patients and Normal Controls Using 4D Flow, ASL, and PW Imaging

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PURPOSE
Chronic cerebrospinal venous insufficiency (CCSVI) hypothesizes an association between venous stenoses/impaired extracranial venous drainage and multiple sclerosis (MS). We recently found MS patients have greater IJ flattening and more non-IJ collaterals than normal patients without MS. We now seek to determine any corresponding quantitative differences in extracranial venous drainage and cerebral perfusion.
MATERIALS & METHODS
Gender and age-matched normal (n=10) and MS patients (n=10) underwent TRICKS MRA/MRV (TRICKS) of the head and neck, bolus perfusion-weighted imaging (PWI), arterial spin labeling (ASL), and time-resolved, 3D velocity encoded MR imaging (4D Flow) at 3 T. Perfusion-weighted imaging, ASL, and 4D Flow data were analyzed using in-house software programs. Two experienced neuroradiologists reviewed vascular imaging without any knowledge of cohort status and assigned scores (normal=0, mild=1, moderate=2, severe=3) for the presence and severity of non-IJ collaterals (TRICKS). PWI (CBV, MTT, Tmax) and ASL. Cerebral blood flow (CBF) data were calculated for ROIs including either white matter or gray matter at the level of the centrum semiovale. For 4D Flow data, manual segmentation (ROI analysis) was performed at similar levels in the upper, mid-, and lower jugular veins in normal and MS patients. Correlations between collateral scores and flows were tested with Jonckheere-Terpstra nonparametric test for trend. Comparison of jugular venous flow between groups was done using a Mann-Whitney test stratified by location (upper, mid, lower). Comparisons of cerebral perfusion employed a standard t-test.

RESULTS
There were six (75%) and five (83%) women in the normal and MS cohorts, respectively. The mean ages of the two cohorts were 46.2 and 42.6 years. The mean EDSS of our MS cohort was 3.25 (1-6). Seven patients (88%) have relapsing-remitting MS. Arterial spin labeling, PWI, and 4D Flow data were available for 20, 19, and 14 patients, respectively. Right dominant IJ drainage was seen in seven (88%) normal patients and three (50%) of MS patients. The average collateral scores were 0.8 and 1.8 for normal and MS patients, respectively. There was correlation between higher collateral scores and reduced internal jugular blood flow (P = 0.01). A near significant difference in jugular blood flow was seen between normal patients and MS patients (P=0.06). Arterial spin labeling CBF for white and gray matter was 20.3 and 41.9 ml/100 g/min in normal patients and 22.8 and 45.6 ml/100 g/min in MS patients (P > 0.05). Similarly, PWI demonstrated no differences in CBF between the two groups. Mean transit time and Tmax values for white/gray matter were 8.4/9.3 and 2.5/1.8 seconds, respectively in normal patients and 7.2/8.3 and 2.7/2.3 seconds in MS patients (P<0.05).

CONCLUSION
There is a correlation between higher collateral scores and reduced jugular blood flow. Even though there was a nearly significant difference in jugular blood flow between normal and MS patients in this small study, no differences were seen in cerebral perfusion. Thus, to date, we find no direct evidence that the non-IJ collaterals, more commonly seen in MS patients, insufficiently drain the brain of MS patients in the position in which our images/data are acquired. The relationship between impaired extracranial venous drainage (CCSVI) and MS disease requires further study.

KEY WORDS: CCSVI, phase-contrast imaging, jugular vein
RESULTS
fMRI. When present, activations were located in the temporal lobes, mono or bilaterally depending of the characteristics of the cerebral lesions. Patients were divided into two groups: the ones showing clear-cut activations (15 patients, 65%) and the ones showing no activation (8 patients, 35%). H1-MRS spectroscopy. Considering the NAA/Cho ratios, we divided patients into three groups: NAA/Cho ratios ≤ 1 (undoubtedly pathologic), NAA/Cho ratios in the range between 1.1 and 1.6 (moderately pathologic), and NAA/Cho ratios ≥ 1.7 (normal). Considering the NAA/Cho ratio of the 15 activated patients, five (33%) of them showed a NAA/Cho ratio ≤ 1, six (40%) of them showed a NAA/Cho ratio in the range between 1.1 and 1.6, and four (27%) of them showed a NAA/Cho ratio ≥ 1.7. Discussion. When taking into account the clinical course of our patients, we noted that the VS patients showing a clinical improvement in time (from VS to MCS/SD) all appertained to the activated group, whereas all the patients showing no clinical improvement appertained to the nonactivated group. Moreover, in the activated group, there was a loose correlation between the size of the activations and the NAA/Cho ratio values: the wider the activations the higher the NAA/Cho ratio values. Furthermore, when the follow up of the patient was feasible, we observed that a favorable clinical evolution was associated with an increase in the size of the activated areas together with a normalization of the NAA/Cho ratio values, whereas an unfavorable clinical evolution was associated with a reduction in the size of the activated areas and a worsening of the aforementioned values. In the activated group (15 patients), only three patients (20%) showed no clinical improvement.

CONCLUSION
On the basis of the data at our disposal at present, it is possible to assert that the two advanced techniques (fMRI and H1-MRS spectroscopy) we used may represent a powerful diagnostic/prognostic support in patients suffering from VS/MCS/SD. Naturally, a higher number of patients have to be examined to confirm our hypotheses.

KEY WORDS: fMRI, spectroscopy, vegetative state

Identification of Venous Signal on Arterial Spin Label MR Images Improves Diagnosis of Dural Arteriovenous Fistulae and Small Arteriovenous Malformations

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PURPOSE
Dural arteriovenous fistulae (dAVFs) and small arteriovenous malformations (AVMs) are difficult to detect on conventional MR imaging (MRI)/MR angiography (MRA) or CT angiography (CTA) examinations, and often require digital subtraction angiography (DSA) for definitive diagnosis. In arterial spin label (ASL) imaging, the decay of the labeled blood water is short compared with capillary transit times, and therefore ASL signal typically is not seen within veins. Since they lack a capillary bed, dAVF/AVMs have shortened blood transit times, and venous ASL signal can be seen. This study assessed the clinical value of the “venous ASL sign” to detect dAVF or small AVMs.

MATERIALS & METHODS
Two neuroradiologists and one neurologist reviewed MRI studies of 26 patients who also underwent DSA for suspected vascular lesions, of which 15 were positive for dAVF or small AVM (<2 cm). Pseudocontinuous ASL was performed at 1.5 T with a background-suppressed 3DFSE readout. Using a five-point scale, the readers assessed the likelihood of a positive DSA study before and then after reviewing the ASL findings. In addition to the presence of high ASL signal in venous structures (“venous ASL sign”), the readers also documented the presence of other imaging findings, including acute or chronic hemorrhage, edema, abnormal MRA, serpiginous vessels, and venous enhancement. Sensitivity and specificity, logistic regression, and receiver-operator characteristic (ROC) analyses were performed.

RESULTS
Venous ASL signal was seen frequently in DSA positive cases, as demonstrated in Figure 1, for a patient with a small dAVF draining into the left transverse sinus. The sensitivity, specificity, positive predictive value, and negative predictive value of the venous ASL sign for predicting a positive DSA study was 78%, 85%, 88%, and 74%, respectively. There was a significant increase in the area-under-the-curve (AUC) of the ROC for the readers after review of the ASL images (AUC = 0.798 pre-ASL; AUC = 0.891 post-ASL; p=0.02). This effect was mainly due to an increase in sensitivity. Multivariate logistic regression identified venous ASL signal as the strongest predictor of positive DSA study, with an odds ratio of 17.3 (95% confidence interval: 2.8-108).
CONCLUSION
Presence of the venous ASL sign improved the ability to identify dAVF and small AVMs using MRI. Attention to this sign may improve triage to DSA in patients with suspected small vascular malformations.

KEY WORDS: Arterial spin labeling, arteriovenous malformation, dural arteriovenous fistula

Changes in Arteriovenous Malformation Angioarchitecture and Hemodynamics after Stereotactic Radiosurgery Assessed by Dynamic MR Angiography and Phase-Contrast Flow Assessments: A Prospective Follow-Up Study

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PURPOSE
This study was designed to assess the effects of arteriovenous malformation (AVM) volume on blood flow characteristics and changes in the angioarchitecture and hemodynamics induced by radiosurgery by using MR PC measurements.

MATERIALS & METHODS
Sixty-five patients (31 males, 34 females; average age 37 years) with cerebral AVMs underwent a prospective MR imaging (MRI) protocol shortly after or before stereotactic radiosurgery including morphologic series, gadobutrol-(Gadovist®) enhanced MR angiography (MRA) and bilateral ECG triggered MR PC measurements of the internal carotid artery (ICA). For statistical analysis patients were assigned to two each of three subgroups in respect to AVM volume. Statistical analysis included two-group mean comparison tests and linear regression analysis for identification of relationships between AVM volume and ICA blood flow characteristics (p = 0.05). Totally, 34 patients of the initial group underwent follow up within the time range from 2 up to 4 years.

RESULTS
The subgroup with the smallest AVM volume (3.5 to 10 ccm) and in 22 cases (34%), AVM volume exceeded 10 ccm. Over all subjects, a significant relationship between mean arterial blood flow in the ICA on the side of the lesion and the AVM volume was revealed (p = 0.0002). In large (volume >10 ccm) and medium-sized AVMs (>3.5 <10 ccm) the ICA blood flow was increased significantly on the side of the malformation (9.56 ± 3.57 ml/sec vs 6.04 ± 2.4 ml/sec; 7.35 ± 2.95 ml/sec vs 5.31 ± 1.91 ml/sec; p = 0.0004), whereas in lesions smaller than 3.5 ccm, no significant rise of the mean blood flow was detectable (3.06 ± 1.9 ml/sec vs 4.2 ± 1.54 ml/sec; p = 0.055). At follow up, a significant decay of AVM volume or even complete obliteration was found in 25 of 34 patients (73.5%). In these patients, the mean blood flow on the side of the lesion had diminished significantly (7.2 ± 3.29 ml/sec to 4.66 ± 1.63 ml/sec) and was not increased anymore in comparison with the contralateral ICA (4.00 ± 1.2 ml/sec; p = 0.11). These changes correlated with a significant reduction of the average AVM volume (7.88 ± 11.4 vs 0.5 ± 0.77 ccm; p = 0.0026).

CONCLUSION
Based on our findings we can assume that the AVM angioarchitecture has a significant impact on the blood flow characteristics in the feeding artery. After successful therapy a significant reduction of the shunt volume after radiosurgery leads to normalization of the hemodynamics. Radiosurgery of nidal vessels is followed by a proliferation of the intima leading to a considerable increase of vessel resistance and reciprocally to a drop of the blood flow.

KEY WORDS: AVM, hemodynamics, MRA techniques

Computed Tomographic Angiography and Venography in Place of Catheter Angiography for Patients with Spontaneous Acute Intracerebral Hemorrhage

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PURPOSE
In hemorrhagic stroke patients without pre-existing hypertension or aged below 45 years, catheter angiography or digital subtraction angiography (DSA) remained the gold standard for investigation of any underlying vascular lesion. With the technology of multi-slice computed tomography (MDCT), we explored the effectiveness of using computed tomographic angiography and venography (CTAV) in place of DSA in patients with spontaneous acute intracerebral haemorrhage.

MATERIALS & METHODS
Setting and subjects: In a regional neurosurgical center in Hong Kong, we prospectively recruited 109 patients with nonhypertensive spontaneous intracerebral hemorrhage for this comparative study. Study instruments: All patients had CTAV in a single procedure using a MDCT with 64 detectors. They then would schedule to have catheter angiography
the next day. Main outcome measures: Positive and negative predictive values in detecting vascular lesions causing the intracerebral haemorrhage.

**RESULTS**

Vascular pathologies causing hemorrhage were identified 37 (33%) patients, which included cerebral arteriovenous malformation in 22 patients. The positive predictive value and negative predictive value of CTA for vasospastic pathologies causing hemorrhage were 97.3% and 100% respectively. Cohen’s Kappa coefficients were 0.98 (p<0.001) and 0.97 (p<0.001) for vascular lesions and cerebral arteriovenous malformation respectively. Cohen’s Kappa coefficient for cerebral arteriovenous malformation grading was 0.93 (p<0.001). There were 29 arterial feeder origins and 29 venous sinus/deep venous drainage systems identified from DSA, in which 28(97%) arterial feeder origins and 24(83%) venous sinus/deep venous drainage systems were identified concordantly from CTA. Cohen’s Kappa coefficients for identifications of arterial feeder origins and venous sinus/deep drainage systems were 0.94 (p<0.001) and 0.78 (p<0.001) respectively.

**CONCLUSION**

Computed tomographic angiography and venography were able to screen vascular lesions causing spontaneous acute intracerebral hemorrhage with high diagnostic accuracy.

**KEY WORDS:** Intracerebral hemorrhage, angiography, computed tomography

**ePoster 092**

**CT Angiography for Evaluation of Cerebral Vasospasm following Subarachnoid Hemorrhage**

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**PURPOSE**

Cerebral vasospasm (CV) is one of the most dreaded complications in patients who survive acute subarachnoid hemorrhage (SAH) and conventional cerebral angiography [digital subtraction angiography (DSA)] is the gold standard for its diagnosis in clinically symptomatic patients. We evaluated CT angiography (CTA) as a noninvasive alternative for diagnosis of CV and its potential for making treatment decisions.

**MATERIALS & METHODS**

Consecutive patients with SAH and suspected vasospasm were included when both CTA and DSA were performed within 24 hours. Two neuroradiologists retrospectively analyzed CTA and DSA studies independently. Assessment included presence of central and peripheral vasospasm and grading of severity of CV. A treatment recommendation based on CTA was compared to actual treatment received.

**RESULTS**

Final analysis included 34 patients. CT angiography was more accurate for diagnosis of central than for peripheral CV with high sensitivity (82% and 92%), specificity (73% and 90%), accuracy, PPV and NPV for central vasospasm. For grading the severity of vasospasm CTAs sensitivity, specificity and accuracy were high for most central arteries. Reader’s recommendation of angioplasty according to CTA was significantly predictive of actual receipt of angioplasty but overestimated actual receipt of triple H treatment. The interobserver agreement for the treatment decision was excellent.

**CONCLUSION**

CT angiography is reliable for diagnosis of cerebral vasospasm after SAH especially for depicting central vasospasm. It is helpful in treatment decision making specifically regarding the need for balloon angioplasty.

**KEY WORDS:** Postaneurysmal subarachnoid hemorrhage, cerebral vasospasm, CT angiogram

**ePoster 093**

**Evaluation of Sensitivity of CT Angiogram Generated from the Dynamic Cerebral CT Perfusion to Diagnose Cerebral Aneurysms in Nontraumatic Subarachnoid Hemorrhage**

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**PURPOSE**

The conventional CT angiogram (CTA) utilizing 140 kV and current of 300-380 mA has an established sensitivity in detecting cerebral aneurysms of 95% (0.91-0.97) for aneurysms > 3 mm, compared to the gold standard digital subtraction angiography (DSA). We evaluated the sensitivity of cerebral CTA obtained from the CT perfusion acquisition (CTP/CTA) utilizing low voltage/ampere (80kV; 250 mA) in detecting cerebral aneurysms in patients with aneurysmal subarachnoid hemorrhage compared to DSA.

**MATERIALS & METHODS**

Between July 1, 2009 and September 30, 2010, a total of 87 patients were admitted to the neurovascular service in a level 1 trauma center with nontraumatic subarachnoid hemorrhage. All clinically stable patients who present with nontraumatic subarachnoid hemorrhage undergo CTP/CTA to obtain a baseline cerebral perfusion map before intervention. Three independent physicians; two board-certified radiologists (staff with 4 years experience in neuroradiology, and a neuroradiology fellow), and a radiology resident reviewed the DSA obtained within 2 days of the CTP/CTA and compared them to the CTP/CTA data. Dynamic CT perfusion was performed using a 128-slice (Definition AS+; Siemens Medical Solutions, Munich, Germany) with a technique of 80 kV, 250 mA and scan time of 40 seconds after the injection of 40 cc nonionic contrast agent followed by a saline chase with a flow rate of 8 cc/s. CT angiography images were obtained from the dynamic volume perfusion data. The
sequence with the best arterial opacification was chosen for analysis at an independent 3D workstation vitrea enterprise suite (VES 1.1). Out of the 87 patients, 31 were excluded. Exclusion criteria were as follows: patients who did not have a DSA, underwent intervention before CTP/CTA, or had a nonaneurysmal nontraumatic SAH.

**RESULTS**

Fifty-six patients with 71 aneurysms were included in our study. Six of these aneurysms were present on DSA but were missed in the original CTP/CTA report. Two of the six missed aneurysms were identified by the reviewers on the CTP/CTA. The other four aneurysms were not identified by any of the three reviewers on the CTP/CTA. Three of the four aneurysms were obscured by adjacent atherosclerotic calcifications, ossified petroclinoid ligament, or bone. Three of the four missed aneurysms measured 2 mm and the fourth measured 3 mm on DSA. The overall sensitivity of CTP/CTA was 94%; however the sensitivity for aneurysms > 2 mm was 98.5%, and for aneurysms > 3 mm was 100%.

**CONCLUSION**

CT angiography images generated from the dynamic low voltage/ampere CT perfusion data (80 kV; 250 mA) is as sensitive as the conventional CTA utilizing 140 kV and current of 300-380 mA in detecting cerebral aneurysms in nontraumatic SAH. CT perfusion/CTA helps the radiologist to diagnose cerebral aneurysms in addition to providing functional information about cerebral blood flow and vasospasm as previously documented.

**KEY WORDS:** CTA, CT perfusion, cerebral aneurysms

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**Diagnostic Yield of Catheter Angiography in Patients with Isolated Nontraumatic Subdural Hemorrhage**

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**PURPOSE**

To determine the yield of catheter angiography for the detection of causative vascular abnormalities in patients with isolated nontraumatic intracranial subdural hemorrhage (SDH).

**MATERIALS & METHODS**

We conducted a retrospective review of all patients who underwent catheter angiography at our institution for evaluation of nontraumatic SDH without associated intracerebral or subarachnoid hemorrhage over a period of 5 years. Noncontrast CT examinations were reviewed by two experienced neuroradiologists to determine, by consensus, the SDH location, maximum axial width and attenuation relative to the underlying brain parenchyma. Catheter angiograms were reviewed by experienced interventional neuroradiologists to determine the presence of an underlying vascular abnormality for the SDH. Medical records were reviewed for baseline clinical characteristics.

A total of 30 SDHs were identified in 25 patients included in our study. Thirteen patients were female (52%) and 12 male (48%). Mean patient age was 54.7 years (median 58 years, range 22-73 years). Twelve patients had a history of hypertension (48%), seven were receiving antiplatelet therapy (28%), and three had an international normalized ratio ≥ 1.5 (12%). Eighteen SDHs were left-sided (60%) and 12 right-sided (40%). Mean maximum axial SDH width was 10.2 mm (median 8.5 mm, range 2.5-23 mm). Compared to the underlying brain parenchyma, 15 SDHs were hyperdense (50%), seven isodense (23.3%), six heterogeneous (20%), and two hypodense (6.7%). Catheter angiography demonstrated an underlying vascular abnormality for the SDH in five patients (20%), three of whom were female (60%) and two male (40%). Three of these five patients had a history of hypertension (60%) and one was receiving antiplatelet therapy (20%). Three of the SDHs with an underlying vascular abnormality were left-sided (60%) and two right-sided (40%); three were hyperdense (60%) and two isodense (40%). The vascular abnormalities identified were two dural arteriovenous fistulas (dAVF, Figure 1), two ruptured aneurysms (a 10 mm left posterior communicating artery aneurysm and a 6 mm left paraclinoid internal carotid artery aneurysm) and a 1 mm right middle meningeal artery pseudoaneurysm in a patient who had undergone an ipsilateral craniotomy for brain tumor resection. One dAVF and the left posterior communicating artery aneurysm were treated surgically (40%), one dAVF and the left paraclinoid internal carotid artery aneurysm were treated endovascularly (40%), and the right middle meningeal artery pseudoaneurysm thrombosed spontaneously (20%).
CONCLUSION
Catheter angiography is a valuable tool in the evaluation of patients with isolated nontraumatic SDH, demonstrating an underlying vascular abnormality in 20% of patients.

KEY WORDS: Subdural hemorrhage, catheter angiography, aneurysm

ePoster 094a

Vegetative State: May the Advanced MR Techniques (fMRI and Spectroscopy) be of Help in Prognosis?

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PURPOSE
Consciousness disorders are now considered ad a broad spectrum of clinical entities ranging from coma, to vegetative state (VS) and minimally conscious state (MCS) and severe disease (SD), up to the recovery of independence. The differential diagnosis between the different states is difficult but is very important, also because of the different prognosis. Advanced MR technologies, such as fMRI and spectroscopy, are now available to throw more light on this problem. Aim of our study was to analyze, by fMRI and spectroscopy, a cohort of 24 patients, suffering from different degrees of consciousness impairment, to assess the value of MR advanced technologies in the differential diagnosis and prognosis of these patients.

MATERIALS & METHODS
Patients. We enrolled 24 patients (age comprised between 17 and 58) with outcome of comas: 20 of them had polytrauma outcomes, three of them had cerebral anoxia, one of them had encephalitis outcome. Each patient underwent morphological, fMRI and H1-MRS spectroscopy analysis. A 3 T Signa Excite system and an 8 channel phased array coil were used to acquire morphological sequences fMRI and H1-MRS spectroscopy. fMRI. Functional [axial single shot (SS), echo planar image (EPI), gradient echo (GE)], and morphological (isovolumetric 3D spoiled grass - inversion recovery, SPGR-IR) sequences were acquired. We used a block paradigm of the kind: 30 s stimulus vs 30 s rest, for a total length of 5 min. Three different paradigms were applied: 1) in the stimulus phase, the patient heard the voice of a relative telling an emotionally significant episode, vs silence; 2) in the stimulus phase, the patient heard the same voice telling the same episode as in point 1), but the voice was played in the reverse order, vs silence; 3) in the stimulus phase, the patient heard the same voice as in 1), whereas in the rest phase the patient heard the same reverse voice as in point 2).

fMRI analysis was performed off-line by using BrainWave GE proprietary software. Briefly, the processing of this software is semiautomatic and consists in segmentation and coregistration of the morphologic sequence to the fMRI sequence, after the appropriate corrections (motion correction, smoothing, etc.). The final parametric maps were calculated at a p<0.01 threshold and superimposed to the morphological coregistered segmented images. Spectroscopy (single voxel, point-resolved spectroscopy sequence (PRESS)). We analyzed the following metabolite ratios: mI/Cr, Cho/Cr, NAA/Cr, NAA/Cho. Resulting spectra were processed by SAGE Software (Spectral Analysis, GE Medical System). Particularly, we focused on NAA/Cho ratio, because it has been showed that a reduction of this ratio has a negative prognostic value. We compared the NAA/Cho values obtained in VS/MCS/SD patients with the corresponding values obtained in 16 healthy volunteers (age comprised between 25 and 57), by placing the voxel in the left frontal white matter. Normal NAA/Cho reference values were in the range of 2.0 ± 0.3.

RESULTS
fMRI. When present, activations were located in the temporal lobes, mono or bilaterally depending of the characteristics of the cerebral lesions. Patients were divided into two groups: the ones showing clear-cut activations (15 patients, 65%) and the ones showing no activation (8 patients, 35%). H1-MRS spectroscopy. Considering the NAA/Cho ratios, we divided patients into three groups: NAA/Cho ratios ≤ 1 (undoubtedly pathologic), NAA/Cho ratios in the range between 1.1 and 1.6 (moderately pathologic), and NAA/Cho ratios ≥ 1.7 (normal). Considering the NAA/Cho ratio of the 15 activated patients, five (33%) of them showed a NAA/Cho ratio ≤ 1, six (40%) of them showed a NAA/Cho ratio in the range between 1.1 and 1.6, and four (27%) of them showed a NAA/Cho ratio ≥ 1.7. Considering the NAA/Cho ratio of the eight patients showing no activation, three (38%) of them showed a NAA/Cho ratio ≤ 1, five (62%) of them showed a NAA/Cho ratio in the range between 1.1 and 1.6, and no one (0%) showed a NAA/Cho ratio ≥ 1.7. Discussion. When taking into account the clinical course of our patients, we noted that the VS patients showing a clinical improvement in time (from VS to MCS/SD) all appertained to the activated group, whereas all the patients showing no clinical improvement appertained to the nonactivated group. Moreover, in the activated group, there was a loose correlation between the size of the activations and the NAA/Cho ratio values: the wider the activations the higher the NAA/Cho ratio values. Furthermore, when the follow up of the patient was feasible, we observed that a favorable clinical evolution was associated with an increase in the size of the activated areas together with a normalization of the NAA/Cho ratio values, whereas an unfavorable clinical evolution was associated with a reduction in the size of the activated areas and a worsening of the aforesaid values. In the activated group (15 patients), only three patients (20%) showed no clinical improvement.

CONCLUSION
On the basis of the data at our disposal at present, it is possible to assert that the two advanced techniques (fMRI and H1-MRS spectroscopy) we used may represent a powerful diagnostic/prognostic support in patients suffering from VS/MCS/SD. Naturally, a higher number of patients have to be examined to confirm our hypotheses.

KEY WORDS: fMRI, spectroscopy, vegetative state
ePoster 095

Basal Ganglia: Network Anatomy, Functional Aspects and Clinical Considerations

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PURPOSE
The expanding and critical role of the basal ganglia in different neural networks has been the focus of recent investigations. The intricate contributions of these deep nuclei to the motor pathways as well as the less intuitive nonmotor loops now can be appreciated in greater detail. These neural pathways and their functional significance, however, have not been emphasized in the radiologic literature. Knowledge of these pathways is increasingly important in the interpretation of diffusion tensor imaging (DTI) and fMRI data as well as routine clinical MR imaging of the brain.

MATERIALS & METHODS
This exhibit will describe the fiber pathways connecting the basal ganglia to the body movement, oculomotor, prefrontal, and limbic neural loops/circuitry. The morphology and location of these pathways will be related to readily visible anatomical landmarks and the functional significance of these connections will be illustrated.

RESULTS
The key anatomical components of the motor loop include the primary motor, premotor, and somatosensory cortices, putamen, globus pallidus externa and interna, ventral lateral and ventral anterior thalamic nuclei, and subthalamus. The oculomotor loop involves the frontal and supplementary eye fields, posterior parietal and prefrontal cortices, body of the caudate, globus pallidus interna, substantia nigra pars reticulata, and mediodorsal and ventral anterior thalamic nuclei. The prefrontal loop includes the dorsolateral prefrontal cortex, anterior caudate, globus pallidus interna, substantia nigra pars reticulata, and mediodorsal and ventral anterior thalamic nuclei. The limbic loop involves the amygdala, hippocampus, orbital-frontal, anterior cingulate, and temporal cortices, ventral striatum, ventral pallidum, and the mediodorsal nucleus.

CONCLUSION
The globus pallidus contributes to several important functional pathways that affect more than major body movements with which it has been conventionally associated. Knowledge of these neural networks will not only improve the interpretation of routine MR imaging of the brain, DTI and fMRI but also will influence the application of those techniques.

KEY WORDS: Basal ganglia, network anatomy, functional aspects

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ePoster 096

Functional and Dysfunctional Anatomy of the Amygdala and Regional White Matter Pathways

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PURPOSE
The amygdala plays a central role in emotional processing as well as many neuropsychiatric disorders. The amygdaloid neural network, however, has been relatively opaque to routine MR imaging (MRI). Advancements in MRI technology, especially diffusion tensor imaging (DTI), advanced anatomical dissection techniques, physiologic mapping, and clinical investigations have improved the study of intracranial white matter pathways including the fiber tracts associated with the amygdala. A thorough understanding of the anatomy and functional significance of these structures is paramount to the interpretation of MRI and DTI of these areas of the brain. This exhibit addresses functional networks relevant to the amygdala and nearby pathways, from a clinical imaging perspective. Detailed discussions about the amygdala and other pathways will include anatomical connections, cortical correlates, anatomical landmarks needed to identify these structures on standard imaging, DTI of these structures, and clinical findings associated with injuries to these nuclei and pathways. Anatomical drawings, pathway diagrams, and DTI are utilized to illustrate the relevant anatomy and the underlying functions and deficits associated with these structures will be highlighted.

MATERIALS & METHODS
The amygdala is a complex structure composed of multiple deep nuclei that are not visible on the cortical surface. The amygdala is located just anterior to the uncal recess of the temporal horn of the lateral ventricle, which separates the amygdala from the pes hippocampus. The amygdaloid nuclear complex consists of the cortical, medial, accessory basal, basal, central, and lateral nuclei. Many intrinsic fiber pathways link these nuclei but the major extra-amygdaloid fiber bundles consist of the lateral olfactory stria, stria terminalis, and the ventral amygdalofugal pathway. The connection of the amygdala with the ventral prefrontal cortex (VPFC) and amygdala, supports their essential role underlying emotional dysregulation, a core feature of bipolar disorder. The amygdala forms extensive connections with key structures including the diencephalon, substantia innominata, mediofrontal cortex, lateral preoptic-hypothalamic zone, and inferior thalamic peduncle (to mediodorsal thalamic nucleus).

RESULTS
This fiber network contributes to processing emotionally and socially relevant information to detect dangers in the environment and modulate subsequent responses, which can profoundly influence human behavior. The amygdaloid intralimbic connections plays a major role in the processing and memory of emotional reactions.
CONCLUSION
The primary goal of the exhibit is to arm neuroradiologists with an understanding of the anatomical and functional implications of the amygdala and other regional pathways, maximizing diagnostic utility of DTI in daily radiologic practice.

KEY WORDS: Amygdala

ePoster 097
Basal Ganglia. Something More than Movement: Motion, Cognition, and Emotion
González Montaño, V.1 · Leo Barahona, M.1 · Zamorano Pozo, T.1 · Querol Pascual, R.1 · Fernandez Gil, M.1 · Álvarez-Linera Prado, J.2
1Infanta Cristina Hospital, Badajoz, SPAIN, 2Ruber Internacional, Madrid, SPAIN

PURPOSE
The basal ganglia are a group of nuclear structures that are located in the central nervous system, deep to subcortical white matter. They have many connections between them and with other structures, and their main function is to control movement. But not only movement, they also play an important role in cognition and emotion. Their alteration is associated with motor disorders, as well as with psychiatric diseases and memory impairment. Our objective is: 1. To explain the structural and functional anatomy of basal ganglia. 2. To show the MR techniques that allow us to properly study the anatomy and function of this region. 3. To review motor disorders and clarify their association with alterations in emotion and cognition.

MATERIALS & METHODS
We will explain the anatomy of the basal ganglia and their numerous connections. We will use simple drawings, structural MR images and advanced MR imaging (MRI) based on tractography and functional MRI.

RESULTS
As in a dance, not only the movement is important but the knowledge of the steps, precision, and emotion are needed to dance with feeling and harmony. The basal ganglia combine all these functions. Motor disorders are not just an alteration of movement; they also are accompanied by changes in memory and personality. Neuroradiology helps us in the diagnosis of these disorders and in their functional analysis.

CONCLUSION
We would like to explain the relationship between motor disorders and emotional and cognitive alterations and to consider the diseases and disorders affecting the basal ganglia as a whole.

KEY WORDS: Basal ganglia, anatomy

ePoster 098
Cerebellum: Structural and Functional Anatomy
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PURPOSE
Spreading the structural complexity of the cerebellum and multiple connections in the brain to better understand its involvement in motor and cognitive functions.

MATERIALS & METHODS
We want to review the complex anatomy and the function of the cerebellum. We will use comprehensible schemes and advances MR imaging (MRI) techniques, as tractography and functional RM.

RESULTS
The cerebellum is a region of the brain whose main function is to integrate sensory pathways and motor pathways. The cerebellum integrates all information received to define and control the cerebral cortex orders sent to the locomotive through the motor pathways. However, the cerebellum, not only plays an important role in motor functions but also receives information from other areas of the central nervous system, such as the parietal association cortex and the limbic system, involved in cognitive and emotional functions. Cerebellar damage include alterations in executive functions, learning, memory, attention, visuospatial functions, language and personality changes. Show structural and functional anatomy of the cerebellum that enable its integrative function.

CONCLUSION
Knowledge of structural and functional anatomy of the cerebellum is essential to give meaning to the clinical and imaging findings of different cerebellar lesions, and to understand the integrative function of it.

KEY WORDS: Cerebellum, anatomy, imaging

ePoster 099
Limbic System: An Underground Network in Our Central Nervous System
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1Infanta Cristina Hospital, Badajoz, SPAIN, 2Ruber Internacional, Madrid, SPAIN

PURPOSE
The limbic system is a complex circuit located in the middle region of the cerebral hemispheres, whose connections extend to the rest of the central nervous system and the rest of our body. This circuit is essential to establishing the relationships between people, based on memory, learning and emotions. These intricate functions characterize the human being and its alteration is associated with diseases such as dementia and psychiatric disorders. Our goal is: 1. To
explain the structural and functional anatomy of the limbic system. 2. To review the appropriate radiologic techniques for evaluation of the limbic system, structurally and functionally. 3. To understand the pathophysiology of diseases such as epilepsy, dementia and psychiatric disorders.

**MATERIALS & METHODS**

We review the complex anatomy and the function of this cerebral area. We use comprehensible schemes and advance MRI techniques, as tractography and functional RM.

**RESULTS**

Science has advanced in the knowledge of behavior, emotions and memory as well as in their disturbances. Nowadays we know that there is an intimate relationship between these functions, behavioral disorders/addictive disorders and the alterations of the limbic system. Their knowledge and their diagnosis has contributed markedly to MR imaging (structural and functional images).

**CONCLUSION**

Neuroradiology is fundamental in the knowledge of the limbic system, not only to know the structural anatomy but also to know their functions. Today we are attending to a development in radiologic conception: from structure to the function. This is fundamental to acquire an integral and proper evaluation of diseases.

**KEY WORDS:** Limbic, anatomy, rm

| Head and Neck |
| 100-106 |

ePoster 100

**Causes of Failed Stapes Surgery: Preoperative CT Findings with Surgical Confirmation**

Whetstone, J. L. · Nguyen, A. · Nguyen-Huynh, A. · Hamilton, B. E.

Oregon Health & Science University
Portland, OR

**PURPOSE**

Stapes surgery usually is performed in the clinical setting of otosclerosis with the goal of hearing preservation. Revision stapes surgery is performed for unsuccessful primary surgery, delayed failure, and surgical complications, and confers a higher failure rate. The purpose of this review is to familiarize the reader with the CT findings of stapes surgery failure and the relevant preoperative contraindications to stapes surgery. The current limitations of standard CT for complication detection also are discussed.

**MATERIALS & METHODS**

We retrospectively reviewed the imaging and medical records of all patients undergoing stapes or stapes revision surgery at our institution between December 1999 and December 2009. All patients with high-resolution CT scans of the temporal bone were reviewed and correlated to clinical findings at otoscopy and surgery. Temporal bone CTs were assessed retrospectively by two reviewers, one with head and neck radiology expertise (BH). All imaging findings were correlated to operative findings. Examples of surgically confirmed causes of stapes surgery failure and preoperative findings that were contraindications to stapes surgery are highlighted.

**RESULTS**

A total of 340 patients who had undergone stapes surgery or revision surgery were identified from the department of neuro-otology clinical records. From this subset, 60/340 had temporal bone CTs available in PACS for review. Of these 60, 16 patients (5 males and 11 females, 16-87 years of age, mean age of 56 years) had subsequent intraoperative reports that could be correlated to CT findings. All patients had a history of otosclerosis who were presenting for revision stapes surgery. We assessed normal postoperative findings and contrasted them to causes of failed stapes surgery that included ossicular necrosis, prosthesis disconnection or migration, abnormally deep intrusion of the stapes piston into the vestibule, perilymph fistula, granulation tissue, and inappropriate piston size. Preoperative CT findings that are contraindications to stapes surgery include superior semicircular canal dehiscence, ossicular fixation, and tympanosclerosis.

**CONCLUSION**

CT evaluation in the setting of planned primary or revision stapes surgery is challenging for the radiologist. Inherent limitations of spatial resolution and beam-hardening artifact of the small metallic stapes piston prostheses remain problematic for correct piston localization and sizing, and granulation tissue and perilymph fistula remain hard to diagnose. However some cases of piston dislocation, ossicular chain disruption or necrosis, and overt vestibular penetration can be suggested and should be investigated routinely. This series additionally highlights important contraindications to stapes surgery: superior semicircular canal dehiscence, ossicular fixation, cholesteatoma, and tympanosclerosis.

**KEY WORDS:** Otosclerosis, stapes surgery, CT

ePoster 101

**Variations in the Course of the Cervical Vagus Nerve on Thyroid Ultrasonography**

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**PURPOSE**

The purpose of this study was to evaluate the incidence and type of variation in the course of the cervical vagus nerve (VN) on thyroid ultrasonography.

**MATERIALS & METHODS**

From August 2009 to September 2010, 163 consecutive patients were evaluated by ultrasound for the screening and characterization of thyroid nodules (mean age = 49.0 ± 14.4 years, M:F = 20:143). Two types of variation were defined as follows: (1) anterior variation, when the course of the VN changes from the typical location to an anterior location in

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**ePoster 100**

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Oregon Health & Science University
Portland, OR

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Stapes surgery usually is performed in the clinical setting of otosclerosis with the goal of hearing preservation. Revision stapes surgery is performed for unsuccessful primary surgery, delayed failure, and surgical complications, and confers a higher failure rate. The purpose of this review is to familiarize the reader with the CT findings of stapes surgery failure and the relevant preoperative contraindications to stapes surgery. The current limitations of standard CT for complication detection also are discussed.

**MATERIALS & METHODS**

We retrospectively review the complex anatomy and the function of this cerebral area. We use comprehensible schemes and advance MRI techniques, as tractography and functional RM.

**RESULTS**

Science has advanced in the knowledge of behavior, emotions and memory as well as in their disturbances. Nowadays we know that there is an intimate relationship between these functions, behavioral disorders/addictive disorders and the alterations of the limbic system. Their knowledge and their diagnosis has contributed markedly to MR imaging (structural and functional images).

**CONCLUSION**

Neuroradiology is fundamental in the knowledge of the limbic system, not only to know the structural anatomy but also to know their functions. Today we are attending to a development in radiologic conception: from structure to the function. This is fundamental to acquire an integral and proper evaluation of diseases.

**KEY WORDS:** Limbic, anatomy, rm

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**ePoster 101**

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front of the common carotid artery (CCA); (2) medial variation when the course of the VN changed from the typical location to a medial location to CCA (between CCA and thyroid gland). The incidence of each of the variation was studied.

**RESULTS**
Variation in the course of the VN occurred in 5.5% (18/326) of cases. The anterior variation was observed in 4.3% (14/326, R:L=4:10), and the medial variation was observed in 1.2% (4/326, R:L=3:1). For both variations, the VN was close to or nearly abutted the thyroid gland after it changed course.

**Conclusion**
Variation in the course of the cervical VN could be assessed by ultrasonography. Two variations were observed in 5.5% of cases. The anterior variation was more common than the medial variation.

**Key Words:** Vagus nerve, variation, ultrasound

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**ePoster 102**

**Evaluation of Carotid Plaque Using 3D T1-Weighted Black-Blood Vessel Wall MR Imaging at 3 T: Comparison of Turbo SE and Gradient-Echo Sequences**

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Tsu, JAPAN

**Purpose**
Black-blood (BB) carotid wall MR imaging typically is performed using a 2D sequence. However, a common problem that arises with 2D imaging is the poor spatial resolution in the slice-select direction and the lack of full coverage of carotid plaque. In contrast, 3D imaging can provide high-resolution images and improved anatomical coverage with retrospective visualization of the vessel wall using multiplanar reconstruction. Consequently, 3D imaging is more suitable for the evaluation of carotid plaque, particularly when quantification of carotid plaque volume is needed. 3D T1-weighted BB vessel wall imaging includes two sequences: turbo spin-echo sequence (e.g., VISTA) and gradient-echo sequence (e.g., THRIVE). Our study was conducted to compare the capability in the delineation of carotid plaque and the difference of signal intensity of the plaque between VISTA and THRIVE.

**Materials & Methods**
For this study, 43 patients with moderate or severe carotid stenosis were enrolled. MR imaging was performed using a 3 T MR unit (Achieva Quasar-dual; Philips Co.) with a 16-channel neurovascular array coil. The carotid wall MR imaging consisted of two sequences of 3D T1-weighted BB imaging including volume isotropic TSE acquisition (VISTA) and T1-high-resolution isotropic volume excitation (THRIVE). The parameters and imaging time of VISTA and THRIVE are as follows: T1-TFE, TR / TE = 5 / 2.3, FA = 13, TI = 600 ms, and 4 min 2 s for THRIVE, T1-TSE, TR / TE = 350 / 24, refocusing control angle = 40, 3 min 48 s for VISTA. Consequently, 3D images were obtained in coronal plane, and longitudinal and cross-sectional images were reconstructed. The border between plaque and the lumen adjacent the plaque was rated visually (four-point analysis) and quantitatively (contrast ratio). The signal intensity ratio between the plaque and adjacent muscle was also measured. The data were analyzed statistically between VISTA and THRIVE using a Wilcoxon signed-rank test.

**Results**
Visual analysis revealed that the median value of VISTA was significantly higher than that in THRIVE (p = 0.012). In cases with iso-signal intensity plaques, THRIVE occasionally showed that the signal intensity of the vessel lumen was
not reduced because of the flow artifacts, which obscured the plaque border. However, VISTA presented a clear border of plaque because of its inherent flow-void capability. Quantitative analysis showed that median value of contrast ratio was significantly higher than that in THRIVE \( (p = 0.0057) \). The signal intensity ratio between plaque and adjacent muscle was higher in THRIVE than that in VISTA \( (p = 0.0017) \). Cases with a signal intensity ratio greater than 2.0 (hemorrhagic plaque) were 18 in THRIVE, but eight in VISTA.

CONCLUSION
Our preliminary results show that VISTA was superior to THRIVE for plaque delineation and suggest that VISTA is more suitable for measuring plaque volume. However, high signal intensity plaque tended to be underestimated using VISTA, which might be a pitfall for the evaluation of hemorrhagic plaque.

KEY WORDS: Carotid plaque, 3D imaging, black-blood vessel wall imaging

ePoster 103
Evaluation of Facial Artery on CT Angiography Using 64-Slice MDCT: Implications for Facial Plastic Surgery

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Seattle, WA

PURPOSE
Accurate assessment of facial vascular anatomy enables the plastic surgeons to establish an appropriate surgical planning. Although anatomical variation of facial artery has been investigated classically in cadaveric specimens, less invasive in vivo assessment is necessary for preoperative evaluation. The purpose of our study is to evaluate the value of multislice CT angiography (CTA) in assessment of facial artery anatomical variations.

MATERIALS & METHODS
Among 109 consecutive cases of CTA of head and neck, total 30 cases with 59 facial arteries were included in this study. Remaining 79 cases were excluded due to severe dental metallic artifact, motion artifact, small field of view, or weak enhancement of common carotid artery. Thin-slab maximum intensity projection (MIP) and volume rendering were used for postprocessing of CTA. Visual evaluation was performed in both sides. The anatomical variations of the facial artery were classified into the following four groups; type 1: short course, terminate proximal to the superior labial artery, type 2: terminate distal to the superior labial artery near nasolabial fold, type 3: classic course, extends to lateral nasal or angular branch, type 4: duplex with dominant lateral angular branch. The extent of inferior and superior labial artery also was evaluated separately.

RESULTS
Thirteen branches (22%) of the facial artery were classified as type 1, 29 branches (49%) were classified as type 2, and 15 branches (26%) extend beyond nasolabial fold and classified as type 3. Type 4, lateral angular branch as a main terminal branch of the facial artery was seen only in two branches (3%). Inferior labial artery was identified bilaterally in 12 cases (40%), unilaterally in 16 cases (53%), and identified in neither side in two cases (7%). Superior labial artery was identified bilaterally in 75% and unilaterally in 25% of cases.

CONCLUSION
Although the classic anatomy of facial artery extends to medial canthus region and become angular branch, this type of facial artery was seen only in 26%. Although visualization of small arterial branch may be limited due to venous injection, facial CTA has a potential imaging tool for preoperative planning of facial reconstructive surgeries.

KEY WORDS: CT angiography, facial artery, plastic surgery

ePoster 104
Diagnostic Accuracy, Imaging Correlation and Clinical Implications of Ultrasound-Guided Core Biopsy in the Thyroid Lesions

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PURPOSE
Ultrasound has been used extensively to document and follow up thyroid nodules. Suspicous ultrasound findings of thyroid nodules include marked hypoechochogenicity, microlobulated or irregular margins, microcalcifications, or taller than wider in shape. Focal FDG thyroid uptake on PET or PET-CT in lymphoma patients warrants further investigations. The malignancy risk is 30% either due to intercurrent thyroid cancer or lymphomatous involvement. Ultrasound-guided fine-needle aspiration (UG-FNA) is accepted widely
Ultrasound-guided core needle biopsy (UG-Core Bx) is more effective in obtaining adequate material from nodules and more advantage of assessing nuclear changes. UG-Core Bx has not become a standard procedure due to its relatively high-risk of complications and its technical difficulties. The purpose of this retrospective study is to assess diagnostic accuracy, imaging characteristics, and clinical implication of ultrasound-guided core biopsy (UG-Core Bx) of thyroid nodules.

**Materials & Methods**

There were 348 patients who had obtained UG-FNA and or UG-Core Bx of thyroid nodules from 2007 through 2010. A total of 375 UG procedures were done for thyroid lesions with 58 cases of UG-FNA and 317 cases of UG-Core Bx. There were 268 females and 80 males with ages ranging from 6 to 88 years. All UG-FNAs were performed using 22-25 GA aspiration needles with awaiting at ultrasound suite. The UG-Core Bx were performed with a 19GA/20GA Temono semiautomatic biopsy system. The tissue samples were placed in formaldehyde solution and sent to pathology. The biopsy results were divided into two groups based on malignant or nonmalignant pathology reports. The pathology reports and patients’ medical records were reviewed to assess the clinical impact of biopsy procedures.

**Results**

Among the entire biopsy specimens from both UG-FNA and UG-Core Bx, follicular lesions (214 cases, 67.9%) are diagnosed most commonly. This is followed by benign diagnosis (90 cases, 24%) such as adenomas, colloid cyst, inflammation, fibrosis, etc. A total of 36 cases (9.6%) yield malignant diagnosis. There are 21 cases (5.6%) of hyperplastic nodules, 14 cases (3.7%) of Hashimoto and lymphocytic thyroiditis. Four out of 58 UG-FNA cases (6.9%) yield papillary thyroid cancer in two females and two males. Eight of 58 UG-Core Bx cases (13.8%) indicate unsatisfactory sampling. The remainder 46 UG-FNA cases are benign (79.3%). The overall diagnostic rate is 86.2% for UG-FNAs. Thirty-two out of 317 UG-Core Bx cases (10.1%) yield malignant diagnosis in 16 males and 16 females. Both primary thyroid cancer and metastatic disease from renal cell carcinoma, lymphoma, sarcoma, etc. are diagnosed on the core specimen. The diagnostic rate is 100% for UG-Core Bx. A mean of 3 cores were obtained per target. The lesion size ranges from 4 mm to 3.6 cm. There were no complications in UG-Core Bx.

**Conclusion**

Both UG-FNA and UG-Core Bx are safe and reliable techniques with high diagnostic rate in the thyroid nodules in experienced hands. However, UG-Core Bx has the advantage of higher diagnostic accuracy for malignant thyroid lesions.

**Key Words:** Ultrasound-guided FNA, ultrasound-guided core biopsy, thyroid
**CONCLUSION**

Pleomorphic adenomas in parotid and submandibular glands had similar parameter distributions. Pleomorphic adenoma, Warthin’s tumor, and malignant salivary gland neoplasms were distinguishable based on T1 relaxation times and ADC values. Multispectral quantitative MR imaging analysis may achieve more accurate diagnosis in patients with salivary gland tumors.

**KEY WORDS:** Salivary gland tumor, relaxation time, ADC value

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**Fat-Containing Masses of the Prestyloid Parapharyngeal Space: Unusual Case Series**

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**PURPOSE**

Fat-containing tumors of the prestyloid parapharyngeal space are exceedingly uncommon. The purpose is to review the anatomy of the prestyloid parapharyngeal space and unusual congenital and developmental fat-containing prestyloid parapharyngeal masses. The cross-sectional imaging, endoscopic imaging and algorithm for imaging these masses are reviewed.

**MATERIALS & METHODS**

The parapharyngeal space is divided into two compartments based on its relationship to the tensor-vascular-styloid fascia. Differentiating prestyloid pathology from poststyloid pathology is critical in formulating a differential diagnosis and therapeutic plan. The parapharyngeal space is shaped as an inverted pyramid, extending from the base of the skull to the hyoid bone. Intrinsic tumors of the prestyloid parapharyngeal space represent <0.5% of all head and neck neoplasms. Approximately 70% of lesions in the prestyloid parapharyngeal space are benign and 30% malignant. The most common prestyloid parapharyngeal space masses are extrinsic masses with secondary extension into the prestyloid parapharyngeal space, ectopic salivary gland tumors and neurogenic tumors. Fat-containing prestyloid parapharyngeal space masses are rare and often transspatial in extent. Clinical symptoms from these masses include growing neck mass, oropharyngeal mass, unilateral Eustachian tube dysfunctions, dysphagia, dyspnea, obstructive sleep apnea, cranial nerve deficits, Horner’s syndrome, pain, and trismus. A retrospective review of prestyloid parapharyngeal space masses was performed and unusual fat-containing cases were chosen for presentation.

**RESULTS**

Multiple unusual fat-containing prestyloid parapharyngeal masses are presented, including a heterotopic fat-containing pinna in a 4-month-old child, myxoid lipoblastoma, trans spatial cervical lipoma extending into the parapharyngeal space, a prevertebral liposarcoma with extension into the parapharyngeal space, and a periparotid lipoma. The MR imaging of fat-containing lesions in the head and neck is often difficult secondary to suboptimal fat saturation. IDEAL (iterative decomposition of water and fat with echo asymmetry and least-squares estimation) MRI is presented as an alternative to fat-suppression techniques for head and neck imaging.

**CONCLUSION**

As complete excision is the mainstay of treatment for these lesions, imaging is crucial in guiding the surgical approach. As many of the fat-containing prestyloid parapharyngeal masses are transspatial, it is important to understand the range of pathology that may occur in this deep space of the neck.

**KEY WORDS:** Fat-containing masses, prestyloid parapharyngeal space, ideal MR imaging

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**Use of Self-Expandable Stents in the Treatment of Acute Ischemic Stroke**

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**PURPOSE**

Current thrombectomy devices (MERCI clot retriever and Penumbra System) may fail to restore flow of large intracranial vessels during acute ischemic strokes (AIS). We report our single-center experience with the use self-expandable stents (SES) in the treatment of AIS.

**MATERIALS & METHODS**

The stroke database of Baptist Cardiac and Vascular Institute in Miami was reviewed retrospectively from August of 2008 to September of 2010. All cases of AIS in which a SES was deployed as acute endovascular intervention were included in the analysis. Criteria for intervention were: neurologic symptoms due to AIS, a National Institute of Health Stroke Scale (NIHSS) ≥ 4 at presentation, stroke due to a large vessel occlusion and failure or contraindication to intra-arterial thrombolysis and/or mechanical thrombectomy. Good outcome was defined as a modified Rankin Scale (mRS) ≤ 2 on 1 month from hospital discharge.

**RESULTS**

Nineteen patients with AIS who underwent stenting were identified (Table). The mean NIHSS score on admission was 18 (range 6 to 28). All patients had complete occlusion (TIMI 0) of the affected vessel. Six enterprise (Codman Neurovascular/Cordis Corporation) and 13 wingspan stents (Boston Scientific) were deployed. Thirteen (69%) lesions achieved TIMI 3 flow (Figure), five (26%) were TIMI 2 flow and one (5%) TIMI 1 flow after stenting. No intra procedural complications occurred. Symptomatic intracerebral hemorrhage occurred in three (16%) patients, two of whom died.
Eight (42%) patients had a good outcome (mRS 0 n= 4, mRS 1 n=1, mRS 2 n=3). One patient lost follow up. Overall mortality was 26% (five patients).

Table. Patient characteristics.

<table>
<thead>
<tr>
<th>Age</th>
<th>Gender</th>
<th>Occlusion</th>
<th>NIHSS</th>
<th>Initial Therapy</th>
<th>Stent</th>
<th>Time of Intervention (hours)</th>
<th>TIMI</th>
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NIHSS = National Institutes of Health Stroke Scale, TIMI = thrombolysis in myocardial infarction, mRS = modified Rankin Scale, ICA = internal carotid artery, IV = intravenous, IA= intraarterial and M = microcatheter clot maceration. * Approximate time since last seen normal.

RESULTS

The study population is derived from 71 consecutive patients who underwent MERCI thrombectomy without a preprocedure heparin bolus. Cerebral arteriograms were evaluated by three separate reviewers for catheter-induced thrombus, recanalization rates as defined by achieving a TICI score of greater than or equal to 2, and procedure associated complications defined as dissection and arterial perforation.

CONCLUSION

The use of SES in AIS is safe and should be considered when conventional thrombolysis and thrombectomy approaches fail.

KEY WORDS: Thrombectomy, stent, ischemic stroke

Incidence of Catheter-Induced Clot Formation in Acute Ischemic Stroke Patients Undergoing MERCI Thrombectomy: Is Preprocedure Intravenous Heparin Bolus Necessary?

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PURPOSE

The mechanical embolus removal in cerebral ischemia (MERCI) retrieval system is a mechanical thrombectomy device used to re-establish vascular flow in patients with acute large vessel ischemic stroke. Standard practice for interventional neuroradiology procedures is to administer a bolus intravenous heparin dose of approximately 80 IU/kg followed by a continuous heparin infusion for the prevention of catheter-induced clots. Due to increased rates of intracerebral hemorrhage in acute large vessel stroke patients, it has been common practice at our institution to administer only a heparinized saline infusion during MERCI thrombectomy. This is a retrospective pilot study to analyze the incidence of catheter-induced clot formation during MERCI procedure without a preprocedure heparin bolus.

MATERIALS & METHODS

The study population is derived from 71 consecutive patients who underwent MERCI thrombectomy without a preprocedure heparin bolus. Cerebral arteriograms were evaluated by three separate reviewers for catheter-induced thrombus, recanalization rates as defined by achieving a TICI score of greater than or equal to 2, and procedure associated complications defined as dissection and arterial perforation.

RESULTS

The Table lists demographics, preprocedure coagulation status, adjunctive drugs, and outcomes in the 71 study patients. Initial clot locations were 69% right middle cerebral artery, 14.1% internal carotid + cerebral artery, and 16.9% carotid terminus. There were no patients with a catheter-induced thrombus formation during the procedure as ascertained by all three interpreters (95% CI 0-5%). Other results included: mean procedure length of 1.4 + 0.8 hours, recanalization rate of 70.4%, and procedure-related complication rate of 8.5%.

Demographics, preprocedure anticoagulation status, adjunctive drugs, and outcome in the 71 patients

| Age (yr, mean, SD) | 67.6 + 14.1 |
| Male Sex (%)       | 49.3        |
| NIHSS on Presentation (mean, SD) | 18.1 + 5.4 |
| Time from symptom onset to procedure start (hr, mean, SD) | 6.5 + 3.8 |
| History Atrial Fibrillation (%) | 35.2 |
| Home Anticoagulation (%) | 49.3 |
| Aspirin (%) | 40.8 |
| Plavix (%) | 11.3 |
| Warfarin (%) | 9.9 |
| Patients on warfarin with INR > 2.0 (%; N=7) | 42.9 |
| Platelet Count (mean, SD) | 237 + 82 |
| PTT (mean, SD) | 15.2 + 5.5 |
| INR (mean, SD) | 1.2 + 0.6 |
| Intravenous tPA administered (%) | 9.9 |
| Intra-arterial tPA administered (%) | 63.4 |
| Adjunctive verapamil (%) | 14.1 |
| Patients stented (%) | 5.6 |
| 90-Day modified Rankin Scale < 2 (%) | 32.4 |
| 90-Day Mortality (%) | 42.3 |

CONCLUSION

The incidence of catheter-induced thrombus during MERCI procedure is extremely low without the use of preprocedure heparin bolus. Randomized studies need to be performed to determine hemorrhagic rates and outcomes in patients receiving or not receiving heparin bolus during MERCI thrombectomy.

KEY WORDS: MERCI, heparin, stroke
ePoster 109

Intra-Arterial Thrombolysis of Central Retinal Artery Occlusion

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PURPOSE
Central retinal artery occlusion (CRAO) is an ophthalmic emergency with a severe and irreversible visual loss. The effective treatment regimen of CRAO has not been proved. Recently, several literatures have reported improved vision after super-selective administration of a thrombolytic agent directly into the ophthalmic artery. The aim of this study was to assess the safety and efficacy of intra-arterial thrombolysis of the ophthalmic artery.

MATERIALS & METHODS
We retrospectively evaluated recent CRAO patients who underwent selective ophthalmic artery thrombolytic treatment (n = 11). These patients were divided into two groups. In group I, four patients underwent selective intra-arterial thrombolytic treatment within 24 hours after the onset of symptom. In group II, seven patients were treated after 24 hours from symptom onset. All patients underwent preprocedural and postprocedural ophthalmologic examination, funduscopy, and fluorescent angiography. We assessed the improvement in visual acuity and arm to retinal (A-R) time before and after the procedure to evaluate patients’ outcome.

RESULTS
A visual acuity was recovered completely to the previous state in two patients (2/4, 50%) and the others had partial recovery in group I. There was no change of visual acuity in group II patients. However, the retinal perfusion of all 11 patients was improved and there were no systemic or ophthalmic complications.

CONCLUSION
Although, the efficacy of intra-arterial thrombolysis for treatment of CRAO needs to be further evaluated in a controlled study, we suggest that ophthalmic arterial thrombolytic treatment may improve visual acuity of patient who is treated within 24 hours after the onset of symptom. Also, it may improve retinal perfusion, which leads to prevent further progressive complications such as retinal detachment and neovascularization glaucoma.

KEY WORDS: Ophthalmic artery, thrombolysis, intra-arterial

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ePoster 110

Long-Term Angiographic Follow Up following Stenting for Chronic Total Occlusion Older than Three Months of the Proximal Subclavian Artery

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PURPOSE
The purpose of our retrospective study was to investigate success rate, safety and long-term angiographic outcome following stenting for chronic total occlusion (CTO) older than 3 months of the subclavian artery (SA).

MATERIALS & METHODS
Chronic total occlusion (CTO) was defined as total occlusion older than 3 months since initial documentation by conventional angiography, CT angiography or MR angiography. Among 12 patients who underwent stenting of subclavian artery lesions from Jan 2006 to Dec 2009, five patients (three male, mean age 71 years) had CTOs of the left SA and estimated occlusion length was about 40 mm. The five patients presented subclavian steal phenomenon and their brachial systolic blood pressure difference was 42 mmHg (median).

RESULTS
Successful recanalization was achieved in all five patients and the Palmatz stents were implanted. Left vertebral artery flowed antegradely after stenting and their brachial systolic blood pressure difference was reduced to 2 mmHg (median). No complications occurred except pseudoaneurysm at puncture site in one case. Angiography at 1 year after stenting demonstrated neither restenosis nor reocclusion, which was defined as diameter stenosis of more than 50%.

CONCLUSION
Stenting for CTO older than 3 months of the subclavian artery was feasible and safe. Long-term angiographic outcome was favorable.

KEY WORDS: Chronic total occlusion, subclavian artery, stenting

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ePoster 111

Percutaneous Sacroplasty Using Combined Intraoperative Fluoroscopy and CT Guidance

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PURPOSE
To present a combined CT/fluoroscopy technique of sacroplasty, using anatomical diagrams, CT and fluoroscopy images from actual cases. Teaching poster for neuroradiologist/fellow intending to perform these procedures.
**Materials & Methods**
Based on experience with 17 patients utilizing this method. All cases done on GE Innova CT/Angio unit, under general anesthesia.

**Results**
All procedures successfully completed without peri or postoperative complications. Cement leakage: three cases (intraforamina -2, epidural - 1), all asymptomatic. Clinical results briefly discussed.

**Conclusion**
Sacral augmentation (sacroplasty) can be performed with relative ease and low risk. Combined CT/fluoroscopy method allows for precise needle placement (under CT), real-time injection of PMMA (under fluoroscopy) and instantaneous verification of cement distribution (under CT), thus improving patient’s safety.

**Key Words:** Sacroplasty, neoplasm, insufficiency fracture

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**ePoster 112**

**Long-Term Outcome of Stent Placement for the Subclavian Artery Atherosclerotic Occlusive Disease**

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Kashiwara, JAPAN

**Purpose**
Endovascular therapy is one of the major treatment options for stenosis or occlusion of the proximal subclavian artery. The purpose of this study is to evaluate the technical and clinical, immediate and long-term outcome following endovascular therapy in single center up to 7 years.

**Materials & Methods**
Our subjects were 25 cases who had undergone hybrid therapy of percutaneous transluminal angioplasty and stent placement to treat subclavian arterial occlusive lesions in the period between June 2003 and November 2010 (21 males and 4 females, 56-80 years of age with a median age 69 years, three occluded), including two right-sided and 23 left-sided, 17 proximal to the orifice of vertebral artery, seven involved and one distal to the orifice. We retrospectively examined technical success rate (the remaining stricture was 30% or less), the improvements of arm ischemia, subclavian steal syndromes or phenomenon, and systolic blood pressure difference between the two brachial arteries, the requirement of retreatments according to the presence of restenosis, and mortality rates.

**Results**
No perioperative complications were seen in all cases. Revascularizations succeeded technically, and stents were successfully placed in all cases. There were no technical failures necessitating the switch to an axillo-axillary bypass. As immediate outcome, the symptoms of arm ischemia, subclavian steal syndromes or phenomenon, and systolic blood pressure differences between upper arms disappeared in all cases. As long-term outcome by imaging follow up, no significant restenosis was seen at the part of stent region. However, in one case, the stenosis progressed at the ipsilateral subclavian artery proximal to the stent area after 4 years after the first procedure (Figure 1a, arrow). We performed additional angioplasty and stent placement for this case, and the stenosis has been improved (Figure 1b, arrow). All cases were survivals.

**Conclusion**
Stent placements for proximal subclavian arterial stenosis or occlusion technically are successful and clinically effective in all cases. This minimally invasive treatment may be the first choice of treatment for proximal subclavican arterial obstructive lesions. In our study, the long-term result of stent placement for subclavian artery stenosis was also excellent. However, the stenosis might progress proximal and distal the stent region, which requires retreatment. Therefore, imaging follow up is important for detecting late stenosis adjacent to the stent.

**Key Words:** Stent placement, subclavian artery, restenosis

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**ePoster 113**

**Prevalence of Extravertebral Cement Leakage after Vertebroplasty: Procedural Documentation versus CT Detection**

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**Purpose**
Extravertebral leakage of cement is a common occurrence during vertebroplasty. Reported incidence of leakage varies widely across studies. This variation may be a result of the different imaging modalities used for leakage detection, with CT probably more sensitive than fluoroscopy or plain radiography. We compared the relative detection rates of extravertebral leakage noted intraprocedurally with that noted on postprocedure CT scanning in a cohort of patients undergoing vertebroplasty.

**Materials & Methods**
After approval by the local Institutional Review Board, we retrospectively identified 181 patients with 277 levels treated from our vertebroplasty database who had subsequently undergone a CT examination including the treated vertebrae. These CT exams were reviewed and four different categories...
of local cement leakage were recorded: paravertebral leakage, endplate leakage, epidural leakage, and prevertebral venous leakage. We also separately noted the presence of retrograde filling of the cement along the needle tracks. The vertebroplasty reports were reviewed to determine whether, for this same cohort, extravertebral leakages was noted intraprocedurally. The frequency of the different types of leakage and the 95% confidence intervals were calculated; comparisons were made using the Pearson χ2 test with Fisher’s exact probability and were considered significant when p < 0.05.

RESULTS
Among 1255 patients in our entire database, 181 (14%) patients had undergone subsequent CT imaging to include the treated level(s). The subset of patients with CT imaging here did not significantly differ from the overall population of vertebroplasty patients in either age or gender. One hundred and forty-nine (82%, 95% CI 76-87%) vertebroplasty patients had evidence of some type of leakage on CT; of these, 52 (29%, 95% CI 23-36%) had more than one type of extravertebral leakage. Among these 149 patients with leakage noted on CT, only 62 (34%, 95% CI 28-42%) had leakage noted during the procedure (p = 0.01). The most common type of leakage was endplate leakage, found in 81 cases (45%, 95% CI 38-52%), followed by 64 cases of paravertebral leakage (35%, 95% CI 29-43%), 36 cases of epidural leakage (20%, 95% CI 15-26%), and 32 cases of prevertebral venous leakage (18%, 95% CI 13-24%). Retrograde filling of cement along the needle tracks was identified in 34% of cases and was associated significantly with paravertebral leakage (p = 0.02).

CONCLUSION
Cement leakage after vertebroplasty is common and significantly underappreciated by operators during the procedure.

KEY WORDS: Vertebroplasty, CT, leakage

ePoster 114

Angioarchitecture Determines Occlusion Rates following Gamma Knife Radiosurgery for Brain Arteriovenous Malformations

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PURPOSE
To test whether the angioarchitecture of brain arteriovenous malformations determines the obliteration rate following gamma knife radiosurgery.

MATERIALS & METHODS
Retrospective analysis of 117 consecutive patients (male/female: 61/56, age: 6-47 years, mean: 36 years) with brain arteriovenous malformations (BAVMs) who underwent radiosurgery between September 2005 and December 2009 at a single institution. The following angioarchitecturalal characteristics were reviewed by two experienced neuroradiologists in consensus by evaluating the digital subtraction angiogram (DSA) on the day of SRS: Enlargement of feeding arteries, flow-related aneurysms, shift of the arterial watershed, perinidal neoangiogenesis and intranidal aneurysms. The arteriovenous transit time was estimated by counting the number of DSA frames between first depiction of the nidus and first visualization of a vein. Concerning the venous analysis: Venous ectasias, circumscribed venous pouches, venous rerouting and the presence of a pseudophelebetic pattern (corkscrew-like dilated veins draining normal brain parenchyma in the late venous phase) were evaluated in patients who did NOT present with venous stenoses. The radiation plan was reviewed for nidus volume and eloquence of AVM location. A chart review was performed to determine clinical presentation and previous endovascular treatment. Outcome was dichotomized from complete vs incomplete obliteration and chi-square tests were performed, examining whether outcome status was associated with the described factors.

RESULTS
The presenting symptoms were hemorrhage in 72 patients, headaches in 15, seizures in 10, incidental in 5 and other in 15. The mean nidus volume was 3.74 cm3 (range 0.08-14.58 cm3). Embolization prior to SRS had been performed in 23 patients. The follow-up duration ranged from 6-48 months (mean 24 months). In the subsequent analysis, patients with a minimum follow up of 36 months (n = 39) and patients with confirmed complete obliteration prior to 36 months (n = 21) were included to avoid biasing our data with incomplete obliteration due to insufficient follow up. In this group of 60 patients 39 complete occlusions and 21 incomplete occlusions were present. There was no significant association between incomplete obliteration and flow-related or intranidal aneurysms, shift of the arterial watershed, angiogenesis, venous ectasias, eloquence of location, age, previous hemorrhage or embolization. Incomplete obliteration was associated with arterial enlargement (p = 0.023), high flow (0-1 frame between depiction of nidus and depiction the vein) (p = 0.001), venous pouches (p < 0.001), venous rerouting (p = 0.002), pseudophelebetic pattern (0.054) and AVM size ((p = 0.033).

CONCLUSION
In addition to larger AVM size, some angioarchitectonic factors that indicate high flow are associated with lower rate of AVM obliteration following SRS.

KEY WORDS: Angioarchitecture, arteriovenous malformation, radiosurgery
Three-Dimensional Digital Subtraction Angiography-MR Fusion Imaging for the Pretreatment Evaluation of Brain Arteriovenous Malformations: Initial Experience and Correlation with Surgical Observations

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PURPOSE
For the preoperative evaluation of patients scheduled for the surgical or endovascular treatment of brain arteriovenous malformations (AVM), accurate imaging information is essential. The purpose of this study was to assess the usefulness of three-dimensional (3D) digital subtraction angiography (DSA)-magnetic resonance (MR) fusion imaging in conjunction with two-dimensional (2D) DSA for the preoperative evaluation of brain AVMs.

MATERIALS & METHODS
The study population consisted of 12 consecutive patients (8 males, 4 females; age 10-72 years; mean 42 years) with brain AVMs, 10 patients suffered hemorrhage. Preoperatively, all patients underwent MR imaging and 3D DSA in conjunction with 2D DSA. The 3D DSA and contrast-enhanced 3D TFE MR images were semiautomatically fused on a workstation by image fusion software (Philips Medical Systems). Two radiologists independently evaluated the 3D DSA-MR fusion and 2D DSA images. Findings on 3D DSA-MR fusion images were compared with intraoperative observations. The referring neurosurgeons recorded whether and how the additional information provided by 3D DSA-MR fusion images changed their treatment.

RESULTS
In all patients, 3D DSA-MR fusion images clearly demonstrated the spatial relationship of the nidus, feeders, and drainers to the adjacent hematoma and/or brain structures. The spatial relationships visualized on 3D DSA-MR fusion images correlated well with surgical observations. In nine of 12 patients (75%) treated by surgery or embolization, the additional information provided by 3D DSA-MR fusion images affected treatment. Three-dimensional DSA-MR fusion images failed to yield hemodynamic information on the brain AVMs.

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Three-dimensional DSA-MR fusion images, as a supplement to 2D DSA, are useful for the preoperative evaluation of brain AVMs.

KEY WORDS: Brain AVM, 3D angiography, DSA

Safety and Outcome of Using Onyx for Endovascular Embolization of Dural Arteriovenous Fistulae: A Case Series of 39 Consecutive Patients

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PURPOSE
Onyx is a recently developed embolization agent with unique diffusion properties showing considerable promise in the treatment of vascular malformations. Preliminary reports suggest that Onyx is safe and efficacious in treating dural arteriovenous fistulae (dAVF), possibly as the primary treatment modality. This study examines the safety and outcome of 39 consecutive patients treated recently with Onyx at our institution.

MATERIALS & METHODS
We retrospectively identified every patient with a dAVF who was treated with Onyx embolization between 2006 and 2010. Their chart records, clinic notes, neuroimaging, and procedural notes, were reviewed. Results are compared to a pooled analysis of prior reports of Onyx-treated dAVFs and to other treatment modalities. IRB approval was obtained.

RESULTS
Thirty-nine patients (mean age 60 years, 54% acutely symptomatic) with 39 Onyx-treated dAVF (six Borden type I, eight type II, 17 type III, nine carotid-cavernous fistulae) were identified. Angiographic and clinical follow up (mean 6 months) was available for 85% and 90% of the patients, respectively. All six type I dAVF were either cured or left with minimal residual dAVF with resolution or near resolution of their symptoms, and thus requiring no further treatment. Among the 25 type II and type III dAVF, 85% had complete obliteration of cortical venous reflux, and the remainder only had mild residual cortical venous reflux; three of these subsequently were treated successfully with surgery or gamma-knife radiation. Of the nine treated carotid-cavernous fistulae (CCF), seven were angiographically cured and two were left with a mild residual fistula. Permanent complications occurred in four patients (10%, two in CCF patients) including one nonfatal stroke, one fatal stroke, and two cranial nerve palsies. Transient complications, including Onyx embolism with no subsequent permanent clinical sequelae, occurred in 15% of patients. Beyond the perioperative period, no patient had new hemorrhagic or ischemic neurologic events (total 19 patient-years of follow up).
CONCLUSION
This is one of the largest case series of Onyx-treated dAVF, and the largest to our knowledge of patients with angiographic and clinical follow up. The safety and efficacy of Onyx in treating dAVF at our institution is similar to prior reports. A pooled analysis of these findings combined with prior large observational studies of Onyx-treated dAVF is planned and will be compared to the reported safety and efficacy of other treatment modalities.

KEY WORDS: Dural arteriovenous fistula, Onyx, carotid cavernous fistula

ePoster 117
Testing Flow Diverters in Giant Fusiform Aneurysms: A New Experimental Canine Model
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PURPOSE
Flow diverters (FD) are the latest most promising tool to treat giant and complex aneurysms. Currently available experimental aneurysm models do not reproduce potential clinical difficulties in treating these lesions with FDs.

MATERIALS & METHODS
Six large or giant canine fusiform aneurysms were created on the distal carotid artery in four animals. In four aneurysms, multiple arteries branched from aneurysms; in two aneurysms branches were clipped at the time of aneurysm construction. Aneurysms were treated with multiple telescoping prototype flow diverting stents (total of 15 FDs). Angiography was carried out prior to, immediately following, at 2 and immediately before sacrifice at 12 weeks. Macroscopic photography of specimens was, followed by biopsies of selected regions of the tissue formed on the surface of FDs .

RESULTS
Flow diverter stents failed to completely occlude the aneurysms in all six cases, but aneurysms without branches had improved angiographic scores at 12 weeks as compared to those with patent branches. Technical or device-related difficulties occurred in four of six cases. Small defects in neointima formation on the surface of FDs were associated with residual aneurysms or patent arterial branches.

CONCLUSION
Large fusiform carotid aneurysms may reproduce many of the difficulties associated with the treatment of giant aneurysms and could be appropriate for the preclinical testing of FD stents.

KEY WORDS: Giant aneurysms, experimental aneurysm, flow diverter

ePoster 118
Endovascular Surgery with Coil Embolization of Spontaneous Dissecting Aneurysm of the Intracranial Vertebral Artery
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PURPOSE
Pathogenesis and treatment of spontaneous dissecting aneurysm of the intracranial vertebral artery remain controversial. Spontaneous dissecting aneurysm of the intracranial vertebral artery is a rare cause of vertebrobasilar ischemic strokes. It has been associated with a 10% mortality rate in the acute phase. Death is the result of extensive intracranial dissection, brainstem infarction, or subarachnoid hemorrhage. We report 7 years experience at our institute in dealing with spontaneous dissecting aneurysm of the intracranial vertebral artery by endovascular surgery with coil embolization.

MATERIALS & METHODS
Twenty patients with spontaneous dissecting aneurysm of the intracranial vertebral artery in our institute from 2004 to 2010 were managed by endovascular surgery with coil embolization. Nineteen patients were treated with purely coil embolization, and one was managed by colli embolization with stenting assisted. All are followed with image studies.

RESULTS
There were 20 patients, including 8 men and 12 women, with a mean age of 49.9 years. (Youngest: 38 years old; eldest: 73 years old). Among 20 patients, 18 discharged with good results, but two were expired during hospitalization due to brain infarction and brainstem failure respectively. Among 18 successful patients, one got bilateral intracranial vertebral dissecting aneurysm but received only one side endovascular coil embolization, and three got PICA involvement. The mean number of coils is five. (Least: two coils with stent; most: 11 coils.) There were no significant periprocedural complications.

CONCLUSION
Endovascular surgery with coil embolization of spontaneous dissecting aneurysm of the intracranial vertebral artery is an effective and reliable method. Direct occlusion of dissecting segment of vertebral artery with preservation of the PICA leads to a good prognosis. To prevent the bleeding/rebleeding event to the unruptured/ruptured aneurysms and decrease the mortality rate of intracranial vertebral dissecting aneurysm, endovascular coil embolization should be performed as early as possible.
Penetrating Head Injury: Diagnostic and Endovascular Treatment

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PURPOSE
Penetrating head injuries can be the result of numerous intentional or unintentional events, including missile wounds, stab wounds, and motor vehicle or occupational accidents (nails, screwdrivers). Stab wounds to the cranium typically are caused by a weapon with a small impact area and yielded at low velocity. The most common wound is a knife injury, although bizarre craniocerebral-perforating injuries have been reported that were caused by nails, metal poles, ice picks, keys, pencils, chopsticks, and power drills. Objective: Demonstrate that endovascular treatment for vascular lesions caused by penetrating trauma is feasible, safe, durable and highly effective.

MATERIALS & METHODS
Between the years 2005 and 2010 we treated nine consecutive patients with vascular lesions secondary to penetrating wounds at our University Hospital: five gunshot wounds and four stab wounds, seven pseudoaneurysms, two arteriovenous fistulas. We utilized multidetector tomography on four of the patients diagnosing lesions in three of them and on the fourth one the splinters of the bullet blocked visualization of the pseudoaneurysms. Cerebral angiography of the six vessels with digital subtraction and endovascular treatment of the lesions was utilized on all patients. Follow-up cerebral angiography could be done on seven of the patients.

RESULTS
Two traumatic aneurysms and two arteriovenous fistulas were excluded immediately from circulation after stent graft placement without contrast material filling the aneurysm cavity. Four were excluded with coils and one with bare stent plus coils. We did not have complications such as vessel dissection, vessel perforation, or thromboembolism. The mean midterm follow up was 28 months. All patients showed exclusion of the pseudoaneurysms or the fistulas from the circulation on the angiographic follow ups.

CONCLUSION
Our experience demonstrates that endovascular treatment of intracranial traumatic aneurysms is feasible, safe, durable and highly effective. There were no reports of recurrence of the pseudoaneurysms or fistulas on follow-up angiography.

KEY WORDS: Penetrating, injury, head

Stent-Assisted Embolization of Acutely Ruptured Cerebral Aneurysms without Antiplatelet Premedication: A Single Center Experience

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PURPOSE
Use of stent-assisted embolization in acute subarachnoid hemorrhage (SAH) is limited due to the need for antiplatelet premedication. We review our experience and analyze the safety and efficacy of stent-assisted embolization of ruptured intracranial aneurysms during acute SAH without antiplatelet premedication.

MATERIALS & METHODS
Retrospective review of the medical charts and imaging was done in all the patients who were treated using stent-assisted embolization during the acute SAH period from July 1, 2003 to October 31, 2010. Results in 15 consecutive patients (3 men, 11 women; mean age, 50.2 years; range, 32-78 years) were evaluated. On admission 10 patients (66.6%) were in good condition (Hunt and Hess I-III) and five patients (33.3%) were in poor grade (Hunt and Hess IV-V). All the embolizations were performed maintaining a continuous flush of heparinized saline (6000 I.U./1000 ml) in the catheter system. The anticoagulation regimen included post-procedure intravenous heparin using the institutional heparin protocol followed by clopidogrel (75 mg) and aspirin (80 mg) starting the day following the procedure for 6 months. The mean length of the angiographic follow up was 10.5 months (range, 0-48 months).

RESULTS
Total of 17 aneurysms (11 wide-necked saccular aneurysms and six dissecting aneurysms) were treated using 20 intracranial stents (14 Neuroform and 6 Enterprise stents). The stent was deployed successfully in 90% of cases (18 of 20). The stent-assisted coil embolization was done in total of 11 saccular aneurysms while six dissecting aneurysms were treated with stent alone. There was complete occlusion in all the 11 saccular aneurysms and only two cases had minimal neck recanalization (grade 2 of Raymond classification) in the follow-up angiograms. The retreatment rate was 6.66% (1 of 15). The clinical outcome was good in 66.66% of patients (10 of 15). There was no case of intraprocedural stent thrombosis or delayed rebleed. There was one case of severe intracerebral hemorrhage and one case of delayed stent thrombosis, both related to heparin protocol violation.

CONCLUSION
Our results suggest that in the acutely ruptured complex intracranial aneurysms, if necessary, the use of the stent (with or without coils) for the treatment is feasible and is associated with low complication rate, even if antiplatelet premedication is not provided. We believe that the use of continuous heparinized flush plays an important role in reducing the thromboembolic complications.

KEY WORDS: Stent, subarachnoid hemorrhage, complex aneurysm

KEY WORDS: Intracranial vertebral dissecting aneurysm, endovascular surgery, coil embolization
Supernova Hemorrhage: A Previously Undescribed Complication of Arteriovenous Malformations following Gamma Knife Stereotactic Radiosurgery

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Purpose
Hemorrhage constitutes the most feared complication of cerebral arteriovenous malformations (AVMs) in both untreated patients and those treated with gamma knife radiosurgery (GKR). Radiosurgery does not immediately lead to AVM occlusion, requiring up to 2 years following treatment. Postobliteration hemorrhage is exceedingly rare; reported cases occurring months to years after radiosurgery and nidus occlusion typically are associated with residual or recurrent AVM. We report three cases of intracranial hemorrhage in patients with cerebral AVMs previously treated with radiosurgery in which no residual AVM was found on catheter angiography and discuss the potential pathophysiology of the hemorrhages.

Materials & Methods
Retrospective review of medical records and images was performed for three patients.

Results
Patient A had a Spetzler-Martin grade 3 right frontal AVM for which he initially declined treatment. After subsequent intracerebral hemorrhage GKR was performed. Seventeen months post-treatment he presented with seizures and demonstrated subarachnoid hemorrhage and residual AVM nidus with patent venous outflow. Two days later conventional cerebral angiography was performed after clinical deterioration and showed no evidence of residual nidus or associated arteriovenous shunt. Patient B had a right parietal Spetzler-Martin grade 3 AVM that was treated with partial embolization, and the nidus appeared slightly smaller angiographically 11 months later. Gamma knife radiosurgery was performed 28 months after initial detection and embolization. Fifty-five months after treatment she presented with several days of severe headache and confusion and intraventricular hemorrhage on CT and MR imaging, with no clear source of bleeding. Conventional cerebral angiography showed no arteriovenous shunt and no other source of the intraventricular hemorrhage. Patient C had a Spetzler-Martin grade 5 left frontotemporal AVM that caused seizures in childhood prior to diagnosis. She underwent three courses of GKR at 0, 3, and 13 months after detection. Fifty-one months following her final treatment her AVM was now smaller. Angiogram at 57 months demonstrated a new large left deep draining venous varix with venous restriction. At 64 months she presented with a new, severe headache with acute onset. CT and angiography showed partial thrombosis of a large venous varix with concomitant downstream venous outflow restriction, but no definite associated intracranial hemorrhage.

Conclusion
Intracranial hemorrhage following GKR ablation of AVMs usually is associated with residual or recurrent AVM. We report two cases in which no residual AVM was found at the time of hemorrhage, suggesting a possible “supernova” hemorrhage at the time of complete venous outflow occlusion. We hypothesize that the intracranial hemorrhages experienced by patients A and B resulted from the progressive occlusion of nidal venous outflow, with rupture occurring secondary to an acute increase in pressure in residual AVM feeding arteries, nidal components and the proximal venous outflow. The progressive venous restriction and thrombosis demonstrated on sequential imaging in patients A and B support this hypothesis. Furthermore, the progressive venous restriction and thrombosis prior to complete AVM occlusion seen in Patient C illustrate the same concept, though one step prior to hemorrhage.

Key Words: Arteriovenous malformation, gamma knife radiosurgery, hemorrhage

Follow up of Scalp Arteriovenous Malformations Treated with N-Butyl Cyanoacrylate and Onyx 18

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Purpose
Arteriovenous malformations (AVM) of the scalp are relatively rare vascular lesions that present either as a small subcutaneous scalp lump, or a large pulsatile mass with a propensity to massive hemorrhage (cirrhotic aneurysm). On catheter angiography usually an arteriovenous fistula with a venous aneurysm is demonstrated. Treatments include surgical excision, ligation of feeding vessels, transarterial or transvenous embolization, injection of a sclerosing agent into the nidal, and electrothrombolysis. To our knowledge, the use of liquid embolic agents has not been reported. We present our experience at IUMC with percutaneous and transarterial embolization of three scalp AVMs with N-butyl cyanoacrylate (NBCA) and Onyx 18 respectively.

Materials & Methods
We retrospectively identified all patients with arteriovenous malformations of the scalp who were treated with liquid embolics as the single treatment technique at our institution between January 2005 and December 2010. We documented age, gender, presenting symptoms, angioarchitecture of the lesion, post-treatment angiography results, and follow-up MRI/MRA and angiography results when available.

Results
Two female and one male patients were identified, who underwent three procedures for AVM of the scalp repair using NBCA and Onyx-18. The mean age was 49 ± 8 years. Three patients presented with a pulsatile mass in the scalp. Two patients underwent transarterial superselective catheterization of the arterial feeder from the external carotid artery and Onyx-18 was injected under continuous road-map guidance until complete resolution of the malformation and the
cirsoi aneurysm was achieved. One patient underwent percu-

taneous embolization with direct puncture of the cirsoid 

aneurysm and NBCA injection under road map guidance. 

Post-treatment angiography in three patients demonstrated 

complete cure of the lesion. Follow-up angiography was 

available in two patients and follow-up MRI/MRA was 

available in one patient. None of the patients had any signs 

of recurrence in the follow-up examination. The pulsatile 

mass in the scalp also had resolved at the time of the clinic 

follow-up examination.

CONCLUSION
In our experience, the endovascular treatment of scalp arte-

riovenous malformations with cirsoid aneurysms with 

NBCA and Onyx-18 is feasible, safe, durable and highly effective.

KEY WORDS: Cirsoid, fistula, vascular malformation

ePoster 123
Risk Factors Associated with Hemorrhage Presentation
of Brain Arteriovenous Malformation

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PURPOSE
The hemorrhagic events are the main cause of morbidity and 
mortality in patients with brain arteriovenous malformations 
(ARMs), with average annual risk of 2.4%. This study was 
deigned to identify the possible risk factors related to the 
rupture of brain ARM.

MATERIALS & METHODS
The 335 consecutive patients with ARM, admitted into 
author’s department between 2000 and 2009 were enrolled 
in this retrospective study. The clinical and morphologic 
characteristics of them were reviewed. Univariate and multi-

variate analyses were conducted to evaluate the association 
between hemorrhagic presentation and morphologic and 
demographic characteristics.

RESULTS
The mean age of patients was 32.2 years ± 13.8 (SD). The most common clinical presentations were hemorrhage in 45% of patients, seizure in 26%, and focal neurologic deficit in 16%. The ARMs were located cortically in 233 patients (69.9%), deep in 70 (20.9%), and infratentorial in 32 (9.6%). According to Spetzler-Martin classification, the most common grades were II (43.3%) and III (37.3%). The ARMs with smaller size in comparison to the larger ARMs, significantly presented with hemorrhage (p = 0.000). The deep and infratentorial located ARMs were associated with hemorrhage event more than the cortical located ARMs (p = 0.000). Age and the Spetzler - Martin grade were not significant risk factor for hemorrhage presentation (p = 0.922 and p =0.488). The small size and infratentorial and deep location of ARM were independent risk factors of bleeding according to multivariate models (p = 0.000).

CONCLUSION
According to results of this study, the hemorrhagic presenta-
tion was more common in small ARM and infratentorial and 
deep located ARM. But it was not related to the age of patients and Spetzler-Martin grade of ARM.

KEY WORDS: Arteriovenous malformations, hemorrhage, rupture

ePoster 124
Intra-Arterial Cone Beam CT Angiography for the 
Precise Anatomical Localization of Dural and Pial 
Arteriovenous Fistulas

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PURPOSE
Cone beam CT angiography (CBCTA) provides enhanced 
vascular imaging for neurointerventional treatment planning, 
particularly of intravascular stents, thromboemboli, in-stent 
stenosis, and calcifications. In conjunction with traditional 
digital subtraction angiography (DSA) and 3D-DSA tech-
niques, intra-arterial CBCTA offers superior contrast resolu-
tion to delineate the adjacent cross-sectional anatomy and 
soft tissue architecture. We evaluated this technique and its 
efficacy in delineating the subtle arteriovenous anatomy of 
dural/pial arteriovenous fistulas (AVFs) for treatment-plann-
ing purposes.

MATERIALS & METHODS
We performed a retrospective review of intracranial and 
spinal dural/pial arteriovenous fistulas that underwent diag-
nostic DSA and intra-arterial CBCTA procedures. Cone 
beam CT angiography scanning was performed with flat 
detector rotational angiography (Artis Zee Biplane, 
Siemens); 496 projection frames were acquired over a 200 
degree arc (18 second rotation time, 80kV, 260mAs). Planar 
and 3D reconstructions (overlapping 0.5 mm and 5 mm slice 
thickness) were evaluated on an independent workstation 
(Leonardo). We studied patient demographics, presentations, 
classification/anatomical localization of arteriovenous fistu-
as (AVFs), CBCTA technique, treatment, and complica-
tions. Neurointerventionalists/neurosurgeons involved in the 
diagnosis and treatment of these lesions graded any relevant 
 improvement (0 or 1) in anatomical localization, treatment 
planning, or altered management derived from the CBCTA 
technique.

RESULTS
Eleven patients (10:1 male, mean age 62 years) underwent 
12 CBCTA procedures. Intracranial AVFs were classified as 
dural Cognard type 1 (n=2), type 2b, type 3 (n=2), metamer-
ic dural/pial (n=2) and pial presenting with transient 
ischmic attack, headaches, pulsatile tinnitus, or intracranial 
hemorrhages (n=4). Spinal AVFs were limited to dural 
Anson-Spetzler type 1 (n=4) presenting with cervical sub-
arachnoid hemorrhage, intramedullary hemorrhage, or pro-
gressive lower extremity weakness/paresthesias. Cone beam 
CT angiography techniques ranged with respect to intra-arte-
rival diluted contrast (30-50%) injections in the CCA, ICA, ECA, VA, middle meningeal, intercostal and lumbar arteries; rates of 0.3-3.0 mL/sec and total volumes of 3.0-66 mL. A single CBCTA procedure was scanned using lower resolution and radiation dose with faster second acquisition, but still providing accurate AVF localization. Significant improvement in anatomical mapping of AVFs was observed with CBCTA in 12/12 (arterial feeders, arteriovenous junction, venous drainers, or cross-sectional localization), corresponding with an improved treatment plan in 7/12, and altering management or treatment in 3/12. Subsequently, these lesions were treated with Onyx embolization (n=4), microsurgical clipping (n=5) and radiation (n=2) with one patient refusing treatment. Two postprocedural complications included intracranial hemorrhage and myocardial infarction, but no complications were encountered with the CBCTA technique.

**CONCLUSION**
We present a novel application of intra-arterial CBCTA as an adjunct to DSA for the precise anatomical localization of intracranial or spinal dural/pial AVFs. The impact of this technique allows for unparalleled cross-sectional mapping of arteriovenous pathology, assists in treatment planning most notably for microsurgical or radiation treatment, and can potentially alter patient management.

**KEY WORDS:** Arteriovenous fistula, cone beam CTA

ePoster 125

**Semipermeable Stent for Flow Modification in the Management of Intracranial Aneurysms: Mexico City Experience with a New Aneurysm Occlusion Device**

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**PURPOSE**
Initial experience with stent only therapy for intracranial aneurysms has raised concerns because of a high rate of delayed aneurysm rupture presumably due to increased wall tension during the period of progressive thrombosis. We present our experience with a flow diverting (FD) stent designed for immediate and complete aneurysm occlusion.

**MATERIALS & METHODS**
Between August 2010 and December 2010 patients with unruptured intracranial internal carotid artery aneurysms were treated according to an investigational protocol with a balloon mounted microporous membrane-covered stent (Excalibur™, Merlin Medical, Singapore). Unlike conventional FD stents, this novel aneurysm occlusion device (AOD) provides 60-70% surface area coverage regardless of stent diameter enabling higher rates of complete initial aneurysm occlusion. Patients were treated at a single center according to a prospective, single arm protocol approved by the national regulatory body and local institutional review board. If the parent artery harbored a stent of any kind the patient was excluded. No patients received preoperative antiplatelet drugs or intraoperative heparin. All were given a loading dose of tirofiban and started on a 12-hour tirofiban infusion intraoperatively. Several hours prior to stopping tirofiban patients were loaded with Plavix and aspirin. Maintenance therapy with clopidogrel and aspirin was continued for a minimum of 3 months and aspirin indefinitely. Modified rankin score (mRS) and angiography were obtained at 1, 3, and 6 months.

**RESULTS**
Twenty-one patients (19 female) with 24 aneurysms (18 wide neck + 1 fusiform) were entered into the protocol. Patients ranged in age from 34 to 82 years. Aneurysm location was cavernous in five, ophthalmic in ten and supraclinoid in nine. Aneurysm size was < 12 mm in 17 and 12-24 mm in seven. Three aneurysms were previously coiled. Twenty-five stents were implanted in 19 patients. In two patients technical failure was due to stent dislodgment from balloon. Five patients required treatment with more than one stent because a single stent was not long enough to bridge the neck. In two patients multiple aneurysms (5) were treated with a single stent. There were 16 covered side-branches (13 ophthalmic, 1 posterior communicating, 1 meningeal, and 1 anterior choroidal). Follow up ranged from 16 to 180 days (mean 78 days). There was one death due to parent artery perforation during guidewasher positioning. There were no permanently disabling ischemic strokes. At last follow up mRS was 0-2 in 20 (95%) patients. There were five parent artery occlusions explained by clopidogrel noncompliance in one, omeprazole interactions in four, and inadequate stent apposition in two. Excepting three cases with parent artery occlusion all covered side branches remained patent. No patients developed parent artery stenosis ≥ 50% at 6 months. In 19 technical successes, immediate postprocedure 100% aneurysm occlusion occurred in 15, 90-99% in three, and 50-90% in one. At 1 month all 19 had 100% aneurysm occlusion.

**CONCLUSION**
Microporous membrane-covered stents enable high rates of complete initial aneurysm occlusion without the risk of delayed aneurysm rupture. Excellent stent apposition and effective antithrombosis are mandatory to ensure stent patency.

**KEY WORDS:** Intracranial aneurysm, endovascular flow diverter, Merlin MD
Automated Geometrical Characterization of the Carotid Siphon Based on 3D Rotational Angiogram

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PURPOSE
To study the carotid siphon by automated geometric characterization based on high-resolution 3D rotational angiography.

MATERIALS & METHODS
Data of 83 3D rotational angiogram (Allura, Philips Healthcare) of patients treated endovascularly for intracranial aneurysms were used for this study. After segmentation of the arterial tree and central line computation of this anatomy, automatized detection of the carotid artery (from its exit point from the petrous canal to its terminal bifurcation) was realized. Each siphon was quoted by two separate readers according to a shape-based classification. Landmarks based on geometric properties of the center-line were used to delineate four segments (Figure: 1-inferior 2-posterior 3-anterior 4-superior) coinciding with clinical areas of interest on the siphon. For each of those segments the following data were calculated: 1. Lengths: (Euclidean distance and distance between ends) and corresponding arterial tortuosity (relative increment of a curve length deviating from a rectilinear line). 2. Arterial radius, osculating planes changes and bending energy. The whole carotid siphon length and corresponding arterial tortuosity also were calculated.

RESULTS
Conventional angiographic-based shape classification of carotid siphon resulted in substantial intraobserver and interobserver level of agreement (kappa test respectively 0.77 and 0.64 p=0.000). The automated-based geometric characterization was possible for each angiographic dataset and provided the following information regarding vascular tortuosity and radius of the main arterial curves of the siphon. The mean carotid siphon length was 61 mm +/-19 (range 33-106) and calculated tortuosity was 0.9+/-0.3 (range 0.3-1.7). Separate analysis was performed for each segments. Mean radius at posterior, anterior, and superior segments were respectively 4.4; 3.3, 5.4 mm. Plane changes according to coronal, sagital and axial planes were available for review; for the purpose of this study, osculating plane changes for the posterior and superior segments were compared according to the plane of anterior segment and were respectively 41 and 87 degrees. Subgroup analysis of each type of siphon defined according to the angiographic classification was performed but no significant correlation or differences with the automated geometric characterization parameters was found.

CONCLUSION
Angiographic classification of siphon showed good inter and intraobserver reliability. Nonetheless the subdivision in four types of siphon could not correlate to parameters provided by the geometric characterization. Multiple clinical hypotheses (development of intracranial vascular disease) or applications (stent design and endovascular use) would need further investigation and could benefit from the parameters offered by geometric-based definition of the siphon.

KEY WORDS: Carotid siphon, angiography, anatomy

Preliminary Results of Flow Diversion Device (Silk Stent) in the Treatment of Intracranial Aneurysms: A Focus on Technique-Related Artifacts Using a Multidetector 320 Row Scanner

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PURPOSE
The treatment of intracranial aneurysms has an approximate rate of 30% of recanalization. In the last years, many technical advances, such as balloon remodelling technique and stent-assisted coils, have lead to improving results of the endovascular treatment. A new generation of stents has been introduced recently: the flow diversion devices. The aim of our work is to analyze the preliminary results after 1 year experience with a focus on the detection of stent artifacts with the use of multidetector CT (Aquilion ONE) for the early and late follow up.

MATERIALS & METHODS
Since April 2009 a series of 11 patients and a total of 12 intracranial aneurysms were treated endovascularly using Silk stent. Ten patients were female and one was male, ranging from 45 to 63 years of age. All of the aneurysms were broad neck: nine of them were located in the anterior circulation, two in the basilar artery and one in the vertebral artery. Seven patients were treated using one Silk stent, in one patient one Silk stent treated two aneurysms, while in four patients two Silk stents were required in a telescopic...
fashion. All patients had follow-up CT angiography (CTA) performed at 3 months and 1 year and then follow-up angiography at 6 months. The CTAs were obtained on a multidetector 320 row scanner, Aquilion ONE, (640 resolution) acquiring volumetric images.

RESULTS
The immediate short-term and 1 year follow-up data are presented here. The advantages, the limits and the clinical implications of the Silk stent technique also are illustrated. The detection of artifacts by the multidetector 320 row scanner in the follow up of aneurysms is reported. CT angiography using multidetector 320 scanner provided adequate visualization of the intracerebral circulation without artifacts at the stent level. Even in cases when two Silk stents were used the artifacts did not preclude the visualization of the artery. The MPR images enabled a satisfactory evaluation of the stent and its relationship with the parent artery.

CONCLUSION
In our preliminary experience, the multidetector 320 row scanner provides adequate results without evidence of artifacts from material of Silk stent in the follow up of patients treated for intracranial aneurysms. A prospective study is required to confirm these preliminary data.

KEY WORDS: Flow diverter, aneurysms, multidetector scanner

ePoster 128
Endovascular Treatment of Wide-Necked Intracranial Aneurysms Using “Various Generations” of Neuroform Stents: Easier Navigation and Precise Placement with the Newest Generation of the Stent

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PURPOSE
Stent-assisted coiling has been a well established endovascular treatment for wide-necked aneurysms. The neuroform stent is a flexible nitinol self-expandable stent useful for neck reconstruction. The aim of this study was to establish the role of the stent in endovascular management of wide-necked cerebral aneurysms.

MATERIALS & METHODS
Between June 2003 and December 2010, 67 cases of neuroform stents were placed for treatment of wide-necked aneurysms. Postprocedure angiograms demonstrates flow directional changes with total occlusion of the aneurysm in most patients. In some cases there was minimal residual flow, which demonstrated total occlusion on the follow-up angiograms. Inclusion criteria included wide-necked aneurysms. Anatomical and clinical results and complications including distal thrombosis and stent thrombosis will be discussed. Types of stents include various generations of the stent including first generation Neuroform stent, Neuroform 2, Neuroform 2 trio, Neuroform 3 and the latest Neuroform EZ.

RESULTS
With the evolution and newer generations of the stent the navigation and precise positioning has improved significantly. The advantages and pitfalls of the new generation stent will be discussed. Technical considerations, complications and their management also will be discussed. Complete exclusion of the aneurysm was obtained in most of the cases.

CONCLUSION
The newer generations of the neuroform stent has aided in the navigation and precise deployment. Advantages and pitfalls and management of the pitfalls will be discussed.

KEY WORDS: Aneurysm, neuroform, wide neck

ePoster 129
Safety of Intermediate Catheters: A Review of 489 Cases at Two High-Volume Centers

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PURPOSE
Compare and evaluate the two families of intermediate catheters with regards to distal access and safety.

MATERIALS & METHODS
Material use logs were queried to identify patients in which either a penumbra neuron catheter was used, or a concentric distal access catheter (DAC) was used. Two years of data were retrieved at the Cleveland Clinic and 1 year of data were retrieved at Emory University. The cases were reviewed, identifying the role of the catheter during the case, distal most placement, and all complications, whether attributable to the catheter or not. Results were pooled and analyzed.

RESULTS
Overall rate of complication was 5.7%, none of which were directly attributable to the intermediate catheter. 14.8% of the complications related to aneurysm perforation, 18.5% to vessel perforation, while 18.5% related inadvertant embolizate embolization, 11.1% to coil prolapse, and 11.1% to dissection. The neuron family of catheters was advanced farther than the cavernous internal carotid artery (ICA) in anterior circulation use (100%), whereas the DAC catheters frequently were advanced further to this point in 24.2% of the cases, as far as M3 branches. The complication rate among DAC is 12/131 (9.2%); the complication rate for neuron is 15/338 (4.4%). This difference is statistically significant (p = 0.049, chi-square test). The estimated odds ratio is 2.17, indicating that DAC cases in our sample are more than twice as likely as neuron cases to experience a complication. The 95% confidence interval for the true odds ratio is (0.99, 4.76).

CONCLUSION
The use of intermediate catheters to improve ease of access to target lesions appears relatively safe, with overall complication rates in line with historical numbers. However, the
usage of the DAC family seems to confer a higher risk of complication relative to the neuron family, which may relate to the complexity of the cases in which they are employed. Further observation is necessary.

**KEY WORDS:** Intermediate catheters, distal access catheter, neuron catheter

ePoster 130

**Flow-Diverter Stents for the Endovascular Treatment of Intracranial Aneurysms: A Prospective Study in 97 Patients with 111 Aneurysms**

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**PURPOSE**
Flow diverters (FDs) is a new approach to the endovascular treatment of intracranial aneurysms which uses a high density mesh stent to induce sac thrombosis. These devices have been designed for the treatment of complex shaped and large size aneurysms. So far published safety and efficacy data on this approach are limited. We report our 2-year experience with FDs in the treatment of cerebral aneurysms.

**MATERIALS & METHODS**
From September 2008 to December 2010, 111 aneurysms (100/111 anterior circulation, 11/111 posterior circulation) were treated at our institution with FDs (Silk; Balt, Montmorency, France - and Pipeline; EV3, Irvine, CA). A total of 147 FDs were implanted (1 to 8 per aneurysm, mean: 1.3). Modes of presentation were fortuitous (52.3%, 58/111), angiographic recurrence of previously treated aneurysms (27.0%, 30/111), compressive symptoms (18.0%, 20/111), SAH (2.7%, 3/111). Aneurysms were treated with FDs alone in 57.7% (64/111) and with FDs and coils in 42.3% (47/111).

**RESULTS**
All procedures were carried out on flat panel detector angiographic suites allowing 3D reconstruction of both aneurysm and parent vessels (Allura; Philips, Best, The Netherlands). Precise parent vessel measurements allowed choosing precisely the desired FDs in order to conform to aneurysm neck and vessel geometries. One hundred eleven aneurysms (103/111, 92.8% saccular; 8/111, 7.2% fusiform; sizes 1.2 to 80, mean: 12.9 mm) were treated in 97 patients (71 women, 26 men, age ranging from 10 to 85 years, mean: 52 years) in 101 procedures. All patients were premedicated with dual antiplatelet therapy at least for 5 days prior to treatment. Antiplatelet activity assessment was performed in all cases (VerifNow; Accumetrics, San Diego, CA). Access site complications (hematomas) were noted in 5.9% (6/101, 3 requiring blood transfusions). Transient or reversible (<7 days) neurologic complications (8 ischemic, 2 hemorrhagic) were noted in 9.9% (10/101). Permanent neurologic complications were deplored in 7.9% (8/101). Thirty days postprocedural mortality was 4.0% (4/101; 1 ischemic stroke, 1 mesencephalic compression, 1 pulmonary infection, 1 cardiac failure). To date, relief or improvement of compressive symptoms was achieved in 20.0% (4/20). No aneurysms bled or rebled after treatment. Aneurysms treated with FDs alone were slightly smaller than those treated with FDs and coils (mean size: 12.4 and 13.6 mm respectively; P = 0.0362, Unpaired t test with Welch correction). Immediate angiographic occlusion was achieved in 15.6% (10/64) with FDs alone, in 29.8% (14/47) with FDs and coils. Sixty-four (57.6%) aneurysms had been followed (mean: 9 months). At follow up, 71.0% (27/38) of aneurysms treated with FDs, while 96.1% (25/26) of aneurysms treated with FDs and coils were totally occluded (Fisher’s Exact Test, P = 0.012). There was no angiographic recurrence of initially totally occluded aneurysms.

**CONCLUSION**
Flow diverters allow the treatment of aneurysm that were not amenable previously to selective treatment. The combination of FDs and coils provide better rates of aneurysm occlusion at follow up than FDs alone, with no aneurysm recurrence.

**KEY WORDS:** Aneurysm, stent, flow diverter

ePoster 131

**Quantitative Assessment of Parenchymal Blood Volume in Tumor Embolization Using C-Arm CT Imaging: Initial Clinical Experience**

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**PURPOSE**
C-arm CT measurement of cerebral blood volume (CBV) in ischemic stroke patients has already been reported. Our purpose was to evaluate the feasibility of assessing parenchymal blood volume (PBV) using C-arm CT in head and neck neoplasm during preoperative angiographic evaluation and embolization using poly-vinyl alcohol particles.

**MATERIALS & METHODS**
Nine patients diagnosed with head and neck tumor, underwent C-arm CT imaging (DynaCT, Axiom Artis zee, Siemens) using a 8-second 3D subtraction angiography protocol after intra-arterial contrast injection (10% contrast; 1.5cc/sec; 24-27 cc total, x-ray delay of 8-10 seconds after the mask and before the fill acquisition). Parenchymal blood volume maps (in ml/100g of tissue) then were computed by postprocessing using prototype software (Siemens AG, Forchheim, Germany). Four out of these nine patients had C-arm CT imaging before and after the embolization procedure. Parenchymal blood volume maps from these four patients were analyzed to infer quantitative assessment of tumor embolization and vascularity. The remaining five patients had one instance of C-arm CT imaging that was correlated with MR and CT images. Parenchymal blood volume maps also were compared qualitatively with the corresponding 2D angiographic images to assess tumor vascularity.
RESULTS
Quantitative analysis of PBV maps in four patients (2 carotid body tumors, 2 skull base tumors) showed a relative decrease in PBV values after embolization procedure (-63%, -79%, -46%, -42%, respectively) when compared with the preprocedural PBV maps. Parenchymal blood volume maps from the remainder of the patients were qualitatively comparable to the angiographic evaluation of tumor perfusion. Apart from computing the PBV maps, the same C-arm CT data also could be used to generate a fill reconstruction image (equivalent to contrast-enhanced C-arm CT) for soft-tissue evaluation. Because of the diversity of tumor type and small sample size, any inference from comparing the tumor PBV values across these cases could not be performed.

CONCLUSION
Parenchymal blood volume maps could be computed from routine C-arm CT imaging that provides functional information about the tumor perfusion in the angiography suite itself. This could be a valuable tool for quantitative and comparative assessment of the efficacy of tumor embolization. Heretofore, the extent of embolization procedures always has been assessed qualitatively from tumor blush on 2D angiographic images. Further work is required to determine the possible utility of this technique in studying tumor tissue vascularity, in guiding tumor biopsy of non-necrotic tissue, in tumor classification and localizing tumor zones for effective chemo-embolization therapy.

KEY WORDS: Parenchymal blood volume, C-arm CT imaging, tumor embolization

Management of Spinal Epidural Arteriovenous Fistulas

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PURPOSE
Spinal epidural arteriovenous fistulae (SEDAVF) are rare clinical entities, which can sometimes be symptomatic. Clinical progression and management of SEDAVF is not reported well in the literature.

MATERIALS & METHODS
We report a series of five consecutive cases treated at our center to analyze their diagnostic characteristics, clinical history, progression and treatment strategies in their management. We report a successful technique of percutaneous embolization of fistulae in a patient with failed previous attempts.

RESULTS
All five patients were symptomatic; three patients presented with history of back pain, which progressed to myelopathic symptoms such as bilateral leg weakness or numbness, and two patients had symptoms of persistent back pain alone. Of the three patients who had myelopathic symptoms, two were treated successfully with transarterial embolizations with Onyx copolymer (ev3 Neurovascular, CA, USA). The third patient who had a prominent epidural venous pouch with numerous arterial feeders was embolized percutaneously with a flat detector CT-guided navigation (X per CT, Phillips Inc., The Netherlands) and real time fluoroscopic monitoring of the injected n-BCA glue (Trufill, Cordis Neurovascular Inc., FL, USA), after previous unsuccessful attempts with surgery and arterial embolizations. All three treated patients had complete angiographic remission of the fistulae and symptoms on follow up (mean 7.2 months). Of the two patients presenting with back pain alone, one patient was found to have a spontaneous thrombosis of the medullary vein before a scheduled percutaneous intervention and the other patient is being monitored closely.

CONCLUSION
The diagnosis and treatment of SEDAVF can be challenging due to their rare occurrence and intricate pathomechanics. Patients with mild symptoms of pain should be monitored closely. Patients with severe pain or progression of symptoms or myelopathic symptoms need to be treated at the earliest opportunity. Successful percutaneous embolization of fistulae can be performed when a sizeable venous pouch is present in association with numerous arterial feeders.

KEY WORDS: Epidural arteriovenous fistula, percutaneous intervention, glue
ePoster 133

Percutaneous Management of Symptomatic Synovial Cystic Disease and Clinical Outcome

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Purpose
Synovial cysts are extradural lesions for which surgical microdecompression has been the traditional standard of care treatment. We describe different percutaneous treatment options and varying approaches which may be employed for the successful decompression of these cysts.

Materials & Methods
Five patients with symptomatic synovial cysts (Visual Analogue Scores between 4-8) were treated over the past 12 months by varying combinations of percutaneous techniques using CT for guidance. This allowed accurate guidance and subsequent rupture of the cysts. Three of the cases were performed using transfacetal transcapsular approaches, and two required additional interlaminar access and cyst fenestration to weaken the cyst wall prior to rupture. Long-term effectiveness can be judged by follow-up CT or MR.

Results
Percutaneous cyst rupture using these techniques resulted in marked symptomatic improvement. An average reduction of at least 60-70% in the VAS was achieved.

Conclusion
Percutaneous treatment of symptomatic synovial cyst, performed as outpatient procedures seems an effective alternative to surgery in a significant number of patients.

Key Words: Percutaneous management, synovial cyst

ePoster 134

Predictors and Outcomes of Merci Device Fracture during Mechanical Thrombectomy for Acute Ischemic Stroke

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Purpose
Merci retriever device fracture is one of procedure-related adverse events during mechanical thrombectomy for acute ischemic stroke. The purpose of this study was to describe the frequency and predictors of this complication in acute ischemic stroke patients after mechanical thrombectomy and its impact on clinical outcome.

Materials & Methods
We retrospectively analyzed acute ischemic stroke patients with large vessel intracranial occlusions treated by mechanical thrombectomy with Merci devices (Concentric Medical, Inc., Mountain View, CA) at the University of California, Los Angeles from August 2002 through August 2008. Digital subtraction angiograms and medical records were reviewed to identify the presence of device fracture. Univariate logistic regression analyses were performed to define the predictors of device fracture. The impact of device fracture on potential hemorrhage and clinical outcome at discharge were evaluated.

Results
Of 136 consecutive patients treated by mechanical thrombectomy, six (4.4%) experienced intraprocedural Merci devices fracture. In univariate analyses, internal carotid artery occlusion (OR 13.06; 95% CI 1.47 to 115.62, P = 0.01) was associated with device fracture. The fractured devices were ensnared successfully by a Merci device or microsnare (ev3, Inc, Irvine, CA) in three of six patients. Compared with patients with nonfractured devices, those with fractured devices had similar rates of thrombolysis and myocardial infarction (TIMI) grade II and III revascularization (66.8% versus 72.3%; p = 0.67), decreased rates of arterial occlusive lesion (AOL) grade III recanalization (0% versus 14.5%; p = 0.03) and longer mean procedure time (2.5 hours versus 1.8 hours; p = 0.03). In patients with fractured devices, no parenchymal hematomas were found. Hemorrhagic infarction and subarachnoid hemorrhage were found in three and two patients with fractured devices, respectively. There were no significant differences between patients with fractured devices and those with nonfractured devices for independence at discharge (modified Rankin Scale≤2, 0% versus 25%; p = 0.34) and in-hospital mortality (16.7% versus 23.4%; p > 0.99).

Conclusion
The complication of Merci retriever device fracture is relatively infrequent in acute ischemic stroke patients treated by mechanical thrombectomy. Target occlusion location in the internal carotid artery is an independent predictor of intraprocedural device fracture. This complication is not associated with parenchymal hematomas or poor clinical outcomes after thrombectomy.

Key Words: Acute stroke, mechanical thrombectomy, complication

ePoster 135

Endovascular Treatment of Cerebral Venous Sinus Thrombosis in Children: A Case Series

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Purpose
Cerebral venous sinus thrombosis is a serious condition affecting 0.67 per 100,000 children per year. It has a 48% adverse outcome. The symptoms and signs are often non-
specific and this can lead to a delay in diagnosis or it being missed altogether. The most common presenting features are headache (60%), seizures, reduced GCS or cranial nerve palsies. Coma and seizures at presentation are poor prognostic indicators. The diagnosis is made on CT, CTV, MR, MRV. The mainstay of treatment is heparin although this is not universal. The decision to proceed to endovascular treatment is guided by the multidisciplinary team involved in the patients care and should only be considered in the extreme cases where medical management has failed and the child is in poor clinical condition. There is very little published literature on the use of aggressive endovascular treatments in children with venous sinus thrombosis.

**MATERIALS & METHODS**
We present our experience of treating eight children ranging in age from 18 months to 16 years, with a diagnosis of cerebral venous sinus thrombosis. All had the diagnosis made by a neuroradiologist on CT, CTV, MR or MRV. The decision to proceed to endovascular therapy was made on discussion between the neuroradiologists and the clinicians. This was decided only upon discussion due to the very poor clinical state of the patients. Seven children were comatose, one child had signs of raised intracranial pressure with progressive cranial nerve palsies. Seven of the children already had been started on IV heparin and had shown no improvement. A variety of endovascular methods was used, local tPA, disruption of the clot with a microwire and cathether, balloon angioplasty and aspiration of the clot using the penumbrad device.

**RESULTS**
Seven children had good functional outcomes. One child died as a consequence of uncontrolled intracranial hypertension secondary to the venous sinus thrombosis.

**CONCLUSION**
Endovascular therapy appears to have a role in the treatment of venous sinus thrombosis in children when medical therapy has failed and the patient is in a poor clinical condition.

**KEY WORDS:** Endovascular, venous sinus thrombosis

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**ePoster 136**

**MR Imaging Biomarkers to Predict Fetal Development**

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**PURPOSE**
Purpose of this study was to: i) perform multiparameter MR assessment of the gestational ages with biparietal-diameter (BPD), occipital-frontal-diameter (OFD), head-circumference (HC), femur-length (FL), humerus-length (HL), abdominal-circumference (AC) and ii) correlate these findings and the gestational ages with ultrasound measurements.

**MATERIALS & METHODS**
Seventy-two fetal MR images (gestational age=23±8 weeks) having correlarte ultrasound report with biometrics and gestational ages reported within ±3 days of MRI were analyzed retrospectively. High-resolution multi-planar fetal MR protocol comprised of fast-imaging sequences to acquire whole body images of the fetus on 1.5T Siemens scanner. Biparietal-diameter and OFD were measured on transverse axial section of the fetal head which included the falx cerebri, cavum septum pellucidum and thalami. Biparietal-diameter was measured from the outer edge of the parietal bone to the inner edge parietal bone in relation to the anterior abdominal wall. Occipital-frontal-diameter was measured perpendicular to the BPD from the outer edge to the outer edge of the bones in the anterior-posterior plane. The longest transverse width of the cerebellum (TCD) was measured in the posterior fossa views. Abdominal-circumference was measured at the level of the liver and stomach. Humerus-length and FL were measured along the true long axis of diaphyseal shaft excluding the epiphysis. Radiologists were blinded to the ultrasound measurements reported on the ultrasound scan. Once the MRI measurements were reported, corresponding gestational ages were tabulated and correlated with the ultrasound ages using linear squares regression analysis. Student's t-test was performed to determine any significant differences between the biometrics and gestational ages obtained from the two imaging modalities (p≤0.05).

**RESULTS**
Results showed an excellent correlation with insignificant differences between ultrasound and MRI-reported biometrics and gestational ages. All the MR biometric measurements correlated well with the ultrasound measurements (slope 0.97±0.03 and an R2=0.89±0.17). Gestational ages computed from the MR biometrics, also correlated well with the ultrasound ages (slope=0.99±0.01; R2=0.92±0.03). There was no significant difference between the biometrics (p-value=0.13±0.07) and the gestational ages (p-value=0.58±0.25) obtained from both the imaging modalities. Mean gestational age from MR was in excellent correlation with ultrasound mean gestational age (slope=1.05, R2=0.90, p-value=0.495). In addition, MRI was able to provide more information regarding the complex fetal anomalies.
CONCLUSION
Multiparameter assessment of fetal gestational ages was possible with rapid high-resolution MRI sequences. Our future goal is to include new MR biomarkers to demonstrate normal fetal proportions and to be able to predict fetal anomalies from biometric deviations at various gestational ages.

KEY WORDS: Biometry, MR imaging, fetal

Utility of Susceptibility-Weighted Imaging in Pediatric Neurologic Emergencies

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Purpose
To illustrate the value of susceptibility-weighted imaging (SWI) in pediatric neurologic emergencies.

MATERIALS & METHODS
We looked at the findings on SWI sequences as part of magnetic resonance (MR) studies on a 3 T scanner for acute pediatric emergencies in our institution over a 4-year period (2006-2010). Clinical presentations included were focal and generalized seizures, stroke, altered mental status, accidental and nonaccidental trauma. We evaluated the abnormalities seen in these cases on SWI images and compared these findings with conventional images. We also identified examples of false-positive findings on SWI images, and enumerate the reasons for this. Technical factors and image processing methods that can improve the yield of SWI images including optimal slice thickness, value of magnitude and phase images and maximum intensity projections also are elaborated.

RESULTS
Intra-axial and extra-axial hemorrhage, tumor hemorrhage, thrombosis and/or slow flow in the dural venous sinuses, cortical and deep medullary veins, vascular malformations and penumbra regions of infarcts were characterized well on SWI images. In addition, SWI helped characterize infarcts better, helped detect possible nonaccidental trauma by characterizing retinal hemorrhages and in one case, helped differentiate tumefactive demyelination from neoplasm. Use of optimal postprocessing steps can help visualize vasculature and may be able to supplement or in some cases, replace MR angiogram and MR venogram sequences.

CONCLUSION
Susceptibility-weighted imaging, when used judiciously and with optimal technical parameters, is a useful sequence that should be considered as part of MRI protocols designed for imaging acute neurologic emergencies in children. Additionally, since SWI provides detailed vascular anatomy TOF MRA and MRV may be replaced with it to save time in emergencies.

KEY WORDS: SWI, emergencies
patients with hippocampal sclerosis. We have begun investigation of resting state fMRI for evaluation of mesial temporal lobe function.

**MATERIALS & METHODS**

Imaging was performed on a Siemens (Erlangen, Germany) 3 T (Trio) (EPIBOLD sequence, TE = 30ms, flip angle = 90°). Analysis was performed using 1000 Functional Connectomes Project scripts based on AFNI and FSL software packages. We retrospectively analyzed connectivity patterns in five healthy control subjects (ages 11 to 15 years) and compared to two patients (age 17 and 6 years) with memory disruption and epilepsy due to hippocampal sclerosis and three patients (ages 6, 13 and 20 years) with epilepsy without hippocampal sclerosis including one under propofol anesthesia. Resting state data were analyzed for connectivity with ventral precuneus and retrosplenial cortex.

**RESULTS**

The figure shows connectivity patterns for ventral precuneus seed (MNI coordinates: 0, -60, 24) in one of the control subjects and in the patient. Robust connectivity with the ventral precuneus seed point was seen in fusiform gyri, parahippocampus and hippocampus in individual subjects. Connectivity pattern (A) was found to be bilateral and symmetric in control subjects (in agreement with the literature), and in the patients with epilepsy without hippocampal sclerosis. In contrast the epileptic patients with hippocampal sclerosis exhibited an asymmetric pattern (B) of connectivity with decrease in the hippocampal and parahippocampal regions ipsilateral to their sclerosis.

![Image of connectivity patterns](image)

**CONCLUSION**

Epilepsy patients with hippocampal sclerosis revealed a deviation from typical connectivity pattern in controls with diminished connectivity on the side ipsilateral to seizure onset, also not seen in patients with extratemporal epilepsy. This connectivity in memory networks revealed with fcMRI analysis appears to be sufficiently robust, to be clinically applicable in assessment of both adult and pediatric subjects with epilepsy, warranting further study to correlate with Wada and neuropsychiatric testing.

**KEY WORDS:** Functional connectivity, hippocampal sclerosis

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**ePoster 139**

**Radiation Dose and Developmental Differences in Deep Gray Matter Nuclei Tissue in Healthy Children and Patients Treated with Brain Radiation**

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**PURPOSE**

Whole-brain radiation therapy (RT) has improved survival among children with brain malignancies. However, RT can generate an array of adverse effects associated with a range of clinical pathologies, including neurocognitive deficits. The aim of this prospective study was to evaluate changes in deep gray matter integrity and related neuropsychologic performance among patients receiving brain radiation.

**MATERIALS & METHODS**

Nine pediatric patients (7 boys; mean age 11.8 ± 3.8 years) who received brain radiation were examined. The control group was comprised of nine healthy children (2 boys; 11.2 ± 1.8 years). The patients were examined at four visits: before or early in the course of RT, at 6, 15, and 27 months following completion of RT. Controls were examined at the same time intervals. Gray matter DTI data were acquired at 1.5 T with 15 noncollinear diffusion gradient directions (b = 1000 s/mm²). The following parameters were used: 24 axial slices (5 mm, no gap), 96*96 acquisition matrix, FOV 240 mm². Apparent diffusion coefficient (ADC), axial and radial diffusivities were calculated using “DTI Studio” in the following regions-of-interest: thalamus, globus pallidus, putamen, caudate head, and hippocampal head. Radiation dose to each individual region was calculated using Pinnacle software. Linear mixed effects models analysis was applied for statistical evaluations.

**RESULTS**

The overall analysis revealed higher ADC and axial and radial diffusivities in patients than controls (p = 0.025, 0.005, and 0.017, respectively). In the individual regional analysis, the mean ADC was significantly higher in patients than in controls at all visits in the putamen and caudate, and the first and last visits in the hippocampal head (all p < 0.05). Among examined regions, the most prominent effects of radiation doses on diffusivity were detected at the 6 and 27 month follow-up, with no general pattern relating DTI measurements and regional radiation dose. Compared to healthy children, patients tended to perform better at all time points on neuropsychologic tests of dexterity, memory, and motor persistence and inhibition. All subjects improved their performance on these tests over time.

**CONCLUSION**

In normal development, mean diffusivity of deep gray matter decreases with age. In our study, a significant increase in the mean ADC calculated over time from five separate regions comprising deep gray matter and the hippocampal head was detected in patients compared with age-matched controls. Abnormal ADC was observed despite no visible pathology on conventional MR imaging (MRI) at the start of
the study, and throughout the 27 months of observation. These findings suggest that patients with brain malignancies may have abnormal deep gray matter development at the outset. Radiation and related treatment may contribute to gray matter damage. Neuropsychologic testing suggested that DTI may detect abnormalities in deep gray matter before they become clinically apparent.

**Key Words:** DTI, radiation, neuropsychologic

**ePoster 140**

**Brain Metabolism in Autism and Relation to Disease Severity**

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**Purpose**

There is strong evidence that autism is associated with abnormal brain development, but the nature of this aberrant neurodevelopment is not well characterized. Disorders of the amygdala, hippocampus and cerebellum play an important role in the characteristic cognitive and emotional dysfunction in patients with autism. The aim of this study is to evaluate the neurobiologic abnormalities in autistic children, using magnetic resonance spectroscopy (MRS) to evaluate the major brain metabolites in the left cerebellum (C) and left amygdala-hippocampus (AH) regions and to assess their relevance to the severity of the disease.

**Materials & Methods**

Twenty autistic children (17 males and 4 females, age ranging from 3 to 12 years old) were recruited from the genetics clinic and were enrolled in the study. They were seven mild, seven moderate and seven severe cases of children with autism rated according to the Childhood Autism Rating Scale (CARS). Seven healthy gender- and age- matched children served as controls. Patients and controls were subjected to detailed history taking, clinical examination and pedigree construction. Single voxel short echo MRS was performed for all autistic participants. Ratios of the major metabolites: N acetyl aspartate (NAA), choline (Cho), creatine (Cr), and myoinositol (mI) were compared between the four groups.

**Results**

The MRS results revealed that NAA/Cho in the C region, NAA/Cr in AH region were significantly lower (P = 0.009, 0.03), while Cho/Cr in the C region was significantly higher (P = 0.002) among patients compared to controls. The mean values of NAA/Cho and NAA/Cr in the C region were significantly lower among patients with moderate as compared to mild autism (P = 0.009, 0.001 respectively), and in severe as compared to mild autism (P = 0.02, 0.03 respectively). Meanwhile, the mean value of Cho/Cr in C region was significantly higher among patients with severe as compared to mild autism (P = 0.007) and mI/Cr in AH region was significantly higher in moderate versus mild autism (P = 0.01). However, there were no significant differences in metabolites ratios between patients having moderate and those with severe autism. In the C region, the NAA/Cr ratio showed significant negative correlation, while Cho/Cr ratio showed significant positive correlation with the degree of severity of autism.

**Conclusion**

This study highlights changes of the major brain metabolites in autistic children which correlate with the severity of the disease. MR spectroscopy can be a helpful tool in the follow up and the understanding of the pathophysiology of autism which will lead to the development of new therapeutic approaches.

**Key Words:** Autism, MRS, brain metabolites

**ePoster 141**

Quantification of Optic Canal Stenosis Reversal after Hematopoietic Stem Cell Transplantation in Pediatric Patients with Osteopetrosis as Measured on CT and MR Imaging

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**Purpose**

Osteopetrosis is a rare but devastating inherited disorder of excessive bone formation due to osteoclastic dysfunction. Visual loss secondary to optic canal stenosis is a debilitating symptom, and often the initial presentation of osteopetrosis. Hematopoietic stem cell transplantation (HSCT) is the only known durable treatment of osteopetrosis, first reported to be successful in humans in 1980. Visual loss is noted to improve after HSCT but the mechanism remains unclear; the most common purported mechanism is reversal of optic canal stenosis with associated CN II decompression. However, the efficacy of HSCT in reversing optic canal stenosis is not well studied, with only one case report of a single patient described in the American Journal of Ophthalmology. We believe this is the largest case series that quantifies the change in optic canal diameter before and after HSCT.

**Materials & Methods**

At our institution, 24 patients with severe osteopetrosis were treated with HSCT in the past 33 years. Of these, five patients with childhood onset of disease (mean age at HSCT: 0.75 years) had suitable cross-sectional neuroimaging studies before (average: 73 days) and after (average: 185 days) HSCT. Two adult patients who were transplanted with delayed onset of disease were not included. We measured the optic canal diameter on all computed tomography (CT) and MR imaging (MRI) studies available for each patient. The optic canal diameter also was measured in 17 age-matched control patients (mean age: 2.24 years). Comparisons of the optic canal diameters before and after HSCT were performed.
RESULTS
The mean optic canal diameter in the five osteopetrosis patients before HSCT was 1.93 ± 0.50 mm compared to 2.53 ± 0.54 mm, indicating a 31% increase after HSCT (p < 0.01). In the control population, the mean optic canal diameter was 3.86 ± 0.49 mm.

CONCLUSION
Optic canal diameters increased after HSCT in patients with osteopetrosis, but optic canal diameter measurements did not return to the average values measured in age-matched controls over the study interval. It remains uncertain if the optic canals of osteopetrosis patients will ever normalize after HSCT or remain smaller in diameter than those of unaffected patients. Follow up over several years may be necessary, but these data were unavailable for this study. Regardless, measurements of optic canal diameters prior to HSCT on cross-sectional neuroimaging studies of osteopetrosis patients will serve as a baseline for comparison on future studies after HSCT.

KEY WORDS: Optic canal, osteopetrosis

ePoster 142
Adding to the Spectrum of Unusual Findings in a Rare Pediatric Neurocutaneous Syndrome: Head and Neck MR Angiography and MR Imaging in PHACE Syndrome

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PURPOSE
Head and neck vascular and structural abnormalities in PHACE are broad and our understanding regarding the phenotypic spectrum of the disease and frequency of different findings are largely derived from case series or case studies. Our goal was to systematically evaluate MR imaging (MRI) and MR angiography (MRA) head and neck images of children with PHACE syndrome to characterize the type and location of arteriopathy, to delineate associated intra and extracranial abnormalities and to estimate the prevalence of these findings.

MATERIALS & METHODS
After IRB approval was obtained from each of four participating institutions, MRI and MRA examinations of the head and neck in 20 patients meeting consensus diagnostic criteria for PHACE syndrome with at least one cerebrovascular or cardiovascular major criteria were reviewed and were reviewed for the presence of vascular, intracranial and extracranial abnormalities. All imaging was performed between March of 2000 and September of 2010. All studies were reviewed independently by two fellowship-trained pediatric neuroradiologists and one fellowship-trained pediatric vascular and interventional radiologist. Differences in interpretation were resolved by consensus.

RESULTS
Patient age at time of imaging ranged from 2 days to 4 years old. By study design, arteriopathy was observed in all patients. Tortuosity was the most common finding seen in 60% (12/20) of subjects and ectasia (30%) was the second most common finding. Interestingly, a characteristic focal tortuosity was seen at the junction of the cervical and petrous portions of the ICA in 30% (Figure). Neck findings included coarctation of the aorta in (35%), aberrant right subclavian artery in (25%), low common carotid artery bifurcation (20%), and ICA nonvisualization or long segment narrowing (20%). A focal notching/indentation of the cerebral peduncles was seen in 20%. Notable intra and extracranial findings included cerebellar hypoplasia (25%), internal auditory canal (IAC) hemangiomas (20%), orbital coloboma or staphyloma (15%) and ischemic infarcts (15%) as have been noted previously in children with PHACE.

CONCLUSION
Our retrospective study of 20 children with PHACE syndrome revealed an incidence of common arterial and brain structural findings similar to that published in the literature with additional features including focal notching of the cerebral peduncles and focal tortuosity of the internal carotid arteries at the junction of the cervical and petrous segments as additional characteristic but not diagnostic features of PHACE syndrome.

KEY WORDS: PHACE, hemangioma, MR imaging

ePoster 143
Assessment of Tuberous Sclerosis Complex Tuber Types Using Diffusional Kurtosis Imaging

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PURPOSE
To quantitatively characterize the in vivo microstructure of tuber lesions (L) as compared to perilesion tissue (P) and normal-appearing contralateral perilesion tissue (CP) in three tuber types correlated to symptom severity (type C > B > A) in tuberous sclerosis complex (TSC) patients using metrics derived from diffusional kurtosis imaging (DKI).
Materials & Methods
Six TSC patients (2 w/refractory epilepsy, 2 w/history of seizures, 1 w/no seizures) ages 2.23 - 10.17 years, were recruited from the NYU Langone Medical Center. Whole brain T1-weighted magnetization-prepared rapid acquisition gradient-echo (MPRAGE), T2-weighted, fluid-attenuated inversion recovery (FLAIR) and DKI images were acquired at 3 T. Parametric maps for mean kurtosis (MK), axial kurtosis (KII), radial kurtosis (Kperpendicular), fractional anisotropy (FA), mean diffusivity (MD), axial diffusivity (DII) and radial diffusivity (Dperpendicular) were calculated using diffusional kurtosis estimator. Fluid-attenuated inversion recovery and MPRAGE images were registered to maps using ART2. Tuber types were identified as previously described. An oval region of interest (ROI) was drawn within the identified lesion on the registered FLAIR in one slice where there was normal-appearing tissue in the contralateral region. The same ROI was replicated over the perilesion region adjacent to the lesion boundary and over the contralateral region matching the perilesion location for control. All ROIs had the same shape and area; they were sampled from WM and applied to maps to obtain metric means.

Results
In all tuber types, lesions are associated with a significant increase in diffusivity (indicated by MD most strongly in the radial direction) and a significant decrease in diffusional heterogeneity (indicated by MK). Lesion anisotropy (indicated by FA) is decreased significantly in types B and C. Mean diffusivity and MK are decreased significantly in both axial and radial directions in type C. Perilesion tissue does not differ significantly from normal contralateral tissue in all types. Compared to lesion, perilesion tissue diffusivity and heterogeneity differs significantly in types A and B but not in type C. This suggests perilesion tissue heterogeneity in type C is more similar to lesion tissue.

Conclusion
Degree of aberrant metric trends in the lesion and perilesion tissue generally increases from tuber types A to C corresponding to dominant types of increasing symptom severity. Given the very small cohort, interpretation of these results should be made with caution thus future analysis will include more subjects.

Key Words: DKI, TSC, diffusion

ePoster 144
Assessment of Dynamic Leakage on MR Perfusion Imaging in Patients with X-Linked Adrenoleukodystrophy before and after Bone Marrow Transplantation

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Purpose
The leading edge (LE) of contrast enhancement in cerebral X-linked adrenoleukodystrophy (ALD) is thought to relate to ongoing demyelination/inflammation with enhancement attributed to blood-brain barrier (BBB) disruption. For dynamic susceptibility contrast MR perfusion (DSC-MRP), contrast leakage into the extracellular space via a disrupted BBB has been well established, and thus presence or absence of dynamic leakage (DL) can serve as a marker of BBB integrity. The purpose of this study was to measure DL in various regions affected by ALD pre- and post-bone marrow transplant (BMT).

Materials & Methods
After IRB approval, DSC-MRP was performed using a 3 T unit in seven patients with posterior-type ALD prospectively <30 days prior to and 30-60 days post-BMT. Using coregistered postcontrast 3D T1-weighted images, region of interests (ROIs) were drawn by a staff neuroradiologist around the LE, centrally within visually affected parieto-occipital white matter (POWM), corpus callosal splenium (SpCC) and visually unaffected frontal white matter (FWM). Dynamic leakage was measured within each ROI and comparisons were made between pre- and post-BMT values. Dynamic leakage also was measured in seven control patients in similar locations (excluding LE, since not present). A separate ROI also was drawn around the visually abnormal region on the DL images and around the LE, and the mean areas of these two ROIs were recorded (cm2).

Results
Dynamic leakage was absent/zero in seven control patients in all ROIs. Prior to BMT, DL was positive (>0.00) in the LE of all seven patients (range 0.01-0.02); specifically, DL was positive within POWM in one, SpCC in two, and absent/zero within visually unaffected FWM in all seven patients. Post-BMT, DL was absent/zero in the LE in six patients and reduced by 50% (measured 0.01) in the seventh, while being absent/zero in the POWM, SpCC, and FWM in all seven patients. The mean area of the CE ROI was 2.5 cm2; for DL
the mean was 3.2 cm², which highly correlated ($r=0.987, p<0.0001$). At follow up, the DL had visually nearly disappeared and was not measurable in all seven patients.

**CONCLUSION**

The LE of contrast enhancement in ALD involves BBB dysfunction, as evidenced by positive DL measurement pre-BMT on DSC-MRP. Following BMT, the resolution/reduction of DL associated with reduction in LE enhancement suggests improvement in BBB integrity. The slightly greater area of DL pre-BMT as compared to the LE suggests a small zone of milder BBB dysfunction or potentially reversible early injury.

**KEY WORDS:** Leakage, adrenoleukodystrophy

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**Intermediate Variant Maple Syrup Urine Disease: Characteristic and Differentiating Imaging Features**

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**PURPOSE**

To present the MR imaging characteristics of intermediate variant maple syrup urine disease.

**MATERIALS & METHODS**

We review the MR imaging of a previously healthy 4-month-old child who presents with new onset infantile spasms.

**RESULTS**

Maple syrup urine disease is an autosomal recessive metabolic disorder caused by defective oxidative carboxylation of branched chain amino acids. The most common and most severe form of the disease is the classic type which manifests within the first weeks of life. The radiologist is frequently the first to suggest the diagnosis in a newborn infant in light of significant brain swelling and abnormal signal predominantly involving the brainstem and the cerebellum. A milder form of the disease, referred to as intermediate, comes about later in infancy or in early childhood, in patients with higher residual enzymatic activity. We present the characteristic imaging features of this disorder that help suggest the diagnosis and differentiate it from other pathologies, more frequently suspected in this age group, and that can result in similar swelling and signal abnormality in the brainstem and cerebellum.

**CONCLUSION**

The characteristic parenchymal swelling, distribution of signal abnormality predominantly involving globus pallidus, brainstem, and cerebellum, and reduced white matter diffusion seen with maple syrup urine disease should alert the radiologist to the possibility of this diagnosis, in particular in the older infant or young child where this disorder is rarely suspected. Several differentiating features from other disorders permit early diagnosis and dietary intervention that decrease the severity and progression of neurologic damage.

**KEY WORDS:** Intermediate variant maple syrup urine disease, maple syrup urine disease

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**Time to Extinction of Contrast Enhancement Predicts Better Outcome after Hematopoietic Stem Cell Transplant in X-Linked Adrenoleukodystrophy**

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**PURPOSE**

X-linked adrenoleukodystrophy (X-ALD) is the most common peroxisomal storage disease, leading to very long chain fatty acid (VLCA) accumulation in the cells of the brain, adrenals, and testes. Patients typically present in childhood. When present, cerebral disease generally begins in typical locations, more commonly the corpus callosum, extending into the adjacent white matter. To date, the only curative treatment is hematopoetic stem cell transplantation (HSCT). MR imaging (MRI) staging with Loes scores has shown diagnostic and prognostic significance. In this study we correlate gadolinium contrast enhancement with Loes scores in post-HSCT X-ALD patients.

**MATERIALS & METHODS**

Eighty-six X-ALD patients were evaluated at the University of Minnesota Bone Marrow Transplant clinic extending from 2000-2010. All available MRI images were analyzed and assigned a Loes score based on the currently defined criteria, and a gadolinium enhancement score using a new formula unique to this study. Thirty-five patients had sufficient MRI pre-HSCT (within 30 days), follow-up MRI within the first 60 days, 60-100 days post-HSCT, and 1 year. Patients were divided into groups based on time of extinguishment of enhancement. Group 1 was defined as absence of enhancement on the first post-HSCT study, group two extinguished by the 60-100 day MRI, and group 3 greater than 100 days or persistent enhancement.

**RESULTS**

Loes scores increased an average of 2.03 when enhancement was extinguished by the first post-HSCT MRI, 3.46 for days 60-100, and 3.69 for those extinguishing >100 days or longer. Total Loes score at 1 year post-HSCT showed signif-
icant difference between groups 1 and 2 (p<0.01), and between groups 1 and 3 (p=0.01), but not group 2 compared to 3 (p>0.05). Also, the delta Loes scores were not significant (p>0.05).

Figure 1: Average Loes scores for all patients in individual categories. The first bar indicates the average Loes scores for the pre-HSCT MRI. The second shows the average at approximately 1 year. The third bar indicates Pre-Post (delta) Loes score. Data were analyzed using pooled t-tests comparing groups. Group 1 n=15, Group 2 n=12, Group 3 n=8.

CONCLUSION
We believe that for most X-ALD patients, blood-brain barrier (BBB) disruption (and enhancement on MRI) is associated with active demyelination. Prolonged enhancement after HSCT allows more time for demyelination to progress, and this progression can be measured using the objective Loes scale. When enhancement extinguished on the first post-transplant study, patients did better than those when contrast persisted 2 months or longer.

KEY WORDS: Adrenoleukodystrophy, contrast, enhancement

ePoster 147
MR Imaging Appearances in Two Cases of Infantile Refsum’s Disease

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PURPOSE
Infantile Refsum disease (IRD) is a rare peroxisomal disorder inherited in an autosomal recessive fashion. The predominant clinical features of IRD are visual impairment, chronic progressive polyneuropathy and cerebellar ataxia. Associated clinical problems include anosmia, sensorineural deafness, cardiomyopathy, skin rash, bone deformities and renal dysfunction. Magnetic resonance (MR) imaging of the brain has not been well documented in this disorder. The paucity of MR features in the literature reflects the rarity of IRD. We present two cases of IRD.

ePoster 148
Primary Small Vessel Central Nervous System Vasculitis in a Young Female

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PURPOSE
Primary angiitis of the central nervous system in childhood (ePACNS) is a reversible, rare cause of severe neurologic impairment in the pediatric population. This entity is classified into different subtypes based on distinct radiologic, histopathologic and clinical features, each with different
prognoses and treatments. We will discuss clinical and radiologic findings in a 9-year-old female with small vessel primary central nervous system vasculitis, who presented with anisocoria and panuveitis. MR imaging findings include a subependymal miliary pattern of enhancement that has, to our knowledge, not been described previously in association with cPACNS. We also will discuss briefly MRI and angio graphic findings in other subtypes of this rare disorder.

**Materials & Methods**

The clinical data and laboratory findings including rheumatologic, microbiologic and biopsy specimens of a child treated for small vessel variant cPACNS were reviewed retrospectively. Imaging modalities reviewed included MR imaging of the brain and cervical, thoracic, and lumbar spine. Review of the relevant literature was performed.

**Results**

An 8-year-old otherwise healthy female presented to emergency department with anisocoria and nonreactive pupils. Fundoscopic examination revealed bilateral uveitis/choroiditis. Following MR images of brain and cervical spine demonstrated scattered foci of T2/FLAIR high signal abnormality in deep white matter, brain stem and cerebellar hemisphere with postcontrast enhancement and a distinctive subependymal and perivenous distribution suggestive of neurosarcoidosis, atypical lymphoma, Lyme disease, vasculitis or miliary tuberculosis. A multidisciplinary clinical approach ruled out infectious or rheumatologic etiologies, secondary central nervous system vasculitis, and disseminated lymphoma. Treatment with steroids was initiated for possible sarcoidosis with a good clinical response. However, upon discontinuation of therapy, the patient deteriorated and her symptoms recurred. A leptomeningeal and parenchymal biopsy showed small vessel variant cPACNS system.

**Conclusion**

Inflammatory central nervous system diseases in children comprise a wide spectrum of heterogeneous conditions, including primary angiitis of the central nervous system. Two subcategories of cPACNS include: angiography-positive cPACNS affecting large and medium-sized vessels, and angiography-negative cPACNS involving small-sized vessels, like the case we are presenting. These subcategories are different in clinical presentation, radiographic findings, prognosis, and treatment. The classic MRI findings in large and medium-sized vessels cPACNS are focal areas of acute ischemia in a vascular distribution. Conventional angiography and MR angiography demonstrates stenosis, tortuosity, beading, and occlusion of the proximal large and medium-sized vessels. Brain biopsy usually is not required due to the specificity of angiographic abnormalities in the pediatric population. Angiography-negative cPACNS, on the other hand, is a distinct clinical entity with different radiologic findings. MR imaging findings in angiography-negative cPACNS are typically multifocal and can involve both gray and white matter. Lesions are not restricted to the vascular territory of a large vessel. The paucity of diffusion restriction and presence of gadolinium enhancement suggest that lesions are inflammatory rather than ischemic. Leptomeningeal enhancement, if present, distinguishes cPACNS from demyelinating diseases. Conventional angiography is, by definition, negative in this subtype. The diagnosis of angiography-negative childhood primary angiitis of the central nervous system mandates an elective brain biopsy.

**Key Words:** Vasculitis, small vessel, CNS
Our preliminary data show that prospective studies are mandatory in order to validate our findings in larger controlled patient groups. Important noninvasive evaluation of critically perfused brain regions can be performed with high quality SWI together with DWI studies, by focusing on the venous drainage in acute cerebral ischemia.

**KEY WORDS:** Susceptibility-weighted imaging, stroke

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**ePoster 150**

**Pediatric Demyelinating Disease on Susceptibility-Weighted Imaging**

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**PURPOSE**
In adults with multiple sclerosis (MS), demyelinating lesions can be associated with hypointense signal on susceptibility-weighted imaging (SWI) (Haacke, et al, 2009). The purpose of this study was to assess the utility of SWI in identifying demyelinating lesions in the pediatric population and determine if the prevalence of SWI findings correlates with the type of disease (i.e., MS versus acute disseminated encephalomyelitis, ADEM), disability as measured by the Extended Disability Status Score (EDSS), or age.

**MATERIALS & METHODS**
Nine children were enrolled prospectively. Diagnosis was determined by a pediatric neurologist after 1 year of follow-up. The neurologist was blinded to the imaging results. Five patients had MS and four had ADEM. MR images were reviewed using standard clinical software. Susceptibility-weighted imaging, T1 pre and postcontrast, and FLAIR images were coregistered using a semiautomated technique. Size, location, and enhancement of each FLAIR hyperintense lesion were documented. Each FLAIR lesion also was assessed for its SWI characteristics.

**RESULTS**
Total FLAIR lesions identified ranged from five to 146, and the percentage of these lesions visible on SWI ranged from zero to 68 percent. When visible on SWI, the lesions appeared as amorphous hypointense lesions, linear hypointensities, or as a combination of these features (Figure). There was a trend (p = .06) between final diagnosis (i.e., MS versus acute disseminated encephalomyelitis, ADEM) and the percentage of lesions visible on SWI. The median percentage of lesions detected on SWI for those with MS was 22% and for those with ADEM was 8%. Both age (Spearman correlation = 0.78, p = .0007) and EDSS (Spearman correlation = 0.36, p = .028) were correlated with the percentage of lesions detected on SWI.

**CONCLUSION**
Susceptibility-weighted imaging can identify some demyelinating lesions in the pediatric population. The percentage of FLAIR lesions visible on SWI is correlated with age. Susceptibility-weighted imaging signal changes were present for all but one patient with MS, while only one of the patients with ADEM demonstrated significant findings on SWI. That particular ADEM patient was significantly older than the typical ADEM cohort. These findings suggest that SWI may offer additional information regarding the underlying pathophysiology of demyelinating diseases. A larger study is warranted to further evaluate its diagnostic and prognostic utility.

**KEY WORDS:** Multiple sclerosis, ADEM, susceptibility

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**ePoster 151**

**Early Delayed Effects of Brain Radiation on Lobar Gray and White Matter Volumes of Pediatric Patients with Correlative Neuropsychologic Deficits**

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**PURPOSE**
The aim of this longitudinal volumetric MR imaging (MRI) study was to evaluate changes in gray matter (GM) and white matter (WM) lobar volumes and neuropsychologic performance among children who received brain radiation, with the focus on early-delayed effects.
**Materials & Methods**

Thirteen pediatric patients who received brain radiation were examined at the initiation and 6 months after completion of radiation therapy. Control group consisted of 40 normally developing children. Lobar gray and white matter volumes were calculated from 3D-SPGR images acquired at 1.5 T. Linear mixed effects (LME) models analyses [with factors group, age at baseline (age0), visit number, and sex] were used to evaluate early delayed effects of radiation on lobar GM and WM volumes, controlling for total brain volume. All participants completed a neuropsychologic assessment at both visits, including measures of attention, executive function, memory, language, and visual and motor skills.

**Results**

The table lists results of the overall LME analyses (p values for main effects and their interactions). In controls, no differences in lobar GM or WM volumes between the baseline and follow-up visits were detected. Lobar GM volumes of patients measured at baseline were nonsignificantly higher compared to controls and increased at the 6-month follow up within the frontal (6%) and temporal (6%) lobes. Lobar WM volumes at baseline did not differ between patients and controls. In patients significantly decreased WM volumes were demonstrated in the frontal, temporal and occipital lobes at the 6-months follow up (p<0.05; mean frontal lobar volumes are shown in the Figure). Neuropsychologic testing demonstrated significant impairment on visual selective attention, verbal working memory, verbal recall, and motor speed in patients (p<0.001 compared with controls). Children receiving radiation treatment at younger ages had the most significant deficits (group x age: p≤0.001).

<table>
<thead>
<tr>
<th>Group</th>
<th>Age0</th>
<th>Visit</th>
<th>Group*Visit</th>
<th>Age0*Group</th>
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<tr>
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<tr>
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<td>NS</td>
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<tr>
<td>WM</td>
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<tr>
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</table>

**Conclusion**

The current study demonstrates significant reductions in lobar WM and increases in lobar GM volumes of pediatric patients 6 months following radiation therapy. These results are in agreement with previous studies showing that radiation induces predominantly WM loss and patients receiving radiation therapy initiated at younger ages have the most significant deficits. The unexpected finding of gray matter volume increase needs further investigation.

**Key Words:** MR imaging, radiation therapy, neuropsychologic testing

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**ePoster 152**

**MR Perfusion at 3.0 T in X-Linked Adrenoleukodystrophy Pre and Posthematopoietic Cell Transplantation: A Preliminary Study**

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**Purpose**

Dynamic susceptibility contrast MR perfusion (DSC-MRP) has become an important tool for diagnosis and understanding the physiology of cerebrovascular disease and neoplasms. To our knowledge, other than a preliminary meeting report, there is no literature utilizing MRP in posterior-type X-linked adrenoleukodystrophy (ALD). Thus, our goal was to determine MRP characteristics in ALD pre and posthematopoietic cell transplantation (HCT) in various regions of interest (ROIs), and to compare these values to controls.

**Materials & Methods**

After IRB approval, seven patients underwent DSC-MRP at 3.0 T <30 days pre-BMT and 30-60 days post-HCT. MR perfusion postprocessing was performed on a DynaSuite Neuro workstation (InVivo, Orlando, Florida). The pre/postcontrast MPRAGE T1-weighted imaging and FLAIR images were coregistered to the MRP maps, and the following ROIs were measured: the total affected white matter (TAWM), centrally within the parietooccipital white matter (POWM), callosal splenium (SplCC), leading edge (LE) of contrast enhancement, and normal-appearing white matter (NAWM). Similar measurements were performed in seven controls. Relative measurements of rCBV, rCBF, rMTT, rTTP, and rPH (peak height) were calculated from these ROIs in ALD patients and controls, and compared using t-tests. Similar MRP measurements were performed post-HCT and compared to pre-HCT measurements and controls.

**Results**

Normal-appearing white matter MRP values in ALD patients were not significantly different from NAWM in controls; within controls there was no significant difference between NAWM and either POWM or SplCC (all p>0.1). In ALD patients pre-HCT, rCBV was only minimally elevated in the TAWM and SplCC (mean 1.07-1.1), but was elevated significantly in the LE (mean 1.84), while being decreased in the POWM (mean 0.80); post-BMT, rCBV changed significantly only in the LE (mean 1.31, p<0.05). For rCBF, there were nearly normal values (near 1.00) in each ROI except for the LE (mean 1.75) pre-HCT; post-HCT, none of these ROIs changed significantly (all p>0.1). For rMTT and TTP, the ROIs were quite variable, but the LE had decreased mean rMTT (-0.63sec) and rTTP (-0.83sec) pre-HCT as compared to NAWM; these improved post-HCT (-0.16sec and 0.10sec, respectively). The LE rPH was much higher pre-HCT (mean 1.92) as compared to POWM, SplCC, and total AWM (all about 1.0); this decreased slightly post-HCT (mean 1.57).
CONCLUSION
This preliminary study demonstrates that MRP findings in ALD are dynamic, being most prominent in the LE, suggesting blood-brain barrier dysfunction. The LE abnormalities appear to lessen after HCT. In addition, the low rCBV centrally within POWM both pre- and post-HCT may reflect irreversible injury.

KEY WORDS: Adrenoleukodystrophy, MR perfusion, hematopoetic cell transplantation

ePoster 153
Vasogenic Edema Characterizes Acute Disseminated Encephalomyelitis in Children

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PURPOSE
The aim of this study was to analyze the localized neuroimaging findings in children with acute disseminated encephalomyelitis (ADEM) and to evaluate the apparent diffusion coefficient (ADC) values in the pathologic brain during the acute phase of the disease.

MATERIALS & METHODS
Seventeen patients with ADEM were identified retrospectively. Patients meeting the diagnostic criteria for ADEM proposed by the International Pediatric Multiple Sclerosis Study Group were included in this study. MR imaging was performed in all patients at disease onset. MR images were evaluated for character and pattern of lesions by two expert neuroradiologists by consensus. All patients had ADC maps and 11/17 patients underwent contrast-enhanced MRIs at presentation.

RESULTS
Seventy percent (12/17) patients presented with vasogenic edema as demonstrated by the ADC map. Cytotoxic edema was observed in only one patient, four patients showed no change on diffusion-weighted imaging. Three of 11 (27%) patients showed enhancement in a scattered punctate fashion. 41.1% of patients presented with gray matter lesions the most common location being the bilateral frontal cortex. 82.4% of patients presented with white matter lesion, bilateral frontal subcortical location being the most common (41%), followed by the bilateral temporal lobes (35%) and the bilateral parietal lobes (23%). 64.7% of patients (11/17) displayed brainstem involvement. Optic tracts were involved in 53% (9/17) of patients. Sixty-six percent of the optic tract involvement was unilateral. Forty-one percent of patients (7/17) showed basal ganglia lesions. Thirty-five percent (6/17) of patients had a thalamic lesion of which 83.3% were bilateral. Twenty-three percent of patients had a lesion in the hypothalamus. Some of the atypical locations were mammillary bodies (one patient) corticospinal tracts (three patients) and corpus callosum (two patients). No patient had gray matter involvement in the cerebellum. Vasogenic edema was observed more frequently in association with white matter lesions (76% of patients) compared to gray matter lesions (71% of patients). Seventy-three percent of lesions in all locations were bilateral in location. Only optic tract involvement was unilateral in 66% of the affected patients.

CONCLUSION
Our study supports the hypothesis that the main pathophysiologic mechanism in ADEM is vasogenic edema, thus explaining in part the reversibility of the lesions. Children with ADEM are classically known to have varied imaging findings. Our study shows that though no location is spared from this multifocal distribution, the brainstem is the most common location followed in order by bilateral frontal white matter, bilateral basal ganglia, unilateral optic tract, bilateral temporal white matter, bilateral thalami, bilateral basal ganglia, bilateral parietal white matter, bilateral optic tracts and bilateral frontal gray matter. Involvement of the optic tract is emphasized as its clinical relevance has yet to be studied. Extensive knowledge of peculiar neuroimaging findings in children with ADEM may help in determining the diagnosis and understanding the pathophysiology of the disease.

KEY WORDS: Acute disseminated encephalomyelitis, vasogenic edema, demyelinating lesion

ePoster 154
Chiari Malformation Correlates with Abnormal Cervical Spinal Canal Dimensions in Scoliotic Patients

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PURPOSE
The association between Chiari malformations and scoliosis is well established. Recent studies also have suggested abnormal cervical spinal canal tapering in patients with Chiari malformation. We tested the hypothesis that, in patients evaluated for treatment of scoliosis, spinal canal dimensions differ between patients with and patients without an associated Chiari malformation.
MATERIALS & METHODS
We reviewed a registry of patients with known scoliosis and sorted patients into three groups: those with a Chiari malformation and syrinx, those with only a Chiari, and those with scoliosis and no Chiari or syrinx. We measured the AP diameter of the upper cervical spinal canal (C1-C4) on sagittal T2-weighted MR images of patients in all three groups using the same methods employed in the previous studies of the cervical spine. We then calculated the taper ratio, defined as the amount of narrowing of the AP diameter per cervical spine level. We made the same measurements in selected age- and gender-matched patients with MR studies read as normal. The differences between groups were tested with mean and measure of variability.

RESULTS
The taper ratio for scoliotic patients with Chiari malformation and syrinx was 0.9 mm per level. The scoliotic patients without a Chiari or syrinx malformation had smaller taper ratios. The control group had a taper ratio of 0.5 mm per level. The taper ratios averaged 0.9 (+/- 0.8) mm/level in those with both Chiari and syrinx versus 0.5 (+/- 0.4) mm/level in controls.

CONCLUSION
Scoliotic patients with a Chiari malformation and syrinx have abnormal tapering of the upper cervical spinal canal. This finding adds additional support to the theory that the Chiari malformation is related to a mesodermal developmental disorder.

KEY WORDS: Chiari, scoliosis, syrinx

ePoster 155
Triangular Parietal Crossroads: Transient Structures of the Fetal Brain as Early Indicators of Cerebral Pathology

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PURPOSE
The integrity of transient structures of the fetal brain has been recognized as mandatory for normal fetal brain development. The so-called triangular crossroads have been described histologically as fiber-rich transient structures of the fetal brain with an abundant extracellular matrix content, situated lateral to the exit of the posterior limb of the internal capsule. Aim of this study was to characterize these structures on in vivo fetal MR images.

MATERIALS & METHODS
In vivo MRIs of 200 fetal brains between the 18th and 39th gestational week (GW) (median GW 27) were performed on a 1.5 T superconducting unit with a cardiac coil, using ultrafast T2-weighted, T1-weighted, diffusion-weighted sequences and diffusion tensor imaging in three orthogonal section-planes. Fetuses were divided in two groups: one with normal brain development (n=100), and the second with pathologic brain development (n=100). In addition to the routine screening for normal or pathologic brain development, in each fetus the area lateral to the exit of the posterior limb of the internal capsule also was assessed with respect to signal intensity, size and shape.

RESULTS
In fetuses with normal brain development we observed triangular-shaped areas with the basis of the triangle in the continuity of the posterior limb of the internal capsule, adjacent to the germinal matrix, and the tip oriented in the direction of the subplate. These zones appeared hyperintense to the subplate on T2-weighted images (Figure), and iso or hypointense on T1- and diffusion-weighted images. They developed and reached their maximum until GW 24, to fade eventually until the GW 28 and becoming isointense with the adjacent structures at latest by the GW 30. The axial extent of the structures did not exceed 0.3 cm2. In different pathologies, such as periventricular leukomalacia (n=6), metabolic diseases (n=1), or malformations (n=15) the triangles where larger as in normals, and/or showed CSF intensity, and/or persisted after the GW 28/30.

CONCLUSION
The transient MR features of the triangular crossroads may be explained with the high water content of the extracellular matrix, which gradually diminishes with ongoing cellular maturation, and thus then blurs with the surroundings. Increased signal-intensity/size or persistence probably reflects oxidative stress or impairment of fiber development in this region, due to a damage (or missing/incorrect formation) of the cells of origin. Normal triangular crossroads should not be misdiagnosed as ischemic lesions. Thus, this region seems to be an early indicator of the presence of cerebral pathology.

KEY WORDS: Crossroads, fetal MR imaging, cerebral pathology
Evolution of Brain MR Imaging Findings within the First Month after Coma Onset from Pediatric Cerebral Malaria


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PURPOSE
The pathogenesis of cerebral malaria (CM) remains elusive. Autopsy data have provided significant insights, but putative pathogenic mechanisms in survivors, who frequently suffer neurologic sequelae, are challenging to assess in malaria-endemic areas. An ongoing case series of brain MR images (MRIs) in pediatric CM reveals a complex heterogeneous set of findings at the time of admission to hospital. Here, we describe the evolution of brain MRI findings in the same patient population, describing findings on admission during the course of the acute illness, and 1 month later.

MATERIALS & METHODS
This prospective study was performed on consecutive children meeting the World Health Organization definition of CM (unarousable coma, asexual P. falciparum parasitemia and no other evident coma etiology) admitted to the Pediatric Research Ward at Queen Elizabeth Central Hospital in Blantyre, Malawi. During two consecutive high transmission malaria seasons (2009/2010), 152 children with CM were enrolled. 120 of whom had malaria retinopathy. Institutional approval was obtained and parental consent was required to participate. All children were imaged on a GE 0.35 T Signa Ovation magnet on the day of admission and daily thereafter until they awoke or died. Follow-up scans were assessed at 1-month postdischarge. The following pulse sequences were used in 2009: Sag T1 FLAIR, Ax T2 FRFSE, Ax T2 FLAIR, Ax GRE, Cor T2 FRFSE, Ax EPI-DWI b=900, Ax PD, and +C Ax T1 sequences; and in 2010: Sag T1 FLAIR, Ax T2 FRFSE, Ax T1, Cor T2 FRFSE, Ax GRE, EPI-DWI b=200, EPI-DWI b=900, Sag 3D SPGR T1, Ax GRE (TE = 8.0, 11.5, 27.5, 31.0 & 47.0 ms) and +C Ax T1 sequences. Two radiologists, blinded to the retinopathy status of the patients, interpreted the acute and subsequent MRI studies together, and recorded the consensus findings using a semiquantitative scoring system.

RESULTS
Twenty-seven of the 120 children with retinopathy positive CM had more than one scan during the acute illness. Of the 120 patients 104 survived and 65 were able to be scanned 1 month later. In patients who were admitted shortly after the onset of coma, increased T2 signal in the basal ganglia was evident initially, and DWI abnormalities in the same area emerged over time. In patients with edema and high T2/high DWI signal changes in various regions on admission, the MRI findings either resolved rapidly (within 2 days), in conjunction with clinical recovery, or increased in severity, often in association with a fatal outcome. In 21 cases, the second and subsequent scans showed increased T2 signal in the corpus callosum and white matter. Frequently, the evolution of concomitant high T2 cortical signal and swelling was noted. An atypical finding was that high DWI signal usually underwent rapid and complete resolution without associated radiographic residua. At 1 month, generalized atrophy and/or persistent high T2 white matter signal abnormality were seen in 46/65 survivors scanned.

CONCLUSION
In acute pediatric CM, brain MRI findings evolve rapidly. As early as 1 month chronic changes indicative of brain injury, including diffuse cerebral atrophy often are evident.

KEY WORDS: Cerebral malaria, subacute, brain
RESULTS
Of the 210 patients included in our study (115 boys and 95 girls), 82% (n=173) demonstrated an interparietal occipital fissure. The mean age of our study population was 32.8 days (d) (SD=27.5 d, range: 0-89 d) while the mean age of those with and without an interparietal fissure was 29.1 d (SD=25.8 d) and 50.4 d (SD=28.6 d), respectively. The mean cranio-caudal length of the fissure was 8.4 mm(SD=4.2 mm, range: 2.5-22.5 mm); all fissures measured between 1 and 2 mm in width. In those 22 patients who demonstrated an interparietal occipital fissure and who had a follow-up CT examination, only three patients over 90 days old (Max: 179 days) still demonstrated this finding (two had evidence of interval partial ossification). The mean age at the time of follow up was 252.2 d (SD=208.4 d, range: 19-679 d).

CONCLUSION
Evaluation of neonatal calvarial fractures is complicated by variant sutures, fissures, and accessory ossicles. The interparietal occipital fissure represents one such variant that can be mistaken for a fracture by CT. This fissure can be identified as a midline lucency approximately 1-2 mm wide and extending caudally from the junction of the sagittal and lambdoid sutures between the superior portions of the paired interparietal portions of the occipital bone. The fissure does not extend into the supraoccipital segment of the occipital bone or to the foramen magnum, contrary to midline occipital bone fractures. The fissure is present in the majority of neonates, but fully ossifies between 3 and 6 months of age. Knowledge of this normal developmental occipital bone anatomy is required to avoid misdiagnosis.

KEY WORDS: Occipital bone, calvarium, anatomy

ePoster 159
Open and Closed Neural Tube Defects: Posterior Fossa Measurements on Fetal MR Imaging
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PURPOSE
Differentiation between open and closed neural tube defects (ONTDs, CNTDs) on fetal MR imaging (MRI) is crucial due to differences in prognosis and counselling. This study aims to quantify posterior fossa abnormalities in dependency of the presence of ONTD or CNTD, and to provide further diagnostic and potentially prognostic parameters.

MATERIALS & METHODS
Orthogonal T2-weighted MR sequences, acquired during clinically indicated MR examinations (1.5 T) of fetuses without spinal dysraphism (n = 99; 17-39 GW), with ONTDs (n = 37; 19-34 GW) and CNTDs (n = 8; 19-32 GW), were used to measure the clivus-occiput angle (α) and the maximum transverse diameter of the posterior fossa (DMPF). For statistical comparison of fetuses with normal brain development with fetuses with spinal dysraphisms fetuses were age and sex matched.

RESULTS
In fetuses without NTDs a significant positive correlation between gestational age and α (r = .952; p<.001) as well as DMPF (r = .601; p<.001) was found. No significant sex-specific differences concerning α or DMPF were found. In fetuses without spinal dysraphism α was significantly different from fetuses with ONTDs (p<.001) but not with CNTDs (p = .327). α also was significantly different between fetuses with ONTDs and CNTDs (p = .029). Diameter of the posterior fossa of fetuses without spinal dysraphism was significantly different from DMPF of fetuses with ONTDs or CNTDs (both p<.001). Between fetuses with ONTDs and CNTDs no significant difference in DMPF was found (p = .618).

CONCLUSION
The morphology and size of the posterior fossa and especially the clivus-occiput angle (α) depends on the presence of an ONTD or CNTD. In contrast to a published ultrasound study α does not remain constant during pregnancy but in our study correlates positively with gestational age. The clivus-occiput angle more than the maximum transverse diameter of the fetal posterior fossa may allow to differentiate between ONTDs and CNTDs and may aid in the evaluation of postnatal prognosis.

KEY WORDS: Fetal MR imaging, neural tube defect, posterior fossa

ePoster 160
Diagnostic Accuracy of Fetal MR Imaging for Cerebellar Abnormalities
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PURPOSE
To determine the sensitivity and specificity of fetal MR imaging (MRI) for cerebellar abnormalities using postnatal MRI as gold standard.

MATERIALS & METHODS
We identified patients imaged by fetal MRI and postnatal MRI. Fetal MRIs included single shot-fast spin-echo T2-weighted imaging. Postnatal MRI technique varied. Fetal and postnatal MRIs were reviewed in a blinded manner by two pediatric neuroradiologists. Cases with compressed cerebellum (e.g., hydrocephalus) were excluded. Cerebellar hemispheres were scored as normal or abnormal. Abnormal categories included small, abnormal morphology, and abnormal signal. Fetal MRI scores were compared with postnatal MR scores. Using postnatal MRI as the gold standard, we calculated sensitivity and specificity and 95% binomial confidence intervals. Two-tailed Fisher’s exact test also was performed for each category, using a significance level of p<0.05.
RESULTS
A total of 98 fetal MR scans were compared against postnatal MRI. Mean GA at fetal MRI was 27.1 weeks (19.71 - 38.14 weeks). Age at postnatal MR ranged from 0 day - 4.7 years. Fourteen cases were excluded due to cerebellar compression or inability to evaluate the cerebellum. A total of 25 patients had a cerebellar abnormality on postnatal MRI, of which 16 were detected by fetal MRI. Mean GA for true positive cases and false negative cases was 27.6 weeks and 26 weeks, respectively. Overall sensitivity of fetal MRI for cerebellar abnormality was 64% (P=0.000, 95% binomial CI of 43%-82%) with 100% specificity (P=0.000, 95% binomial CI of 94-100%). Ten cases had small cerebellum on postnatal MRI; nine were detected by fetal MRI. There was one false positive case. Sensitivity of fetal MRI for small cerebellum was 90% (P=0.000, 95% binomial CI of 56-100%) with 99% specificity (P=0.000, 95% binomial CI of 93-100%). Twelve cases had abnormal morphology on postnatal MRI, and seven were detected by fetal MRI. There were no false positive cases. Abnormal morphology included dysplastic cerebellum, abnormal orientation of fissures and splayed hemispheres in Dandy Walker malformation, and polymicrogyria. Mean GA for cases detected by fetal MRI was 28.1 weeks, compared with 23.4 weeks for those not detected by fetal MRI. Sensitivity of fetal MRI for abnormal cerebellar morphology was 58% (P=0.000, 95% binomial CI of 28-85%) with 100% specificity (P=0.000, 95% binomial CI of 95-100%). Ten cases had abnormal T2 signal in the cerebellum on postnatal MRI, including calcification/hemorrhage, venous anomaly, and cerebellar cysts. Only three cases were detected by fetal MRI; there were no false positive cases. There was no difference in mean GA of false negative and true positive cases. Sensitivity of fetal MRI for cerebellar T2 signal abnormality was 30% (P=0.001, 95% binomial CI of 7-65%) with 100% specificity (P=0.001, 95% binomial CI of 95-100%).

CONCLUSION
The sensitivity and specificity of fetal MRI is good for overall cerebellar abnormalities. Fetal MRI has higher sensitivity for detecting small cerebellum, compared with abnormal cerebellar morphology and is poor for cerebellar signal abnormalities. Knowledge of the diagnostic accuracy of fetal MRI for cerebellar abnormalities is important in accurate counseling of patients who undergo fetal MRI.

KEY WORDS: Fetal MR imaging, cerebellum, diagnostic accuracy

ePoster 161
Nongated Isotropic 3D T2 Fast Recovery Fast Spin-Echo versus Cine Phase Contrast Imaging for Assessment of Cerebrospinal Fluid Flow

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PURPOSE
Nongated isotropic 3D T2 fast recovery fast spin-echo (FRFSE) is an alternative technique to cine phase contrast (PC) for cerebrospinal fluid (CSF) flow assessment. This study compares detection of CSF flow abnormalities in 3D T2 FRFSE versus PC and characterizes CSF dephasing patterns in normal patients (Figure 1) and patients with disordered CSF flow (Figure 2) on 3D T2 FRFSE.
MATERIALS & METHODS
Twelve patients referred for clinical CSF flow imaging underwent 3D T2 FRFSE and PC imaging (4 aqueductal stenosis, 1 posterior fossa cyst, 1 3rd ventriculostomy shunt, 1 normal pressure hydrocephalus, and 5 Chiari I malformations). Two senior neuroradiologists and two radiology residents assessed both sequences for CSF flow abnormalities (binary decision) and recorded CSF dephasing patterns on 3D T2 FRFSE. During product development of 3D T2 FRFSE, CSF dephasing was consistently visualized across the cerebral aqueduct, fourth ventricle, and foramen magnum. Therefore, any departure from this pattern was considered abnormal.

RESULTS
For all readers, CSF flow abnormalities were detected only on 3D T2 FRFSE images in five of five Chiari cases and two of four aqueductal stenosis cases. PC and 3D T2 FRFSE were concordant for the remainder of cases. In no cases did information from the PC imaging change the interpretation rendered by 3D T2 FRFSE. On 3D T2 FRFSE, Chiari I malformations tended to exhibit dramatically decreased preoperative CSF dephasing across the fourth ventricle, which improved postoperatively. Three-dimensional T2 FRFSE was more useful than PC imaging in the assessment of these patients.

CONCLUSION
Nongated 3D T2 FRFSE simultaneously provides high-resolution, reformattable anatomical images with highly sensitive and useful CSF flow information in 5 minutes (versus 15 minutes for PC). Our clinical protocol for CSF flow imaging has been modified based on the results of this study to include the nongated 3D T2 FRFSE sequence.

KEY WORDS: Cerebrospinal fluid flow, phase contrast imaging, obstructive hydrocephalus

ePoster 162


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PURPOSE
Cervical spine CT is a commonly ordered exam in children suffering cervical spine trauma. However, fractures of the cervical spine are an uncommon injury in children and it is unlikely that CT images will reveal ligamentous, soft tissue, and spinal cord injuries, which are more likely to occur. Although ionizing radiation is delivered to the patient, CT remains an exam favored by the emergency department (ED) and other clinicians due to the rapidity of the exam, eliminating the need for sedation that is required in many pediatric patients. The purpose of this study is to describe preliminary imaging findings and feasibility of diagnosing cervical spine injury using a “QUICK” cervical spine MR protocol instead of cervical spine CT, in nonsedated children suffering blunt trauma.

MATERIALS & METHODS
After IRB approval, single-shot T2 fat saturated, fast spin-echo(FSE) and short tau inversion recovery(STIR) images in sagittal and axial planes were added to standard cervical spine trauma protocols. Patients/parents were informed in writing that additional imaging sequences would be performed if the child could tolerate the examination without sedation or if sedation was not prolonged, and were given the option to opt out. Ten children aged 20 months-18 years with history of neck pain following trauma were examined. Six children were imaged while sedated without failure or prolonged sedation time; four children were examined without sedation. Images were reviewed by four blinded, board-certified physicians, three neuroradiologists and one pediatric neurosurgeon on a 3 point scale [1-non-diagnostic, 2-diagnostic for the presence or absence of injury, 3-excellent (equally diagnostic as standard MR sequences)] for diagnostic certainty, image quality, and artifacts. In order to determine feasibility of the QUICK cervical spine protocol, total imaging time, time of imaging sequence, motion artifacts, impact upon daily MR schedule (i.e., availability of add-on exam time, patient tolerance, and clinician acceptance of the examination were tabulated).

RESULTS
Imaging findings of traumatic injury included ligamentous, muscular, and bone marrow edema, spinal cord contusion and prevertebral space hemorrhage. QUICK MR sequences, diagnostic certainty and image quality scores were diagnostic, (mean 2.52 and 2.22), and between observers were not significantly different (p=>0.05). QUICK sequences require 2-2.5 minutes each; average time needed to perform the entire QUICK cervical spine MR protocol is 4-7 minutes. Given this short examination time, patient tolerance of the examination is excellent in that the exam may be performed without sedation even in young children without motion artifacts that reduce diagnostic confidence. Further, adding patients to a busy MR schedule causes minimal impact and clinician acceptance of the imaging results is excellent. Clinician acceptance of the examination results is excellent; cervical spine CT is no longer part of routine pediatric trauma cervical spine imaging.

CONCLUSION
Preliminary use of QUICK cervical spine MR exam protocol in children is diagnostic of the presence and absence of cervical spine injury, with excellent inter-reader agreement. QUICK cervical spine MR exam is feasible in nonsedated children as exam time is short, there is minimal effect upon the MR patient schedule, and clinical acceptance is excellent.

KEY WORDS: Cervical spine, trauma, QUICK MR protocol
ePoster 163

Steel-Jacketed Bullets: An Increasing Risk with MR Imaging?

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PURPOSE
The question of safely imaging a patient with a retained bullet remains unresolved. It is true that the majority of commercially manufactured bullets in the United States are composed of essentially nonferromagnetic materials, a lead core and copper jacket, and are relatively safe in mid to low field MR. However, with the rising cost of raw materials, as well as the sharp increase in demand for bullets worldwide due to the Afghan and Iraq wars, other less expensive manufacturing options are becoming common place. Manufacturers are increasingly manufacturing bullets composed of a lead core and a soft steel jacket. We report testing of a strongly magnetic bullet that is found in handgun cartridges of Russian origin that are readily available with online ordering. This particular bullet presents a commonplace risk for shooting victims who would otherwise benefit from MR imaging.

MATERIALS & METHODS
Web offerings for handgun ammunition were examined with attention to any with variations of conventional copper jackets. A Russian manufacturer, Wolf (Tula, Russia) offers cartridges in common calibers (9 mm, 40, and 45 cal) using a “bimetal” jacket, named as such because they incorporate both copper and steel in jacket. A 180 gr .40 caliber bullet was separated from its case using a kinetic bullet removal device and tested at the bore of a 1.5 T MR scanner (Siemens, Erlangen, Germany) for deflection.

RESULTS
The “bimetal” jacket bullet was found to be strongly magnetic with a deflection of 60 degrees (Figure 1). Using a flat file the jacket was abraded to demonstrate a thin copper cladding over the thick steel jacket.

CONCLUSION
While there appears to be some dialog regarding the safety of imaging patient with imbedded bullets in the literature, physicians and technologists who act as gatekeepers for MR access need to be aware of the availability of steel clad bullets in the marketplace. Because they usually are less expensive to manufacture than full copper-clad ammo, market pressures on the availability and cost of copper may increase demand for this ammunition unless legislation bans their importation and availability.

KEY WORDS: Ballistics, MR imaging safety

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ePoster 164

Findings of PET Using 18F-Fluorodeoxy Glucose and 11C-Methionine in Cases of Intramedullary Tumors of the Spinal Cord

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PURPOSE
Findings of positron emission tomography (PET) using 18F-fluorodeoxy glucose (18F-FDG) and 11C-methionine (11C-Met) in cases of intramedullary tumors of the spinal cord are presented.

MATERIALS & METHODS
Positron emission tomography-CT was performed in seven patients (three males, four females) with intramedullary tumors of the spinal cord. Mean age at time of imaging was 37.0 years (range, 12-56 years). Underlying pathology was ependymoma (n = 4), anaplastic astrocytoma (n = 1), hemangioblastoma (n = 1), and cavernous angioma (n = 1). Positron emission tomography-CT using both 18F-FDG and 11C-methionine was performed in six patients, and PET-CT using 18F-FDG alone was performed in one case of ependymoma. Maximum standardized uptake value (SUV) was measured for each tumor and compared.

RESULTS
Maximum standardized uptake value of 18F-FDG and 11C-methionine in the case of anaplastic astrocytoma were 7.4 and 2.7, respectively. However, SUVmax values for 18F-FDG and 11C-methionine were also relatively high in three of four ependymoma cases. SUVmax was low (2.0 and 1.4, respectively) in the case of hemangioblastoma. In the case of cavernous angioma, although SUVmax of 11C-methionine was low (1.8), SUVmax of 18F-FDG was relatively high (5.2).
using 18F-FDG alone was performed in one case of ependymoma. Maximum standardized uptake value (SUV) was measured for each tumor and compared.

**RESULTS**

Maximum standardized uptake value of 18F-FDG and 11C-methionine in the case of anaplastic astrocytoma were 7.4 and 2.7, respectively. However, SUVmax values for 18F-FDG and 11C-methionine were also relatively high in three of four ependymoma cases. SUVmax was low (2.0 and 1.4, respectively) in the case of hemangioblastoma. In the case of cavernous angioma, although SUVmax of 11C-methionine was low (1.8), SUVmax of 18F-FDG was relatively high (5.2).

**CONCLUSION**

In the diagnosis of intramedullary tumors of the spinal cord, the activity of 18F-FDG and 11C-methionine might be of great value. Both 18F-FDG and 11C-methionine are highly accumulated in anaplastic astrocytoma. However, care should be taken, as 18F-FDG and 11C-methionine may accumulate in ependymoma.

**KEY WORDS:** Spinal cord, neoplasm, PET

**ePoster 165**

**MEDLMEN: A Differential Diagnosis for Intradural, Extramedullary Spinal Masses**

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**PURPOSE**

To illustrate and review the differential diagnosis for intradural, extramedullary spinal masses and discuss the distinguishing imaging features and clinical presentations.

**MATERIALS & METHODS**

This exhibit is based on a retrospective search for intradural, extramedullary spinal masses identified on MR imaging. Images of the representative entities will be presented and distinguishing imaging features, diagnostic imaging pearls, patient demographics, and prognosis will be discussed.

**RESULTS**

Our population had a variety of intradural, extramedullary spinal masses including, but not limited to, metastases, epidermoid, dermoid, lymphoma, meningioma, ependymoma, and nerve sheath complex tumors. We developed the mnemonic medlMEN to help remember the differential diagnosis for intradural, extramedullary spinal masses with the last three entities being the most common.

**CONCLUSION**

Intradural, extramedullary spinal masses have a broad differential. The mnemonic medlMEN can help in remembering a location-based differential diagnosis that includes the majority of intradural, extramedullary pathologic processes. The differential diagnosis can be narrowed significantly by distinguishing these lesions by location, signal characteristics, and patient age.

**KEY WORDS:** Spinal mass, intradural, extramedullary

**ePoster 166**

**Evaluation of Spinal Cord Lesions in Patients with Multiple Sclerosis: Comparison of Different MR Imaging Sequences at 3 T Scanner**

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**PURPOSE**

The aim of this study is to demonstrate the initial results comparing the sensitivity of T1-weighted fluid-attenuated inversion recovery (FLAIR), fat suppressed proton density-(FS-PD) weighted, and fast spin-echo (FSE) T2-weighted MR sequences in the assessment of cervical multiple sclerosis plaques.

**MATERIALS & METHODS**

A retrospective analysis of patients with multiple sclerosis who presented to MRI unit for cervical cord involvement was undertaken. Patients had been examined on 3 T whole-body MR scanner (Achieva XT, Philips Medical Systems, Best, The Netherlands) equipped with explorer gradients (40 mT/m) by using a SENSE spine coil. For acquisition, an 8-element arrayed RF coil, with the 32-channel receiver system, was used. The protocol included sagittal T1-weighted FLAIR (TR/TE/IR 2000 ms/ 20 ms /800 ms), FS-PD (TR/TE/IR1600 ms/8 ms/ 800ms), and FSE T2-weighted (TR/TE/ 3300 ms/120 ms) MR sequences. Parameters for number of slices, matrix size (512 x 512) and slice thickness (3 mm) were identical for all sequences. Lesions also were confirmed on axial FSE T2-weighted (TR/TE/slice thickness 1000 ms/120 ms/4 mm) sequence. All sequences were compared by two independent observers for the presence of multiple sclerosis plaques.
RESULTS
Totally 35 plaques were found in all patients on MRI. Spinal multiple sclerosis lesions were best detected on FS-PD weighted images. The FS-PD, T1-weighted FLAIR, and FSE T2-weighted MR sequences detected 100%, 85% and 71% of all plaques respectively.

CONCLUSION
The initial results of our study show that FS-PD sequence is more effective than T1-weighted FLAIR, and FSE T2-weighted MR sequences and has increased sensitivity for the assessment of spinal multiple sclerosis lesions.

KEY WORDS: Multiple sclerosis, spinal cord, 3 T MR imaging

ePoster 167

Absence of Usual MR Findings with Spinal Dural Fistulas: Do All Patients with Symptoms Need Vascular Imaging?

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PURPOSE
Delayed diagnosis is common with spinal dural fistulas. MR imaging plays an important role in the evaluation of this diagnosis and is thought to be a sensitive screening study prior to spinal angiography. Findings on MR include intramedullary T2 prolongation, abnormal enhancement on the cord, and prominent veins on T2-weighted imaging. However, cord T2 prolongation by itself is a nonspecific finding and can be seen in a wide variety of common diseases. We present a small series of cases from our institution of patients with angiographically proved spinal dural arteriovenous fistulas who did not demonstrate abnormal flow voids or enhancement in the subarachnoid space. However, cord T2 prolongation by itself is a nonspecific finding and can be seen in a wide variety of common diseases. We present a small series of cases from our institution of patients with angiographically proved spinal dural arteriovenous fistulas who did not demonstrate abnormal flow voids or enhancement in the subarachnoid space. Abnormal vasculature, however, was subsequently demonstrated on MR angiography and then confirmed with conventional angiography.

RESULTS
All three patients were symptomatic and had cord T2 prolongation without vascular flow voids or enhancement in the subarachnoid space. Abnormal vasculature, however, was subsequently demonstrated on MR angiography and then confirmed with conventional angiography.

CONCLUSION
Our experience suggests that a symptomatic patient with only cord signal abnormalities on routine MR may still have a spinal dural arteriovenous fistula. In this circumstance, more sensitive studies such as MRA or DSA may be necessary to establish the diagnosis of spinal dural fistula.

KEY WORDS: Dural, arteriovenous fistula, spine

ePoster 168

Muscle Denervation in Upper Limb and Brachial Plexus Injuries: Our Experience in MR Imaging

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PURPOSE
To show our experience in MR imaging (MRI) in relation to denervatory upper limb injuries.

MATERIALS & METHODS
We evaluated nine patients with denervatory pathology of the upper limb using MRI, and studied the neuropathic changes in the affected musculature. These are expressed by modifications in signal intensity of the muscle image in relation to fat, fibrotic and/or edematous content.

RESULTS
We assessed two patients with brachial neuritis (Turner’s syndrome), who presented with edema in the supraspinatus or infraspinatus muscle planes. Other three patients presented with lower extremity weakness and paresthesias. All were evaluated consecutively by conventional MR imaging, MR angiography, and finally conventional angiography.

We identified three patients with angiographically proved spinal dural arteriovenous fistulas who did not have the typical MR imaging features of a spinal vascular malformation. All patients were male, ranging in age from 65 to 72 years, and presented with lower extremity weakness and paresthesias. All were evaluated consecutively by conventional MR imaging, MR angiography, and finally conventional angiography.

RESULTS
All three patients were symptomatic and had cord T2 prolongation without vascular flow voids or enhancement in the subarachnoid space. Abnormal vasculature, however, was subsequently demonstrated on MR angiography and then confirmed with conventional angiography.
fatty replacement and lower muscle volume in the affected limb, with pseudomeningocele formation in the emergence of the nerve root.

**CONCLUSION**
In our experience, MRI has proved to be very useful in identifying denervation patterns in the upper limb. In addition, MRI makes it possible to accurately evaluate the affected limb, with pseudomeningocele formation in the emergence of the nerve root.

**Key Words:** Upper limb, muscle denervation, MR imaging

ePoster 169

**Parametric Maps and Estimation of Therapy-Induced Changes of Spinal Bone Marrow an Imaging Biomarker for Metastases Diseases**

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**Purpose**
Dynamic contrast-enhanced MR imaging (MRI) offers non-invasive characterization of the vascular microenvironment and has not been investigated fully in bone marrow diseases. In oncology practice, current clinical evaluations based on conventional MRI for diagnosis and assessments of treatment response are markedly limited, often depend on changes in tumor size and present with nonspecific lesions. Measuring changes in tumor hemodynamics would give insight into tumor heterogeneity and the derived parametric maps provide pathophysiologic status of metastases. Evaluation of blood pool localization and exchange of contrast agent between vascular bed and interstitium on a voxel-wise basis are of significant prognostic value and for their predictive capability. We aimed to develop an imaging biomarker to facilitate the decision-making process and establish a robust technique to unravel the complexity of tumor vasculature that may aid in therapeutic management by employing the improved T1-weighted DCEMR algorithm.

**Materials & Methods**
Twenty-two spine bone marrow tumor patients aged 45-76 years (mean = 59 years) underwent MRI on 1.5 T GE scanner using 8-channel-CTL surface spinal coil. Lumbar spine study included axial T1-T2, and sagittal T1- T2, IR, DWI, followed by T1-weighted DCE and PCT1. Three DiSPGR-T1-weighted DCEMRI were obtained phases-35, TR/TE= 4-5/1-2s, SThick/FOV=35/36 mm with no-gap, FA-20, FOV=34-36 cm. We generated and evaluated spine bone marrow maps - blood volume and blood flow, uptake curve maps - up-slope and down-slope, enhancement maps - peak and relative map using in-house developed software. The perfusion indices, bone marrow blood volume (Figure a), baseT1 and postcontrast-T1 (Figures b and c). Analyzing tracer behavior on voxel to voxel basis, the effective change in T1 relaxation rate was determined by algorithm before converting MR signal intensities into bone marrow concentration time curve (BMTC). MR signal was modeled in terms of T1-weighted effects of Gd-DTPA and precontrast medium steady state residue K was optimized to BMTC.

**Results**
The generated maps visually appreciate distinct regions fulfilling characteristics of hyper-vasculature and its heterogeneity when compared to tumor, normal and normally radiated regions. The BV maps distinguished pathologic, osteoporotic fractures and offers insight into discrimination between normal marrow and pathologically replaced marrow and accurately characterizes lesions as hyper or hypovascular even with susceptibility artifact, indicate a potential utility with spinal compression fractures.

**Conclusion**
We propose that this robust noninvasive T1-weighted DCEMRI technique improves accuracy of perfusion metrics and enables visual appreciation that could characterize marrow heterogeneity and differentiate between different conditions that affect marrow pathophysiologically.

**Key Words:** Algorithm, DCE-MR, spine bone marrow

ePoster 170

**Prospects for Quantitative Imaging of Myelin with Ultrashort TE 3D Radial MR Imaging**

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**Purpose**
Myelin is a lipid-protein bilayer encaising axons, enhancing nerve conduction. Perturbation to the myelin membrane is the cause of most neurodegenerative disorders. Few alternatives to histology exist for the direct assessment of myelin. MR imaging relaxometry and diffusion methods can indirectly assess myelin; however, they only detect myelin-associated water. The short-T2* of protons in myelin constituents and dominant long-T2* signals in white matter (WM) previously prevented direct detection of myelin. Here, we examined the feasibility of MR to directly image myelin in extracts and excised rat spinal cords (SC). The spectroscop-
ic proton MR signal from myelin was first identified, then myelin protons were imaged with a dual-echo short-TI ultra-short-TE 3D radial sequence (de-STUTE).

**Materials & Methods**

Rat and bovine SCs were harvested from Sprague-Dawley rats and a local butcher. A sucrose gradient method was used to extract intact myelin membrane from SC. Bovine myelin extract was used to prepare a series of myelin/D$_2$O suspensions (113-378 mg/ml). All experiments were performed on a 9.4T vertical bore spectrometer/microimaging system. $^1$H NMR spectra were obtained for rat thoracic SC and myelin extract. Extract also was examined with high-resolution $^1$H, $^3$P and $^{13}$C NMR for identification of lipid components. Rat SC was imaged using 3D de-STUTE (128x128x128, FOV=20mm isotropic). A 5ms adiabatic inversion pulse and TI=500ms inversion time were used to selectively null long-T$_2^*$ signal. A series of 3D ramp-sampled UTE images then were acquired with TE=0.01 and 1.2ms. Magnitude subtraction of the long-TE images from the short-TE images suppressed residual long-T$_2^*$ signal.

**Results**

The SC and extract spectra share a broad, non-Lorentzian resonance (linewidth~1700Hz) whose center chemical shift is consistent with lipid methylene protons. High-resolution spectra of the extract were consistent with the known lipid constituents of myelin showing negligible contributions from proteins thereby strongly supporting the notion that the short-T$_2^*$ signal of SC predominantly consists of myelin lipids. Myelin proton T$_2^*$ was estimated as 0.1-0.2ms. Therefore, ramp-sampled UTE MRI should detect this signal with TE=0.01ms. Figure 1a shows the UTE image signal to be linearly related to myelin extract concentration. The center difference slice image from rat thoracic SC(Figure 1b) shows a signal void for the GM region, lending further support that the strong signal in the peripheral region pertaining to WM arises from myelin.

![Graph](image)

**Conclusion**

This work demonstrates the feasibility of direct quantitative imaging of myelin in situ, without the potential confounds of disease-induced alterations in myelin-associated water relaxation rates.

**Key Words:** Myelin imaging, UTE MR imaging

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**ePoster 171**

**Preliminary Report of Diffusion-Weighted MR Imaging and Apparent Diffusion Coefficient Mapping Evaluation in Patients with Infective Spondylodiskitis**

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**Purpose**

Early diagnosis and prompt initiation of adequate treatment are essential for clinical outcome in infective spondylodiskitis. Thus, MR techniques that could help in the accurate and early detection of infective spondylodiskitis, even diskitis are valuable. Diffusion-weighted imaging (DWI) is based on the random motion of water protons and is used successfully as an important diagnostic tool in the evaluation of different brain disorders. With its ability to detect altered water proton mobility, it also may be useful for the evaluation of spinal disorders including infection, inflammation, infarction, neoplasm, or degenerative changes, may disturb normal tissue architecture and cause ultimate shifting of water molecules between tissue compartments secondary to disruption of cellular structure and membranes permeability or both. We evaluated the patients with infective spondylodiskitis or diskitis with DWI using apparent diffusion coefficient (ADC) analysis to enhance early detection.

**Materials & Methods**

A retrospective analysis was performed of patients who were diagnosed with infective spondylodiskitis/diskitis and had undergone DWI. Regions of interest were drawn in the affected intervertebral disks for ADC calculation. Care was taken to avoid inclusion of vertebral bodies in any region of interest. Apparent diffusion coefficient values were measured and compared with healthy controls and degenerative disk disease groups.

**Results**

The infected disks showed hyperintense signal change on DWI and lower ADC values in comparison with the normal-appearing disks, but higher ADC values in comparison with the degenerative disks.

**Conclusion**

Our preliminary results suggest that the detection and quantification of ADC abnormalities is a supplementary tool to conventional MR imaging. It is hoped that infective spondylodiskitis will be recognized earlier, and appropriate management instituted in a timely fashion.

**Key Words:** Diffusion-weighted MR imaging, apparent diffusion coefficient mapping, infective spondylodiskitis
Clinical Significance of Repeat Vertebroplasty for Recurrent Pain at Cemented Vertebra with Fluid Sign

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PURPOSE
The aims of this study were to determine the association between recurrent pain and fluid sign following percutaneous vertebroplasty (PV) and to assess the clinical significance of retreatment for cemented vertebrae with fluid sign.

MATERIALS & METHODS
Institutional review board approval and informed consent were obtained for this study. Five hundred forty-five patients (478 women, 42 men; mean age, 78.5 years; range, 58-96 years) and 1214 vertebral bodies were treated from January 2008 to December 2009. All patients underwent preoperative magnetic resonance imaging (MRI) with contrast enhancement and computed tomography (CT). Almost all patients showed good response after initial PV. Sixty-one patients developed recurrent pain following successful PV within a year. Of them, 57 revealed subsequent fracture in the adjacent or distant vertebra from the treated vertebra. Another four patients who complained of recurrent pain demonstrated only fluid sign at the bone-cement interface without obvious compression fracture.

RESULTS
In all four of these patients, large cavity formation (cleft) in the vertebral body was noted and there was destruction of posterior wall of the vertebra in preoperative MRI and CT. Definite mismatch was noted in fluid cleft size on STIR images and ill-enhanced area around the enhanced area of fat-suppressed contrast-enhanced images on preoperative MRI. These mismatch areas were considered to be necrotic debris which was thought to be responsible for development of fluid in the treated vertebra.

CONCLUSION
Fluid sign in the treated body represents unhealed bone-cement interface and cement instability. The existence of a large cleft (vacuum or fluid filled) in the treated vertebrae and destruction of vertebral posterior wall may be important factors influencing instability of injected cement.

KEY WORDS: Vertebroplasty, retreatment, fluid sign

Prediction of Vacuum Phenomenon in Vertebral Compression Fractures: Dynamic Contrast-Enhanced MR Imaging Study

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PURPOSE
The nonhealing cleft may be responsible for persistent pain and progressive vertebral collapse after acute injury. If localized kyphosis increased, there is risk of neuropathy appearing as a complication. Even after receiving vertebroplasty, it was reported to be at increased risk for subsequent cemented vertebral refraeture and new adjacent vertebral fractures. Dynamic contrast-enhanced magnetic resonance imaging (DCE-MRI) has been used for the evaluation of bone marrow perfusion. However, there are few reports on the evaluation of osteoporotic VCF and intraosseous cleft formation. We investigate the relationship between intraosseous clefts and bone marrow perfusion using DCE-MRI in patients with osteoporotic VCF before vertebroplasty.

MATERIALS & METHODS
Forty subjects referred for evaluation of VCF underwent DCE-MRI. Bone marrow perfusion, as measured using the DCE-MRI time-intensity curve from a noninjured vertebrae was developed using two distinct parameters including peak enhancement ratio (PER) and enhancement slope. The ratios of the well and the poorly enhanced zone of each injured vertebra were calculated. Multiple logistic regression analysis was used to evaluate the relationships between baseline clinical factors, parameters of DCE-MRI and presence or absence of intraosseous clefts.

RESULTS
Twenty-nine injured vertebrae (72%) had intraosseous clefts. Lower PER of the noninjured vertebrae was associated with higher poorly enhanced zone ratio of the injured vertebra (γ = -0.362, p = 0.017). Multivariate logistic regression analysis identified only lower PER (hazard ratio, 0.000; 95% confidence interval, 0.000-0.096; p = 0.009) was associated with the presence of intraosseous clefts. A PER value less than 0.57 had a sensitivity of 80% and specificity of 90% for predicting intraosseous clefts (Figure 1).
CONCLUSION
In patients with osteoporotic VCF before vertebroplasty, decreased bone marrow perfusion, as measured by DCE-MRI, was associated with intraosseous cleft formation.

KEY WORDS: DCE-MRI imaging, vacuum phenomenon, vertebral compression fractures

**ePoster 174**

Prevention of Epidural Fibrosis with Free Fat Graft or Gelfoam Implant in Spinal Surgeries and Prediction of their Outcome by MR Imaging

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PURPOSE
A prospective study to investigate the effect of free fat graft and Gelfoam placed in the laminectomy defect to prevent epidural fibrosis and predict their outcome by magnetic resonance imaging (MRI).

MATERIALS & METHODS
Fifty consecutive patients underwent posterior decompressive lumbar surgeries and were investigated with free fat graft (n = 29) and Gelfoam (n = 21) placed to cover laminectomy defect and follow up by MRI in 3, 6, 12 months interval for laminectomy membrane formation and the fate of the implants. The size and quality of the grafted fat were accessed on midsagittal T1-weighted MR images with and without gadolinium contrast enhancement. Axial images were used to assess arachnoditis and epidural fibrosis.

RESULTS
Four fat autotransplants (14%) were totally degraded with fibrosis and epidural scar. MR imaging demonstrated with an early enhanced fat graft partially or completely at the third month. Twenty-five fat grafts (86%) survived but demonstrated volume reduction in variable degree at the twelfth month. Survived grafts show both degradation and incorporation of adipose tissue to the recipient laminectomy defect.

Higher percentage of arachnoditis (29%) and laminectomy membrane with epidural fibrosis (38%) were noted in Gelfoam group.

CONCLUSION
MR imaging is a useful tool in the investigation of the fate of free fat graft autotransplantation but also the effect of epidural fibrosis prevention of these implants. The remodeling phenomenon (shrinkage and re-expansion) of free fat graft is not observed in this study but adipose tissue incorporation in the recipient laminectomy defect although volume reduction and degradation are inevitable. The size of fat graft does not have a direct relationship to its viability but an early contrast enhancement of the graft in the first 3 months may herald a failure. Free fat graft autotransplantation is more effective in reducing complications of arachnoditis or laminectomy membrane formation compare to Gelfoam or nothing in large laminectomy defects producing from lumbar surgery.

KEY WORDS: Arachnoiditis, grafts, intervention

**ePoster 175**

Role of Diffusion Tensor Imaging in the Evaluation of Cervical Myelopathy

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PURPOSE
Diffusion tensor imaging (DTI) and fiber tracking (FT) have been used for delineating the white matter tracts in the spinal cord. These MR imaging (MRI) techniques may well be used for detecting and delineating spinal pathology not otherwise noted with conventional imaging methods. In our current study, we present our data from applying DTI and FT in patients undergoing surgical decompression for cervical myelopathy.

MATERIALS & METHODS
In our prospective clinical study, we included 19 patients with cervical myelopathy and 10 controls. All patients underwent MRI examination and sagittal and axial T2-weighted imaging as well as DTI. The values of apparent diffusion coefficient (ADC) and fractional anisotropy were measured and fiber tractography was performed.

RESULTS
For healthy controls, the mean ADC and FA values at the cervical spinal cord were ADC 1.07e-09 (sd 3.22e-10), and FA 0.679e -09 (sd 0.09) at the C4-5 level. In patients with myelopathy, the mean ADC values were 0.589e-10 (sd 0.27)
and the mean FA value 0.423e-10 (sd 0.05). In patients with severe stenosis there was distortion of the spinal cord tracts at the levels of stenosis, therefore values were obtained above and below the level of stenosis.

CONCLUSION
The values of ADC and FA in patients with cervical spondylosis may be of great importance in identifying in a timely fashion early cervical myelopathy and possibly predict outcome of surgical therapy.

KEY WORDS: Cervical, myelopathy, DTI

ePoster 176
Sacroiliac Joints Vacuum Phenomenon: CT Diagnosis and Significance
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PURPOSE
Vacuum phenomenon is found commonly in sacroiliac joints, and the literature suggests it may be a source of back pain. We investigated 1) the prevalence of sacroiliac joints vacuum phenomenon (SJVP), 2) the rate at which it is reported on abdominopelvic and lumbosacral spine computed tomography (CT) images, and 3) the literature supporting its relationship with symptomatic back pain.

MATERIALS & METHODS
CT images of the pelvis and lumbar spine from January to February 2009 were reviewed retrospectively. Six hundred and fifty-two patients were studied during this period. Axial thin section images were reviewed under default lung and bone window setting. The age, sex, symptoms and radiologist reports were assessed from the electronic medical record (EMR).

RESULTS
The prevalence of SJVP on CT imaging was 34%, with higher rates found in female patients (41%, p < 0.001) and the older age group (39%, p < 0.05). Eight-five per cent of the SJVP were present bilaterally. Among the 223 patients with SJVP, only 17% were reported. There were no statistically significant differences between reporting rates for body radiologists and neuroradiologists. Back pain was more frequent (p < 0.05) in patients with SJVP (9%) than without SJVP (5%). The difference in prevalence of SJVP in patients with back pain (49%) and patients without back pain (33%) was statistically significant (p < 0.05).

CONCLUSION
Sacroiliac joints vacuum phenomenon is a prevalent condition with higher rates among older and female individuals. The phenomenon is underreported on CT images and is a potential area where a practice quality improvement (PQI) initiative could be implemented. Although our sample was biased and patient histories were incomplete, we found a statistically significant difference in the prevalence of SJVP between patients with and without back pain. The medical literature on the subject suggests this finding may be worth reporting until further clarification of its significance with a larger scale prospective study.

KEY WORDS: Vacuum phenomenon, sacroiliac joint, computed tomography

ePoster 177
Flexion and Extension MR Imaging of the Functional Cervical Spinal Unit after Cervical Arthroplasty
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PURPOSE
Conventional radiographs after cervical arthroplasty allow the assessment of the osseous structures, the implant and signs of instability but not of the disks and nerve roots. The purpose of this study was to assess the feasibility of flexion-extension MR imaging (MRI) of the cervical spine after cervical arthroplasty at 3 T.

MATERIALS & METHODS
Ten subjects (mean age 55 ± 11 years, 3 female) with clinical indications for cervical arthroplasty and proved nerve root compression were examined before and after cervical arthroplasty. All examinations were performed on an open-bore 3 T MRI (Verio, Siemens, Germany). Supine position was used for neutral position imaging. Extension and flexion were maintained by cushions. Sagittal 3D T2-weighted sequences were acquired for each position. Range of motion (ROM) for the entire spine and each spinal unit was calculated. Nerve root and cord compression in the different positions were evaluated. MR examinations were compared with conventional radiographs.

RESULTS
Mean range of motion was 24 ± 4.3 degrees. The nerve roots and cord could be identified in all subjects before and after surgery. Increased nerve root compression in extension compared to neutral position was observed in seven patients and in one patient in flexion. Spinal cord compression was observed in two patients in extension. There was a significant correlation for ROM between MRI and plain radiographs.

CONCLUSION
Open-bore 3 T MRI scanners allow true flexion-extension imaging of the cervical functional spinal unit after cervical arthroplasty with excellent correlation to conventional radiographs. It demonstrates the functional aspect of degenerative spinal disease.

KEY WORDS: Functional MR imaging, cervical spine, arthroplasty
Digital Subtraction Myelography in the Evaluation of Cerebrospinal Fluid Leaks: Preliminary Results in 20 Patients with Spontaneous Intracranial Hypotension

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PURPOSE
Review our technique and experience in performing digital subtraction myelography (DSM) and present our preliminary results with the use of DSM in the evaluation of cerebrospinal fluid (CSF) leaks in patients with diagnosis of spontaneous intracranial hypotension (SIH).

MATERIALS & METHODS
We retrospectively reviewed 20 consecutive patients who underwent DSM for the evaluation of CSF leaks at our institution from 11/09 to 11/10. All patients had clinical symptoms compatible with SIH as well as epidural fluid collections which were identified on either MR myelogram or CT myelogram. We analyze and present our technical success rate, leak identification rate and postprocedural complications.

RESULTS
The procedure demonstrates high technical feasibility. The majority of the patients underwent DSM under conscious sedation and a small fraction of the patients had the procedure performed under general anesthesia. The diagnostic accuracy of the exam is highly dependent on the image quality and the patient’s ability to maintain suspended respiration. There were no major complications. The rate of minor complications approaches 20% and included headaches, muscle spasms and short-lasting seizures.

CONCLUSION
Digital subtraction myelography is a minimally invasive technique that has the potential of accurately identifying the level of CSF leak in patients with persistent SIH symptoms in which a leak has not been identified by other imaging modalities. Potential complications can be decreased with adequate patient selection and preprocedural planning.

KEY WORDS: Myelography, leak, digital
Notes
Isolated Cortical Vein Thrombosis Associated with Intracranial Hypotension following Epidural Anesthesia

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PURPOSE
Isolated cortical vein thrombosis is a rare complication of intracranial hypotension. Although this has been reported recently in the anesthesia and neurologic literature, it has not been described in the radiologic literature to our knowledge. We will present an instructive scientific exhibit of the CT and MR manifeststions of isolated cortical vein thrombosis in the setting of intracranial hypotension with a review of the literature of this rarely reported entity. A discussion of the proposed pathophysiology for isolated cortical vein thrombosis also will be provided.

APPROACH/METHODS
A 23-year-old G1P1 female presented to the emergency department with severe postural headaches and complex partial seizures on day 4 postpartum. She was previously healthy, with a recent uncomplicated pregnancy and uneventful vaginal delivery, at which time epidural anesthesia was administered. No clinical findings of inadvertent dural puncture were noted at the time of the epidural anesthesia. Initial head CT demonstrated a right subdural collection of mixed density with acute subdural hematoma superficially and a low density collection deep, likely reflecting a subdural hygroma along the brain surface. Small focal areas of hyperdense blood were present along a parasagittal location in the superior parietal region. Brain MR did not demonstrate underlying brain edema. Corresponding to the hyperdensities on CT, susceptibility changes on gradient images involving cortical veins at the parasagittal location in the parietal area were considered highly suspicious for thrombosed cortical veins. CT venography confirmed the isolated cortical vein thrombosis without sagittal sinus thrombosis.

FINDINGS/DISCUSSION
Inadvertent dural puncture during epidural anesthesia is a rare occurrence. If it does occur, intracranial hypotension may result with characteristic imaging findings on brain MR which have been well described in the radiologic literature. Isolated cortical vein thrombosis without sagittal sinus thrombosis secondary to intracranial hypotension has been described only recently in the anesthesia and neurologic literature, but has not been reported in the radiologic literature to our knowledge. It is believed that venodilation of the cortical veins may occur as a result of the intracranial hypotension. This can result in venostasis, which can lead to subsequent development of thrombosis of the cortical veins. The veins that are most susceptible are in the parasagittal location, as they bridge the cerebrospinal fluid (CSF) to join the superior sagittal sinus, consistent with the findings in our case. It is postulated that subdural hygromas in the setting of intracranial hypotension may result from leakage of interstitial fluid from dilated cortical veins. This may progress to the development of subdural hematomas, as in the patient presented in this exhibit. The patient eventually developed venous infarction in the territory of one of the thrombosed cortical veins.

SUMMARY/CONCLUSION
This scientific exhibit has demonstrated the imaging findings of isolated cortical vein thrombosis in the setting of intracranial hypotension on unenhanced head CT, brain MR, and CT venography. These findings have not been described previously in the radiology literature. Based on this exhibit, it is critical that the radiologist carefully scrutinize not only the dural venous sinuses, but also the cortical veins.

KEY WORDS: Cortical vein thrombosis, epidural anesthesia, intracranial hypotension
Scientific Exhibit 002

Review of Advanced Brain MR Imaging Technique Findings in Multiple Sclerosis

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PURPOSE

Multiple sclerosis (MS) is a prevalent chronic disease of the central nervous system, characterized by inflammatory changes as well as neurodegeneration and results in progressive accumulation of areas of myelin and axonal loss. Multiple sclerosis is the most common neurologic disease in young adults and its socioeconomic burden is second only to trauma in this age group. Conventional MR imaging of the brain and spinal cord is used routinely in the evaluation of MS patients but its ability to predict patient outcomes remains modest at best. A number of advanced MR techniques such as magnetic resonance spectroscopy (MRS), diffusion tensor imaging (DTI) as well as magnetization transfer (MT) have been investigated in the context of MS. These techniques can provide significant metabolic and microstructural information, are thought to provide better insight to pathophysiologic mechanisms and therefore can potentially better predict patient outcomes. In this exhibit we will review and illustrate MRS, DTI and MT findings in MS patients. We also will provide a critical review of the available literature regarding the use of these techniques in the context of MS.

APPROACH/METHODS

Our exhibit will provide examples of metabolic alterations in the brain of MS patients as assessed by MRS. We also will provide examples of alterations in DTI and MT parameters in the brain of MS patients. Our examples will include patients with relapsing remitting MS, secondary progressive and primary progressive MS. We will illustrate advanced MR imaging findings in enhancing lesions, chronic lesions and normal appearing white matter. We also will perform a critical review of the literature and provide a summary of available findings regarding the use of each technique in the different MS subtypes in both the cross-sectional as well as the longitudinal setting.

FINDINGS/DISCUSSION

Examples of alterations in different metabolites in the brain parenchyma of MS patients will be provided. For example we will provide examples of reduced N-acetyl-aspartate (NAA) in chronic MS lesions and elevated Choline (Cho)/Creatine (Cr) levels in enhancing lesions as well as normal appearing white matter. Our exhibit also will include a summary of reported MRS findings in the different subtypes of MS in both cross-sectional and longitudinal studies. We also will show examples of alterations in DTI and MT parameters in the brain of MS patients such as reduced fractional anisotropy (FA) and reduced magnetization transfer ratios (MTR) in high T2 lesions. Overview of available cross-sectional and longitudinal study findings focusing on DTI/MTR parameters in different subtypes of MS and correlation with clinical course also will be provided.

SUMMARY/CONCLUSION

Ability of conventional MRI to predict patient outcomes/disability in MS patients is limited. In an effort to define more accurate disease biomarkers, significant research efforts have focused on advanced MR imaging techniques which can provide more detailed evaluation of brain microstructure and metabolism. Our exhibit will provide an overview of reported MRS, DTI and MT findings in different subtypes of MS with examples drawn from our clinical and research experience.

KEY WORDS: Multiple sclerosis, MR imaging

Scientific Exhibit 003

Imaging of Dementia: Neurodegenerative Diseases

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PURPOSE

Until recent years, the role of brain imaging in dementia has been limited, excluding underlying reversible causes. Unfortunately, many of these patients go undiagnosed for years as their initial clinical presentation is subtle. With new advances, we can utilize both anatomical and functional imaging to distinguish among the different subtypes of dementia and identify early disease patterns. With an enhanced knowledge of various subtypes, the radiologist can better assist clinicians in identifying early cases and providing disease-specific therapy.

APPROACH/METHODS

We present chief imaging characteristics of several different types of neurodegenerative diseases leading to dementia: Alzheimer disease (AD), Parkinson’s disease, Lewy body disease, frontotemporal dementia, and a group of other less common causes of dementia.

FINDINGS/DISCUSSION

In addition to characteristic clinical symptomatology, the presence of key imaging features can help distinguish and aid in diagnosis of a particular neurodegenerative disease. These distinguishing features include patterns of atrophy; regional involvement; alterations in signal intensities on MR imaging highlighting involvement of a selective group of neurons; and deficits noted on functional imaging. For instance Alzheimer disease is favored by atrophy of the temporal lobe, hippocampus, and amygdala; increased size of the hippocampal-choroidal fissure; and hypometabolism/hyperperfusion in the posterior parietotemporal lobes. On the other hand, Creutzfeldt-Jacob disease is characterized by rapidly progressive atrophy with signal abnormalities noted in the region of basal ganglia, thalami, cortical gray matter (often involving frontal and temporal lobes), and periaqueductal gray matter. Corresponding regional hypoperfusion and hypometabolism also can be present on SPECT and PET imaging. Interestingly, new technologies such as volumetric imaging potentially can dis-
tinguish patients with mild cognitive deficit (at risk for AD) from normal elderly patients, allowing for prompt initiation of treatment.

SUMMARY/CONCLUSION
With continued advances in imaging and our understanding of early disease patterns in patients with dementia, the referring clinician is increasingly reliant on imaging to guide their clinical decisions. By understanding the important distinguishing imaging features of the various subtypes, the radiologist can better tailor their report to offer the most relevant information to the referring clinician.

KEY WORDS: Dementia, neurodegenerative, Alzheimer disease

Scientific Exhibit 004
Role of MR Spectroscopy as a Diagnostic Aid in Lateralizing Mesial Temporal Lobe Epilepsy
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PURPOSE
Magnetic resonance imaging (MRI) is pivotal in defining the presence of a structural epileptogenic lesion that may co-exist with the site of seizure onset. One of the most common causes of refractory temporal lobe epilepsy is hippocampal sclerosis (HS). While conventional MR sequences can reveal most cases of such pathology based upon visual inspection of volume, altered signal and internal structural definition, some cases remain subtle or reported “nonlesional”, and may necessitate added invasive investigations prior to epilepsy surgery. MR spectroscopy (MRS) and T2 relaxometry can be useful adjunctive MR investigations. Problematic cases also can include amygdalar enlargement (AG) which shows show iso- to slightly hyperintense T2/FLAIR signal without enhancement. Identifying a lesion using additional diagnostic tests such as MRS is crucial for patient prognosis since temporal lobe surgery carries a more favorable outcome than nonlesional epilepsy.

APPROACH/METHODS
We describe a cohort of selected mesial TLE patients to illustrate the application and value of MRS as an adjunctive tool during the noninvasive, presurgical investigation of patients with refractory temporal lobe epilepsy. Single-voxel (TE35 and/or 135) was used to interrogate the amygdala and hippocampal formations, alongside conventional anatomical imaging. With HS, NAA/(Cho + Cr) was considered the most useful parameter and NAA/(Cho + Cr) < 0.71 was considered pathologic of HS with an asymmetry index (AI) > 11%. For patients with bilateral reduced NAA/(Cho + Cr), the required AI was halved to > 5.5% to lateralize an epileptogenic focus. In patients with isolated AG enlargement, asymmetric increased myoinositol/Cr was assessed as a marker of nonspecific gliosis.

FINDINGS/DISCUSSION
N-acetyl aspartate (NAA) is a marker for neuronal and axonal integrity. N-acetyl aspartate levels decline in pathologies that result in neuronal damage or loss. Myoinositol is absent in neurons and is considered a marker for gliosis and reactive astrocytosis. In normal nonepilepsy patients, the hippocampi and amygdala have symmetric anatomical and biochemical features. In HS, there is a progressive decreased NAA/(Cho + Cr) ratio as hippocampal injury worsens, as depicted by signal change and eventual atrophy. In cases of apparent normality on structural MR imaging, MRS can reveal more subtle, but relevant asymmetric metabolic changes that correlate with the suspected epileptogenic lesion. In the enlarged AG, asymmetrically increased myoinositol added to lateralization of the epileptogenic focus. Epileptiform discharges were present in the anterior temporal region ipsilateral to the imaging abnormalities in all patients.

SUMMARY/CONCLUSION
MR spectroscopy can play an important diagnostic investigatory presurgical role in selected cases of mesial TLE. MR spectroscopy can help to more confidently lateralize the epileptogenic lesion in refractory mesial TLE patients clinically suspected to have HS or amygdaloid gliosis but who may have subtle or nonlesional anatomical MR exams.

KEY WORDS: MR spectroscopy, temporal lobe epilepsy

Scientific Exhibit 005
Unusual Neuroimaging Presentations in Patients with Epilepsy: Neuroimaging-Clinical Mismatches
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PURPOSE
MR imaging of the brain plays a key role in the evaluation of anatomical abnormalities involved in epilepsy, but localization of seizure activity can sometimes be difficult, complicated by mismatches between neuroimaging and clinical evaluation. In this study, cases in which seizure focus localization was complicated by mismatches between neuroimaging findings and clinical evaluations were analyzed.

APPROACH/METHODS
Patients with epilepsy and abnormal correlations between neuroimaging and clinical findings (n = 31) were selected retrospectively from a large clinical epilepsy database. All patients had complete neurologic and electrophysiologic examinations, including spot EEG evaluation followed by long-term EEG monitoring or subdural grids. Neuroimaging was performed with conventional MR imaging (MRI) including high-resolution acquisitions, spectroscopy and fMRI. Brain scanning was performed within 36 hours of seizure activity, and images subsequently were evaluated for any structural or metabolic abnormalities. Neuroimaging findings were compared to clinical information, EEG, and
subdural electrodes findings. Diagnoses were confirmed with electrophysiologic, neurosurgical, and available neuropathology results.

**Findings/Discussion**

Neuroimaging-clinical mismatches were demonstrated in cases with 1) structural lesions on MRI (large contralateral lesions), 2) undetectable structural lesions on MRI (seizure focus evaluated on pathology), 3) PET abnormalities (distant foci), 4) spectroscopic abnormalities (contralateral or distant metabolite changes) and 5) nondiagnostic intracranial functional localizations by EEG, subdural electrodes, intraoperative stimulation and WADA. Pathology included mesial temporal sclerosis, neoplasms, encephalitis, hamartias, paraneoplastic syndrome, post-traumatic lesions, stroke and seizure edema. Potential etiologies of mismatches included coexisting pathology, neuroimaging accuracy and timing, unmasking of foci, and metabolic, developmental or physiologic abnormalities.

**Summary/Conclusion**

Neuroimaging findings sometimes can differ significantly from clinical parameters in epilepsy. Careful evaluation and correlation of relevant neuroimaging and clinical characteristics is important to establish accurate seizure focus localization. Further studies, including additional neuroimaging and follow-up scans also may be useful for further evaluation.

**Key Words:** Epilepsy, mismatch

**Scientific Exhibit 006**

**Integrated Presurgical Mapping of Differential Motor Cortical Reorganization: Impact on Surgical Decision Making**

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**Purpose**

To illustrate the critical impact of integrated functional MR imaging (fMRI) and diffusion tensor imaging (DTI) presurgical mapping on surgical decision making, in patients with motor cortical reorganization.

**Approach/Methods**

Five patients with clinical evidence for significant recovery or cortical reorganization after motor system injury were mapped with fMRI and DTI, to determine surgical candidacy and the surgical strategy. All patients suffered unilateral corticospinal and/or corticobulbar motor deficits, complete or near complete recovery of the cortico-bulbar motor functions, and significant recovery of upper and/or lower extremity motor functions. Four patients had persistent spastic hemiparesis of an upper or lower extremity. Surgery was contemplated for resection of recurrent grade II astrocytoma (1 patient), resection of residual AVM nidus (1 patient), and resection of gliotic scar inducing uncontrolled extratemporal epilepsy (1 patient with history of AVM and 2 patients with history of in utero MCA stroke).

**Findings/Discussion**

In each of the five cases, the integrated information derived from both fMRI and DTI was critical in surgical decision-making (Table 1). In two epilepsy cases, hemispherectomy was contemplated to treat uncontrolled seizures. In one of these cases, fMRI indicated significant residual corticospinal motor function in the involved hemisphere and proximity of encephalomalacia to motor white matter, resulting in a decision not to perform hemispherectomy. In a second epilepsy patient, fMRI indicated homotopic motor cortical reorganization of all residual motor functions and hypertrophic motor white matter tracts in the opposite hemisphere, leading to the decision to pursue the work up for hemispherectomy. In a third epilepsy patient with gliotic scar, lower extremity motor activation patterns suggested possible homotopic and nearby ipsilateral heterotopic cortical reorganization and proximity of the gliotic lesion to motor white matter. This led to the decision not to resect the paracentral lobule as contemplated, but to pursue further functional testing with magnetic encephalography (MEG). A patient with recurrent grade II astrocytoma showed significant residual corticospinal motor activity within the involved hemisphere and proximity of recurrence to residual motor white matter, causing the decision to treat with radiation therapy rather than surgery. In the fifth patient, a residual AVN nidus was shown to be present within residual motor white matter in a hemisphere where significant corticospinal motor function was preserved. This resulted in the decision to treat the residual AVM nidus with radiosurgery rather than surgical resection.

**Table 1**

<table>
<thead>
<tr>
<th>Case</th>
<th>Disease</th>
<th>Motor cortical activity</th>
<th>Hemispheric reorganization</th>
<th>WM proximity to lesion</th>
<th>Impact on surgical strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Epilepsy (mesial gliosis)</td>
<td>CS</td>
<td>CS</td>
<td>-</td>
<td>Undetermined heterotopia</td>
</tr>
<tr>
<td>2.</td>
<td>Epilepsy (mesial gliosis)</td>
<td>-</td>
<td>CS</td>
<td>WM</td>
<td>Undetermined heterotopia</td>
</tr>
<tr>
<td>3.</td>
<td>Epilepsy (AVM, resection gliosis)</td>
<td>CB, CS</td>
<td>CS</td>
<td>-</td>
<td>Surgery for posthemisphere focal injury</td>
</tr>
<tr>
<td>4.</td>
<td>Grade IV Astrocytoma</td>
<td>CS</td>
<td>CS</td>
<td>-</td>
<td>Radiation therapy for extratemporal surgery</td>
</tr>
<tr>
<td>5.</td>
<td>Residual AVM</td>
<td>CS</td>
<td>CS</td>
<td>-</td>
<td>Radiation therapy for extratemporal surgery</td>
</tr>
</tbody>
</table>

CS = Corticospinal M1 cortex; CB = Corticobulbar M1 cortex; IOF = Intraoperative functional testing; WM = motor white matter.

**Summary/Conclusion**

The integrated use of both fMRI and DTI is critical in the preoperative assessment of patients with motor recovery and cortical reorganization, and can significantly impact surgical decision-making.

**Key Words:** Motor cortical reorganization, DTI, fMRI
Scientific Exhibit 007

Creutzfeldt-Jacob Disease Revisited: Value of MR Spectroscopy and Diffusion Tensor Imaging

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PURPOSE
Creutzfeldt-Jacob disease (CJD) is a rare spongiform encephalopathy with a fatal prognosis. Since clinical presentation and laboratory findings are not conclusive biopsy and even autopsy used to be needed for the final diagnosis. Recently, reliable ante mortem diagnosis has been possible due to advances in MR imaging, like diffusion-weighted imaging (DWI). However, the value of functional imaging techniques, like MR spectroscopy (MRS) and diffusion tensor imaging (DTI), in the diagnosis of CJD remains to be elucidated. In this exhibit we review the classic imaging features of CJD and report our experience with MRS and DTI in patients with CJD.

APPROACH/METHODS
Patients with biopsy- or autopsy-proved CJD were selected from our PACS system. Evaluation of the MR imaging exams with special attention to the DWI, DTI and MRS sequences was performed. MR spectroscopy and DTI of healthy individuals were used as controls.

FINDINGS/DISCUSSION
The classical imaging features of CJD on T2-weighted imaging, FLAIR and DWI sequences will be reviewed and illustrated. We will present and discuss the findings on MRS and DTI in these patients with comparison to the results in normal subjects.

SUMMARY/CONCLUSION
In patients with CJD abnormalities are found on MRS and DTI, which accurately reflect the pathologic areas on the routine sequences. MR spectroscopy and DTI might be valuable tools in the early detection of CJD.

KEY WORDS: Creutzfeldt-Jacob disease, functional imaging

Scientific Exhibit 008

Imaging Features of Central Nervous System Tuberculosis: Pictorial Review of Its Different Patterns and Chronological Change

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Ulsan, KOREA, REPUBLIC OF

PURPOSE
Tuberculosis can affect virtually any organ system of the body. Brain involvement is one of the common manifestations of tuberculosis and if left untreated can have devastating sequelae. The purpose of this study was to illustrate various central nervous system (CNS) manifestations of tuberculosis seen on computerized tomography (CT) and magnetic resonance imaging (MRI).

APPROACH/METHODS
We retrospectively reviewed data of 18 patients with intracranial tuberculosis between January 2004 and November 2010 in our hospital (Ulsan University Hospital). These consisted of 12 women and six men with a mean age of 40 years (17-73 years). MR imaging was performed on all patients.

FINDINGS/DISCUSSION
In a total of 18 patients, seven had meningitis, 11 patients were found to have tuberculomas which also included three who had accompanying meningitis. Vasculitis resulting in small infarcts was seen in three patients. Hydrocephalus was seen in three patients and choroid plexus tuberculosis (choroid plexitis) was seen in two. Two patients who have tuberculomas on initial MR imaging showed meningitis and one patient who showed meningitis initially showed tuberculomas during follow up. Three patients also have meningeal enhancement or tuberculomas in the spinal cord.

SUMMARY/CONCLUSION
MR imaging has a significant role in the differential diagnosis of the CNS tuberculous infection. Intracranial tuberculosis can have various presentations such as meningitis, tuberculomas or both of them. Possibility of accompanying meningitis or tuberculomas during follow up and rare manifestation such as choroid plexitis and spinal cord involvement should also be kept in mind.

KEY WORDS: Tuberculosis, CT, MR imaging

Scientific Exhibit 009

Pseudoprogression and Pseudoresponse: The Utility of Advanced Imaging MR Techniques: A Primer for the Neuroradiologist

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PURPOSE
Recent use of chemotherapeutic agents in addition to radiation and surgery in the treatment of glioblastoma multiforme has led to camouflageing of true tumor activity which is described as pseudoprogression and pseudoresponse. This has created uncertainty in evaluating the success of treatment and appropriate incorporation of patients into clinical trials. In addition to conventional MR imaging, several advanced imaging techniques such as MR perfusion, mass spectroscopy, diffusion-weighted imaging, fractional anisotropy, and PET have been used to study the effect of temozolomide, the gliadel wafer, and avastin on imaging with respect to true tumor activity. We will describe the current assessment of these imaging techniques and the images themselves.

APPROACH/METHODS
We will 1) review the current literature regarding postchemotherapy findings of pseudoprogression with respect to temozolomide and the gliadel wafer and also pseudoresponse with respect to avastin, 2) describe/demonstrate respective MR and PET findings of pseudoresponse
and pseudoprogression, 3) differentiate the utility of the various imaging modalities in determining pseudo changes from true tumor activity, 4) discuss modifying factors such as MGMT genetic status and changes in assessment using the new RANO criteria.

**Findings/Discussion**
Temozolomide and the implanted gliadel wafer have shown increased progression-free survival (PFS) and overall survival but also have yielded contradictory increase in contrast enhancement on conventional MR imaging without increased tumor activity (known as pseudoprogression). Methylated MGMT promoter status has been shown to influence the augmented effectiveness of temozolomide on PFS and pseudoprogression. Avastin, an antiangiogenic agent, has led to improved quality of life with concurrent decreased contrast enhancement without increased length of survival (known as pseudoresponse). Various MR techniques and PET have been able to characterize findings with respect to pseudoprogression and pseudoresponse and might be helpful in differentiating pseudo from true status. The new RANO criteria also adjust for shortcomings of the MacDonald criteria such as evaluation of irregularly shaped, multifocal, immeasurable, and nonenhancing lesions.

**Summary/Conclusion**
Pseudoprogression is the incongruent increase in tumor size and enhancement with conventional MR imaging after concurrent plus adjuvant chemoradiotherapy in regards to improved prognosis via progression-free survival and overall survival. Pseudoresponse is the decrease in size and enhancement after antiangiogenic therapy with improved symptoms and quality of life but without increase in length of survival. Advanced MR and PET may be useful in differentiating pseudo findings from true progression and/or response.

**Key Words:** Brain tumor, pseudoprogression, pseudoresponse

**Scientific Exhibit 010**
**Diffusion-Weighted Imaging in Detection of Extra-Axial and Extracranial Metastatic Disease**
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**Purpose**
To demonstrate the utility of diffusion-weighted imaging (DWI) in detecting extra-axial and extracranial metastatic disease on MR imaging (MRI) brain studies.

**Approach/Methods**
MR imaging brain examinations of patients in our institution with a known primary malignancy were reviewed. All patients underwent MRI brain as per standard departmental protocol which includes axial diffusion-weighted imaging (DWI) with corresponding axial ADC map and postcontrast T1-weighted imaging in three planes. The MRI brain studies were reviewed by a board-certified neuroradiology fellow with 6 months neuroradiology experience and a board-certified neuroradiology attending with 7 years neuroradiology experience. The studies were read specifically looking for the presence of extra-axial and extracranial disease which was positive on diffusion-weighted imaging. The locations and characteristics of these lesions including whether or not these were visible on non-DWI sequences was recorded. Correlation was made with other imaging modalities such as bone scan or PET imaging and pathology where available.

**Findings/Discussion**
Multiple extra-axial and extracranial lesions were identified which were positive on DWI. Of these the most common were skull vault metastases. Dural metastatic disease, adenopathy, parotid and lacrimal gland infiltration and other osseous metastases including mandibular metastases also were identified and were more conspicuous on DWI. Leptomeningeal metastases involving the cranial nerves also were evidenced by increased conspicuity of cranial nerves on the DWI sequence. Diffusion-weighted imaging is well established in the detection of ischemia and more recently has been used to help characterize intracranial neoplasm on the basis of increased cellularity. Similarly extra-axial and extra-cranial malignant disease may be detected and characterized on DWI.

**Summary/Conclusion**
Diffusion-weighted imaging is useful and complementary to routine MRI brain imaging in the detection of extra-axial and extra-cranial metastatic disease in patients with known primary neoplasm who are undergoing MRI brain imaging. This fast simple sequence effectively increases the conspicuity of extracranial and extra-axial lesions, often a relative blind spot on MRI brain imaging, and increases the radiologists’ confidence in characterizing these lesions.

**Key Words:** Extra-axial, diffusion-weighted imaging, metastases

**Arterial Spin Labeling of Brain Tumors: Differentiation between Hemangioblastoma and Metastatic Tumors Based on Quantitative Analysis**
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Fukuoka, JAPAN

**Purpose**
Hemangioblastoma and metastatic tumors are the major differential diagnoses for the posterior fossa tumors in adults. Their discrimination is essential for the therapeutic decision. Arterial spin labeling (ASL) is a noninvasively quantifiable method for blood flow measurement and has been reported to be useful in differentiating high- and low-grade gliomas. Our purpose was to evaluate the efficacy of ASL in differentiating hemangioblastomas from metastatic tumors.
APPROACH/METHODS
A total 16 patients including five with a hemangioblastoma (mean 44.6 years) and 11 with a pathologically proved metastatic tumor (mean 62.8 years; five from lung cancer, three from breast cancer, one from renal cell carcinoma, one from gastric cancer and one from unknown origin) were enrolled in this study. Arterial spin labeling was performed using a pulsed ASL method at a 3 T unit. From the ASL data, maps of absolute blood flow were calculated. An absolute tumor blood flow (aTBF) was measured as a mean blood flow value within a region-of-interest drawn in the tumor. In addition, a relative tumor blood flow (rTBF) was obtained by normalizing the aTBF by a blood flow measured in the normal appearing cortical gray matter in the contralateral hemisphere. The aTBF and rTBF values were compared between hemangioblastomas and metastatic tumors.

FINDINGS/DISCUSSION
Both the aTBF and rTBF values were significantly higher in hemangioblastomas (mean aTBF±SD=437±274 mL/100g/min, mean rTBF±SD=9.98±4.72) in comparison with metastatic tumors (mean aTBF±SD=146±146 mL/100g/min, mean rTBF±SD=.33±2.31) (p<0.05). For both indices, the two groups were clearly separable with only an exceptional case of a metastasis from renal cell carcinoma that showed very high aTBF (559 mL/100g/min) and rTBF (8.83).

SUMMARY/CONCLUSION
Our results demonstrated that ASL provides useful information to differentiate between hemangioblastomas and metastatic tumors. Metastasis from renal cell carcinoma may mimic hemangioblastoma on ASL blood flow measurement.

KEY WORDS: Arterial spin labeling, hemangioblastoma, metastatic tumor

Scientific Exhibit 012
Is Demyelination a Sentinel Sign of Primary Central Nervous System Lymphoma?: A Retrospective Review with Pathologic Correlation

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1Hospital Son Espases, Mallorca, SPAIN, 2Hospital Nuestra Señora del Rosario, Madrid, SPAIN

PURPOSE
Primary cerebral lymphoma (PCNSL) is a challenging neuroradiologic diagnosis increasing in prevalence. We have encountered several cases with large areas of demyelination. Presentation and imaging findings are protean.

APPROACH/METHODS
Large areas of demyelination on MR imaging (MRI) of patients with PCNSL have drawn our attention. A retrospective review of all pathologic proved cerebral lymphomas from two different medical centers from the last 8 years was undertaken. Twenty-two cases were analyzed, all were diffuse large B cell lymphomas. In nine cases prominent areas of demyelination/vasogenic edema were present.

FINDINGS/DISCUSSION
Clinical presentation, evolution and imaging studies (CT, MRI, DSA, MRS and other) were reviewed. In seven of nine cases with demyelination on MRI there was histologic evidence of demyelination with rarefaction of white matter, myelin loss, gliosis and partial axonal loss. MR spectroscopy was obtained in five patients, two with areas of demyelination. Ages ranged from 40 to 79 years. Lesions were frequently multifocal on MRI. Not all lesions enhanced. In some cases episodes of clinical worsening occurred with vascular involvement. In two cases prolonged survival (over 6 months after diagnosis) was documented. Radiologic leukoencephalopathy and histologic evidence of demyelination are more common in lymphomas expressing BCL2 and BCL6.
Primary central nervous system lymphoma not always presents as a hyperattenuated white matter lesion with enhancement. Large areas of demyelination are present in many cases, sometimes preceding enhancing tumor.

**Key Words**: Lymphoma

**Scientific Exhibit 013**

**New Response Assessment in Neuro-Oncology Criteria for Brain Tumors: A Primer for the Neuroradiologist**

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**Purpose**
The introduction of new chemotherapeutics drugs has invariably resulted in new MR imaging findings. In 2010, new response criteria for brain tumors addressing these findings emerged while the old MacDonald criteria became progressively obsolete. Therefore, we seek to introduce the new Response Assessment in Neuro-Oncology (RANO) criteria, published already in the neuro-oncology field, into the neuroradiologic realm and discuss, illustrate, and compare the previous MacDonald criteria to these new criteria.

**Approach/Methods**
We will 1) review the MacDonald Response Criteria for Malignant Gliomas, 2) discuss/radiographically demonstrate the limitations of MacDonald Criteria - such as pseudoprogression/pseudoresponse/radiation effects/treatment effects - and overcoming these limitations, 3) discuss/radiographically demonstrate the new Response Assessment in Neuro-Oncology (RANO) criteria, and 4) discuss the future direction of brain tumor response criteria as well as the role of volumetric/advanced MRI/PET. Sample cases will be used to illustrate criteria and compare the two criteria.

**Findings/Discussion**
The new RANO criteria take into consideration the new imaging findings which have surfaced due to post-treatment changes and thus ensure standardization in clinical trials. The RANO criteria use FLAIR [in addition to contrast enhancement (CE)] to determine tumor response. As such, an increase in FLAIR signal in presence of stable CE during Avastin therapy reflects progressive disease. Tumor volume, advanced MRI techniques and PET, although not part of RANO/Macdonald criteria, might be helpful to differentiate post-tx changes, pseudoprogression/pseudoresponse from true tumor response/progression.

**Summary/Conclusion**
The RANO criteria account for the different imaging findings seen post-treatment and thus ensure accurate standardization in clinical trials as well as provide guidelines for consistent and accurate diagnosis of progressive versus nonprogressive disease.

**Key Words**: Brain tumor, response criteria, CNS neoplasm
Scientific Exhibit 014

Incidental Findings in Brain and Spine Imaging

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PURPOSE
Incidental findings or “incidentalomas” are defined best as previously undetected abnormalities of potential clinical relevance that are unexpectedly discovered and are unrelated to the original purpose of the study (1). The availability and widespread use of cross-sectional imaging as well as the quality of imaging technology including computed tomography (CT) and magnetic resonance imaging (MRI) in both clinical practice and research has led to the widespread detection of incidental findings. The challenge for radiologists is to not only identify such findings but also to determine whether they are clinically significant. All clinicians are faced with balancing the consequences of cost, patient anxiety, and possible downstream morbidity in working up findings that have a high likelihood of being inconsequential. However, a small percentage of such findings may require urgent medical attention (2, 3). Failure to identify findings of potential clinical significance can have adverse effects for patients as well as potential medicolegal consequences for practitioners. Moreover, when such lesions are detected incidentally, their clinical significance may be uncertain because they often are not imaged with a protocol optimized for their characterization. Attentiveness toward incidental findings also has become increasingly relevant with advent and widespread use of PACS systems, which has increased the number of reported findings as well as the number of recommended and completed follow-up studies. While some groups have suggested classification schemes for management of incidental findings (4), standard follow-up protocols currently are not established. In this exhibit, we demonstrate a range of incidental findings incidentally detected on cross-sectional imaging studies of the brain and spine.

APPROACH/METHODS
We retrospectively searched the imaging database at the NYU-Langone Medical Center for brain and spine cross-sectional imaging studies that contained incidental findings.

FINDINGS/DISCUSSION
Illustrative incidental findings are depicted and discussed, including a range of relatively benign lesions to lesions that warrant immediate clinical attention. Also discussed is the appropriate follow up of intermediate severity or incompletely characterized lesions. “Blind spots” are highlighted on spine and brain imaging studies to avoid missing such lesions entirely.

SUMMARY/CONCLUSION
For the neuroradiologist reading cross-sectional imaging studies of the spine or brain, vigilance for incidental lesions outside the region of clinical interest is critical, as their discovery and documentation may significantly impact patient outcome.

REFERENCES
3. Katzman G.L., Dagher AP, Patronas, NJ. Incidental findings on brain magnetic resonance imaging from 1,000 asymptomatic volunteers. JAMA 1999:281;36-39

Key Words: Incidental findings, incidentaloma

Scientific Exhibit 015

Diffusion Tensor Tractography of Olfactory Pathways

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PURPOSE
To evaluate the application of diffusion tensor imaging (DTI) to visualize the olfactory pathways, and define these tracts with respect to both anatomy and function. Diffusion tensor imaging can be used to trace fiber tracts and connect the olfactory nerves to the olfactory tracts, thalamus and cortex. This can be useful to further evaluate patients with olfactory dysfunction.

APPROACH/METHODS
Cases included normal subjects, patients with orbitofrontal lesions including head trauma, meningioma, sarcoid, anosmia (congenital), and postneurosurgical procedures. All subjects were evaluated with a standard MR imaging (MRI) protocol, including high-resolution images on a 1.5 T system. Diffusion tensor images were acquired using 25 gradient directions. Diffusion tensor images were produced using seeding of regions of interest (ROIs) to evaluate tracts extending from the olfactory bulbs to multiple brain regions, including primary, secondary and tertiary projections. Functional MRI (fMRI) of olfactory stimulation was performed to superimpose regions of activation on fiber tractography.

FINDINGS/DISCUSSION
Diffusion tensor imaging demonstrated olfactory pathways that extended from the olfactory nerves, bulbs and tracts, to the amygdala, thalamus, orbitofrontal cortex and other cortical projections, and connections across the anterior commissure. Tractography and fractional anisotropy maps demonstrated the structural connectivity properties of the olfactory pathways. Functional MRI regions of activation demonstrated functional connections to the fiber tracts. Patients with postneurosurgical procedures had absent connections from the orbitofrontal regions to secondary pathways in the brain. Other cases showed connections but of variable degree of deformity or connectivity.
**Summary/Conclusion**
Diffusion tensor imaging can be used to visualize olfactory pathways from the olfactory nerves, bulbs and tracts to the amygdala, thalamus, and cortical regions. This is the first functional demonstration of the human olfactory pathway system in the evaluation of olfactory pathophysiology.

**Key Words:** Olfaction, DT imaging

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**Scientific Exhibit 016**

**Flow-Related Artifacts in MR Imaging and MR Angiography of the Central Nervous System**

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Philadelphia, PA

**Purpose**
With MR imaging (MRI) now a mainstay of neuroradiology, it is crucial for the neuroradiologist to be familiar with MR technique in order to optimize studies to various patient needs and to be able to interpret the MR study confidently. Inclusive of this is the ability to recognize and understand the myriad of MR artifacts which can obscure anatomy and can be confused with pathology. The purpose of this review exhibit is to present the most relevant flow-related MR and MR angiography (MRA) artifacts in a concise form, including: ghosting, flow-related enhancement, slow flow, signal loss from intravoxel dephasing and motion, as well as 2D and 3D time of flight (TOF) artifacts such as suppression of flow in subclavian steal and recirculation flow in the carotid bulb.

**Approach/Methods**
Various flow-related MRI and MRA artifacts are collected and displayed with sample images and a discussion of each to include mechanism responsible for their formation, their presentation within an image, as well as their significance. In addition, methods to rectify different artifacts and strategies to try and avoid them also are discussed.

**Findings/Discussion**
Vascular and cerebrospinal fluid (CSF) flow can create artifacts of various degrees due to the change in location of excited and/or unexcited hydrogen protons. Ghosting artifact is a replication of a "mobile" structure in the phase direction due to spatial misregistration that results from rhythmic motion. Paradoxical or flow-related enhancement can be seen on the first or last image of a sequence due to signal from unsaturated protons moving into the interrogated field. Intermediate signal often arises in an area of slow flow and may be misinterpreted as thrombus or tumor. Artifacts on 2D TOF imaging are common and may be caused by susceptibility artifacts, shine through, and reversed flow in loops and subclavian steal. "Venetian blind" artifacts occur in 3D TOF imaging secondary loss of flow-related enhancement as protons traverse the MOTSA volume and can be minimized by modifying the flip angle of the acquisition throughout the acquisition.

**Summary/Conclusion**
This exhibit will provide a concise, image-based demonstration and discussion of common flow-related artifacts that may occur on MR exams on a daily basis. Knowledge of the mechanism, appearance, and correction of these artifacts is essential for the accurate analysis of MR and MRA of the central nervous system.

**Key Words:** Artifacts, flow artifacts, MR imaging/MR angiography

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**Scientific Exhibit 017**

**Structural and Functional Characteristics of Patients with Phantosmia and Congenital Hyposmia**

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**Purpose**
To study the structural and functional central nervous system (CNS) characteristics of patients with phantosmia and congenital hyposmia. Although most of these patients have loss of smell, the relative degree and role of structural abnormalities in these patients is not known.

**Approach/Methods**
Subjects were identified by extensive olfactory testing and all had proved smell loss. Clinical presentation included either phantosmia (n = 10, ages 32.0 ± 11.6 years, mean ± SD) or congenital etiology (Type 2 with no defined genetic abnormalities) (n = 29, ages 28.0 ± 16.7 years). All cases were evaluated with a standard MR imaging (MRI) protocol, including high-resolution coronal images. Images then were evaluated for any structural abnormalities in the orbitofrontal cortex, olfactory bulbs and temporal lobes.

**Findings/Discussion**
Patients with phantosmia generally had normal bulbs but mild bilateral hippocampal malrotations across all ages. Patients with congenital hyposmia usually had decreased size of olfactory bulbs and olfactory grooves, with abnormal orbitofrontal sulcation. Consistent anatomical deformities in the latter group included abnormal hippocampal sizes and shapes. The degree and laterality of these hippocampal mal-
forms correlated directly with structural changes involving olfactory bulbs and orbitofrontal sulcation, and was greater and more frequent in patients less than 18 years old.

Summary/Conclusion
The structural and functional abnormalities in the brains of patients with phantosmia often involve mild hippocampal abnormalities, whereas the abnormalities in the brains of patients with congenital hyposmia are more severe and generalized. These results indicate that olfactory dysfunction mechanisms in congenital hyposmia involve different degrees of severity in different brain regions, whereas in phantosmia there are milder but more localized structural brain changes.

Key Words: Olfaction, hyposmia

Scientific Exhibit 018
Cerebral Amyloid Angiopathy Mimicking Brain Glioma
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Purpose
Cerebral amyloid angiopathy (CAA) is a neurologic condition affecting elderly patients in which β-amyloid protein is abnormally deposited within cerebral blood vessel walls, with subsequent compromise in the integrity of the vessels leading to asymptomatic brain parenchymal microhemorrhages and occasionally hemorrhagic stroke. There have been a few prior reports of mass-like abnormalities associated with CAA. In this report, we present six additional biopsy proved cases of cerebral amyloid angiopathy with imaging appearance similar to that of glioma to help elucidate the imaging findings and natural history of the tumefactive variant of this process.

Approach/Methods
IRB approval was obtained for this retrospective review. We identified six patients (3 male, 3 female; age range 62-77 years) presenting to our tertiary care institution with imaging findings of tumefactive mass interpreted as high-grade glioma but subsequently proved to represent CAA.

Findings/Discussion
All six cases demonstrated infiltrative mass lesions involving white matter greater than gray matter. Enhancement ranged from none, to mild leptomeningeal, to avid leptomeningeal enhancement with no parenchymal enhancement in any case. In three cases susceptibility-weighted imaging (SWI) was performed demonstrating microhemorrhages. In these cases amyloid angiopathy was included in the differential preoperatively and surgical biopsy included both white matter and cortex/leptomeninges allowing pathologic diagnosis of amyloid angiopathy. Cerebral amyloid angiopathy was not suspected initially in three of our cases because of lack of susceptibility-weighted imaging. In these cases nondiagnostic biopsies were obtained initially as only white matter was included in the specimen. In two cases characteristic microhemorrhages were identified only retrospectively on conventional T2-weighted sequences. In the final case fast spin-echo T2 images did not demonstrate microhemorrhage. All six patients responded to administration of steroids with marked reduction or complete resolution of white matter signal abnormality on subsequent MR imaging.

Summary/Conclusion
This report confirms existence of a tumefactive variant of CAA. Findings in this case series suggest that in an elderly population, SWI/GRE imaging should be part of prebiopsy imaging. If characteristic microhemorrhages are identified, differential diagnostic considerations should include tumefactive CAA, so that appropriate biopsy of the cortex and leptomeninges can be performed. Biopsy of white matter alone may be nondiagnostic in these cases. Although there are no known prevention strategies, tumefactive cerebral amyloid angiopathy may be responsive to steroids or immunosuppressants, as inflammation appears to be a pathologic hallmark for this process. Appropriate diagnosis of tumefactive CAA may help prevent morbidity resulting from unnecessary aggressive surgical resection or radiation therapy.

Key Words: Cerebral amyloid angiopathy, glioma, susceptibility-weighted imaging

Scientific Exhibit 019
Diffusion-Weighted Imaging in Traumatic Brain Injury
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Purpose
MR imaging (MRI) is often helpful in distinguishing among the various types of injury to the brain that can result from trauma, as well as delineating the extent of injury. Diffusion-weighted imaging (DWI) is abnormal in many of these injuries, for a variety of reasons. We review and illustrate the different patterns seen in DWI in imaging traumatic brain injury.

Approach/Methods
Diffusion-weighted imaging, often thought of primarily for its sensitivity to acute infarction, also can be abnormal in a variety of mechanisms that can be seen in trauma. In addition, the sensitivity of DWI can reveal injuries that might otherwise be very subtle or obscure. Restricted diffusion may occur with cytotoxic edema, hematoma, pus, disruption of fiber tracts, and other settings. The pattern is often key to understanding the mechanism of trauma.

Findings/Discussion
We present a range of findings in MRI of traumatic brain injury with an emphasis on DWI and the typical patterns seen. These include: extra-axial hemorrhage, with a variable extent of restricted diffusion; contusions, in which diffusion abnormalities may occur but usually are less extensive than edema and hemorrhage (e.g., FLAIR and GR sequences); shearing injury, in which DWI, FLAIR, and GR are complementary, DWI may be very sensitive, and distribution is pre-
dominantly subcortical, callosal, and brainstem; secondary infarction, for which DWI is highly sensitive, and vascular patterns are key to recognition; secondary infections; and fat embolism, with a highly disseminated, “star-field” pattern and sometimes paucity of other intracranial MRI abnormalities. T2 shine-through also should be recognized as a potential confounding appearance.

**SUMMARY/CONCLUSION**
Patterns of DWI abnormalities, in conjunction with other MRI findings, can be helpful in discriminating different types of traumatic brain injury and may aid in prognosis.

**KEY WORDS:** Trauma, diffusion-weighted imaging

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**Scientific Exhibit 020**

**The Big, the Bad and the Ugly: A Review of Large and Giant Intracranial Aneurysms**

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**PURPOSE**
To review the pathologic anatomy, imaging findings, natural history and management of large and giant intracranial aneurysms.

**APPROACH/METHODS**
A literature search was performed and retrospective review of patients presenting to and managed at our institution over the last 10 years.

**FINDINGS/DISCUSSION**
From our neurovascular database, 40 patients fulfilled the criteria for large or giant intracranial aneurysms. The location, size, the presence or absence of thrombus and changes within the adjacent brain were documented. 1. The pathologic anatomy of large and giant intracranial aneurysms will be reviewed. 2. Management options will be discussed with illustrative cases. 3. Various treatment options including endovascular (both constructive and parent vessel sacrifice), surgical and conservative will be discussed. 4. Review of the clinical outcomes and stratification of results based on aneurysm morphology.

**SUMMARY/CONCLUSION**
Large and giant intracranial aneurysms have a poor outcome on conservative management. Endovascular therapy is evolving rapidly in the management of this complex pathology. Peri-aneurysmal thrombus is a poor predictor of clinical outcome and performance.

**KEY WORDS:** Giant intracranial aneurysms

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**Scientific Exhibit 021**

**Segmental Vulnerability in Cerebral Arteries: A Comprehensive Review of Cases**

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**PURPOSE**
To illustrate several cases of intracranial vascular anomalies under the category of segmental vulnerability.

**APPROACH/METHODS**
We performed a retrospective and prospective analysis of the angiographies performed in our department between January 1997 and October 2010. All cases were studied with rotational 3D angiographies using Philips Allura Monoplane and Siemens Axiom Artis dBA biplane angiographs. Some studies were complemented with magnetic resonance angiography (MRA) and computed tomography angiography (CTA). Different variables were analyzed and frequency tables were created.

**FINDINGS/DISCUSSION**
We found 13 cases of segmental vulnerability in cerebral arteries. The alterations were different kinds of dysplasia and dolichoectasia of the cerebral arteries. They were mainly in the supraclinoid internal carotid artery (9/13 cases), posterior cerebral artery (3/13) and the basilar trunk (3/13). Six patients had associated sacular aneurysms. On case showed an aberrant origin of ophthalmic artery arising from the basilar trunk. The main clinical presentation was headache. Three dimensional angiography allowed a better anatomical understanding of the segmental alterations and diagnosis of small aneurysms.

**KEY WORDS:** Giant intracranial aneurysms
SUMMARY/CONCLUSION
Segmental vulnerability of cerebral arteries is a rare condition. Three dimensional rotational study is essential to a good understanding of these anomalies.

KEY WORDS: Segmental vulnerability, cerebral arteries, dysplasia

Scientific Exhibit 022
CT Angiographic Appearance of Pathologic Dural Arteries: Anatomical Review

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PURPOSE
1. Illustrate the CT angiographic appearance of enlarged dural arteries secondary to dural arteriovenous fistulas (dAVFs). 2. Review the normal course and supply of major intracranial dural arteries.

APPROACH/METHODS
We performed a retrospective imaging review of dAVF patients treated at Massachusetts General Hospital who underwent both noninvasive vascular imaging with CT angiography (CTA) and catheter angiography.

FINDINGS/DISCUSSION
Dural arteries are best appreciated on digital subtraction angiography (DSA), and play an important role in various neurologic disorders such as dAVFs, tumors and arterial steno-occlusive disease. In-depth knowledge of the dural arterial system is critical for the safe treatment of these diseases. Consequently, neurointerventional radiologists must be aware of the normal and variant anatomy of the dural arteries, their collateral pathways and their supply to eloquent structures. Under normal conditions, dural arteries are difficult to visualize on noninvasive imaging due to their small size and proximity to the bone and skull base. As such, diagnostic neuroradiologists often ignore these vessels during imaging review. However, given the improvements in CT angiographic technique, a basic knowledge of dural arterial anatomy is becoming increasingly important for diagnostic interpretation. This is particularly true in the setting of dAVF where pathologically enlarged dural arterial feeders are often readily apparent, and may be an important clue to the diagnosis of this potentially devastating disorder. In our series of patients, we were able to identify pathologic enlargement of major dural arteries on CTA including the middle meningeal artery, the lateral and marginal tentorial branches of the meningohypophyseal trunk, the posterior meningeal artery, the artery of the falx cerebelli, transosseous branches of the occipital artery and skull base branches of the ascending pharyngeal artery.

SUMMARY/CONCLUSION
Pathologic enlargement of the dural arteries is conspicuous on CT angiography and should suggest the diagnosis of dural arteriovenous fistula. Recognition of these pathologic vessels is facilitated by a basic knowledge of dural arterial anatomy. In the setting of intracerebral hemorrhage or suspected vascular malformation, recognition of enlarged dural arteries on CTA should prompt further investigation with cerebral angiography.

KEY WORDS: Dural artery, arteriovenous fistula, anatomy
**Scientific Exhibit 023**

**Tumors of the Skullbase Foramina: A Pictorial Review**

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**PURPOSE**
To review skull base anatomy utilizing CT and MR imaging by considering differential diagnoses of tumors involving the skull base foramina.

**APPROACH/METHODS**
CT and MR imaging of tumors involving each skull base foramina will be presented with imaging characteristics and location of the tumors highlighted.

**FINDINGS/DISCUSSION**
Skull base foramina are important anatomical landmarks which contain predominantly nerves and vessels, serving as the tissue of origin for tumors which primarily involve these sites. The most common entities are from nervous tissue origin, including peripheral nerve sheath and neuroendocrine tumors, and perineural spread of primary head and neck malignancies. Non nervous origin tumors include meningiomas and rare vascular tumors. Knowledge of the normal and abnormal CT and MR appearance of the skull base foramina correlated with neurologic deficits, if present, can decrease the chance of missed findings at the foramen.

**SUMMARY/CONCLUSION**
Skull base neuroforamina can be involved by various benign and malignant neoplasms. Understanding the specific skull base foramen involved as well as the imaging characteristics of the tumor are important for proper radiologic diagnosis.

**Scientific Exhibit 024**

**Hemodynamic Balance and Functional Vascular Layer Concept in Head and Neck Arterial Structure**

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**PURPOSE**
To understand the three dimensional vascular territory of the external carotid artery and its branches in the concept of functional vascular layer.

**APPROACH/METHODS**
To determine the vascular territory of the head and neck, functional layers based on the anatomical functional concept with hemodynamic balance were described. Anatomical findings obtained from digital subtraction angiography (DSA) and flat panel detector computed tomography (FPD-CT) with super selective injection of contrast material, and 3D CT angiography were evaluated.

**FINDINGS/DISCUSSION**
The four functional vascular layers were reconstructed ideally. The musculo-cutaneous layer was fed by facial artery, superficial temporal artery, and occipital artery. The neuro-meningeal layer was fed mainly by middle meningeal artery, ascending pharyngeal artery and their anastomosis. The naso-masticatory layer was fed by maxillary artery and its branches. The oro-laryngeal layer was fed by lingual artery, superior thyroid artery and their branches and collateral circulations. These four layers had collateral network formation with each other. These functional vascular layers were superimposed on the CT image for easy understanding of the vascular territory in the head and neck.

**SUMMARY/CONCLUSION**
The concept of functional vascular layer makes it easy to understand the vascular territory of external carotid artery and its branches. This will be effective for understanding blood supply of the tumors or vascular malformations, especially for identifying the dangerous anastomosis in the interventional radiologic procedure in this region.

**KEY WORDS:** Head and neck, artery, anatomy
Scientific Exhibit 025

Pitfalls in the Imaging of Facial Pain: A Pictorial Essay

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PURPOSE
Atypical facial pain is described as a persistent localized facial pain that does not have the classical characteristics of cranial neuralgias and for which there is no obvious cause. The diagnosis and treatment therefore are often difficult, with surgical treatments used for trigeminal neuralgia, such as trigeminal vascular decompression, being ineffective. Imaging studies including CT and MR imaging (MRI) often are performed in the evaluation of atypical facial pain to exclude other diagnoses. This pictorial essay will highlight key diagnoses and pitfalls discovered in the imaging of patients with suspected atypical facial pain or trigeminal neuralgia. Recommendations for imaging, especially for the patient referred for preoperative neurovascular surgery for facial pain, are presented.

APPROACH/METHODS
Patients undergoing CT or MR imaging for the work up of atypical facial pain or trigeminal neuralgia were included in this pictorial essay. The normal anatomy of the trigeminal nerve is reviewed in schematic form along with CT and MRI correlations, with an emphasis on potential sites of processes that may cause facial pain syndromes, and their ensuing relevant clinical findings. A systematic approach to the pathologic spectrum that can result in facial pain will be presented, depicting key diagnoses and pitfalls in the imaging of atypical facial pain including those that have, in some cases, resulted in misdiagnosis and unnecessary surgical treatment.

FINDINGS/DISCUSSION
A systematic approach to evaluating imaging of patients presenting with atypical facial pain is presented. Key diagnoses described include disorders of the jaw and teeth including osteonecrosis and chronic odontogenic infection, inflammatory disease of the paranasal sinuses, disorders of the temporomandibular joint, bone pathologies at the skull base, orbital pathologies that may result in facial pain, noncompressive disorders of the trigeminal nerve including nerve sheath tumors and perineural spread of tumor, and brainstem etiologies of facial pain. Examples of typical compressive causes of trigeminal neuralgia also are reviewed for comparison.

SUMMARY/CONCLUSION
The clinician may request high-resolution T2 images in anticipation of neurovascular decompression or ablation of the cisternal segment of CN V, but the neuroradiologist must methodically search for other causes for the pain. This pictorial reviews our experience with unusual and unexpected lesions detected in patients assumed to have compressive syndromes at cisternal CN V.

KEY WORDS: Atypical facial pain, trigeminal neuralgia

Scientific Exhibit 026

Dynamic Arterial and Valsalva-Augmented Venous Phase Imaging of Orbital Vascular Pathologies

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PURPOSE
To illustrate the utility of dual phase multidetector computed tomography (DP-MDCT) using Valsalva in the assessment and treatment of orbital vascular lesions.

APPROACH/METHODS
The Valsalva maneuver is used commonly by clinicians to assess the venous distensibility of an orbital vascular malformation. Traditionally the imaging assessment of venous distensibility of orbital vascular malformations was by direct coronal CT. In our institution, we perform dynamic arterial and Valsalva-augmented venous phase MDCT. The MDCT data acquired must be isotropic by matching the collimation and pitch. After bolus injection of intravenous contrast at 3.5 ml/s, data are obtained in the arterial phase at 30 seconds. The patient then is instructed to perform a Valsalva maneuver. Imaging is repeated in the venous phase at 70 seconds. Image reconstructions are obtained at 1 mm intervals in the axial plane and as maximum-intensity-projection in the coronal and sagittal planes at 2 mm intervals. This technique is reproducible and comfortable for the patient.

FINDINGS/DISCUSSION
There has been increasing understanding of the nature of orbital vascular lesions, their natural history and their response to therapy. Our dual phase technique is capable of demonstrating distensibility of venous pathologies. This provides the radiologist and surgeon anatomical detail as to the extent, type and constituents of a vascular lesion. This is particularly useful in cases of mixed venous lymphatic malformations and highly distensible venous malformations/varices These radiologic features can potentially alter conservative, percutaneous, endovascular or surgical treatment options. We will demonstrate the clinical utility of this technique through illustrative examples of various orbital vascular lesions including venous varix, mixed venous-lymphatic malformation, hemangioma, and arteriovenous malformation.
Figure 1a: Arterial phase coronal image of a known venous malformation demonstrating phleboliths, b: delayed Valsalva-augmented phase image demonstrating significant venous distension. There was marked associated proptosis (not shown).

SUMMARY/CONCLUSION
This DP-MDCT technique optimizes the assessment of orbital vascular malformations by defining anatomical and temporal lesional detail as well as potential venous distensibility. This information is important to the radiologist and surgeon because of potential follow up and management implications.

KEY WORDS: Orbit, vascular malformation, computed tomography

Scientific Exhibit 027
Perineural Spread of Head and Neck Tumors: Knowledge of Anatomy Is Crucial for the Radiologist
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PURPOSE
One of the anatomical pathways through which head and neck tumor may spread involves the perineural route. The nerves involved usually have complex pathways through skull base foramina and findings can be subtle.

APPROACH/METHODS
We will demonstrate the nerves most commonly involved with perineural tumor infiltration, including the second and third divisions of the trigeminal nerve and the facial nerve, and the optimal methods for their imaging evaluation. Imaging strategies with computed tomography (CT) and magnetic resonance (MR) imaging at each segment of nerve involvement are suggested.

FINDINGS/DISCUSSION
Primary and secondary head and neck cancers spread through skull base foramina. Understanding the exact sequence of anatomical involvement is helpful for evaluating the imaging findings. The radiologist must have a thorough knowledge of the normal anatomy and the pathologic spectrum of the skull base to determine the extent of abnormality and to help plan the surgical approach. Both high-resolution direct coronal CT and MR imaging clearly show perineural tumor below the skull base.

SUMMARY/CONCLUSION
Knowledge of the anatomy of the nerves commonly involved with perineural spread and proper use of imaging modalities will allow early detection and proper management of perineural spread in the setting of certain head and neck cancers.

KEY WORDS: Perineural, tumor, skull base

Scientific Exhibit 028
Hemodynamic Difference between Unruptured Aneurysms and Ruptured Aneurysms
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PURPOSE
Mechanisms of cerebral aneurysm appearance, enlargement, and rupture are not yet fully understood. Various hemodynamic parameters have been proposed for estimating the risk of rupture of cerebral aneurysms with limited success. Many studies have suggested that wall shear stress (WSS) may predict aneurysm rupture. However it is still controversial. Some researchers reported that high WSS may initiate aneurysm formation, while others reported that low WSS causes rupture. For that purpose we introduced a new hemodynamic parameter - energy loss (EL), postulating that the transfer of energy by the interaction of the hemodynamic forces with the aneurysmal wall can be related to the risk of rupture. We supposed that this parameter and WSS eventually may have clinical application.

APPROACH/METHODS
Digital images in DICOM format were converted to STL surface mesh. The STL then was restructured as a 3D geometric mesh model. Finally, the 3D mesh was analyzed using a mathematical formula for fluid flow. The calculations in this study were performed under pulsatile flow conditions. Forty side-wall internal carotid posterior communicating artery (IC-pcom) aneurysms and 40 middle cerebral artery (MCA) bifurcation aneurysms of medium size were investigated for EL and wall shear stress (WSS), followed by a period of observation during which 6 IC-pcom and 7 MCA aneurysms ruptured (34 and 33 remained unruptured respectively, with the same location and similar size as the ruptured cases).
FINDINGS/DISCUSSION
There was no statistically significant difference between ruptured and unruptured aneurysms for WSS. On the contrary, the EL in ruptured aneurysms was higher than that of unruptured aneurysms.

SUMMARY/CONCLUSION
The research indicates that there is more complex flow pattern with significant turbulence inside aneurysms that will rupture. The EL created by an aneurysm was clearly different between subsequently ruptured and unruptured aneurysms. The results indicate that EL may be an important parameter to estimate aneurysm rupture and that potentially can be developed into a clinical application.

KEY WORDS: Aneurysm, CFD, rupture risk

Scientific Exhibit 029
Imaging Characteristics of Extracranial Meningiomas
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PURPOSE
Meningiomas are the most common extra-axial lesions of the central nervous system, accounting for 30% of primary intracranial neoplasms. Although most meningiomas are intracranial and easily diagnosed, they may alternatively present as extracranial masses, and thus pose a challenging radiologic differential diagnosis. In this exhibit, we compare CT and MR features of extracranial meningiomas to those of intracranial meningiomas. We also describe a scheme for classifying modes of extracranial spread.

APPROACH/METHODS
A retrospective multi-institutional EMR review revealed 44 patients with extracranial meningiomas. Optic nerve sheath meningiomas were excluded because they are common and expected lesions. Findings on CT and MRI sequencing, pathologic tumor grade, mode and location of extracranial spread, and anatomical sites of involvement were tabulated and compared with those of typical intracranial meningiomas (homogenous isodense enhancement on CT with hyperostosis, isointensity on unenhanced T1- and T2-weighted images with brisk uniform enhancement). Radiographic presence of hyperostosis, erosions, calcifications, and foraminal enlargement also were recorded.

FINDINGS/DISCUSSION
The average age at diagnosis for an extracranial meningioma was 51.9 with a 64% female predominance. The classic features of intracranial meningiomas were shared by 30% of extracranial meningiomas. Almost all of the tumors had well-defined borders, and 69% had hyperostosis of underlying bone. Although all the tumors were uniformly isointense to brain on T1-weighted images, only 55% had T2 signal isointense to brain. Brisk enhancement was seen in 82% of cases, but was identified more easily on MR than on CT. Pathologically, 30% of cases were WHO Grade II or III. Extracranial meningiomas can be classified by mode of spread as transforaminal (27.3%), transosseous (43.1%), both (22.7%), or may be purely extracranial (6.9%). They also can be classified by the site of extracranial location: orbital (24%), anterior skull base (20%), sphenoid (38.67%), or temporal/occipital (17.33%). The specific extracranial location most likely to be involved was the infratemporal fossa (12.8%).

SUMMARY/CONCLUSION
Extracranial meningiomas are challenging to diagnose because they are rare and unexpected. However, distinct radiologic signs, and a familiarity with the most frequent locations and modes of extracranial spread, can assist radiologists in making this diagnosis.

KEY WORDS: Extracranial meningioma, radiology, location

Scientific Exhibit 030
Characteristic Visual Field Defects Resulting from Perichiasmal Skull Base Tumors
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PURPOSE
The purpose of this study is to review the characteristic visual field defects associated with pathologic lesions along the optic pathway. Chiasmal and perichiasmal skull base tumors along with their associated visual field defects will be highlighted.

APPROACH/METHODS
A database of 393 patients at our institution with skull base tumors that either primarily or secondarily involved the optic pathway was reviewed. Patients with characteristic visual field defects by Humphrey 30-2 visual field testing who also had radiologic images on our picture archiving and communication system (PACS) were selected. Case examples were organized according to geographical positioning along the optic pathway along with the resultant visual field defect.

FINDINGS/DISCUSSION
Pathologic lesions in certain geographic locations have been demonstrated to result in characteristic visual field defects. We present examples of pathologic lesions effecting the intraorbital optic nerve, intracranial optic nerve, anterior optic chiasm, central optic chiasm, posterior optic chiasm and optic tract that result in characteristic visual field defects [unilateral field loss; cecocentral scotoma; junction field loss
ipsilateral temporal or nasal hemianopia plus contralateral superior quadrantanopia potentially due to Wilbrand’s knee); bilateral superior altitudinal hemianopia; bitemporal hemianopia and unilateral homonymous hemianopia. Skull base tumors (pituitary adenomas, craniopharyngiomas and meningiomas) often may cause mass effect on the optic chiasm and perichiasmal region thus resulting in visual field defects. These field defects can frequently be predicted after close observation of skull base tumor growth and the associated mass effect on the optic pathway.

**SUMMARY/CONCLUSION**

Characteristic visual field defects can be predicted based upon the geographical location of skull base tumors and close observation of their associated mass effect on the optic pathway. Conversely, the observation of characteristic visual field defects can help guide clinicians in treatment of specific regions of skull base tumors that would have the greatest clinical benefit.

**KEY WORDS:** Visual field defects, skull base tumors, optic chiasm and perichiasmal region

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**Scientific Exhibit 031**

Utility of MR Imaging and MR Angiography in the Differential Diagnosis of Pediatric Vascular Anomalies

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**PURPOSE**

To stress the role of MR imaging and MR angiography in the evaluation of head and neck hemangiomas and other vascular anomalies in the pediatric population, based on the classification of the International Society for the Study of Vascular Anomalies (ISSVA). To improve our knowledge, understanding and management of different types of vascular anomalies of head and neck in children, being able to recognize the findings in each lesion.

**APPROACH/METHODS**

Vascular anomalies are divided into two main types (ISSVA): a) vascular tumors: the most common is infantile hemangioma. b) vascular malformations: malformations are categorized depending on the type of vascular channel involved, as slow flow and fast flow lesions. It is essential to recognize the different types of lesions in order to perform a correct clinical diagnosis and to be aware of imaging findings that may help in the differential diagnosis. It also is important to agree on a consensus terminology with our clinical and surgical colleagues, to avoid diagnostic misinterpretations.

**FINDINGS/DISCUSSION**

With a 1.5 MR imaging unit, we studied patients younger than 10 years of age. Different imaging findings are described in vascular tumors and malformations as well as high flow and slow flow lesions. We particularly address findings that may help in the differential diagnosis of infantile hemangiomas.

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**Scientific Exhibit 032**

Congenital Disorders of the Internal Auditory Canals

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**PURPOSE**

To illustrate the spectrum of imaging findings encountered in congenital and developmental disorders of the internal auditory canals (IACs) and their contents in children.

**APPROACH/METHODS**

A variety of congenital and developmental disorders of the internal auditory canals are encountered on cross-sectional imaging studies in the pediatric age group. Abnormalities of the internal auditory canals and its contents are easy to overlook. Their detection may provide clues to the diagnosis of more extensive malformations and developmental disorders. This educational exhibit will demonstrate the spectrum of abnormalities encountered in a large pediatric neuroradiology practice. The picture archiving and communication systems (PACS) at our institute were searched for keywords related to the common disorders involving the IACs and additional lists of teaching files were searched for the uncommon lesions.
Congenital and developmental disorders of the IACs can be asymptomatic or can present with sensorineural hearing loss, lower motor neuron facial palsy, and/or tinnitus among other symptoms and signs. The spectrum of imaging findings of developmental and congenital disorders of the internal auditory canals will be presented. They will include absent or stenotic IACs, duplication of the IAC, dilated and patulous IACs, and abnormal orientation of the IACs. Developmental disorders of the seventh and eighth cranial nerves including aplasia or hypoplasia of the facial, vestibular and/or cochlear nerves will be shown, some in the context of more broad cranial nerve abnormalities and brainstem malformations. Other entities will include prominent vascular loops and malformations as well as congenital tumors involving the internal auditory canals. The imaging findings will be discussed in their appropriate clinical context. A demonstration of the variable appearances of these abnormalities will be illustrated.

Summary/Conclusion
An educational pictorial display of congenital disorders of the IACs on cross-sectional imaging will be presented. Depiction of many of these uncommon disorders can be of value for practicing neuroradiologists and neuroradiologists in training.

Key Words: Pediatrics, congenital, internal auditory canals

Scientific Exhibit 033

CT Anatomy after Various Types of Laryngectomy
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Purpose
After laryngectomy for the treatment of laryngeal or hypopharyngeal carcinoma, the most primary concern is directed to early detection of tumor recurrence. However, surgery alters or obliterates tissue planes between various normal structures, making clinical assessment less reliable. Radiologic studies including CT and MR imaging can provide valuable information about the occurrence of recurrent tumor by disclosing cross-sectional anatomy which has been distorted by surgery. To take best advantage of cross-sectional imaging, the radiologist has to become familiar with various techniques used for the resection of the larynx and also with the postoperative anatomy seen on imaging studies. The purpose of this study was to evaluate the normal CT appearance of the larynx after conservative and radical surgery.

Approach/Methods
Postoperative (conservative surgery n = 43, radical surgery n = 20) CT examinations of 63 patients of asymptomatic and who had no change of the imaging findings on serial follow-up images were analyzed retrospectively.

Scientific Exhibit 034

Laryngeal Trauma: CT Features and Potential Mimics
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Purpose
To demonstrate the common imaging presentations of laryngeal trauma and to provide differentiating characteristics based on the surgical classification and potential mimics.

Approach/Methods
The radiologic examination of laryngeal trauma may not be performed acutely because of the possibility of airway compromise and the need for definitive surgical intervention. However, when laryngeal injury is suspected on a neck CT, the reporting radiologist should be aware of the spectrum of pathologies that may be encountered. Treatment, whether medical or surgical intervention can depend on the results of
imaging studies, such as the degree of cartilaginous displacement and airway compromise. There also are other laryngeal pathologies which can be confused with acute trauma. The improved knowledge of the imaging patterns might increase the likelihood of accurate preoperative diagnosis of these lesions and guide therapy.

**Findings/Discussion**
All patients who received CT neck for laryngeal trauma were reviewed from 1995 to 2010. All cases had direct arylngoscopy followed by medical or surgical treatment. This yielded 25 cases which met the inclusion criteria.

**Summary/Conclusion**
An overview of the imaging characteristics of laryngeal trauma, based on the degree of severity and surgical classification will be discussed. We will emphasize key imaging findings such as cartilage fracture (most importantly the cricoid cartilage), displaced fracture fragments, soft tissue injury and anterior commissure trauma. Imaging of the secondary findings of the laryngeal trauma and potential mimics of laryngeal trauma also will be discussed.

**Key Words:** Larynx, trauma, CT

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**Scientific Exhibit 035**

**Imaging Characteristics and Patterns of Spread of Aggressive Sinonasal Tumors**

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**Purpose**
To provide a comprehensive review of the imaging findings, path of spread and clinical presentations of aggressive sinonasal tumors.

**Approach/Methods**
The clinical presentations and behavior of aggressive sinonasal tumors as documented in the literature will be illustrated with prime imaging examples from the authors’ case files into an educational display.

**Findings/Discussion**
The major goals of imaging aggressive sinonasal tumors are to identify the primary abnormality, to provide a differential diagnosis, and determine the extent of the neoplasm’s margins. Determining the local extent of the neoplasm involves identifying perineural spread, orbital invasion, involvement of the skull base and intracranial extension. Further extent of the neoplasm requires the evaluation of lymph node involvement. Having a good understanding of the behavior and imaging characteristics of these tumors allows the radiologist to offer a streamlined approach to sinonasal tumor imaging and obtain a thorough radiologic investigation. By providing the appropriate imaging work up, the radiologist can solidify their role in ensuring optimal patient management.

**Summary/Conclusion**
Using our knowledge of the behavior and imaging characteristics of aggressive sinonasal tumors, radiologists can tailor imaging algorithms to obtain the necessary information that will allow referring clinicians to make an informed decision regarding patient management.

**Key Words:** Sinonasal, aggressive

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**Scientific Exhibit 036**

**Imaging Features of Lacrimal Apparatus Tumors**

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**Purpose**
The lacrimal drainage apparatus consists of the lacrimal canaliculi, lacrimal sac, and nasolacrimal duct. Lacrimal apparatus tumors are rare. Primary tumors of the lacrimal apparatus may include squamous cell carcinoma, adenoid cystic carcinoma, transitional cell carcinoma, lymphoid tumors, and mucoidermoid carcinomas. Secondary involvement of the canaliculi and lacrimal drainage apparatus can occur from any cutaneous lesion that involves the eyelid and/or conjunctiva including BCCA, SCCA, sebaceous cell carcinoma and also from any neoplastic process involving the paranasal sinuses. Metastatic lesions to the lacrimal sac can originate from any distant site and may include carcinomas or melanomas. The purpose of this study is to present the CT and MR imaging features of lacrimal apparatus tumors.

**Approach/Methods**
We retrospectively studied 14 patients with lacrimal apparatus tumors. Eleven patients had primary tumors of the lacrimal apparatus and three patients had tumor spread to the lacrimal apparatus from a secondary site. We characterized the lacrimal apparatus tumors by degree of enhancement, signal characteristics on MR imaging, and local/regional spread. We investigated the extent of involvement of the lacrimal sac, duct, and the lacrimal bony canal by tumor. We also sought to determine if dacrocystocele formation was a common feature associated with these tumors, and if perineural tumor or intracranial tumor extension was present at the time of initial imaging.

**Findings/Discussion**
In 12 patients, tumor involved both the lacrimal sac and nasolacrimal duct. One patient had tumor confined to the lacrimal sac and one patient had tumor involvement of only the nasolacrimal duct. In 11/12 patients who had undergone CT, the nasolacrimal bony canal generally was expanded without frank destruction of the lacrimal bony canal. Moderate contrast enhancement was observed in all tumors on CT and MR imaging. In all patients investigated with MR, the tumors were isointense on T1-weighted imaging and isointense to low signal intensity on T2-weighted imaging. Thirteen patients had tumor spread from the lacrimal sac into the medial canthus. Two patients had orbital intracranial...
spread of tumor, four patients had ethmoid sinus tumor extension. Four patients had tumor extension into or from the inferior meatus of the nasal cavity.

**SUMMARY/CONCLUSION**

It appears that lacrimal apparatus tumors in general tend to expand the lacrimal bony canal, rather than frankly destroy it. These tumors demonstrate moderate contrast enhancement in all cases and appeared isointense on T1-weighted imaging and isointense to dark on T2-weighted imaging. As one would expect, the medial canthus was involved by tumor in most cases, as a result of direct tumor spread to this area from the lacrimal sac. However, intracranial extension of tumor was not commonly seen. Interestingly, dacrocystocele formation was noted in only one patient. Intracranial tumor extension or perineural tumor spread was not observed in any patient. Clinical relevance/application - To our knowledge there is no large series of cases reported in the radiology literature on lacrimal apparatus tumors.

**KEY WORDS:** Lacrimal apparatus tumors, lacrimal sac, naso-lacrimal duct

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**Scientific Exhibit 037**

**Pictorial Review of Pediatric Sinus Disease and Complications**

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**PURPOSE**

Review normal anatomy as well as both benign and malignant pathology which may present as sinus pain or rhinorrhea.

**APPROACH/METHODS**

Retrospective review of teaching files in pediatric patients who presented with sinus-related pain. Cases depicted include infectious etiologies such as chronic fungal disease, subperiosteal abscess leading to superior orbital vein thrombosis, Pott’s puffy tumor and epidural abscess from frontal sinusitis; dysplasias such as leontiasis ossea fibrous dysplasia, osteopetrosis; developmental disease such as sphenoid mucoceles; hematologic diseases like extramedullary hematopoesis; or neoplastic processes such as rhabdomyosarcoma, juvenile nasopharyngeal angiofibroma.

**FINDINGS/DISCUSSION**

Paranasal sinus infection in children often is diagnosed and treated without the need for imaging. A small percentage of cases where symptoms and signs are persistent or severe require imaging to rule out complications or mimickers of underlying pathology. A strong index of suspicion is required in such cases with cross-sectional imaging evaluation with CT and MR of the paranasal sinuses and, where appropriate, the orbits and brain (with attention to the cavernous sinus). In some cases, a combination of modalities can be helpful to provide complementary information making a more accurate diagnosis possible.

**SUMMARY/CONCLUSION**

Cross-sectional imaging and a thorough understanding of pediatric sinus anatomy and pathology narrows the differential diagnosis that may be useful to the referring clinician.

**KEY WORDS:** Anatomy, sinusitis

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**Scientific Exhibit 038**

**Craniofacial Resection: What the Radiologist Needs to Know**

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**PURPOSE**

Craniofacial resections are complex surgical procedures performed on patients with extensive anterior skull base disease due to aggressive neoplasms, extensive inflammatory diseases, or complicated infectious processes. This surgery generally is performed by a collaborative team of neurosurgeons, ophthalmologists, oral-maxillofacial surgeons, plastic surgeons, and otolaryngologists in hopes of limiting or preventing vision loss, CSF leak, intracranial extension of disease, and/or intracranial vascular compromise. Imaging typically is obtained for preoperative planning and for postoperative baseline, complications, and disease recurrence. The purpose of this educational exhibit is to review the surgical approaches, and summarize the spectrum of postoperative changes including expected findings, complications, and recurrence of disease.

**APPROACH/METHODS**

Retrospective review of patients who underwent craniofacial resection at a tertiary referral center and underwent preoperative and postoperative CT, 3D reconstructions, and/or MRI. Through example illustrations and cases, we will review the spectrum of relevant preoperative and postoperative imaging findings.

**FINDINGS/DISCUSSION**

The indications for craniofacial resection are reviewed. The surgical approaches are outlined with illustrative figures. The expected postoperative findings are demonstrated and include craniotomy/cranectomy defects, extracranial soft tissue thickening and dural enhancement. The temporalis free flap can be seen at the cranial floor defect and can potentially mimic residual disease to the unfamiliar observer. Postoperative complications include injury to the brain from aggressive frontal lobe retraction, CSF leak, cephaloceles, intracranial hypotension, meningitis and intracranial and extracranial abscess formation. Recurrent disease can be differentiated from expected postoperative findings at follow-up imaging and is recognized as increased nodular enhancement, although care must be taken to distinguish this from granulation tissue and surgical packing material.

**SUMMARY/CONCLUSION**

The radiologist should be familiar with the indications, surgical technique and range of postoperative findings of craniofacial resections. Identifying expected postoperative find-
ings and familiarity with possible complications of craniofacial resections helps guide the clinical team in further patient management.

**KEY WORDS:** Craniofacial resection

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**Scientific Exhibit 039**

"It's Not All Hay Fever": Radiologic Criteria and Differential Diagnosis of Allergic Fungal Sinusitis

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**PURPOSE**
To provide a comprehensive review of allergic fungal sinusitis with an emphasis on the radiologic criteria and differential diagnosis.

**APPROACH/METHODS**
The clinical presentation, pathophysiology, CT/MR findings, differential diagnosis and treatment of allergic fungal sinusitis will be discussed.

**FINDINGS/DISCUSSION**
Allergic fungal sinusitis (AFS) is the most common of five main diagnostic types of fungal rhinosinusitis disorders currently recognized. Allergic fungal sinusitis typically occurs in immunocompetent, nondiabetic patients many of whom have history of asthma and/or sinonasal polyposis. Clinically, patients often present with signs and symptoms of nasal airflow obstruction, allergic rhinitis or chronic sinusitis. Allergic mucin production likely is initiated by an IgE-mediated (Type I) inflammatory response to the presence of extramucosal fungus within the sinus cavity. Accumulation of allergic mucin obstructs the involved sinuses initiating a vicious cycle. Grossly, allergic fungal mucin is sometimes described as having a “peanut butter” or “axle grease” appearance and consistency. A precontrast sinus CT is the best initial approach to the diagnostic workup of AFS. Characteristic findings include unilateral or asymmetric heterogeneous opacification of the paranasal sinuses, most commonly involving the ethmoid sinus. The allergic mucin has a characteristic hyperdense appearance likely due to the presence of calcium, heavy metals (iron and manganese) and inspissated secretions. Bony expansion, remodeling, or thinning of the involved sinus walls are common associated findings due to the expansile nature of the accumulating allergic mucin. Bony erosion may occur allowing for extension of disease most commonly into the orbit followed by the anterior, middle, and posterior cranial fossae, respectively. MR imaging may be helpful if there is intracranial extension of disease or, if a confident diagnosis cannot be achieved by CT. The high protein and low water content of allergic fungal mucin gives rise to a central hypointense T1 and marked low T2 signal. These MR signal characteristics are very specific for AFS and can be mistaken for absence of disease. Restricted diffusion may be present. Postcontrast CT/MR imaging in AFS is remarkable only for peripheral mucosal enhancement. Sinonasal polyposis, antrochoanal polyp, mucocele, esthesioneuroblastoma and rare osteoid/choanal matrix-producing sinonasal sarcomas may be considered in the differential diagnosis. A comprehensive treatment approach depends on complete removal of all fungal mucin (usually requiring endoscopic surgery) and long-term prophylaxis with antifungal medications, corticosteroids and/or immunotherapy. Nonetheless, some patients may still develop a recurrence despite complete removal of disease.

**SUMMARY/CONCLUSION**
Allergic fungal sinusitis is a discrete clinical and diagnostic entity, which may be suggested initially by its characteristic CT appearance. The best patient outcomes can be facilitated by proper communication between radiology, medical and surgical specialists.

**KEY WORDS:** Allergic, fungal, sinusitis

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**Scientific Exhibit 040**

Sinonasal Tumors - Olfactory Neuroblastomas Versus Sinonasal Undifferentiated Carcinomas: Revisiting Marginal Cysts

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**PURPOSE**
To study the presence of and also characterize marginal or intratumor cysts in sinonasal tumors with intracranial extension. To revisit marginal cysts and immune histochemical markers in sinonasal tumors. The sinonasal tumors with neuroendocrine markers can pose a challenge to pathologists and MR imaging may be helpful.

**APPROACH/METHODS**
Retrospective database search. Sinonasal tumors with intracranial extension included. Only sinonasal undifferentiated carcinomas (SNUCs), olfactory neuroblastomas (ONBs) and sinonasal tumors with neuroendocrine differentiation. The tumor cysts characterized as follows: (A) round-ed or ovoid exophytic marginal cysts at the tumor interface with the brain (typical cysts described in the literature for ONBs), (B) nonexophytic cysts abutting the intracranial tumor margin (2mm or less lateral rim enhancement), (C) intratumor cysts, not abutting the intracranial tumor margin and, (D) no margin or tumor cysts. Immune histochemical markers reviewed.

**FINDINGS/DISCUSSION**
The distribution of cases from the database which met the criteria of the study were as follows: SNUC (4), small cell undifferentiated cancer (1), sinonasal malignant tumor with neuroendocrine differentiation (1) and ONB (5). The different types of cysts seen in these tumors were: SNUC (type A-0, type B-3, type C-2, type D-0), ONB (type A-2, type B-2, type C-1, type D-1), sinonasal malignant tumor with neuroendocrine differentiation (both type B & C) and small cell undifferentiated cancer (type D). The intratumor and nonexophytic marginal cysts in tumors other than ONB had irregular nonrounded appearance. The ONB consistently showed positivity for at least one neuroendocrine marker (synaptophysin, chromogranin and neuron specific enolase) plus char-
acteristic S-100 staining of sustentacular cells. The nonONB tumors consistently showed cytokeratin positivity and variable positivity for neuroendocrine markers.

**SUMMARY/CONCLUSION**
The exophytic marginal rim-enhancing cysts are a characteristic feature of ONBs. Marginal or intratumor cysts can be seen in SNUC and other sinonasal tumors.

**KEY WORDS:** Sinonasal undifferentiated carcinomas, olfactory neuroblastomas, cysts

### Scientific Exhibit 041
**Discrimination, Rollover, Absent Reflexes and More: Differential Diagnosis and Imaging Implications of Audiological Findings: Beyond Sensorineural and Conductive Hearing Loss**

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**PURPOSE**
Review audiological techniques and findings that impact differential diagnoses in hearing loss. Highlight imaging protocol and interpretation strategies tailored to clinical and audiological findings.

**APPROACH/METHODS**
As a former practicing otologist/neurotologist turned radiologist, the author summarizes the various audiological tests and findings encountered in imaging study requisitions. The diagnostic implications of these audiological findings are summarized with accompanying suggestions for imaging strategy and illustrative imaging cases.

**FINDINGS/DISCUSSION**
Practicing neuroradiologists are keenly aware of the diagnostic implications of sensorineural hearing loss (SNHL) and conductive hearing loss (CHL), but a wealth of information is available in additional audiological findings. Abnormalities of speech discrimination and processing, retrocochlear signs (rollover, etc.), fistula testing, absent reflexes, Tullio’s phenomenon, etc., have implications directly relevant to the performance and interpretation of diagnostic imaging. In addition to pure tone and speech audiometry, findings in posturography, electrocochleography, otoacoustic emissions, and electronystagmography, carry diagnostic implications directly relevant to the neuroradiologist. Information obtained from advanced audiological testing often is directly relevant to the planning, performance and interpretation of imaging studies.

**SUMMARY/CONCLUSION**
Armed with the clinical and diagnostic implications of audiological findings beyond SNHL versus CHL, the practicing radiologist is optimally positioned to recommend imaging strategies and interpret findings.

**KEY WORDS:** Hearing loss, audiology
Scientific Exhibit 042

Patriotic Approach to Middle Ear Masses: Red, White and Blue

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PURPOSE
This exhibit explores middle ear masses of the temporal bone from an otologic and radiologic perspective. The ENT surgeon’s otoscopic view in combination with the radiologic features allows most middle ear lesions to be accurately identified on preoperative imaging.

APPROACH/METHODS
Through the use of graphic diagrams, otoscopic images, and CT and MR images of the temporal bone, we illustrate the spectrum of middle ear masses separated primarily by their otoscopic appearance of red, white and blue hues.

FINDINGS/DISCUSSION
The imaging appearance of middle ear masses frequently overlaps on conventional CT and MR images. The primary location of the mass in addition to typical imaging features such as bone destruction helps to shorten the differential possibilities. The otoscopic appearance, and specifically the perceived color of lesions as red, white or blue, may be key in determining an accurate preoperative diagnosis. Common “red” lesions often are described as vascular retrotympanic masses. These include glomus tympanicum and glomus jugulare paragangliomas, which may be differentiated on CT or MR, and an aberrant internal carotid artery. An aberrant internal carotid artery is an important middle ear mass that may mimic a paraganglioma on otoscopic appearance, though the diagnosis is made readily on CT or MR. Common “white” lesions include congenital and acquired cholesteatomas which may be differentiated on their imaging features, and schwannomas which may present as a mass pedunculating from the facial nerve or the round window niche. Other less common middle ear masses also are reviewed including meningoima and adenoma which typically have a “tan-white” hue on otoscopic view. Common “blue” retrotympanic masses include cholesterol granuloma which has classic hyperintense T1 and T2 signal characteristics, and a dehiscent jugular bulb.

SUMMARY/CONCLUSION
Middle ear masses, at first glance, may seem difficult to diagnose by imaging appearances. If the otoscopic findings, particularly the retrotympanic lesion color, are combined with the imaging features, the diagnostic differential of possible lesions becomes significantly refined and more accurate.

KEY WORDS: Middle ear mass, otoscopy, glomus tympanicum

Scientific Exhibit 043

High-Resolution MR Imaging of the Temporal Bone at 3 T Using a 32-Channel Head Coil

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PURPOSE
Drawbacks to application of 3T MR imaging in the temporal bone includes its vulnerability to the susceptibility effect and high SAR (special absorption ratio). The purpose of this exhibit is to present appropriate high-resolution imaging protocols for the temporal bone by using a 32-channel head coil which can provide high signal-to-noise ratio.

APPROACH/METHODS
Characteristics of some sequences of high-resolution 3D T2-weighted imaging (T2WI) and postcontrast T1-weighted imaging (T1WI) are presented. The utility of 3D FLAIR also is shown. In addition, utility and limitation of diffusion-weighted imaging (DWI) is discussed. Finally, high-resolution MR images of some important diseases such as sensorineural hearing loss, cholesteatoma and facial nerve palsy are presented.

FINDINGS/DISCUSSION
First spin-echo (FSE) sequences with variable flip angle of refocusing pulses such as SPACE can provide high-resolution heavily T2WI and T1WI with sufficient SNR, minimum susceptibility artifacts and allowable SAR. Gradient-echo (GRE) sequences are more vulnerable to susceptibility effects. Signal intensity of vascular structures is quite different between FSE and GRE sequences. Thin slice DWI can be obtained with sufficient SNR and reasonable scan time by using echo-planar imaging (EPI). However, EPI DWI is vulnerable to susceptibility effects even with parallel imaging and thin slice thickness.

SUMMARY/CONCLUSION
High-resolution T1- and T2-weighted imaging using 3D FSE sequence is a robust technique for evaluating temporal bone at 3 T with a 32-channel head coil.

KEY WORDS: Temporal bone, high-resolution imaging, 3 T

Scientific Exhibit 044

Imaging of Intralabyrinthine Schwannomas: A Pictorial Review

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PURPOSE
Intralabyrinthine schwannomas are relatively rare benign tumors that were first reported in the early part of the 20th century either at autopsy or incidentally discovered during surgical labyrinthectomy. More recently, they are increasingly being diagnosed by MR imaging using high-resolution...
technique targeted to the IAC and labyrinth. Patients classically present with symptoms indistinguishable from those produced by the more common intracanalicular tumors (hearing loss or balance disturbance), underscoring the importance of a systematic inspection of the labyrinth on all IAC MR examinations. This pictorial essay reviews the typical location and appearance of these tumors within the bony labyrinth using a previously described classification system (1), and discusses the most useful imaging techniques in their detection.

**APPROACH/METHODS**
MR examinations and electronic medical records on all patients with pathologically proved and presumed intralabyrinthine schwannomas diagnosed between 1995 and 2010 were reviewed for this pictorial essay.

**FINDINGS/DISCUSSION**
In presenting the various appearances of these tumors, we use the classification previously proposed by Kennedy, et al. categorizing tumors as transcanalicular, cochlear, vestibular, cochleovestibular or transotic. This anatomical classification scheme can aid in determining whether surgical or conserva- 
tive management is most appropriate. We review the evolution of MR imaging techniques employed in the evaluation of the IAC and labyrinth over the past 15 years and demonstrate the best available three-dimensional sequences to detect intralabyrinthine schwannomas.

**SUMMARY/CONCLUSION**
Intralabyrinthine schwannomas are rare tumors that are being detected increasingly on high-resolution MR imaging. Familiarity with their appearance, location, and extent are critical in determining the most appropriate course of management.

**REFERENCES**

**KEY WORDS:** Intralabyrinthine, schwannoma, temporal bone

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**Scientific Exhibit 045**

**Causes of Failed Stapes Surgery: Preoperative CT Findings with Surgical Confirmation**

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**PURPOSE**
Stapes surgery usually is performed in the clinical setting of otosclerosis with the goal of hearing preservation. Revision stapes surgery is performed for unsuccessful primary surgery, delayed failure, and surgical complications, and confers a higher failure rate. The purpose of this review is to familiarize the reader with the CT findings of stapes surgery failure and the relevant preoperative contraindications to stapes surgery. The current limitations of standard CT for complication detection also are discussed.

**APPROACH/METHODS**
We retrospectively reviewed the imaging and medical records of all patients undergoing stapes or stapes revision surgery at our institution between December of 1999 and December of 2009. All patients with high-resolution CT scans of the temporal bone were reviewed and correlated to clinical findings at otoscopy and surgery. Temporal bone CTs were assessed retrospectively by two reviewers, one with head and neck radiology expertise (BH). All imaging findings were correlated to operative findings. Examples of surgically confirmed causes of stapes surgery failure and preoperative findings that were contraindications to stapes surgery are highlighted.

**FINDINGS/DISCUSSION**
A total of 340 patients who had undergone stapes surgery or revision surgery were identified from the department of neuro-otology clinical records. From this subset, 60/340 had temporal bone CTs available in PACS for review. Of these 60, 16 patients (5 males and 11 females, 16-87 years of age, mean age of 56 years) had subsequent intraoperative reports that could be correlated to CT findings. All patients had a history of otosclerosis who were presenting for revision stapes surgery. We assessed normal postoperative findings and contrasted them to causes of failed stapes surgery that included ossicular necrosis, prosthesis disconnection or migration, abnormally deep intrusion of the stapes piston into the vestibule, perilymph fistula, granulation tissue, and inappropriate piston size. Preoperative CT findings that are contraindications to stapes surgery included superior semicircular canal dehiscence, ossicular fixation, and tympanosclerosis.

**SUMMARY/CONCLUSION**
CT evaluation in the setting of planned primary or revision stapes surgery is challenging for the radiologist. Inherent limitations of spatial resolution and beam hardening artifact of the small metallic stapes piston prostheses remain problematic for correct piston localization and sizing, and granulation tissue and perilymph fistulae remain hard to diagnose. However some cases of piston dislocation, ossicular chain disruption or necrosis, and overt vestibular penetration can be suggested and should be investigated routinely. This series additionally highlights important contraindications to stapes surgery: superior semicircular canal dehiscence, ossicular fixation, cholesteatoma, and tympanosclerosis.

**KEY WORDS:** Otosclerosis, stapes surgery, CT
Endovascular Treatment of Direct and Indirect Carotid-Cavernous Fistulas

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PURPOSE
Carotid-cavernous fistula (CCF) can be either direct or indirect, spontaneous or post-traumatic. We are reporting our experience with different methods of endovascular treatment of carotid-cavernous fistulas.

APPROACH/METHODS
We retrospectively analyzed the endovascular treatment of 14 patients (7 males, 7 females, ages 19 to 66 years) with 16 CCFs admitted between April 1999 and November 2008. Institutional Review Board approval was obtained for use of the covered stent (Graftmaster, Abbott vascular, Abbott Park, IL). Eight of the direct CCFs were treated via a transarterial route using the Graftmaster stent, coils, and/or detachable silicone balloons. Eight of the indirect CCFs were treated via the transvenous route through the inferior petrosal sinus (IPS), the superior ophthalmic vein after exposure and cut-down and direct puncture via a transorbital approach, via cortical veins, or through open craniotomy using coils and/or Onyx. The direct CCFs were treated via a transarterial approach using the Graftmaster stent, coils, and/or detachable silicone balloons.

FINDINGS/DISCUSSION
There were eight direct CCFs and eight indirect CCFs. Five of the direct CCFs were post-traumatic and 1 was iatrogenic status post-trans-sphenoidal surgery. All of the indirect CCFs were spontaneous. Thirteen of the 16 treated cases were successful at closing the CCF. One patient had an occluded IPS and attempted access to the CCF via the IPS was unsuccessful. A transarterial route using Onyx also was unsuccessful. Finally an attempt was made to gain access to the CCF via a cortical vein, which resulted in perforation of the vein. This patient then was treated successfully by direct puncture of the cavernous sinus via open craniotomy and went on to make a complete recovery. One patient initially showed persistent fistula after covered stent placement and coil embolization; however, there was complete closure of the CCF at a subsequent 1.5 year angiographic follow up. One direct and one indirect fistula were not closed successfully; however, had subsequent treatment at an outside institution, with positive outcomes.

SUMMARY/CONCLUSION
Carotid-cavernous fistulas can be treated using a variety of endovascular approaches and devices. In our experience for access, we favor the transvenous IPS approach for indirect CCFs; however when the IPS can not be cannulated the direct transorbital approach is very effective. We favor covered stent placement for treatment of direct CCFs, if the patient’s anatomy is favorable.

KEY WORDS: Carotid-cavernous fistula, endovascular treatment

Value of Angiographic Flat Panel Detector Computed Tomography in the Evaluation of Intracranial Stents

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PURPOSE
To suggest a standard for performing intracranial stenting treatments.

APPROACH/METHODS
We reviewed our data from September 2007 to August 2010. We performed 98 angiographic flat panel detector computed tomography (ACT) in 77 patients undergoing procedures or control angiographies for intracranial stents. We used a Siemens™ Axiom Artis dBA Biplane angiograph with Flat Panel and DynaCT® technology. All the images were analyzed in a Leonardo Flash WorkStation.

FINDINGS/DISCUSSION
We used ACT in 77 procedures and 26 control angiographies. In 16 cases we used it to visualize the relationship between the stent and microcatheter during aneurysm treatment. In the other cases we evaluated the stent deployment, mesh status, struts opening and bendings or stenosis. We studied different kinds of stents like Neuroform, Enterprise, Leo, Silk, Wingspan and WallStent. Metal artifacts were seen when combining a stent and coils for aneurysm treatment, which altered the visualization of the stent structure. In 69 cases we used diluted contrast for viewing the relationship between the stent and the vessel. In 24 cases we performed a nonenhanced technique. We had no complications when performing ACT.
SUMMARY/CONCLUSION
The use of ACT has become an essential tool in evaluating intracranial stents. It gives us a clear and real vision of the device during the procedure or follow up. We think it should be a standard in any center performing intracranial stenting treatments.

KEY WORDS: Flat panel CT, stents, aneurysm

Scientific Exhibit 048
Endovascular Therapy for Acute Vertebrobasilar Stroke: Literature Update
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PURPOSE
Basilar artery occlusion is an infrequent but often fatal form of acute stroke: death or long-term disability often results if the vessel is not recanalized. Despite this, there is controversy within the stroke literature regarding the use of endovascular techniques as the mainstay of acute treatment. We review the evidence for the use for endovascular therapy and new frontiers in development of this field.

APPROACH/METHODS
1) A critical discussion of published research comparing intravenous (IVT) and intraarterial thrombolysis (IAT). 2) Appraisal of preliminary results using mechanical methods of clot disruption. 3) Results of small series describing use of angioplasty+/−stenting. 4) Use of intravenous thrombolysis as a bridge to endovascular therapy. 5) Recommendations for construction of a randomized controlled trial.

FINDINGS/DISCUSSION
Use of aggressive interventional therapies for treatment of this condition often is advocated, but remains controversial. The results of a large meta-analysis (1) and the BASICS prospective registry-based study (2) concluded no significant benefit of IAT over IVT. However these studies exhibit potential bias. In the meta-analysis, recanalization was evaluated with time-of-flight MRA in the IVT group: this is insensitive to low flow states and it is plausible, therefore, that the basilar artery was only partially occluded with residual flow maintaining the perfusion of the brain stem. The BASICS trial included more IVT patients with less severe deficits. Furthermore, 55% of IVT patients were treated within 3 hours of symptom onset, whereas only 23% IAT patients received such an early intervention. Prognosis often is related to early recanalization: in the largest series (3) of 180 patients treated with IAT, some degree of recanalization was seen in 74% of patients, much higher rates than published in even the most favorable series using intravenous therapy. Importantly, however, survival rates in these patients approached 50%, a considerable improvement on rates of 90% dead or dependent in conservatively managed patients. As “time is brain” and local thrombolysis can result in posterior fossa hemorrhage in as many as 15% of patients, attempts to safely speed up recanalization have involved mechanical methods. Case series using simple loop-shaped tool clot disruption show recanalization in 50% of cases prior to introduction of thrombolysis, whereas a small study describing the use of the Possis Angiojet catheter shows recanalization rates approaching 100% (4). Endovascular approaches also allow simultaneous acute treatment of the high grade stenoses (a frequent etiology of basilar artery occlusion) to prevent early reocclusion by transluminal angioplasty+/−stenting: initial experience with this is encouraging. Intravenous and Intraarterial thrombolysis may be used in combination, with IVT being used as a “bridge” to IAT. Nonrandomized case control studies show improve rates of recanalization over IAT alone (5). Institution of “drip, ship and retrieve” protocols whereby IVT is administered in community hospitals prior to transfer to a neurointervention center for endovascular therapy also shows promise (6).

SUMMARY/CONCLUSION
Firm conclusions based on current evidence are not possible. A prospective randomized controlled trial is needed to compare IVT alone to intraarterial therapies (including mechanical methods) with or without bridging IVT.

KEY WORDS: Basilar, thrombolysis, endovascular
Scientific Exhibit 049

Imaging and Pathophysiology of Calcifications in Pediatric Neuroradiology

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PURPOSE
Calcifications can be an important clue in the diagnostic process of many pediatric neurologic conditions. Since magnetic resonance has been established as the main neuroimaging technique, especially for children, the detection of brain calcifications has become occasional even if sometimes they can give important information about the underlying pathologic process. The aim of our study is to provide an up-to-date review of calcifications and of their role in pediatric neuroradiology.

APPROACH/METHODS
In order to achieve the above-mentioned goal, our study was organized in the following steps: 1. to analyze the main diseases presenting cerebral calcifications as a relevant neuroradiologic finding; 2. to review the pathogenetic mechanisms leading to the deposition of calcium; 3. to provide the neuroradiologist with key semeiologic criteria leading to a correct interpretation of the presence of cerebral calcifications; 4. to illustrate the techniques available today to detect calcifications focusing on the different sensibilities.

FINDINGS/DISCUSSION
Many diseases in pediatric neurology can present calcifications as a neuroradiologic finding. Among these, we can identify infectious diseases, inflammatory conditions, congenital malformations, endocrine dysfunctions, inherited metabolic diseases, vascular abnormalities and tumors. Different pathogenetic mechanisms can lead to brain calcifications, ranging from microangiopathy to dystrophic phenomenon. A sole specific mechanism usually is identified for each disease, even if, more rarely, in some cases many underlying pathogenetic mechanisms can be recognized. The localization, the number, the size, the shape and the symmetry of the calcifications are related strictly to the underlying pathogenetic mechanism and, ultimately, to the disease. The CT scan is still nowadays the gold standard of diagnosis for the detection of calcium deposits. The recent introduction of sequences such as the susceptibility-weighted imaging (SWI) has dramatically improved the ability to identify calcifications with magnetic resonance and many studies in the literature have demonstrated its reliability. In the basic MR sequences, calcifications can be missed easily or misrecognized, also due to their challenging signal characteristics.

SUMMARY/CONCLUSION
Calcifications can be an important hint in the diagnostic work up of children with neurologic disease. In particular, in cases of brain abnormalities of undetermined origin, the use of the CT scan or of SWI can detect the presence of calcifications and, thus, provide essential information. The detection and accurate evaluation of brain calcifications based on specific semeiologic criteria can narrow the differential diagnosis and avoid delays in the correct management of many pediatric neurologic conditions.

KEY WORDS: Calcifications, pathogenesis, CT

Scientific Exhibit 050

Patterns of Polymicrogyria Related to Variable Pathophysiology

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PURPOSE
Polymicrogyria is a common malformation of cortical development that may result in disability due to epilepsy as well as neurological and intellectual impairment. Polymicrogyria forms in response to a variety of insults during development of the cortex, primarily involving the stages of neuronal migration and cortical organization. Congenital infection, ischemia, or genetic mutations are all known causes. An understanding of developmental processes of migration and cortical organization, and the underlying cell and molecular physiology is important in understanding the morphology seen at imaging. Specific morphologic patterns of polymicrogyria and associated findings at imaging may suggest the underlying etiology of the polymicrogyria. The purpose of this exhibit is to illustrate the imaging findings of polymicrogyria with specific attention to the patterns and associated findings that may suggest the underlying cause. The exhibit will explore the putative cellular and molecular processes felt to be responsible for the morphologic changes, features of polymicrogyria.

APPROACH/METHODS
The well described principles of normal cortical development will be used as a basis to illustrate the changes that occur that result in polymicrogyria. Clinical cases of polymicrogyria from a variety of causes including specific genetic mutations, congenital infection, and syndromes with polymicrogyria will be used to demonstrate the wide range of variation in the imaging appearance of polymicrogyria. Where known, the underlying cellular, molecular, and/or genetic causes will be discussed.

FINDINGS/DISCUSSION
Polymicrogyria is a relatively common cause of epilepsy and developmental delay encountered in clinical practice. A classification scheme for malformations of cortical development based on the stage of development disrupted has been used (1). Polymicrogyria is considered to disorder of neural organization, but is heterogeneous in phenotype and underlying pathophysiology (2). Identifying specific etiology and a genetic basis can have important clinical and prognostic implications. Cases used to illustrate specific pathophysiology will include congenital infection; genetic causes including PTPN11 mutation, PAX6 mutation, PEX1 mutation, and syndromic genetic conditions including trisomy 20. Many possible causes for malformations of cortical development
have been identified, and testing for all of the possibilities in every case may not be feasible. Identifying specific morphological patterns on neuroimaging, combined with clinical presentation may allow for more directed testing and lead to improved disease assessment and management (2).

**SUMMARY/CONCLUSION**

An understanding of developmental processes such as neuronal migration and cortical organization, and the underlying cell and molecular physiology is important in understanding the morphology seen at imaging. This exhibit will illustrate these processes, and how specific pathophysiology affects development, and the relationship between pathophysiology and imaging phenotype.

**REFERENCES**


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**KEY WORDS:** Malformation of cortical development, polymicrogyria

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**Scientific Exhibit 051**

**Loeys-Dietz Syndrome: An Example Case and Review of Recent Literature**

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**PURPOSE**

Loeys-Dietz syndrome is a recently described genetic connective tissue disorder distinct from Ehlers-Danlos syndrome and Marfan’s syndrome with more severe neuroradiologic manifestations. We present an example case and describe its distinctive radiologic findings. A review of the literature is presented with a focus on distinguishing neuroradiologic characteristics of Loeys-Dietz syndrome from other similar connective tissue disorders.

**APPROACH/METHODS**

A case of a 6-year-old patient with genetically confirmed Loeys-Dietz syndrome, type I, is presented with imaging findings on CT, CTA, and MR. Distinguishing radiologic characteristics of Loeys-Dietz syndrome are discussed with a focus on neuroradiologic manifestations. Associated cardiovascular and musculoskeletal findings are reviewed briefly. The genetic basis of Loeys-Dietz syndrome is discussed and a review of recent literature is performed showing the increased prevalence of neurovascular complications and the importance of distinguishing Loeys-Dietz syndrome from other connective tissue disorders.

**FINDINGS/DISCUSSION**

Loeys-Dietz syndrome is a recently described genetic connective tissue disorder distinct from Ehlers-Danlos syndrome and Marfan’s syndrome with more severe neuroradiologic manifestations. Our example case had the characteristic triad of findings of Loeys-Dietz syndrome: arterial tortuosity, hypertelorism, and bifid uvula/cleft palate. The patient also had many of the additional findings associated with Loeys-Dietz syndrome including scoliosis, crainosynostosis, Chiari malformation complicated by hydrocephalus, C1-C2 dysplasia with subluxation, aortic root dissection, and mesenteric aneurysms. We demonstrate these findings on CT, CTA, MRI, and multiple 3D reconstructions. We review recent literature comparing findings of Loeys-Dietz syndrome to Ehlers-Danlos syndrome and Marfan’s syndrome including findings of increased prevalence of vertebral artery tortuosity in Loeys-Dietz syndrome. A more malignant course for Loeys-Dietz syndrome is described with arterial aneurysms with an increased propensity for rupture or dissection, specifically at the aortic root. It is important for the radiologist to be aware of the characteristic neuroradiologic findings of Loeys-Dietz syndrome and its more aggressive course when describing the differential diagnosis and recommending follow-up imaging.

**SUMMARY/CONCLUSION**

Loeys-Dietz syndrome is a recently described genetic connective tissue disorder with multiple distinctive neuroradiologic manifestations that has a more malignant course than Ehlers-Danlos syndrome and Marfan’s syndrome. Early diagnosis, short interval follow-up imaging, and prophylactic surgical intervention is essential in preventing catastrophic neurologic and cardiovascular complications.

**KEY WORDS:** Loeys-Dietz syndrome, aneurysm

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**Scientific Exhibit 052**

**PHACE: Imaging Findings and Comprehensive MR Imaging Protocol**

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**PURPOSE**

To illustrate the brain, head and neck MR imaging (MRI) features of PHACE (Posterior fossa anomalies, Hemangiomas, Arteriopathy, Cardiac anomalies/Coarctation of aorta, Eye abnormalities) syndrome. Based on the anticipated imaging findings, we propose a comprehensive MR imaging protocol for evaluation of patients with PHACE.

**APPROACH/METHODS**

This exhibit will illustrate some of the common imaging features of PHACE. Specifically, images will show typical brain parenchymal abnormalities, frequent sites of hemangiomas (facial/scalp, neck and intracranial), types of intra and extracranial arteriopathy (including ectasia, tortuosity, narrowing, dysgenesis, aberrant vessels, aberrant origin and course of normal vessels, persistent embryonic vessels, etc.) and eye anomalies (coloboma, staphyloma, microphthalmia). We also propose a MR protocol suitable for imaging in children in whom PHACE is suspected. This protocol was accepted by consensus in a multidisciplinary PHACE Research Workshop (jointly organized by Medical College...
of Wisconsin, National Organization of Vascular Anomalies and Hemangioma Investigator Group) held in Milwaukee, WI on 15-18 September, 2010.

FINDINGS/DISCUSSION
PHACE syndrome includes a spectrum of brain structural and arterial abnormalities associated with large facial infantile hemangiomas. Intra and extracranial arterial anomalies are the most common extracutaneous findings reported in this disorder. We have found specific patterns and sites of vascular involvement in these patients and will illustrate that in this exhibit. The proposed MRI protocol is based on the targeted approach to the findings anticipated in the PHACE. It also is designed to obtain comprehensive evaluation in most time efficient way in order to minimize duration of anesthesia/sedation in these infants and children. It is divided into three components: 1. Brain parenchymal evaluation; 2. Head and neck soft tissue evaluation; 3. Evaluation of the neck and brain arteries. Based on the abnormalities detected on the initial imaging, subsequent scans may be further tailored for limited follow up of specific abnormalities (arteriopathy in most cases).

SUMMARY/CONCLUSION
PHACE syndrome is a relatively recently described entity. Imaging findings in this condition are complex and imaging experience is largely confined to a few tertiary care centers with expertise in the field of vascular anomalies. With this exhibit we share our experience in the neuroradiologic imaging of PHACE syndrome patients and also propose a comprehensive MRI protocol for these patients.

KEY WORDS: PHACE, MRI protocol, arteriopathy

Scientific Exhibit 053
Tips and Tricks for Improving Detection of Focal Cortical Dysplasia

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PURPOSE
To describe techniques for improving detection of focal cortical dysplasia on MR imaging (MRI).

APPROACH/METHODS
Patients with MRI negative epilepsy have poorer postsurgical epilepsy control compared to patients with MRI visible lesion. Hence, it is important to identify a lesion on neuroimaging to improve epilepsy surgery outcome. Sensitivity of MRI for detecting a lesion depends on the pathologic substrate, MRI techniques and the interpreting physician. Most patients with MRI negative epilepsy are considered to have focal cortical dysplasia that are subtle. Improvements could be made to imaging techniques and the interpretation of imaging to improve detection of FCD.

FINDINGS/DISCUSSION
Contrast and resolution of MRI can be used to improve detection of FCD. Imaging parameters can be optimized to increase gray-white matter distinction. Multiple sequences and windowing of images can provide different contrast to increase the conspicuity of FCD. Increasing the resolution of imaging also can increase the detection of FCD. The interpreting physician should be familiar with normal sulcation and gyration pattern to detect aberrations from normal and also recognize the varying appearances of FCD. Metabolic review of images and also reviewing the images in the context of the seizure semiology and location of the epileptogenic zone, and/or abnormal metabolism or flow from PET or SPECT respectively will increase the yield of MRI interpretation.

SUMMARY/CONCLUSION
Imaging identification of FCD can be improved by optimizing imaging techniques, meticulous review of imaging particularly in the context of the clinical information and functional imaging.

KEY WORDS: Focal cortical dysplasia, epilepsy

Scientific Exhibit 054
Diffusion Tensor Imaging Data Confirm Efficacy of Reradiation Treatment in Pediatric Patients with Diffuse Intrinsic Pontine Glioma

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PURPOSE
Diffuse intrinsic pontine gliomas (DIPG) are high-grade, locally infiltrative tumors, which have a poor prognosis. Conventional MR imaging has established prognostic value in the treatment of brain stem tumors; however, routine sequences cannot precisely define the extent of white matter tract involvement, i.e., are the tracts just displaced, partially/completely infiltrated, or disrupted. Studies have shown that diffusion tensor imaging (DTI) can better delineate and quantify white matter tract involvement in pediatric brain tumors, including DIPG. Our goal was to use 3D color fiber tract maps, and quantitatively assess DTI data in the pons before and after reradiation treatment to see if the DTI data correlate with clinical findings.

APPROACH/METHODS
We retrospectively analyzed DTI data (FA, ADC and 3D color fiber track analysis) in five pediatric patients prior to and then following reradiation treatment. For the pre- and post-XRT scans, six regions of interest were drawn in the mid-pons in the location of the bilateral corticospinal, transverse pontine and medial lemnisci tracts. Diffusion tensor imaging (DTI) was acquired from GE - 1.5 T and 3.0T MR scanners. The acquisition parameters were: FOV = 22 cm, image matrix of 128 x 128, slice thickness of 3.5 - 5.0 mm, diffusion gradients were applied to 27 directions, with b-value of 1200 s/mm2. This is equivalent to in-plane resolution of 1.72 mm. Total of 24 - 30 slices were acquired covering from the medulla to the top of the brain. The acquisition time was 4 - 5 min.
**FINDINGS/DISCUSSION**

At MD Anderson Cancer Center, five patients with DIPG have received a second dose of XRT in hope of halting the progression of malignancy. Clinical results have been very encouraging, including regained ability to ambulate ($n = 3$), and improved speech ($n = 2$), ataxia ($n = 3$) and ocular movements ($n = 2$). Two patients had improved Lansky play score, and two patients were able to discontinue steroids. Clinical results were affirmed by DTI analysis post reradiation, which showed fiber track recovery as evidenced by better visualization of the corticospinal, transverse pontine and/or medial lemnisci tracts. These results also are reflected in qualitative measured FA and ADC values.

**SUMMARY/CONCLUSION**

Reradiation may be considered in select group of patients where the primary irradiated targets responded better to treatment than corticospinal tracts. We also found differences in response to treatment in fiber tract integrity. To our knowledge, ours is the first radiologic study that looks at the benefits of reradiation in fiber tract integrity. Our findings suggest that reradiation might be considered in select patients, as conventional MR fails to detect improvement in fiber tract integrity. To our knowledge, ours is the first radiologic study that looks at the benefits of reradiation treatment. We also found differences in response to treatment between different fiber tracts, i.e., transverse pontine tracts responded better to treatment than corticospinal tracts. Reradiation may be considered in select group of patients with DIPG, particularly those with long interval since initial radiation.

**KEY WORDS:** Diffuse intrinsic pontine glioma, diffusion tensor imaging, reradiation treatment

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**Scientific Exhibit 055**

**Usual and Unusual MR Imaging Findings of Enterovirus 71-Related Encephalomyelitis**

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**PURPOSE**

Most enterovirus (EV) 71 infections manifest as mild cases of hand-foot-mouth disease/herpangina (HFMD/HA) with seasonal variations having peak incidence during the summer. Meanwhile, EV71 uncommonly involves the central nervous system (CNS), causing severe neurologic disease. Typically, enteroviral encephalomyelitis involves central midbrain, posterior portion of medulla oblongata and pons, bilateral dentate nuclei of cerebellum, and ventral roots of cervical spinal cord. Recently, some pediatric patients with HFMD/HA and neurologic symptom were confirmed EV71-related encephalomyelitis. The purpose of the study is to review the typical and atypical MR findings in CNS involvement of EV71 enteroviral infection.

**APPROACH/METHODS**

Among the consecutive patients who had HFMD and clinically suspected encephalitis or myelitis underwent brain or spinal MR imaging, five patients revealed abnormal MR finding. Diffusion-weighted and conventional MR and follow-up MR images were obtained. From CSF, stool, or nasopharyngeal swab, EV71 was confirmed in each of five patients.

**FINDINGS/DISCUSSION**

MR imaging studies of three patients showed hyperintensity in posterior portion of brain stem on T2-weighted and FLAIR images, which is typical MR finding of EV71 encephalitis. The remaining two cases revealed unusual manifestation; abnormal enhancement along ventral roots at conus medullaris level without brain involvement (one case) and hyperintensity in left hippocampus on T2-weighted and FLAIR images (one case). On follow-up MR imaging, most lesions are improved but left hippocampal atrophy was noted in the last case.

**SUMMARY/CONCLUSION**

Most cases of EV71 encephalomyelitis show relatively characteristic MR findings, so that imaging can be helpful in diagnosis. However, clinicians and radiologists also should be aware of unusual CNS manifestation of EV71.

**KEY WORDS:** Enterovirus, brain MR imaging, spine MR imaging

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**Scientific Exhibit 056**

**Infantile Hemangiopericytoma: A Distinct and Benign Clinical Entity**

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**PURPOSE**

Infantile (or congenital) hemangiopericytoma is a distinct clinical entity with a more benign course than the malignant hemangiopericytomas seen in older children and adults. We present an example case and review its imaging findings and differential diagnosis. A review of the literature is presented in the context of emerging pathology literature that distinguishes the aforementioned condition from malignant forms seen in older patients.

**APPROACH/METHODS**

A case of a 2-month-old patient with pathology-proved intracranial infantile hemangiopericytoma is presented with imaging findings on CT and MR. A differential diagnosis is discussed to emphasize typical imaging findings representative of hemangiopericytoma rather than meningioma. The pathologic and histologic characteristics of the infantile hemangiopericytoma are presented. A review of the literature is presented describing the location and histologic characteristics of the published cases of intracranial infantile hemangiopericytoma.

**FINDINGS/DISCUSSION**

Infantile hemangiopericytoma is a clinical entity separate from the malignant forms of hemangiopericytomas seen in older children and adults. Emerging pathology literature suggests that this tumor is part of a spectrum of myofibroblastic lesions that includes myofibromatosis. Although usually extraaxial and dural based, primary intraaxial lesions have been described. It is important to recognize the imaging
characteristics suggestive of hemangiopericytomas and include it on a differential from meningioma on CT and MR imaging. Imaging characteristics suggestive of hemangiopericytoma include a nonbroad-based, lobulated lesion with flow-voids, and heterogeneous enhancement. We review cases in the literature of intracranial infantile hemangiopericytomas and describe their specific location and histologic characteristics. It is important for the radiologist to be aware of the more benign course of these lesions when recommending follow-up imaging.

**Summary/Conclusion**
Infantile hemangiopericytoma is a distinctive clinical entity with a more benign course than malignant forms of hemangiopericytomas seen in older children and adults. New pathology literature suggests that infantile hemangiopericytomomas exist on a spectrum of benign myofibroblastic lesions that includes myofibromatosis.

**Key Words:** Hemangiopericytoma, pediatric neoplasms

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**Scientific Exhibit 057**

**Many Faces of Intracranial Germ Cell Tumors**

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**Purpose**
The purpose of this educational exhibit is: 1) to review the clinical and histologic spectra of intracranial germ cell tumors, 2) to review various radiographic manifestations of intracranial germ cell tumors, and 3) to discuss characteristic imaging features that can help differentiate these histologic types.

**Approach/Methods**
We retrospectively reviewed our patient database to identify patients with pathologically proved intracranial germ cell tumors. Imaging studies (CT and MR imaging) and clinical charts were examined. Through illustrative case examples, we will review the spectrum of imaging patterns on these imaging modalities that can help to narrow the differential diagnosis.

**Findings/Discussion**
Intracranial germ cell tumors are not uncommon in Japan and other Asian countries. There are a variety of histologic types: germinoma, teratoma, choriocarcinoma, yolk sac tumor, embryonal carcinoma, mixed germ cell tumor. They usually arise in the pineal (50%) or suprasellar (30%) region, and rarely arise from the basal ganglia (3%). Germinoma is the most common tumor among the germ cell tumors. Various histologic types and their characteristic imaging findings are reviewed and discussed.

**Summary/Conclusion**
Differentiation of histologic types or germ cell tumors is crucial because it affects both management and prognosis. For this reason, it is important that the radiologist be aware of the various germ cell tumor types and their imaging characteristics.

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**Scientific Exhibit 058**

**Eyes Wide Open: Differentiating Features of Pediatric Orbital Lesions on CT and MR Imaging**

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Lexington, KY

**Purpose**
This report emphasizes the key imaging features in order to provide an approach for developing relevant differential diagnosis of various orbital lesions encountered in children including: infection, neoplasm, inflammation and infiltration, developmental anomalies, and trauma.

**Approach/Methods**
Brief overview of orbital anatomy emphasizing orbital compartments. This retrospective case review of pathologically and clinically proved pediatric orbital lesions has been accumulated over a 5-year time period at multiple tertiary referral centers. High quality MR and CT images illustrate the findings and complement the succinct review of various diseases within the orbit. Examples discussed include, but are not limited to, the following: infection, neoplasm, inflammation and infiltration, developmental anomalies, and trauma. Key imaging features and location were reviewed including calcification, fat containing, globe size, mass effect, enhancement pattern, and single vs multiple lesions in order to differentiate orbital pathology.

**Findings/Discussion**
The following types of pediatric orbital lesions are included in this review: abscess, inflammatory pseudo tumor, dermoid cysts, cephalocele, hemangioma, lymphangioma, primary orbital varix, rhabdomyosarcoma, histiocytosis, orbital lymphoma, optic nerve glioma, nerve sheath meningioma, neurofibroma, retinoblastoma, persistent primary hyper plastic vitreous, and coat’s disease.

**Summary/Conclusion**
A wide spectrum of orbital lesions is seen in the pediatric population. A multimodality imaging approach plays a crucial role in the diagnosis and management of these entities. Some lesions have characteristic imaging findings; others have a nonspecific appearance and need pathologic clinical confirmation to arrive at a specific diagnosis. Viewers of this exhibit will gain or refresh information about the key characteristics that allow differentiation of orbital pathology.

**Key Words:** Pediatric, orbital lesions, retinoblastoma
Scientific Exhibit 059

Value of FIESTA/CISS Sequence in Pediatric Neuroimaging

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PURPOSE
To describe the value of FIESTA/CISS images in pediatric neuroimaging.

APPROACH/METHODS
We conducted a retrospective review of magnetic resonance imaging (MRI) studies performed at our institution over a 3-year period (2007-2010) and identified cases where the use of high-resolution fast imaging employing steady state acquisition (FIESTA) or constructive interference in steady state (CISS) imaging helped in making a diagnosis or helped clarify a finding seen on conventional imaging sequences.

FINDINGS/DISCUSSION
FIESTA and CISS are both ultrafast pulse sequences that provide high-resolution images with outstanding image contrast between the cerebrospinal fluid and brain parenchyma and high signal-to-noise ratio, thereby improving conspicuity of small intraventricular lesions like aqueductal webs, septations and encysted components of hydrocephalus, intraventricular masses including small aqueductal cavernomas (which are difficult to see in routine sequences), subependymal cysts. These sequences help in depicting small intra and extra-axial tumor nodules, cranial nerve anatomy and various pathologies or inner ear. Other than helping in differentiating lesions within the cerebrospinal fluid (CSF) we were able to characterize the vessel wall in vasculopathies like moyamoya disease, and defining the morphology of intracocular and intraorbital structures including the extraocular muscles. In addition, these sequences are well suited to define pathology in the spinal canal including nerve root avulsions, thickened filum, filar cysts, and drop metastases within the spinal canal. The limitations of this sequence including the reduced contrast resolution also are highlighted.

SUMMARY/CONCLUSION
FIESTA/CISS images can help answer a variety of questions in a number of neurologic disorders in children. It can be used also for brain lab protocols and avoid repeated contrast injection.

KEY WORDS: FIESTA, CISS, neuroimaging

Scientific Exhibit 060


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PURPOSE
The diversity and complexity of congenital spine malformations can make the radiologic diagnosis challenging. An understanding of spinal embryology is crucial to the classification and understanding of spinal dysraphisms. This exhibit reviews the basic embryology of normal and abnormal spinal cord development with examples and descriptions of the major malformations as seen on MR imaging (MRI).

APPROACH/METHODS
An embryologic-based approach is provided to better understand the causes for and imaging appearances of congenital spinal anomalies. This will be demonstrated through a combination of MR images, clinical photos, and illustrations.

FINDINGS/DISCUSSION
Classically, spinal dysraphisms are divided into open and closed defects. In open defects the abnormal neural tissue projects out through a posterior skin defect. In closed defects a continuous skin covering overlies the abnormality. Myelomeningoceles are the most common open spinal dysraphisms. Closed dysraphisms are further characterized by whether or not there is an underlying mass. While this approach is helpful in the initial work up of patients with spinal dysraphisms, knowledge of where the defect took place in embryogenesis is important for a more thorough understanding of these abnormalities. The important embryologic stages of spinal cord development include gastrulation (2-3 weeks), primary neurulation (3-4 weeks) and secondary neurulation (5-6 weeks). Developmental errors at any one of these stages produce predictable anomalies. During gastrulation the notochord develops. Abnormalities at this stage involve not only the spinal cord, but structures that the notochord induces, such as the osseous spine. Diastematomyelia and neuroenteric cysts are examples of closed dysraphic defects that arise during gastrulation. Primary neurulation accounts for 90% of spinal cord development. During this stage the neural tube is formed. Both open and closed dysraphic defects arise during this stage. These can be further divided into premature disjunction and nondisjunction anomalies. Familiar examples include lipomyelocoeles, dorsal dermal sinuses and myelomeningoceles. During secondary neurulation the caudal neural tube is formed by the caudal cell mass. The caudal neural tube is initially solid and then undergoes canalization and regression to form the conus medullaris and filum terminale. This two-step process is known as “canalization with retrogressive differentiation”. Tethered cord syndrome, filum fibrolipoma and anterior sacral meningocele are the results of errors during this process of embryogenesis.

SUMMARY/CONCLUSION
Knowledge of the normal development of the spine provides a framework for understanding the diversity and complexity of the congenital spinal anomalies.
Scientific Exhibit 061
MR Imaging of the Developing Pediatric Spine: A Pictorial Review

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Lexington, KY

PURPOSE
To become familiar with the MR imaging (MRI) appearance of the normal pediatric bony spine and changes which occur during development from infancy to early adulthood.

APPROACH/METHODS
Key characteristics described in literature will be discussed and MRI examples will be used to illustrate different stages of the maturing pediatric spine from ages 0 to 18 years old. There will be a focus on the appearance of the spine in T1-weighted images, with examples of T2-weighted images also being shown.

FINDINGS/DISCUSSION
As seen in other parts of the body, the spines of children have a different MR appearance compared to those of adults. It is important to be familiar with the appearance of the normal pediatric spine and how it changes in order to differentiate what is normal and abnormal. In the case of infants, one must be aware of the very different appearance of the vertebrae and disks compared to that of the older child and adult. For example, the shape of the vertebrae is overall ovoid instead of rectangular, and the vertebral endplates, which are comprised of hyaline cartilage, create bands of significantly different signal not seen in vertebrae of older children. The disks are thinner than those of an adult. The relative T1-weighted signal of the vertebral disks compared to disk changes over time. As the pediatric patient grows older, replacement of hematopoetic marrow with fatty marrow occurs and also creates changes in vertebral signal relative to disk. The change in alignment of the spine as the child begins to bear weight and shape of the spinal canal also will be briefly discussed.

SUMMARY/CONCLUSION
The MRI appearance of the normal pediatric bony spine from infancy to early adulthood undergoes characteristic changes in signal, shape, and alignment of the spine. Being able to identify changes that occur in the MRI appearance of the spine also helps one gain an appreciation of physiologic changes, such as those that occur in bone development and marrow composition.

KEY WORDS: Spine, pediatric, MR imaging

Scientific Exhibit 062
A Neuroradiologist Visits New York
Kagetsu, N. J.
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PURPOSE
To determine locations/attractions in New York City that may be of special interest to neuroradiologists who attend the 49th Annual ASNR Meeting.

APPROACH/METHODS
A review of the 26-year experience of a neuroradiologist in New York City.

FINDINGS/DISCUSSION
Multiple points of interest were identified: The hospital where the "cerebral angiography" scene from the movie "The Exorcist" was filmed. The location in the American Museum of Natural History that describes the important feature of temporal bone anatomy that distinguishes mammals from premammalian reptiles. The location in the American Museum of Natural History that identifies a mammal that has a persistent stapedial artery as the normal condition. The street corner named for a famous scientist (a household name for neuroradiologists) who lived in New York City. The restaurant where the ASNR was founded. The street where Woody Allen's character worried about having a brain tumor, before (and after) getting his brain CT scan.

SUMMARY/CONCLUSION
New York City has many locations that may be "off the beaten path" and of interest to neuroradiologists.

KEY WORDS: Anatomy

Scientific Exhibit 063
Checking Your Steps - Know the Facets: A Pictorial Review of the Cervical Facet Joints
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PURPOSE
To review the anatomy of and disease processes involving the facet joints within the cervical spine.

KEY WORDS: Spine, pediatric, MR imaging
APPROACH/METHODS
A literature search was performed and retrospective review of radiographic, CT and MR imaging of patients presenting with cervical facet joint disease to our institution over the last 10 years was undertaken.

FINDINGS/DISCUSSION
1. The normal radiographic, CT and MR anatomy of the cervical spine is described. 2. The imaging appearances of various disease processes involving the cervical facet joints including trauma, infection, neoplasm, inflammatory arthropathy and degenerative disease is reviewed with illustrative cases. 3. The relevance of facet joint blocks in patients with neck pain is discussed with procedural details. 4. Imaging appearances and the complications following instrumentation are discussed.

SUMMARY/CONCLUSION
Disease processes involving the facet joints of the cervical spine are common. Recognition of the pathologies may need more than one imaging modality. This scientific exhibit will assist with recognition of these various pathologies.

KEY WORDS: Cervical, facet joints

Scientific Exhibit 064

Diskography: A Radiologist's Review of Anatomy, Technique, and Pathology

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PURPOSE
Diskography remains an important source of information for surgical planning and before surgical intervention, especially in conjunction with cross-sectional imaging. Most of the available published material on diskography has been from nonradiology sources. We will report our institution's experiences with diskography as correlated with cross-sectional imaging done by our institution and outside films when available as well as an in-depth review of the anatomy of the intervertebral disk and the technique of diskography.

APPROACH/METHODS
We retrospectively reviewed all diskography cases performed at our institution from 2009-2010. When available, findings were correlated with cross-sectional imaging such as CT and MR.

FINDINGS/DISCUSSION
We identified a minimum of 15 patients who had diskography performed between January 2009 and August 2010. Diskography findings were compared to CT and MR imaging (MRI) findings for correlative purposes.

SUMMARY/CONCLUSION
This study reviews the anatomy of the intervertebral disk and technique of diskography as well as providing multiple cases in which the findings from diskography are correlated with CT and MRI. We found diskography to be a very effective tool in cases where cross-sectional imaging and clinical examinations were not definitive.

KEY WORDS: Diskography, diskogram, anatomy

Scientific Exhibit 065

Treatment of Postoperative Spinal Cerebrospinal Fluid Leaks with CT Fluoroscopy-Guided Blood and/or Fibrin Sealant Patching

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PURPOSE
In this exhibit we present the CT fluoroscopy-guided blood and/or fibrin sealant patching technique as a minimally invasive method for treating postoperative spinal cerebrospinal fluid (CSF) leaks.

APPROACH/METHODS
Patients with postoperative CSF leaks were selected from a cohort of patients with intracranial hypotension induced orthostatic headaches, referred to our radiology department for CT fluoroscopy-guided therapeutic blood and/or fibrin glue patching. The steps in successful diagnosis and treatment of postoperative CSF leaks are: 1. Dynamic CT myelogram of the operated area (cervical, thoracic or lumbar spine) for diagnosis and characterization of CSF leaks. 2. Creative approaches for planning the CT fluoroscopy-guided patching procedure, depending on the location and extent of CSF leaks. 3. CT fluoroscopy-guided blood and/or fibrin sealant patching. Successfully treated postoperative CSF leaks are usually narrow necked and can be located along ventral, lateral or dorsal aspects of the thecal sac. Wide-necked postoperative CSF leaks usually are not treated successfully via percutaneous patching, given the lack of adequate local mass effect by blood or fibrin sealant injected around the area of leak.

A. Prone dynamic CT myelogram image demonstrates extravasation of contrast into bilateral screw tracts, with the site of CSF leak along the right ventral aspect of the thecal sac filling the right screw tract and communicating with the contralateral screw tract at its ventral aspect. B. CT fluoroscopy image with percutaneous needle placement at the level of left-sided screw tract, at its ventral aspect, closest to the communication with the right-sided screw tract.
Scientific Exhibit 066
Human Notochord: A Pictorial Review

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**Purpose**
To review the embryology, anatomy, diseases associated with and imaging findings of the human notochord.

**Approach/Methods**
A literature search was undertaken and retrospective review of patients with disease associated with the human notochord who presented to our institution over the last 10 years was undertaken.

**Findings/Discussion**
1. The normal embryology and anatomy of the human notochord will be reviewed. 2. The pathologic processes arising in the human notochord will be described. 3. The imaging findings encountered at our institution in patients with notochord abnormalities including benign and malignant notochordal tumors, echordosis physaliphora and benign notochordal canals will be discussed. 4. The imaging findings will be correlated with pathophysiology.

**Summary/Conclusion**
The notochord is the embryologic precursor for the nucleus pulposis and portions of the notochord can persist after birth in a number of sites, namely the skull base, the odontoid peg and the coccyx. Notochordal vestiges in humans can present as varied pathologies at these sites. Therefore this scientific exhibit reviews the normal embryology and anatomy of the human notochord along with the pathologic processes arising in the notochordal remnants and the resultant phenotypes. The imaging findings encountered at our institution will be presented and correlated with pathophysiology.

**Key Words:** Human notochord, chordoma, echordosis physaliphora

Scientific Exhibit 067
Clinical Applications of High-Resolution Spinal Imaging

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**Purpose**
Imaging studies are often an essential component of the evaluation process for patients with suspected spinal pathology. Accurate diagnosis may remain challenging despite standard modern MR imaging (MRI) technique. Three-dimensional constructive interference in steady state (CISS) is a sequence that achieves greater levels of spatial and contrast resolution than conventional imaging. In this poster, we will review anatomy as seen on high-resolution imaging, and our initial experience over the last 2 years utilizing CISS imaging for problem solving in challenging spine cases.

**Approach/Methods**
High-resolution imaging (CISS) was performed as an adjunct to conventional spinal MR imaging modalities when the initial studies failed to sufficiently clarify the diagnosis. Each of the examinations was supervised directly or personally performed by the attending neuroradiologist, and tailored to the individual clinical question. For this exhibit, we have selected cases of normal and pathologic spinal anatomy that best exemplify the strengths of CISS imaging. Additionally, we have optimized our technique over time and suggest parameters for high-resolution imaging acquisition within a clinically acceptable time.

**Findings/Discussion**
Constructive interference in steady state imaging of the spinal column and spinal canal reveals more anatomical detail than typically available on conventional sequences. With respect to the compartments of the spinal canal, this allows for differentiation of the epidural, subdural and subarachnoid spaces. When evaluating the neural structures within these spaces, high-resolution imaging allows for delineation of the fine anatomy of the nerve rootlets, nerve roots, and dorsal root ganglia. When abnormalities are small or differentiation of compartments relays upon subtle distinctions, this high-resolution imaging is critical. In all of the cases presented, CISS helped to ultimately establish an accurate diagnosis.

**Summary/Conclusion**
Spinal CISS imaging can be used as a technique for problem solving when traditional modalities are inadequate for diagnosis. As the modality becomes more routinely used, we expect that high-resolution imaging of the spine will have a growing impact on patient care. In summary, this exhibit illustrates applications of CISS imaging for the spine and discusses its potential for wider use in patient care.

**Key Words:** CISS, spinal imaging, MR imaging
Scientific Exhibit 068

Spinal Cord Tumors and Tumor-Like Conditions: A Pictorial Essay

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PURPOSE
To illustrate the MR imaging appearance of various spinal cord tumors and tumor-like conditions, with examples of ependymoma, astrocytoma, hemangioblastoma, lipoma, neuromyelitis optica, sarcoidosis, and spinal cord infarct.

APPROACH/METHODS
MR scans of spinal cord tumors and tumor-like conditions performed at our teaching hospital during the past 2 years were reviewed, and the best quality scans were selected for presentation.

FINDINGS/DISCUSSION
The most common spinal cord tumors are ependymoma and astrocytoma. Imaging features favoring ependymoma over astrocytoma include: a location in the central cord, intratumoral hemorrhage, dense cellularity (areas of relative hypointensity on T2-weighted imaging (T2WI), a plane of separation between the tumor and the spinal cord (pseudo-capsule, cystic capping), and a propensity for the conus. Ependymomas are more common in adults and in patients with NF-2; astrocytomas are more common in children and in patients with NF-1. Hemangioblastomas are very vascular tumors that are of pial origin. They are, therefore, superficial lesions and more commonly are located dorsally. They can be sporadic or part of Von-Hippel-Lindau syndrome. Lipomas can be diagnosed confidently when a T1-weighted hyperintense mass is seen that becomes hypointense with fat suppression, although a fat-containing dermoid might occasionally mimic a lipoma. Remodelling of the adjacent osseous structures can be seen with spinal lipomas. Entities that mimic tumors include: tumefactive demyelination (as can be seen with neuromyelitis optica), sarcoidosis, and spinal cord infarcts. In neuromyelitis optica, the clinical presentation of pre-existent or coexistent vision loss is the key to the diagnosis. In sarcoidosis, appearances can be quite variable, but there is usually a history or corroborating imaging evidence of pulmonary sarcoidosis. Clinical history also is critical in making the diagnosis of a spinal cord infarct. Arterial infarcts usually involve the central gray matter and classically adhere to anterior or posterior spinal artery territories, but can involve the entire cross section of the cord.

SUMMARY/CONCLUSION
The MR imaging appearance of various spinal cord tumors and tumor-like conditions are illustrated. Imaging features that can help to order the differential diagnosis are presented, but good clinical information often is the key to the diagnosis.

KEY WORDS: Spinal cord tumors, tumor-like conditions

Scientific Exhibit 069

Foix-Alajouanine Syndrome: A Pictorial Essay on Spinal Dural Arteriovenous Fistulas

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PURPOSE
Spinal dural arteriovenous fistulas represent an aberrant communication between a radiculomeningeal artery and a radicular vein, typically in the thoracic or lumbar spine. When resultant venous hypertension causes motor and sensory symptoms including weakness, gait disturbance, parasethsias, and even radicular pain, the clinical syndrome is known as Foix-Alajouanine syndrome. This exhibit reviews the MR and angiographic imaging findings of this uncommon but important disease.

APPROACH/METHODS
In addition to our existing neurointerventional database, case selection was augmented by the use of a data mining program to search the Radiology information system at the University of Maryland Medical Center utilizing key words “spinal dural arteriovenous fistula” and “AV fistula.” Imaging findings and clinical notes were reviewed, and exemplary cases are presented here.

FINDINGS/DISCUSSION
MR findings of venous congestion in and around the spinal cord are characteristic. The spinal cord may be enlarged and exhibit ill-defined “flame-shaped” T2 hyperintensity centrally. Dilated pial veins appear as prominent intrathecal flow voids on T2-weighted sequences and serpentine extramedullary enhancement following administration of intravenous contrast. Pre- and post-treatment angiograms are presented, demonstrating the complex anatomy of these fistulas.

SUMMARY/CONCLUSION
Spinal dural arteriovenous fistulas and their resultant venous hypertension can cause progressive radiologic and clinical findings in affected individuals. Spinal dural arteriovenous fistula often is unsuspected clinically, and diagnosis of this rare syndrome requires familiarity with the typical imaging features of this potentially treatable disease.

KEY WORDS: Foix-Alajouanine syndrome, spinal dural arteriovenous fistula, AV fistula
Scientific Exhibit 070

Nontumoral/Nontraumatic Cervical Spinal Cord Hyperintensities: Differential Diagnosis and Anatomo-Physiologic Correlation

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PURPOSE
The aim of our study is to provide an instructional review of the major conditions leading to nontumoral/nontraumatic cervical spinal cord T2 hyperintensities, with specific attention to the clinico-neuroradiologic correlations.

APPROACH/METHODS
1) The anatomy and vascular supply of the cervical spinal cord and the syndromes related to the cervical spinal cord damage were reviewed; 2) An exhaustive literature review on the principal causes of cervical spinal cord T2 hyperintensities was performed; 3) Examples of several pathologies characterized by T2 hyperintensities in the cervical cord are presented and discussed in order to establish an organized diagnostic approach for these lesions.

FINDINGS/DISCUSSION
In a cross section of the spinal cord the central butterfly-shaped gray matter is formed by the neuronal bodies and it is surrounded by white matter columns, called funiculi, containing descending (motor) and ascending (sensitive) myelinated fibers. The blood supply depends on a larger anterior and on two smaller posterior spinal arteries, all of them arising usually from the vertebral artery. The venous drainage is provided by six spinal veins (two medians and four laterals) which form a minute and tortuous plexus ending in the intervertebral veins. The clinical presentation of a cervical spinal cord involvement is strictly related to the location of the lesion. In particular, damage to dorsal columns will cause sensitive symptoms, while the involvement of anterior columns will produce motor impairment. The extent of the spinal cord involvement also affects the clinical presentation: in fact a diffuse injury can lead to a hemicord or whole cord syndrome with both major sensitive and motor impairment. Timing is another important factor: intramedullary myelopathy may present with a hyper-acute (e.g., infarction), acute (e.g., myelitis) or subacute (e.g., sarcoidosis) onset. In the literature the presence of cervical intramedullary high T2 signal has been described as the expression of a wide range of pathologic processes such as disruption of the blood-central nervous system (CNS) barrier; edema, necrosis, abnormal cerebrospinal fluid (CSF) spaces or a combination of these conditions. For illustrative purpose, we will provide an example of the following myelopathies, highlighting for each one the imaging pattern, the anatomical-clinical correlation and the diagnosis: vitamin B12 deficiency; hypoxic-ischemic damage; radiation-induced damage; myelitis; sarcoidosis.

SUMMARY/CONCLUSION
The knowledge of the cervical spinal cord anatomy and related clinical presentations is essential for the interpretation of the cervical T2 hyperintense lesions on MR imaging.

Our work emphasizes that a correct anatomo-functional correlation is still valuable and crucial in the diagnostic work up of patients with a spinal cord involvement. We propose a review of the main cervical spinal cord myelopathies, with functional-imaging-pathologic correlation in order to: 1) highlight the differences of these conditions, sometimes very subtle; 2) facilitate the differential diagnosis for junior radiologists.

KEY WORDS: Cord, anatomy, hyperintensities

Scientific Exhibit 071

Spinal Dural Arteriovenous Fistulas: Neuroradiologic Diagnosis and Treatment Options

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PURPOSE
To recognize the MR imaging (MRI) findings associated with spinal dural arteriovenous (AV) fistulas and to discuss the various treatment options.

APPROACH/METHODS
We present a case series of four middle-aged patients diagnosed with spinal dural AV fistulas and their radiologic findings on MRI and angiography. We also discuss two cases where incomplete angiograms lead to a delay in diagnosis. We then discuss the treatment options and outcomes of the patients treated with endovascular techniques, surgery, or with a combination of both.

FINDINGS/DISCUSSION
Each patient in our case series presented with nonspecific symptoms of back pain and progressive weakness. Each patient received a MRI of the spine, which demonstrated some key findings that aided in the eventual diagnosis. The findings included diffuse high T2-weighted signal in the thoracic spinal cord extending to the conus medullaris with multiple serpentine vessels running along the surface of the spinal cord. Spinal angiography was performed which confirmed the diagnosis. Additional radiologic and angiographic findings are discussed as well as two cases in which incomplete angiography lead to a delay in diagnosis. Each patient was treated with endovascular techniques, surgery, or with a combination of both with significant resolution of their symptoms. The treatment outcomes are discussed and the literature on the topic was reviewed.

SUMMARY/CONCLUSION
Spinal dural AV fistula is a very difficult clinical diagnosis as the symptoms associated often are nonspecific and commonly are associated with more benign processes such as degenerative disk disease. The role of the diagnostic and interventional neuroradiologist is key in establishing the diagnosis and, in some cases, providing the definitive treatment. It is of critical importance to be familiar with the disease and to recognize the spinal MRI and angiographic findings associated
with spinal dural AV fistulas. Failure to do so can delay successful treatment and result in subsequent permanent damage and impairment to the patient.

**KEY WORDS:** Spinal, fistula

**Scientific Exhibit 072**

**Cervicocranium Revisited: Finding the Correct CT Measurements to “Rule In” Craniocervical Injury**

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**PURPOSE**
The aim of this exhibit is to: 1. Review the normal bone and soft tissue anatomy of the cervicocranium with imaging correlation. 2. Become familiar with various measurements used to evaluate the cervicocranium. 3. Review the current literature regarding portability of plain film measurements to CT. 4. Stress the importance of evaluating the soft tissues on imaging including CT and MR.

**APPROACH/METHODS**
Patients with cervicocranial injuries were identified with retrospective review of our imaging database. Through case examples, we will illustrate various techniques of measuring cervicocranial relationships, review traumatic pathology and imaging pitfalls that lead to distortion of such measurements, and provide a review of the current literature supporting the use of various measurements on CT with an emphasis on the sensitivity and specificity of injury diagnosis.

**FINDINGS/DISCUSSION**
Injuries to the cervicocranium usually are the result of blunt trauma and are associated with high morbidity and mortality. Patients often are unresponsive or have altered mental status at the time of presentation and thus adequate physical examination is not possible. Injuries to the cervicocranium may be subtle on plain film. In the trauma setting, CT is the preferred imaging modality for initial evaluation of the head and cervical spine at our institution. Accurate rapid diagnosis is essential for appropriate management and satisfactory outcomes. This is limited by factors including low incidence, subtlety of imaging findings, satisfaction of search in cases of multitrauma, and lack of familiarity with this anatomical region. Recent literature has described the portability of various measurements historically used to evaluate the cervicocranium on plain film to CT.

**SUMMARY/CONCLUSION**
Knowledge of the normal anatomical relationships and most sensitive and specific CT measurements will aid in the accurate and rapid diagnosis of cervicocranial injuries in an effort to reduce morbidity and mortality associated with trauma.

**REFERENCES**

**KEY WORDS:** Cervicocranium, trauma
Electronic Scientific Exhibit (eSE)
1–137
Exhibit Hall 4A

Monday, June 6 - Wednesday, June 8
6:30 AM – 9:00 PM

Thursday, June 9
6:30 AM – 3:00 PM

Note: A missing Electronic Scientific Exhibit number indicates an abstract has been withdrawn.

Adult Brain
001-049

Electronic Scientific Exhibit 001
Use of Susceptibility-Weighted Imaging to Predict the Outcome of Large Vessel Occlusion Disease

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PURPOSE
Large vessel occlusion disease contributes to 24% of cases of acute stroke and is associated with worse outcomes. Our purpose is to investigate whether the susceptibility-weighted imaging (SWI) results of those with documented occluded large vessels can be used to predict their clinical outcomes.

APPROACH/METHODS
From April 2009 to March 2010, 235 patients visited our emergency department with clinical suspicion of acute infarction and transient ischemic attack. Images for 53 patients who received both traditional and susceptibility-weighted MR imaging within 12 hours of symptom onset and who had confirmed occlusion of either the internal carotid or middle cerebral arteries were available for analysis. Demographic and clinical variables and 6-month modified Rankin Scale scores were collected and combined with blinded interpretations of MR results. Phases of radians and signal intensities of selected regions of interest in the affected territory in the SWI were compared with those in the contralateral side. Presence of intraarterial thrombus, transmedullary vein, luxury flow and hemorrhage spots also were included.

FINDINGS/DISCUSSION
Those patients who co-morbid with DM (O.R = 1.7), old lacunar infarctions (O.R = 2.6), MR evidence of early hemorrhage (O.R = 3.3), transmedullary vein (O.R = 2.2) were predisposed to worse outcomes. The presence of anterior or posterior communicating arteries showed no significant benefits (O.R = 1.3). The SWI signal intensity in the region of interests of the affected territory was significantly lower than the contralateral side (250 + 24.35 vs 270 + 47; P = 0.045). The phase of radians of the region of interest of the affected territory was larger than the contralateral side but the difference was not significant.

SUMMARY/CONCLUSION
Susceptibility-weighted imaging provided more comprehensive data than traditional MR imaging, including information on microbleeding and the extent of deoxygenization. It can be used not only to decide the proper timing for revascularization of chronic occlusive vessels, but also to guide thrombolytic therapy for better patient selection in acute infarctions.

KEY WORDS: Cerebral ischemia, susceptibility-weighted imaging, large vessel occlusion

Electronic Scientific Exhibit 002
Troubleshooting Stroke Mimics and Concealed Strokes: The Neurologist and the Neuroradiologist’s Perspective

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PURPOSE
To present case scenarios illustrating clinical and imaging pitfalls in the work up for acute stroke.

APPROACH/METHODS
Using a case-based format, we discuss clinical entities that may have an initial clinical or imaging presentation that mimics stroke, and also stroke cases with a misleading initial presentation, that may delay the diagnosis. The role of the different imaging modalities such as computed tomography (CT), MR imaging (MRI), angiographic studies and perfusion imaging is discussed.

FINDINGS/DISCUSSION
Non-witnessed seizures may result in Todd’s paralysis and post ictal mental status changes, that frequently are interpreted as acute stroke. These patients may have epilepto-
genic lesions such as cavernous malformations, tumors, or infectious processes that may simulate the findings of acute infarct. Furthermore, perfusion abnormalities with a regional distribution may be mistaken as ischemic penumbra. Multiple sclerosis can present with acute neurologic deficit, as well as areas of restricted diffusion that may simulate small vessel infarcts. Tumors, complicated migraine, metabolic disorders and other stroke mimics can misguide the clinical approach of patients with acute neurologic deficit. On the other hand, patients with atypical-appearing stroke may be misdiagnoses as infection, tumor or other entities, which results in delay in treatment.

SUMMARY/CONCLUSION
We discuss clinical and imaging pitfalls in the diagnosis and work up of stroke syndromes, as well as tools that we have found useful to tell them apart.

KEY WORDS: Stroke, infection, seizure

Electronic Scientific Exhibit 003
Brainstem Stroke: The Use of Propeller Diffusion-Weighted Imaging to Overcome Artifacts
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PURPOSE
Correct diagnosis of acute ischemic lesions in the brainstem is crucial since it contains several gray matter nuclei with vital functions mixed with white matter tracts with very important connections. On conventional MR imaging (MRI) and echo-planar diffusion-weighted imaging (EPI DWI), brain stem infarcts demonstrate similar imaging characteristics to cerebral infarcts. However, the proximity of these lesions to the skull base often causes severe image distortion. Propeller DWI is one approach to reduce artifacts on DWI in this region and improve the detection rate of small brain stem infarcts. We have encountered several cases that initially were considered negative for acute infarction, since restricted diffusion by the use of EPI DWI alone was masked by susceptibility from the skull base.

APPROACH/METHODS
In this review we will emphasize this problem and show examples of how using the propeller technique for DWI in cases of suspected brain stem infarct is more accurate.

FINDINGS/DISCUSSION
In addition, the use of different imaging planes should be exploited as a further step towards overcoming such image distortions. We consider the two approaches to be complimentary to each other and will discuss the advantages and the disadvantages of both.

SUMMARY/CONCLUSION
We encourage the use of both conventional EPI DWI using optimized image projection and propeller DWI as they are complimentary and may be used in suspected cases of brain stem ischemic stroke that are negative on the routine axial EPI DWI.

KEY WORDS: Brain stem stroke, propeller DWI

Electronic Scientific Exhibit 004
Gadolinium-Enhanced MR Imaging in Multiple Sclerosis
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PURPOSE
To become familiar with the role of contrast-enhanced MR imaging (MRI) in the initial diagnosis of multiple sclerosis (MS) and to learn about the natural history of contrast-enhancing lesions in MS and the effect of treatment on them.

APPROACH/METHODS
Based on published data and our own experience, we review the role of contrast-enhanced MRI at diagnosis and follow up of multiple sclerosis, the effect of different treatments on the natural history of contrast-enhancing lesions, and the different strategies that can be used for increasing the sensitivity of MR imaging in demonstrating active demyelinating lesions.

FINDINGS/DISCUSSION
In multiple sclerosis patients gadolinium-enhanced T1-weighted imaging is highly sensitive in detecting inflammatory activity. Longitudinal and cross-sectional MR studies have shown that the formation of new MS plaques is often associated with contrast enhancement, mainly in the acute and relapsing stages of the disease. The gadolinium enhancement varies in size and shape, and usually lasts from a few days to weeks, although this time period is shortened by steroid treatment. MR imaging is extremely valuable for achieving an early diagnosis of MS according to the 2005 McDonald criteria. In these criteria the presence of at least one gadolinium-enhancing lesion is one of the requisites for demonstrating demyelinating lesions disseminated in space and time, which allow a diagnosis of MS. More recently it has been proposed that a single brain MRI scan that demonstrates both gadolinium-enhancing and nonenhancing lesions suggesting dissemination in time is highly specific (86%) for predicting early development of clinically definite MS. Interferon beta (IFNβ) and glatiramer acetate (GA) are the most widely used and accepted treatments for RR MS. Clinical trials with these immunomodulatory agents in this clinical phenotype have shown an evident effect in reducing clinical and MRI disease activity (new T2 or gadolinium-enhancing lesions), and progression of disability. Recent data have shown that the simultaneous presence of relapses or increased disability and active lesions on brain MRI (either new T2 or contrast-enhancing lesions) significantly predicts the risk of having a poor response to IFNβ treatment in the following years. This information is especially important nowadays, when new second-line treatments, such as natalizumab, are available for treating MS. Several methods have been proposed to increase the sensitivity of gadolinium-enhanced MRI for detecting disease activity in routine clinical practice. These include: the introduction of a minimum 10-20 minute delay between gadolinium injection and scanning, the use of high gadolinium doses or gadolinium...
Purpose

Due to its unique sensitivity in detecting disease activity, gadolinium-enhanced MRI is extremely valuable not only for achieving an early diagnosis of MS, but also in selecting patients for immunomodulatory treatment and monitoring disease activity. Recent data also support the value of gadolinium-enhanced MRI in predicting treatment response. The use of cost-effective strategies that increase the sensitivity of gadolinium-enhanced MRI for detecting disease activity might improve our capability in the initial diagnosis and in monitoring treatment for the disease.

Key Words: Multiple sclerosis, contrast-enhanced, MR imaging

Electronic Scientific Exhibit 005

Neuroimaging in Toxic Brain Injuries

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Purpose

Various endogenous and exogenous agents adversely affect the central nervous system. The purpose of this educational exhibit is to present the central nervous system MR imaging (MRI) findings associated with the accumulation of abnormal endogenous and exogenous substances in the brain. The intracranial findings can be subtle, and it is critical to recognize them promptly in order to administer the correct treatment.

Approach/Methods

In this educational poster, MRI findings in patients with abnormal levels of endogenous metabolites and exposure to exogenous toxic agents are reviewed. Abnormal levels of the following endogenous metabolites are discussed and shown: lactate, bilirubin, copper, iron and ammonia. The exogenous toxins include: carbon monoxide, acetone, cocaine, heroin, alcohol, chemotherapeutic agents, immunosuppressants and antiseizure medication. MR imaging and spectroscopic findings are described and correlated with the clinical and laboratory findings.

Findings/Discussion

MR imaging plays an important role in the diagnosis of toxic encephalopathy. A cursory review of this topic is insufficient to make an accurate diagnosis. A thorough understanding of the biochemical mechanism by which toxic agents affect specific anatomical structures in the brain is needed. Specific types of toxins tend to affect specific brain structures more than others. MR imaging findings tend to show symmetrical pattern abnormalities. This study outlines how an understanding of the metabolism, distribution and tissue affinity of toxic agents is paramount for the recognition of subtle toxic effects seen on MRI examinations of the brain.

Summary/Conclusion

The toxic effects of various drugs and metabolites often are overlooked in the larger picture of complex medical problems. Their prompt recognition plays a critical role in the recognition and ultimately management of central nervous system (CNS) complications. The overriding goal of this exhibit is to unravel some of the complexity faced by the neuroradiologists interpreting MRI findings in cases of neurotoxic encephalopathy. This review will arm neuroradiologists with a format specifically designed to provide a biochemical frame of reference that can be applied to clinical imaging practice.

Key Words: Drugs, metabolites, toxicity

Electronic Scientific Exhibit 006

Beyond Mesial Temporal Sclerosis: Findings in Normal MR Imaging of the Brain in Patients with Epilepsy

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Purpose

To demonstrate subtle MR imaging (MRI) findings in patients with epilepsy, many of which were overlooked on initial interpretation.

Approach/Methods

MR scans of the brain acquired using a dedicated epilepsy protocol on a 3T scanner as part of a phase I evaluation in patients with medically refractory seizures were evaluated retrospectively in light of relevant surgical or pathologic findings. MR imaging findings in 120 consecutive patients undergoing epilepsy surgery were evaluated. The incidence of “missed” findings on formal neuro-radiologic interpretation of the imaging will be reported. We will present a pictorial essay demonstrating a spectrum of MRI structural lesions in patients with epilepsy. A summary of the common pitfalls in the interpretation of MR imaging of patients with epilepsy will be presented.

Findings/Discussion

The presence of a lesion on MR imaging is a major factor that affects the candidacy of a patient for surgical intervention and the prognosis for seizure freedom after epilepsy surgery. Commonly identified structural lesions include hippocampal sclerosis, areas of gliosis, tumors, cavernous malformations, cortical dysplasia, and gray matter heterotopia. A closer evaluation, however, may reveal additional structural abnormalities that are not infrequently present, and often are overlooked on initial interpretation. Examples include: temporal lobe volume loss, diffuse or focal cortical thickening, abnormalities in the junction of gray and white matter, other subtle abnormalities of cortical organization, and small meningoencephaloceles of the middle cranial fossa. A few simple modifications to standard epilepsy protocols may enhance the opportunity to recognize subtle structural abnormalities. Skin to skin acquisition of high-resolution coronal or coronal oblique T2-weighted imaging improves detection of lobar or regional white matter volume asymmetries, blurring of the gray-white matter interface,
middle cranial fossa meningoencephaloceles, and provides another plane of assessment for detection of focal congenital or acquired lesions. We also have found that addition of a magnetoencephalography sequence on all of our 3 T epilepsy scans has aided in detection or confirmation of subtle abnormalities of cortical organization or differentiation.

SUMMARY/CONCLUSION
By making radiologists more aware of the spectrum of MRI findings that may be seen in patients with epilepsy, particularly subtle and often overlooked findings, and optimizing epilepsy imaging protocols, radiologists can generate more accurate and useful reports, improving patient care.

KEY WORDS: Epilepsy, seizure, meningoencephalocele

Electronic Scientific Exhibit 007
Postictal Encephalopathy: Characteristic Findings, Differential Diagnoses, and Imaging Pitfalls with Emphasis on Diffusion-Weighted Imaging

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PURPOSE
This exhibit seeks to illustrate MR imaging (MRI) findings associated with postictal encephalopathy, with an emphasis on diffusion-weighted imaging (DWI), and to review seizure-related pathology with discussion of the differential diagnosis and imaging pitfalls.

APPROACH/METHODS
We conducted a systematic review of the MRI studies of 47 postictal patients (age range: 1 to 91 years). We evaluated these studies for: the distribution and extent of T2/FLAIR abnormalities; DWI hyperintensity and apparent diffusion coefficient (ADC) values to assess for vasogenic versus cytotoxic edema; and the degree of contrast enhancement. In our cohort, 23 patients had cryptogenic seizures. The remainder of the patients in this series had seizures related to immune-mediated processes (6), stroke (5), infection (4), derangements of metabolism (4), underlying neoplasm (3) and congenital abnormalities (2). In addition, we discuss cases demonstrating the differential diagnosis of postictal encephalopathy (e.g., mesial temporal sclerosis, herpetic and nonherpetic limbic encephalitis, Hashimoto encephalopathy, anti-NMDA encephalopathy, hypoxic ischemic encephalopathy, PRES, CNS vasculitis, extrapontine myelinolysis, mitochondrial encephalopathy, gliomatosis, Langerhans cell histiocytosis, neurofibromatosis type 1 and Creutzfeldt-Jakob disease).

FINDINGS/DISCUSSION
The findings of postictal encephalopathy included increased T2/FLAIR signal and DWI abnormalities in the hippocampi, pulvinar and medial aspect of the thalami and within the neocortex and underlying white matter. In our cohort, 29 patients had abnormalities in the neocortex, 21 patients had hippocampal involvement, and 11 patients had thalamic abnormalities. Signal alterations related to ictal or postictal status can be misdiagnosed as infarction, tumorous conditions, encephalitis or other encephalopathy. This may result in unnecessary or invasive management such as conventional angiography, biopsy, or inappropriate therapies. In addition, we demonstrate cases in which awareness of postictal encephalopathy prevents “satisfaction of search” errors when multiple pathologic processes are present simultaneously. There are two proposed pathophysiologic mechanisms of postictal encephalopathy. 1) A seizure focus induces a hypermetabolic state which results in consumptive hypoxia, hypercarbia and lactic acidosis, which impairs vascular autoregulation in the affected areas of cortex, leading to vasogenic edema which may lead to disruption of the blood-brain barrier. 2) Intrinsic neuronal seizure activity increases the release of glutamate resulting in cytotoxic edema in the cortex and subcortical white matter, especially if seizures are prolonged (tonic-clonic or status epilepticus). FLAIR and T2 sequences are relatively sensitive in detecting edema, but lack specificity with regard to vasogenic versus cytotoxic etiology. Diffusion-weighted imaging increases this specificity. Whether perictal lesions are reversible or irreversible on MR imaging seems to depend on the duration and/or severity of the seizures.

SUMMARY/CONCLUSION
We illustrate MRI findings associated with postictal encephalopathy, with an emphasis on DWI. We also review seizure-related pathologies and discuss the differential diagnosis and imaging pitfalls (including a discussion of mimicks and concurrent pathologies), as precise diagnosis is important to assure appropriate medical management.

KEY WORDS: Postictal encephalopathy, seizure, diffusion-weighted imaging

Electronic Scientific Exhibit 008
Sense and Sensitivity: The Prefrontal Brain

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1Osatek S.A., Galdakao-Bizkaia, SPAIN, 2Hospital Galdakao, Galdakao-Bizkaia, SPAIN

PURPOSE
The aim of the exhibit is to describe the morphologic and functional anatomy of the prefrontal cortex and its relationship and interactions with the deep gray matter and other cortical areas by means of diffusion tensor imaging (DTI) and functional magnetic resonance imaging (fMRI).

APPROACH/METHODS
We have analyzed morphologic, DTI and fMRI sequences in normal volunteers with 1.5 T and 3 T magnets. Morphologic analysis was done in the 1.5 and 3 T systems with T1 3D gradient-echo sequences with an in plane resolution of 1x1 mm. Diffusion tensor images were acquired in the 3 T system using axial single-shot EPI employing 32 diffusion directions and a b factor of 800. Functional MR imaging sequences were obtained in the 3 T system using axial single shot EPI in a block design. Paradigms highlighting executive
and working memory functions such as n-back test, Sternberg test and emotional discrimination tasks such as recognition of emotional faces and gaze were used.

**Findings/Discussion**

The prefrontal area is highly developed in humans and it is related to high order functions. It is implicated in planning complex cognitive behaviors, personality expression, decision making and moderating correct social behavior. Its basic activity is considered to be orchestration of thoughts and actions in accordance with internal goals. It is divided in three main functional areas, dorsolateral, ventral and orbital. It has extensive connections with deep gray matter and other cortical areas. The prefrontal cortex connects with the basal ganglia, ventral and dorsal striatum and accumbens nucleus, and dorsomedial, intralaminar, anterior ventral and pulvinar nuclei of the thalamus. Almost all the association fascicles, except for the inferior longitudinal fascicle, interconnect the prefrontal brain with the rest of the cortical areas. Diffusion tensor imaging depicts the different fascicles such as the superior longitudinal fascicle (including its four subcomponents, the fourth being the arcuate fascicle), superior and inferior fronto occipital fascicles and uncinate fascicle connecting to the other lobules. Functional MR imaging paradigms that explore working memory or interference activate dorsolateral prefrontal and anterior frontal cortex. Emotional discrimination tasks also activate orbitofrontal cortex.

**Summary/Conclusion**

A thorough knowledge of the prefrontal morphologic and functional anatomy is mandatory to understand degenerative and psychiatric pathology which may affect this area.

**Key Words:** Prefrontal, DTI, anatomy

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**Electronic Scientific Exhibit 009**

**Quantitative Diffusion Tensor Imaging in Trigeminal Neuralgia: A Useful Physiologic Biomarker of Nerve Injury?**

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**Purpose**

Trigeminal neuralgia is a chronic debilitating condition that can be refractory to medical, radiosurgical and surgical intervention. In many cases, this condition is thought to be related to a vascular loop in close proximity to the trigeminal nerve, particularly close to the root entry zone (REZ), where the nerve exits the lateral pons. It is postulated that chronic irritation of the REZ causes progressive injury of the nerve resulting in pain. Thus far, anatomical imaging of nerves and vascular loops has been inconclusive since in any given case no definite correlation can be defined between the side of symptoms and presence or absence of a vascular loop. We hypothesized that quantitative diffusion tensor imaging (DTI) might be a potential “physiologic” biomarker for nerve injury in patients with trigeminal neuralgia.

**Approach/Methods**

Under IRB approval we retrospectively reviewed clinical and imaging data from 26 patients with trigeminal neuralgia who had MR imaging studies that included DTI. MR imaging was obtained using a 3 T Philips Achieva and included T1-weighted thin-section images pre and postgadolinium, 3D balanced FFE images of the basal cisterns, high-resolution 3D time-of-flight MRA and DTI. Diffusion tensor imaging was done using B values of 0 and 1000, 16 gradient directions, 2 mm slice thickness. Diffusion tensor imaging analysis was performed on a Philips Extended Workspace workstation to track fibers through both trigeminal nerves using regions of interest (ROIs) placed at the REZ and over the cisternal segments of the trigeminal nerves, before entry into Meckel’s cave. Quantitative values for fractional anisotropy (FA) and apparent diffusion coefficient (ADC) were calculated for each nerve fiber tract and for each ROI. Mean FA and ADC values were correlated to the side of pain. Individual patient DTI values for nerves on symptomatic versus asymptomatic sides were compared.

**Findings/Discussion**

Anatomical images showed no significant pathology. We found that FA and ADC values were remarkably reproducible across all nerves evaluated and fell within a narrow range. Further, no statistically significant difference in these parameters between “affected” and asymptomatic nerves was detected.

**Summary/Conclusion**

We conclude that current DTI technology and analysis techniques failed to demonstrate a correlation with side of nerve injury and pain symptoms in patients with trigeminal neuralgia. Limitations from thin section imaging, skull base susceptibility, pulsatile motion or inadequate B0 correction may have limited sensitivity and further research in this area is required.

**Key Words:** MR imaging, diffusion tensor imaging, trigeminal neuralgia
Imaging of Multiple Sclerosis: The Role of Diffusion Tensor Imaging and Fiber Tractography

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PURPOSE
• Review conventional MR imaging (MRI) features of multiple sclerosis (MS). • Review basic concepts of diffusion tensor imaging (DTI) and fiber tractography. • Discuss applications of these techniques in MS imaging.

APPROACH/METHODS
Review the characteristic MRI features and distribution of MS lesions. Discuss the limitations of conventional MRI of MS. Provide overview of the basic concepts of DTI and fiber tractography. Review the utility and methods of DTI and fiber tractography analysis in white matter of the brain and spinal cord. Discuss the role of these techniques in evaluation of MS lesions, normal-appearing white matter, and differential diagnosis of demyelinating disease.

FINDINGS/DISCUSSION
Diffusion tensor imaging abnormalities can be detected in normal-appearing white matter of the brain and spinal cord as well as in T2 hyperintense lesions. Fiber tractography can resolve derangements in specific CNS pathways. Diffusion tensor imaging also may be useful in differentiating MS from secondary demyelinating conditions.

SUMMARY/CONCLUSION
Diffusion tensor imaging is a highly sensitive technique and can detect and quantify white matter injury in multiple sclerosis. Diffusion tensor imaging is a promising technique for characterization of early MS and CIS and may assist in differentiation of MS from other white matter disease. This technique may allow for earlier detection of MS and improve evaluation of treatment response.

KEY WORDS: Multiple sclerosis, diffusion tensor imaging, tractography

What the Heck Are Kurtosis, K-Trans and Boxcar Designs? A Primer to Understanding Advanced Neuroimaging Jargon

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PURPOSE
• To review the terminologies used in advanced neuroimaging modalities. • To discuss each individual parameter measured in advanced neuroimaging modalities with emphasis on their pathophysiologic relevance and current clinical applications.

APPROACH/METHODS
A. Introduction to terms used in advanced neuroimaging parameters: • Diffusion-weighted imaging - apparent diffusion coefficient (ADC), eADC, parametric response maps, ADC histograms; • Diffusion tensor imaging - fractional anisotropy, diffusivity (axial and radial); • Kurtosis, HARDI and Q-ball vector analysis; • Functional MRI (fMRI) - BOLD, "boxcar" experimental designs, paradigms-motor, visual, verb generation, semantics; • CT and MR perfusion - blood volume, blood flow, mean transit time, capillary permeability, K-Trans. B. Pathophysiologic parameters measured in each modality. C. Current applications in clinical neuroimaging: • Differentiation of benign versus malignant pathologies; • Characterization of tumors with respect to their
molecular/biologic behavior; • Distinguishing recurrent tumor versus post-therapy changes; • Localization of "eloquent" brain areas as a guide for neurosurgery in tumor resection.

**Summary/Conclusion**
Knowledge of terminologies used and parameters measured in advanced neuroimaging modalities is essential for accurate interpretation and their application in appropriate clinical settings.

**Key Words:** DTI, functional MR imaging, perfusion imaging

**Electronic Scientific Exhibit 012**
MR Phase-Contrast Cerebrospinal Fluid Flow Studies: A Tutorial and Literature Review

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**Purpose**
The purpose of this presentation is 1) to describe the physics and proper interpretation of MR phase-contrast cerebrospinal fluid (CSF) flow studies, 2) to discuss the pathophysiology of diseases of CSF flow, and 3) to review the literature on the diagnostic and prognostic value of this imaging technique.

**Approach/Methods**
A series of diagrammatic movies are utilized to describe the physics of MR phase-contrast imaging. The physical underpinnings of the velocity encoding parameter and the phase aliasing artifacts are explained. Case studies then are used to demonstrate the technique’s application to diseases of CSF flow, including symptomatic Chiari malformation, syringomyelia, obstructive hydrocephalus, and normal pressure hydrocephalus. Disease pathophysiology and the diagnostic and prognostic value of the study are discussed in the context of these cases. The application of quantitative post-processing to studies of normal pressure hydrocephalus also are discussed in detail.

**Findings/Discussion**
Cerebrospinal fluid pulses in sync with the cardiac cycle. Cereospinal fluid flows caudally during systole, and cranially during diastole. Disruption of this natural CSF flow is the basis for many neurologic diseases. MR phase-contrast imaging has the ability to noninvasively detect fluid velocities inside the body. Thus, this technique can directly visualize in vivo CSF flow, making it a powerful diagnostic tool. However, proper study interpretation often is challenging due to complications such as phase aliasing or multistep postprocessing procedures.

**Summary/Conclusion**
The MR phase-contrast CSF flow study is an important tool in the characterization and diagnosis of symptomatic Chiari malformation, syringomyelia, obstructive hydrocephalus, and normal pressure hydrocephalus. An understanding of the fundamental physical concepts of MR phase-contrast CSF flow studies can aid in proper study interpretation.

**Key Words:** Phase-contrast MR imaging, cerebrospinal fluid flow

**Electronic Scientific Exhibit 013**
Bipolar Disorder and Obsessive-Compulsive Disorder: A Comparison Model of Functional Neuronal Connectivity with Diffusion Tensor Imaging

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**Purpose**
Bipolar disorder (BPD) and obsessive-compulsive disorder (OCD) are common, potentially debilitating psychiatric illnesses. Bipolar disorder manifests as mood alternations between depression and mania. Obsessive-compulsive disorder has been characterized by persistent thoughts and attempted neutralization via another repetitive thought or action. The impetus to incorporate modern neuroimaging techniques to help establish the correct psychiatric diagnosis is reflected in the current research efforts for the upcoming Diagnostic and Statistical Manual of Mental Disorders (DSM) V. Multiple clinical studies have utilized diffusion tensor imaging (DTI) to assess the fractional anisotropy (FA) of affected white matter (WM) tracts of patients with either BPD or OCD. The possibility of overlapping WM tract abnormalities in these two discrete disorders has not been readily addressed, however, despite their well accepted co-occurrence. We incorporate a visualization method to display DTI FA values and propose a comparison model of functional neuronal connectivity in these related disorders.

**Approach/Methods**
A literature search with the keywords “Bipolar Disorder” or “Obsessive-compulsive Disorder” and “Diffusion Tensor Imaging” was performed on Google Scholar, which encompasses the PubMed database. Included DTI studies compared FA in individuals with BPD or OCD to controls. Studies that lacked published coordinate data of identified regions of interest in either the Montreal Neurological Institute (MNI) or Talairach spaces were excluded. Factors evaluated were the number of study subjects and controls, p-values (with or without correction for multiple comparisons), MNI or Talairach coordinates of multiple regions of interest with attention to relative FA values, and the number of voxels in each region. Forty-six BPD and 16 OCD regions of interest then were mapped on a reference brain with data weighted by both the number of voxels in the region of interest and by their statistical significance. Study data were assigned to groups (BPD and OCD) of different hues, with luminance and opacity levels corresponding to the degree of statistical significance. A visual representation of the relative strength of the inferences which could be drawn was thereby achieved. A comparison model then was constructed to suggest commonly affected WM tracts in both BPD and OCD.

**Findings/Discussion**
Our comparison model enables assessment of those WM tracts which are affected in both BPD and OCD in a visually appealing and informative manner. Presenting compiled data sources with emphasis on their relative statistical sig-
nificance can help to overcome such previous study limitations as small sample size and inconsistent statistical analysis. The clinical implications of these findings, with a discussion of the neurobiologic basis of these disorders, also will be presented.

**SUMMARY/CONCLUSION**

Bipolar disorder and OCD are clinically significant psychiatric conditions that demonstrate abnormalities of neuronal connectivity. We have developed a visualization method, utilizing FA values from DTI, to illustrate the WM tract abnormalities common to both entities. We hope that a comparison model of BPD and OCD may provide new insights to both researchers and clinicians alike as to these and other potentially associated disorders.

**KEY WORDS:** Bipolar disorder, obsessive-compulsive disorder, diffusion tensor imaging

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**Electronic Scientific Exhibit 014**

**MR Imaging Findings in Hashimoto’s Encephalopathy: A Case-Based Pictorial Essay and Review of the Literature**

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**PURPOSE**

There has been increasing awareness of central nervous system (CNS) autoimmune-mediated disorders that lead to cognitive impairment, behavioral changes, and seizures, many of which are reversible with immunomodulatory therapy. Hashimoto’s encephalopathy (HE), also known as steroid responsive encephalopathy associated with autoimmune thyroid disease (SREAT), is a subtype of autoimmune-mediated encephalopathy (AME) that occurs in patients with elevated anti-thyroid peroxidase (anti-TPO) and/or anti-thyroglobulin (anti-TG) serum antibodies. Many radiologists are not yet familiar with HE. In this exhibit, we review its clinical features and variety of MR imaging (MRI) manifestations.

**APPROACH/METHODS**

We retrospectively evaluated medial records and imaging studies for seven patients presenting to our institution over a 10-year period, from 07/2000 to 12/2009, with acute/subacute onset encephalopathy and/or seizures, who subsequently were diagnosed with HE. The different patterns of MRI abnormalities, clinical presentation, and systematic diagnostic work-up and treatment of HE are discussed in a case-based pictorial essay with reference to the scientific literature.

**FINDINGS/DISCUSSION**

MR imaging patterns in our patients included supratentorial leukoencephalopathy (n=3), limbic encephalitis (n=1), focal cortical/subcortical edema (n=1), global parenchymal atrophy (n=1), and a normal exam (n=1). Presenting symptoms included acute/subacute onset cognitive impairment, neuropsychiatric symptoms, seizures, ataxia, and myoclonus, which improved variably in each patient after corticosteroid treatment. Infectious, toxic, metabolic, neoplastic, and other possible autoimmune etiologies were excluded in all patients. All seven patients had elevated serum anti-TPO (n=6) and/or anti-TG antibodies (n=6). Two patients had subclinical hypothyroidism, one patient had subclinical hyperthyroidism, and four patients were euthyroid, although all were euthyroid at the time of definitive diagnosis and steroid treatment. Hashimoto’s encephalopathy is diagnosed in patients with acute or subacute onset encephalopathy with positive anti-TPO and/or anti-TG antibodies and is considered a diagnosis of exclusion after infectious, toxic, metabolic, neoplastic, and other autoimmune etiologies are ruled out. Current evidence suggests that the antithyroid antibodies are not pathogenic, but rather markers of autoimmunity for other possible novel antineuronal antibodies. Patients are often euthyroid at presentation but also may be hypothyroid or hyperthyroid with persistent encephalopathy after correction of thyroid function. The recommended diagnostic work up for these patients include brain MRI with and without contrast, cerebrospinal fluid (CSF) analysis (including protein, glucose, cell count, IgG index, oligoclonal bands, cytology, and ruling out infectious etiologies as clinically indicated), electroencephalography (EEG), and serum and CSF CNS auto-antibody panel testing. According to the literature, the most common MRI pattern is a normal exam with or without age-appropriate multifocal periventricular and subcortical white matter signal changes. Additional reported brain MRI patterns associated with HE include leukoencephalopathy, limbic encephalitis, cortical edema, and global brain atrophy, as are seen in our series.

**SUMMARY/CONCLUSION**

Hashimoto’s encephalopathy is a diagnosis made in patients with reversible AME who have a negative CNS autoantibody panel and have positive anti-TPO and/or anti-TG serum antibodies in whom other etiologies have been ruled out. Given that this condition is typically reversible with treatment, it is important for the radiologist to consider HE and other AMEs in patients with the above-mentioned patterns of MRI abnormalities in the appropriate clinical setting.

**KEY WORDS:** Hashimoto’s, encephalopathy, MR imaging

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**Electronic Scientific Exhibit 015**

**Diffusion-Weighted Imaging: Fungal Central Nervous System Infections with Clinicopathologic Correlation**

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**PURPOSE**

The purpose of this exhibit is to review the magnetic resonance imaging (MRI) findings with an emphasis on diffusion-weighted imaging (DWI) findings of fungal central nervous system (CNS) infections.

**APPROACH/METHODS**

We retrospectively reviewed the MR images of 22 patients who presented with neurologic abnormalities and were subsequently proved to have CNS fungal infections. Cases include disseminated aspergillosis (10), ventricular aspergillosis (1), invasive aspergillosis (1), invasive
mucormycosis (4), disseminated cryptococcus (2), ventricular cryptococcus (1), coccidiomycosis (1) and candidiasis (2). All patients had some form of immune dysfunction, including neutropenia following chemotherapy for malignancy (AML, ALL, or CLL), immunosuppressive therapy, primary immunodeficiency, HIV, or diabetes. Pathology-autopsy and microbiology proved 15 and seven cases, respectively. The DWI with apparent diffusion coefficient (ADC) map and conventional MRI for each study were reviewed and correlated with macro and micropathologic findings.

**FINDINGS/DISCUSSION**

Aspergillus infection is associated with vasculitis leading to infarction and hemorrhage; abscess formation then rapidly ensues with typical round lesions located at the basal ganglia or gray-white junction having minimal peripheral contrast enhancement on MRI. Severe diffusion restriction associated with decreased ADC usually is present representing cytotoxic edema, necrotic infarcted tissue, hemorrhage, and abscess which were seen on pathology. Less aggressive infection with granulomatous change is typical in relatively immunocompetent patients. Mucormycosis is often a complication of singoenic infection in diabetic patients. Diffusion restriction with low ADC values in an inferior frontal location is typical, with direct extension from the infected paranasal sinus. Basal ganglia involvement is associated with spotty diffusion restriction and surrounding extensive vasogenic edema. Cryptococcal infections typically form cystic lesions of variable enhancement involving the basal ganglia, meninges, and ventricles. T2-weighted and DWI signal are isointense to cerebospinal fluid (CSF). Candidiasis presents with ring or nonenhancing microabscesses that often measure less than 3 millimeters and show diffusion restriction. The lesions of coccidiomycosis are associated with granulomatous meningitis and diffuse pachymeningeal enhancement, deep cerebral infarcts, and ventricular enlargement with periventricular diffusion restriction.

**SUMMARY/CONCLUSION**

Fungal CNS infections have typical MRI and DWI findings that can aid in early diagnosis and allow timely, aggressive treatment with antifungal therapies and surgical interventions to manage these otherwise rapidly fatal infections. Radiologic-pathologic correlation is presented.

**KEY WORDS:** Infection, fungal, DWI

**Electronic Scientific Exhibit 016**

**Imaging Spectrum: Pituitary Gland**

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**PURPOSE**

To review the imaging and clinical features of both the normal and abnormal pituitary gland with focus on magnetic resonance imaging.

**APPROACH/METHODS**

Normal pituitary gland as well as multiple cases of abnormalities involving the pituitary gland with discussion of the imaging, clinical, and pathologic features.

**FINDINGS/DISCUSSION**

Normal imaging features of the pituitary gland will be reviewed. Imaging features and clinical information for each of the following pituitary abnormalities with pathology correlation: Pediatric/congenital including septo-optic dysplasia, pituitary duplication, ectopic posterior pituitary, Langerhans cell histiocytosis, tuber cinereum hamartoma, empty sella, and Rathke cleft cyst, as well as cyst complicated by hemorrhage. Neoplasm including microadenoma, macroadenoma (including invasive macroadenoma), adenoma complicated by hemorrhage, craniopharyngioma, pilocytic astrocytoma, and metastatic disease. Traumatic including hemorrhage. Pregnancy-related including Sheehan syndrome and hemorrhage. Inflammatory and other miscellaneous conditions including sarcoidosis, lymphocytic hypophysitis, and pseudotumor cerebri.

**SUMMARY/CONCLUSION**

A wide gamut of abnormalities may involve the pituitary gland. After reviewing this exhibit, one will have a better understanding of pathology which may involve the pituitary gland as well as the associated imaging and clinical findings.

**KEY WORDS:** Pituitary, review
Primary Posterior Fossa Masses in Adults and Pediatrics: A Pictorial Review

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**PURPOSE**

Posterior fossa masses commonly are encountered in adults and children necessitating familiarity with both common and uncommon imaging appearances. This case-based electronic exhibit will review common primary intraaxial and extraaxial posterior fossa masses. A myriad of different primary posterior fossa masses will be reviewed and categorized primarily by age and location but also emphasizing distinguishing imaging features when applicable. In addition to frequently encountered adult and pediatric posterior fossa masses, uncommon and atypical examples will be reviewed.

**APPROACH/METHODS**

Categorized by age and location, this case-based presentation will review primary posterior fossa masses. With each case, there will be a brief discussion of distinguishing demographic and imaging features that will aid the radiologist in providing a confident and germane differential diagnosis.

**FINDINGS/DISCUSSION**

Common primary posterior fossa pediatric tumors such as pilocytic astrocytoma, medulloblastoma, ependymoma, and glial tumors will be reviewed. Common primary intraaxial posterior fossa tumors in adults also will be reviewed, including: Central nervous system lymphoma, ependymoma, and glial tumors. The posterior fossa is also a common location for extraaxial masses; therefore, posterior fossa meningiomas, choroid plexus papillomas, schwannomas, dermoids, aneurysms, and clival masses will all be reviewed. In addition to the more frequently encountered posterior fossa masses, we will review some select rare cases of a pathologically proved hemangioblastoma in a 2-month old, a fatally hemorrhagic cystic schwannoma, Lhermitte-Duclos, and a solitary fibrous tumor.

**SUMMARY/CONCLUSION**

After viewing this presentation, the audience should be familiar with common primary intraaxial and extraaxial adult and pediatric posterior fossa masses. Additionally, uncommon appearances/presentations of common masses and uncommon pathologic entities will be reviewed.

**KEY WORDS:** Posterior fossa, intraaxial, extraaxial
**APPROACH/METHODS**

Give the current explanations through advanced interactive 3D diagrams of the cellular changes that occur after combined chemo-irradiation that result in an increase of contrast enhancement or edema, known as pseudopseudoprogression; and the changes at the cellular level after therapy with antiangiogenic agents, resulting in a decrease in tumor enhancement without a decrease is tumoral activity known as pseudoresponse. Correlate pathologic tissue samples with MR images of pseudopseudoprogression and pseudopseudoprogression.

**FINDINGS/DISCUSSION**

There are imaging alternatives for the detection of these changes such as advanced MR imaging (MRI) techniques (MR perfusion, MRS, DWI, FA), PET and potential MR biomarkers. Explain the response assessment in neuro-oncology (RANO) criteria, created to overcome the confusion issues presented by these new entities.

**SUMMARY/CONCLUSION**

New mixed treatment regiments for glioblastoma multiforme have triggered new imaging findings known as pseudopseudoprogression. The neuroradiologist must be aware of these findings to avoid misdiagnosis. Understanding the causes of the phenomena, how they present and the tools to avoid these pitfalls are essential to avoid misinterpreting images.

**KEY WORDS:** Pseudopseudoprogression, pseudopseudoprogression, chemotherapy

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**Electronic Scientific Exhibit 020**

**Added Value of Diffusion to Perfusion in the Preoperative Grading of Diffuse Gliomas**

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**PURPOSE**

To compare baseline relative cerebral blood volume (rCBV) and minimum apparent diffusion coefficient (ADC) with histopathology in 159 confirmed diffuse gliomas. To estimate a cutoff rCBV and ADC value for differentiation between high- and low-grade gliomas. To investigate whether combined rCBV and ADC values improve diagnostic accuracy of MR imaging in the preoperative grading of gliomas.

**APPROACH/METHODS**

One hundred and fifty-nine patients (92 men, 67 women; age ranging 23 to 79 years) with pathologically confirmed gliomas were included in the study. Diagnoses were confirmed histologically by surgical resection (68.55%) or biopsy (31.45%). Dynamic contrast agent-enhanced T2*-weighted gradient-echo echo-planar images were acquired during the first pass of a bolus of gadolinium contrast agent (1.0 mMol/ml) at a dose of 0.1 mmol/kg. Color-coded rCBV maps were generated to target regions of maximal abnormality. We placed three regions of interest (ROIs) within the tumor, on areas showing the highest intratumoral rCBV. The maximum rCBV value in intratumoral ROIs was selected for quantitative analysis and correlated with corresponding specimen histopathology. Diffusion-weighted images (DWI) were obtained before contrast administration by using a single-shot spin-echo echo-planar imaging (EPI) sequence (b = 1000 s/mm2) and ADC maps were calculated. Circular ROIs were placed over the whole tumor to select the region of minimum ADC. We compared rCBV and minimum ADC values between high-grade (III and IV) and low-grade (II) gliomas.

**FINDINGS/DISCUSSION**

In total we investigated 34 low-grade and 125 high-grade gliomas. The rCBV values were higher in the high-grade gliomas (0.87-14.60, mean 6.10 ± 3.24) than in 34 low-grade gliomas (0.85 - 7.02, mean 2.37 ± 1.41) (p < 0.001). Nevertheless, there is a potential mismatch among grades II and III (p = 0.063). The ADC values of solid tumor portions of the high- and low-grade gliomas were 0.7961 ± 0.178 and 1.2078 ± 0.275, respectively (p < 0.001). Relative cerebral blood volume and ADC values were significantly correlated in the discrimination of the low- and high-grade gliomas. The areas under the ROC curve were 0.86 and 0.908 for the rCBV and ADC, respectively. Combination of rCBV and ADC values increased the area under the ROC curve (0.93). The rCBV cut-off value of 1.96 could be used with high sensitivity (100%) in the discrimination of low- and high-grade gliomas. The ADC threshold value of 0.890 x 10-3 mm2/s could be used with high sensitivity (90.9%) and specificity (79.5%) in the characterization of high-grade gliomas.

**SUMMARY/CONCLUSION**

Usefulness of perfusion- and diffusion-weighted images for preoperative grading of gliomas is well recognized. Relative cerebral blood volume values for high-grade gliomas were significantly different from those of low-grade gliomas, particularly between grades II and IV. However, intermediate grade gliomas were quite similar to grade II tumors. Minimum ADC correlated significantly in the discrimination of the low- and high-grade tumors, even better than rCBV. Combined rCBV and ADC values improve diagnostic accuracy of MR imaging in the preoperative grading of gliomas.

**KEY WORDS:** Neoplasm, brain, DWI

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**Electronic Scientific Exhibit 021**

**Sellar and Parasellar Lesions: A Pictorial Essay**

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**PURPOSE**

Describe essential anatomy of sellar and parasellar regions. Discuss and illustrate common sellar and parasellar lesions: Sarcoidosis, Rathke cleft cyst, pituitary adenoma, aneurysm, arachnoid cyst, epidermoid/dermoid, craniopharyngioma, hypothalamic glioma, metastasis and meningioma, among others, to include some unusual sellar and parasellar lesions mimicking more commonly seen entities. Present a system-
atic approach to describe location, extension and adjacent structure involvement of sellar and parasellar lesions. Discuss the MR imaging (MRI) features that are helpful in formulating an appropriate differential diagnosis and radiologic report for sellar and parasellar lesions.

**Approach/Methods**
A retrospective review of the head computed tomography (CT)/MRI database from January 2009 to December 2010 will be performed at PACS stations. Studies with sellar and/or parasellar region lesions will be retrieved. An electronic scientific presentation will be performed after reviewing the literature.

**Findings/Discussion**
The sellar and parasellar regions encompass important anatomical structures with complex anatomical relationships. As such, a diverse group of lesions can be described in these regions. Among pathologies found are: neoplastic, vascular, congenital, or infectious/inflammatory etiologies. Magnetic resonance imaging is the modality of choice for evaluation of these regions, although CT may provide complementary information.

**Summary/Conclusion**
With regard to the sella and parasellar regions, the radiologist has an important role in guiding patient care. Accurately distinguishing between lesions of the sellar and parasellar regions helps direct therapy appropriately at the earliest possible stage. Imaging characteristics of the most common sellar and parasellar lesions, as well as those of some unusual lesions, will be described with particular emphasis on MR findings and regional anatomy.

**Key Words:** Sellar, parasellar

**Electronic Scientific Exhibit 022**

**Blood-Brain Barrier Imaging in Brain Tumors: Concepts and Methods**

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**Purpose**
A lot of work has been done in the past to understand the structural/molecular composition of blood-brain barrier (BBB) and the role it plays in various pathologic processes including brain tumors. Various imaging techniques have been used in animals and human subjects to evaluate BBB leakiness in brain tumors as higher tumor vascular leakiness is known to be associated with higher grade and malignant potential of the tumor and hence poor patient prognosis. These imaging techniques range from routine postcontrast T1-weighted images to measurement of vascular permeability employing various quantitative or semiquantitative indices based on multicompartment pharmacokinetic models. The purpose of this educational exhibit is to discuss BBB anatomy, various clinically available imaging techniques to evaluate tumor vascular leakiness (perfusion imaging) including their advantages and limitations as well as the clinical utility of measuring vascular permeability in brain tumors. We also will describe the various permeability-related indices along with the pharmacokinetic models to simplify the nomenclature soup.

**Approach/Methods**
The exhibit will include in-depth discussion of techniques such as MR perfusion (dynamic susceptibility contrast T2*, DCE-T1 weighted imaging) as well as CT perfusion. We will discuss the methodology, and advantages and limitations of various techniques, including their clinical utility and future directions. We also will describe the concepts of tumor angiogenesis, vascular permeability and imaging of tumor vascular heterogeneity in detail by including clinical cases. In addition, a brief review of futuristic modalities based on nanotechnology and macromolecular contrast agents also will be done.

**Findings/Discussion**
Malignant gliomas are usually very heterogeneous and have complex vasculature. They often show angiogenesis and increased vascular permeability. In vivo measurement of this abnormal/increased tumor vessel permeability could be used as an imaging biomarker to assess the tumor grade and aggressiveness. It also can be used to study the response of tumors to various therapies, especially antiangiogenic therapy. Understanding the concept of permeability can help in understanding the mechanism of entry of therapeutic agents into the central nervous system and development of methods to selectively alter the BBB to enhance drug delivery. In a recent study it was suggested that cerebral blood volume (CBV) and permeability surface area product (PS) may represent different aspects of tumor vasculature and PS providing information about the degree of abnormality of the BBB, correlating with microvascular cellular proliferation (MVCP) as well as showing weak correlation with VEGFR-2 expression, hence suggesting that in vivo assessment of permeability in tumors may lead to an assessment of aggressive angiogenic phenotype which may have important clinical implications.

**Summary/Conclusion**
A thorough knowledge of molecular structure of the BBB and its role in brain tumors and angiogenesis is very important. Equally important is understanding of the physiologic basis of various in vivo imaging indices/parameters used to assess tumor vascular leakiness. After reading this education exhibit, the reader is expected to have an insight into angiogenesis of brain tumors, heterogeneity of tumor vasculature, various in vivo imaging techniques available for measuring permeability and its clinical implications.

**Key Words:** Blood-brain barrier, permeability, perfusion
Electronic Scientific Exhibit 023

Intraventricular Neoplasms: Imaging and Histopathologic Correlation

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PURPOSE

Intraventricular tumors are a heterogeneous group of neoplasms with varied imaging appearances sharing limited real estate in the brain. The central theme of this exhibit is to explore the histologic basis of the key imaging features of intraventricular neoplasms. Typical and unusual imaging appearances of common and uncommon intraventricular tumors are described.

APPROACH/METHODS

Cases of various intraventricular neoplasms from several institutions (one of which is a major cancer center) are presented with emphasis on correlation between imaging and histology. Clinical presentation, epidemiology, relevant anatomy, pathophysiology, and genetics also are discussed.

FINDINGS/DISCUSSION

Despite representing less than 10% of primary brain tumors, intraventricular neoplasms span a wide array of histologies with ependymoma, subependymoma, central neurocytoma, subependymal giant cell astrocytoma, and choroid plexus papilloma/carcinoma being the most common. Intraventricular location also may be an unusual presentation for tumors which are typically extraventricular as exemplified by oligodendroglioma, dysembryoplastic neuroepithelial tumor (DNET), and metastasis. An understanding of the histopathology of these tumors often explains differences in their imaging appearances. For example, intraventricular DNET is a rare nonenhancing tumor with a cystic imaging appearance correlating well with the histologic pattern of glioneuronal elements between which neurons float in pale mucin-rich matrix.

SUMMARY/CONCLUSION

Knowledge of histology is key to the understanding of the varied imaging presentations of intraventricular tumors.

Electronic Scientific Exhibit 024

Challenges of Post-Therapy Brain Tumor Evaluation: What the Radiologist Needs to Know

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PURPOSE

The objective of this exhibit is to illustrate the challenges of interpreting MR imaging of glioblastoma multiforme patients who are being treated with a combination of radiation, temozolamide and antiangiogenic therapies. This is important because although these agents are becoming standard of care, there is still considerable lack of understanding and uncertainty in interpreting changes in the tumor and surrounding tissue that are observed using conventional and advanced neuroimaging techniques.

APPROACH/METHODS

A wide range of instructive cases of treated GBM will be discussed utilizing both conventional and advanced neuroimaging. The use of advanced neuroimaging including MR spectroscopy, MR perfusion and diffusion-weighted imaging (DWI) will be assessed as problem-solving tools in these cases and possibly as noninvasive biomarkers of future clinical trials.

FINDINGS/DISCUSSION

Distinguishing active tumor from treatment effects is a major, perennial challenge for the radiologists. Moreover, with the advent of newer treatments, it is important for the radiologist to understand the pathophysiologic spectrum of post-therapy brain tumors to avoid misinterpretations. To highlight these challenges, the exhibit will be divided broadly into the following major subcategories: Early postoperative DWI, radiation necrosis, pseudoprogression and pseudorespomse. To speak the same language as our referring clinicians, it is also important to be aware of the McDonald criteria, the newer RANO criteria and the caveats to these criteria, which will be discussed briefly in the exhibit.
SUMMARY/CONCLUSION
It is pertinent for the radiologist to work closely with the brain tumor group, including referring surgeons, radiation oncologists and neuro-oncologists. Moreover, understanding the spectrum of MR abnormality teamed with the knowledge of type and timing of treatment strengthens the radiologist’s understanding of the post-therapy evaluation of brain tumors and will help to add value to our reports.

KEY WORDS: Brain tumors, post-therapy, GBM

Electronic Scientific Exhibit 025
Pictorial Review of Anterior Third Ventricle Anatomy and Pathology

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PURPOSE
Demonstrate the morphologic details of the anterior third ventricle and show the normal radiologic appearance on high-resolution imaging. A spectrum of various pathologic conditions and congenital variations will be discussed.

APPROACH/METHODS
From our extensive database of cases from neuroradiology departments of adult and children’s hospitals, cases that depict anatomy and various pathologies involving the floor of the third ventricle are selected and presented in an organized fashion.

FINDINGS/DISCUSSION
1. An interactive pretest on the anatomy of the third ventricle with special attention to the anterior wall. 2. Pictorial description of: Gross anatomy, histology, blood supply and imaging anatomy. 3. A case-based discussion of the pathologies in this region. These include but are not limited to cases such as: a. Tumors involving septal area. b. Tumor involving the limbic system extending to the septal area. c. Infectious and inflammatory conditions involving the anterior third ventricle. d. Metabolic conditions involving the anterior third ventricle. e. Cyst involving the arachnoid membranes around the third ventricle (Ex: Cyst of liliquest membrane). f. Aneurysms of the anterior part of the circle of Willis. g. Imaging of surgical changes at the floor of the third ventricle. 4. An interactive post-test on the anatomy and lesions of the limbic system.

SUMMARY/CONCLUSION
The anterior wall of the third ventricle has a complex anatomical organization which is well visualized on high-resolution imaging. Understanding the morphological variations in this region can help us interpret the pathologies in a rational manner.

KEY WORDS: Third ventricle, lamina terminalis

Electronic Scientific Exhibit 026
Practical Approach to Evaluation and Monitoring Criteria in High-Grade Gliomas

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PURPOSE
To illustrate the recently published recommendations for monitoring high-grade gliomas (2010 RANO Criteria) and its advantages over the conventional method of evaluation based on the McDonald criteria, with examples and practical recommendations on oncology patients with high-grade gliomas.

APPROACH/METHODS
We retrospectively reviewed MR imaging (MRI) studies of patients undergoing neuro-oncologic management of high-grade gliomas, estimating lesion behavior (response, stability,
progression) by the application of the conventional criteria of McDonald and the recently published evaluation criteria for high-grade gliomas monitoring [Response Assessment in Neuro-Oncology (RANO 2010)] to establish advantages and disadvantages of each method. A review of the literature on the evaluation criteria for the monitoring of high-grade gliomas also will be provided.

FINDINGS/DISCUSSION

Until recently, tumor response to treatment in high-grade gliomas was based on two-dimensional measurement of the lesion on CT and MRI studies, clinical evaluation and dose of corticosteroids (McDonald criteria). This method was limited by its emphasis and dependence on specific measurement of the contrast-enhancing tumor only. New therapy strategies used in glioblastoma may result in changes in the tumor enhancement behavior, such as early transient enhancement (pseudo-progression), limiting recognition of true tumor progression. Tumor assessment of treatment response is also difficult in gliomas treated with antiangiogenic therapy, which can decrease contrast enhancement by CT and MRI due to decreased vascular permeability rather than true antitumor effect (pseudo-response). Additional limitations of McDonald conventional criteria include the difficulty in measuring irregular lesions morphology, interobserver variability, lack of measurement of the nonenhancing tumor component, tumor multifocality, measurements of cystic lesions and surgical cavities. The RANO 2010 tumor monitoring criteria is based not only on gadolinium enhancement on T1-weighted MRI sequences, but also considers T2/FLAIR tumor behavior, presence of new lesions, response to corticosteroids and clinical status. The current recommendations define tumor behavior as disease progression, stable disease, partial response and complete response.

SUMMARY/CONCLUSION

Modern neuroimaging plays a key role in the evaluation of tumor response to cancer therapy. Physicians involved in the monitoring of high-grade glioma patients must be familiar with the conventional criteria of McDonald and the recently published Response Assessment in Neuro-Oncology (RANO 2010) evaluation criteria, and the advantages and disadvantages of each method. This work presents these concepts and examples to facilitate the user to reach a working knowledge of these criteria.

KEY WORDS: Monitoring criteria, high-grade gliomas, evaluation

Electronic Scientific Exhibit 027

Stability and Relaxivity of Gadolinium Contrast Agents and Impact on Clinical Practice

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PURPOSE

Gadolinium-based contrast agent stability and relaxivity frequently are misunderstood concepts. By means of a critical review of the data, we examined certain myths and misconceptions associated with the concept of relaxivity. Likewise data on contrast agent stability can seem confusing and seemingly contradictory. We evaluated data on the relationship between contrast agent molecular structure and relaxivity and stability, and examined how these properties may impact contrast agent use in clinical practice.

APPROACH/METHODS

R1 relaxivity is a measure of the signal-producing capacity of a given gadolinium agent and is defined as the inverse of longitudinal recovery time (T1); the shorter the T1 relaxation time, the higher the r1. The reported relaxivity of a given agent depends on measurement conditions (biological milieu, temperature, field strength). Gadolinium agents may be divided into standard relaxivity agents (gadopentetate dimeglumine, gadoteridol, gadobutrol, gadodiamide, gadoversetamide) and higher relaxivity agents (gadobenate dimeglumine, gadoxetic acid, gadofosveset), although within the high relaxivity group there are marked differences between agents. Gadolinium is a toxic heavy metal, and in this context stability refers to the ability of the gadolinium-chelate complex to hold onto its gadolinium, particularly in conditions approximating the in vivo environment. Stability is measured in various ways and under various conditions. We reviewed thermodynamic, kinetic, and conditional stability data for the available gadolinium agents, as well as the result of challenge studies in which gadolinium agents are incubated with competitor ions under physiologic conditions.

FINDINGS/DISCUSSION

The relaxivity of a gadolinium agent is related to the way it interacts with serum proteins once injected. The agents with “standard” relaxivity exhibit minimal to no protein interaction upon injection. The higher relaxivity agents exhibit various degrees of protein interaction, from a weak and transient interaction (gadobenate dimeglumine) to strong and lasting protein binding (gadofosveset). A number of studies have demonstrated the benefit of higher relaxivity gadolinium agents for various neuroimaging applications. Some higher relaxivity agents (gadobenate dimeglumine and gadoxetic acid) are also lipophilic molecules which are taken up by normal hepatocytes in the liver, making them useful for delayed imaging of the biliary system. The macrocyclic agents (gadoteridol and gadobutrol) are the most stable agents by a number of measures, followed by certain of the linear ionic agents (gadobenate dimeglumine and gadopentetate dimeglumine, gadofosveset) and lastly by the nonionic linear agents (gadodiamide, gadoversetamide). The stability of gadolinium agents is related inversely to their propensity to cause interference with various lab tests (i.e., colorimetric measurement of serum calcium or other metabolites) or to be associated with the development of nephrogenic systemic fibrosis (NSF) in patients with poor kidney function.

SUMMARY/CONCLUSION

The relaxivity and chemical stability of gadolinium-based MR contrast agents differ among the various agents and these differences have relevant clinical implications for the practicing neuroradiologist.

KEY WORDS: Gadolinium, relaxivity, NSF
Value of the Sagittal Nongated 3D T2 FRFSE Sequence in Assessing Cerebrospinal Fluid Flow Dynamics

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PURPOSE
Phase contrast imaging traditionally has been utilized to assess cerebrospinal fluid (CSF) flow dynamics in patients with disordered CSF flow. The purpose of this study is to explain the scientific rationale for increased sensitivity to CSF flow utilizing nongated isotropic 3D T2 FRFSE imaging. Multiple case examples are shown which demonstrate both patient and obstructed CSF flow in certain pathologic entities.

APPROACH/METHODS
T2-weighted 3D FRFSE with variable flip refocusing enables acquisition of anatomical, high-resolution, reformat-able images in all planes within 5 minutes. This technique is considerably more sensitive to CSF flow than FSE with conventional 180° refocusing. Cerebrospinal fluid appears dark in areas where CSF flow is considerable. Cardiac gating (triggering the acquisition such that the lowest flip angles are concurrent with slow CSF flow) was eliminated in this sequence to enhance sensitivity to CSF flow. Following FDA approval of the 3D FRFSE product in 2009, the T2 3D FRFSE sequence was incorporated into the clinical protocol for patients with suspected disordered CSF flow. Case examples of the nongated 3D FRFSE patients in patients with normal CSF flow is shown in order to define the appearance of normal CSF flow jets (Figure 1). Following this, multiple case examples of disordered CSF flow are demonstrated patients with pathologies including obstructive third ventricular cyst (Figure 2), aqueductal web, Chiari one malformations, adult and pediatric tectal gliomas, normal pressure hydrocephalus, and tectal cavernoma.

FINDINGS/DISCUSSION
The unique motion sensitivity of variable flip FSE has been utilized successfully to enhance CSF signal voids in patients with suspected disordered CSF flow.

SUMMARY/CONCLUSION
Recognizing disordered CSF flow in certain pathologies is critical to further define the treatment algorithm in these patients. Although CSF flow cannot be quantitated utilizing this technique, nongated 3D FRFSE demonstrates excellent sensitivity to CSF flow.

KEY WORDS: CSF flow, CUBE

Dissecting the Human Brain Limbic Pathways. A High-Resolution Diffusion Tensor Imaging Tractography Study on 3 T

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PURPOSE
Lack of adequate neuroimaging sensitivity and spatial resolution, so far, impeded depiction of small limbic structures such as fornix, cingulum and hippocampo-hypothalamic pathway within the human brain. The purpose of the current study is to demonstrate the feasibility of parcellation and quantification of limbic structures in relation to the gray matter nuclei using deterministic fiber tractography and high spatial resolution diffusion tensor imaging (DTI) data on 3 T.

APPROACH/METHODS
Subjects: Five healthy men (age range 24-37 years) were studied and written informed consent was obtained from all subjects. Conventional and DT-MRI Acquisition: Data were
acquired using a Philips 3.0 T Intera system using aSENSE receive head coil. Diffusion-weighted image (DWI) data were acquired axially using a single-shot multi-slice 2-D spin-echo diffusion with the balanced Icosa21 tensor encoding scheme. The b-factor = 500 sec mm-2, TR/TE = 14460/60 msec, FOV = 256 mm x 256 mm and slice thickness/gap/ # slices = 1 mm / 0 mm / 120. The EPI phase encoding used a SENSE k-space undersampling factor of two, with an effective k-space matrix of 112 x 112 and an image matrix after zero-filling of 256 x 256. Fiber Tracking: We used the FACT algorithm (DTIStudio) to reconstruct limbic pathways with a fractional anisotropy (FA) threshold of 0.22 and angle threshold of 60 degrees.

**FINDINGS/DISCUSSION**

To our knowledge, the current study is the first to present fornix, cingulum and hippocampo-hypothalamic pathways using high spatial resolution DTI measurements on 3 T. These delicate tracts are clearly distinguishable and reproducible using current technique. We demonstrated the ability to separate and quantify the tract volume and corresponding diffusion tensor metrics of these limbic pathways. We also demonstrated the relationship of these tiny tracts with gray matter nuclei (hypothalamus and hippocampus). Using high spatial resolution especially thinner slice thickness (1 mm) in this study reduced the partial volume effect as well as incoherence due to the fiber intercrossings within each voxel and we were able to reconstruct and visualize the whole limbic trajectories by deterministic approach.

**SUMMARY/CONCLUSION**

This work aimed to demonstrate the feasibility of in vivo quantification and visualization of human limbic pathways in relation to the gray matter nuclei (hypothalamus and hippocampus) on 3 T.

**KEY WORDS:** Limbic, high resolution, tractography

**Electronic Scientific Exhibit 030**

**Volume Intensity Projection: Advancing the State-of-the-Art in Three-Dimensional Visualization of Craniofacial Pathology**

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Purpose

Three-dimensional (3D) surface renderings and 3D maximum intensity projection (MIP) reconstructions are powerful methods that allow visualization of volumetric computed tomography (CT) data sets in three dimensions. However, neither is without its limitations. Recently, a new advanced visualization technique known as volume intensity projection (VIP) was introduced that improves upon these methods in several ways, especially with regard to the display of craniosynostoses, craniofacial trauma, and surgical hardware. Among its advantages is its ability to maintain the increased conspicuity of cranial suture lines, fractures, and surgical hardware that is typically seen in MIP, while preserving the depth information that is inherent to traditional 3D surface renderings. The purpose of this exhibit is to familiarize the viewer with all of these advanced visualization techniques and to demonstrate the advantages of VIP through the presentation of various pathologies, each with side-by-side comparisons of these different visualization methods.

**APPROACH/METHODS**

This will be achieved by first familiarizing the viewer with more traditional methods such as 3D surface rendering and 3D MIP. Once a knowledge of these techniques is established, VIP will be described with an emphasis on its improvements on the conventional techniques. This will be accomplished in an image-rich presentation, using side-by-side comparisons of these different methods on various pathologies, including multiple craniosynostoses and craniofacial injuries, as well as their postsurgical appearances. A background on advanced 3D visualization will be provided, with explanations of how these methods work to display volumetric CT data.

**FINDINGS/DISCUSSION**

An emphasis will be placed on the ability of VIP to convey depth information inherent to 3D surface renderings while preserving the increased conspicuity of cranial suture lines, fractures, and surgical hardware that is typically attributed to MIP images.

**SUMMARY/CONCLUSION**

Volume Intensity Projection is a powerful new method of advanced 3D visualization that improves upon past methodologies. After completing this exhibit, the viewer will come away with a knowledge of the various 3D visualization techniques and will be familiarized with the advantages of VIP, especially with regard to the display of craniofacial pathology.

**KEY WORDS:** Postprocessing, advanced visualization, 3D

**Electronic Scientific Exhibit 031**

**Normal and Pathologic Cerebral Venous System: Appearance on DynaCT Digital Angiography and Correlation with Two-Dimensional Digital Subtraction Angiography**

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**PURPOSE**

Cerebrovascular disorders account for tremendous morbidity and mortality. Digital subtraction angiography (DSA) remains the gold standard imaging modality for evaluating these lesions. While the arterial anatomy is well demonstrated by DSA, capillary and venous anatomy often is evaluated suboptimally due to the effects of contrast dilution, small vessel caliber, and overlapping structures. Moreover, motion artifacts are accentuated over the course of acquisitions leading to increased quality deterioration in the venous phase. DynaCT digital angiography (also known as cone beam or C-arm CT) offers a solution to these challenges via its superior spatial resolution and ability to detect vessels with low contrast concentrations. These studies are typically
acquired over 20 seconds, which affords complete coverage of the capillary and venous phases. This enables DynaCT to achieve excellent resolution of very small venules and fully delineate complex venous morphologies that are otherwise inadequately shown on DSA. This modality has the additional benefit of being able to show the relationship between the veins of interest and surrounding parenchymal or osseous structures. The purpose of this exhibit is to illustrate the broad clinical utility of DynaCT as an adjunct for DSA in elucidating normal and pathologic cerebral venous system anatomy.

**APPROACH/METHODS**
We retrospectively identified cerebral DynaCT studies performed at our institution between 2009-2010 using an IRB-approved neurovascular database. Images were reviewed and selected from over 40 of these cases to illustrate normal and pathologic cerebral venous anatomy, with an emphasis on findings that best demonstrated the strengths of DynaCT studies.

**FINDINGS/DISCUSSION**
Excellent detail of small venous structures can be appreciated on DynaCT images. The high spatial resolution of DynaCT images allowed definition of subependymal, transcerebral, and subcortical veins that were not well demonstrated on corresponding DSA images. This additional anatomical detail was clinically useful in a number of settings. For dural arteriovenous fistulas, DynaCT effectively and more precisely demonstrated cortical venous reflux and the presence of venous aneurysms. For developmental venous anomalies, DynaCT offered a markedly superior assessment of the degree of venous stenosis and delineated communication between the anomalous and normal venous channels of the skull base. Other pathologies for which DynaCT revealed important anatomical details included arteriovenous malformations, venous thrombosis of the cortical veins and sinuses, sinus pericranii, and tumor infiltration of the venous system. In many of these cases, DynaCT helped to reveal important nuances of the venous anatomy that had important implications for subsequent management.

**SUMMARY/CONCLUSION**
DynaCT is still in its early stages of development, but this technology already can contribute markedly to the understanding of cerebral venous anatomy in a spectrum of cerebrovascular diseases. As this modality becomes adopted more widely, its potential applications toward diagnostic and therapeutic decision-making will be more fully appreciated. We hope that this exhibit will enhance current understanding of applications for DynaCT and expand interest for its further use.

**KEY WORDS:** DynaCT, venous anatomy, vascular malformation

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**Electronic Scientific Exhibit 032**

**Quantitative Susceptibility Mapping of Brain Tumors: Correlation with Histologic Grade**

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**PURPOSE**
Prior work using T2*-weighted gradient-echo and susceptibility-weighted MR imaging (SWI) have shown correlations between histopathologic tumor grade and intratumoral susceptibility from elevated levels of ferritin and transferrin receptors, intralosional hemorrhage, and microvasculature within brain tumors. Higher grade tumors are associated with neovascularity and an increase in intratumoral microhemorrhages, which can be evaluated with SWI techniques due to the paramagnetic effects of blood breakdown products and deoxyhemoglobin. The susceptibility distribution can be further calculated by quantitative susceptibility mapping (QSM), a technique that incorporates anatomical information from the SWI magnitude image and overcomes the ill-posed magnetic field to susceptibility source inverse problem. The purpose of this study was to determine if intrinsic tissue susceptibility differences calculated by QSM correlated with higher tumor grade. Correlation between intratumoral SWI signal intensity, apparent diffusion coefficients (ADC), and QSM-derived susceptibility values were evaluated to assess if intratumoral susceptibility values offer additional complementary information of the tumor microenvironment.

**APPROACH/METHODS**
With IRB approval, ten patients with pathologically proved brain tumors were analyzed. Patients were categorized into three groups for analysis: 1) benign tumors (4 meningiomas), 2) intermediate grade tumors (1 recurrent grade II oligodendroglioma, 2 grade III astrocytomas) and 3) high-grade tumors (3 recurrent grade IV glioblastomas). MR imaging was performed on a 3 T GE scanner; a multiecho spoiled gradient-echo sequence with 7 TEs was utilized. Susceptibility maps were generated using a morphologically enabled dipole fitting (MEDI) technique. The MR sequences were coregistered into MNI space using FLIRT. Regions of interest (ROI) were drawn in AFNI by a neuroradiologist on tumor tissue as well as contralateral normal-appearing white matter (NAWM) on T1 postcontrast sequences. Two-tailed t-tests were performed in MATLAB between intratumoral susceptibility values and histopathologic tumor grade to assess for statistically significant differences.

**FINDINGS/DISCUSSION**
In all four patients with benign meningiomas, QSM showed a relative increase in intratumor susceptibility, compared to CNAWM (range: 6.7 to 20.3 ppm; mean: +11.3; sd: 6.16). In patients with intermediate grade gliomas, QSM showed a mean change in intratumoral susceptibility for this cohort of +7.3 ppm (sd: 17.5). In all three patients with recurrent grade IV glioblastoma, QSM showed a relative decrease in intratumor susceptibility, compared to CNAWM (range: -1.71 to -63.1 ppm; mean: -24.4; sd: 33.7). For all ten patients, the
relative phase shift in the tumor compared to CNAWM was correlated significantly with tumor grade \((r=-0.66, p=0.03)\). There was no correlation between tumor grade and SWI signal intensity \((r=-0.27, p=0.42)\) or ADC \((r=-1.1, p=0.8)\) values. Additionally, it was observed that the variance of intratumoral QSM values was increased relative to the variance of QSM values in the contralateral white matter.

**Summary/Conclusion**
Relative QSM phase shifts appear to correlate with histopathologic grade of intracranial brain tumors in this pilot study. By calculating the intrinsic tissue susceptibility, quantitative susceptibility mapping may offer a noninvasive evaluation of the tumor microenvironment without the need for contrast agents. Further validation of these findings and correlation with additional parameters such as MR perfusion data is needed.

**Key Words:** Quantitative susceptibility mapping, brain tumors

**Electronic Scientific Exhibit 033**

**3D or Not 3D: Applications of 3D Acquisitions for Neuroimaging**

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**Purpose**
To present the various emerging 3D (isotropic) MR imaging (MRI) acquisition sequences that may be of use in neuroimaging, especially in conjunction with specialized postprocessing, and discuss the potential benefits and drawbacks of employing these methodologies in place of currently utilized 2D sequences for neuroradiology applications.

**Approach/Methods**
Our presentation will convey information about scan times, effects of field strength, standard parameters for neuroimaging and associated limitations of 3D sequences and their respective 2D counterparts. We also would present examples of the many ways 3D acquisitions can enable automated or semiautomated methods to assist in typical clinical neuroimaging scenarios, such as leveraging subtraction or intercalated images by registering 2D prior studies to 3D volumes and producing plane-matched reformats of 3D data.

**Findings/Discussion**
The presentation will: (1) Demonstrate the advantages and disadvantages of 3D neuroimaging; (2) Describe which types of sequences are (a) routinely 3D, (b) can be done 3D, or (c) for which there is no clinically feasible 3D method; (3) Emphasize the role/importance of motion correction; (4) Outline potential applications with clinical examples (tracking size, finding new lesions, creating intercalated images to facilitate easier difference detection); (5) Put forward the idea of atlas registration and advantages for structured reporting, reducing radiologist interpretation time, improving interobserver variability, and for facilitating large-scale imaging analysis studies; (6) Explore possible synergy of 3D neuroimaging with synthetic MRI to reduce exam times; and (7) Illustrate possible impediments to implementing 3D (1.5 T, PACS workflow issues, scan times, lower in-plane resolution).

**Summary/Conclusion**
Three-dimensional acquisitions have the potential to allow automated and semiautomated direct comparisons of disease progression/treatment effects with greater reproducibility than can be achieved routinely with conventional 2D imaging. With improvements in computation and postprocessing technologies, the ability to leverage isotropic MRI data will only become more powerful. This should, in turn, allow neuroradiologists to provide faster, more accurate, and more reproducible interpretations, and to facilitate translational clinical research, including methodologies such as structured reporting, data mining, and voxel-based analysis.

**Key Words:** 3D, MR imaging, neuroimaging

**Electronic Scientific Exhibit 034**

**Clinical Utility of Quantitative Susceptibility Mapping: A Novel MR Approach for Characterizing Tissue Susceptibility Effects**

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**Purpose**
Susceptibility-weighted imaging is an advanced MR technique that identifies foci of hemorrhage, iron deposition or calcification in the brain, and visualizes small cortical veins. Local susceptibility effects cause strengthening (paramagnetic effect) or weakening (diamagnetic effect) of local magnetic field. This results in dephasing of spins and signal loss on susceptibility-weighted imaging. Raw phase data acquired during susceptibility-weighted imaging contains a wealth of additional clinically important information, not normally analyzed or interpreted by the radiologist. Using a newly developed mathematical analysis, quantitative susceptibility mapping (QSM), raw data normally discarded by the MR scanner is used to estimate local susceptibility properties of each brain voxel. The purpose of this exhibit is: 1) To introduce the concept and basic methodology of QSM; 2) To provide a pictorial essay demonstrating the utility of QSM in a variety of clinical settings, including hemorrhage, vascular malformations, stroke, brain tumors, aging, postcontrast imaging and venography.

**Approach/Methods**
Quantitative susceptibility mapping was applied retrospectively to raw data from patients undergoing susceptibility-weighted MR imaging, for other clinical indications. Susceptibility imaging was performed on a 3 T GE scanner with an 8-channel birdcage head coil. A multiecho spoiled gradient-echo sequence with 7 TEs was utilized; uniform TE spacing=5ms and TR=42.1ms; flip angle=15 degrees; bandwidth=62.5 kHz; FOV=122 cm; slice thickness=3mm (ZIP2 to an effective thickness of 1.5 mm); matrix size=320x224; acquisition time=2:33 min. Susceptibility maps were gener-
ated using a morphology-enabled dipole inversion technique (MEDI). The resulting maps were compared to traditional MR pulse sequences, both qualitatively and quantitatively, using voxel-based analyses. The data were binned, according to pathology, which was determined by reviewing the patient’s medical records and other available imaging studies.

**FINDINGS/DISCUSSION**
Quantitative susceptibility mapping accurately characterizes tissue susceptibility effects and distinguishes hemorrhage (paramagnetic) from calcification (diamagnetic). Quantitative susceptibility mapping provides excellent visualization of deep gray nuclei, including the putamen, globus pallidus, red nucleus, substantia nigra and dentate nucleus, due to the presence of heavy metal deposition. Quantitative susceptibility mapping can quantify the heavy metal (iron) deposition that increases with aging. Quantitative susceptibility mapping provides excellent visualization of vascular malformations and small cortical veins. Quantitative susceptibility mapping can quantify the oxygen saturation in venous blood. Early data from tumor analysis suggest QSM accurately represents the heterogeneous microenvironment in and surrounding infiltrative tumors and can help predict histologic grade. Normal, intact myelin is diamagnetic. Early data suggest that QSM can be used as a problem-solving technique to distinguish between white matter processes consisting primarily of edema (e.g., acute stroke, brain metastasis) from processes that alter the underlying architecture of white matter (e.g., gliosis, laminar necrosis, tumor infiltration). Postcontrast QSM imaging provides excellent tissue contrast and can be used to quantify the tissue concentrations of gadolinium.

**SUMMARY/CONCLUSION**
Quantitative susceptibility mapping accurately separates paramagnetic from diamagnetic susceptibility effects. Quantitative susceptibility mapping generates a unique MR contrast, unrelated to T1, T2 and T2* tissue properties. Voxel-based QSM measurements reflect the complex and heterogeneous microenvironment of brain tissue and provide important information about normal and abnormal tissue, that cannot be obtained using traditional MR sequences.

**KEY WORDS:** Susceptibility-weighted imaging, MR imaging, anatomy

**Electronic Scientific Exhibit 035**
**Calcium-Aided Diagnosis in Neuroimaging**
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**PURPOSE**
Calcium is the most abundant and essential mineral in the human body. Deposition of calcium is seen in many physiologic and pathologic processes, both localized and systemic. In neuroimaging, analysis of the pattern of calcium deposition may provide clues to the correct diagnosis, as well as narrow down the diagnostic possibilities. This is a pictorial illustration on how calcium deposition can aid in neuroimaging diagnosis.

**APPROACH/METHODS**
We emphasize the value of calcium by addressing the following: 1. Demonstrate how the presence of calcium may provide clues and lead to the correct diagnosis; 2. Analysis of the location, pattern, and distribution of calcifications and how this may narrow down the differential diagnosis; 3. Exemplify how calcium can serve as an "Aunt Minnie" in selected classic cases; 4. Illustrate the value of calcifications in aiding diagnosis in the broader categories including infectious/inflammatory, ischemic, neoplastic, traumatic, vascular, metabolic, etc.

**FINDINGS/DISCUSSION**
Careful analysis and characterization of calcium deposition in the brain and spine may enable the radiologist to narrow down the differential diagnosis. For instance, tram-track like, unilateral cortical calcifications are pathognomonic for Sturge-Weber syndrome; bilaterally symmetric calcifications at the gray-white matter interface are described in patients with mineralizing microangiopathy following radiation and/or chemotherapy; partially calcified subcortical and cortical nodules are seen in oligodendrogliomas; and subependymal, periventricular calcifications are observed in children with congenital cytomegalovirus infection. In many clinical situations, the value of calcium in aiding diagnosis cannot be overemphasized.
SUMMARY/CONCLUSION
Careful analysis of the pattern of calcium deposition may truly aid in neuroimaging diagnosis.

KEY WORDS: Calcifications, calcium, calcium deposition

Electronic Scientific Exhibit 036
MR Imaging Assessment of Trigeminal Neuralgia

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PURPOSE
To demonstrate MR imaging features of various clinical forms of trigeminal neuralgia.

APPROACH/METHODS
MR imaging of trigeminal neuralgia is used currently to assess neurovascular contact, mass lesions, nerve enhancement, multiple sclerosis lesions and the extent of nerve thickening or atrophy. Dedicated MR sequences are required to assess the course of trigeminal nerve with emphasis on preganglionic cisternal segment emerging from the root entry zone, interdural segment in the Meckel’s cave and postganglionic segment including ophthalmic, maxillary and mandibular divisions. In this exhibit, we will exhibit MR imaging features of various clinical forms of trigeminal neuralgia in correlation with clinical presentation.

FINDINGS/DISCUSSION
The clinical forms of trigeminal neuralgia that may be correlated with MR imaging include typical, atypical, multiple sclerosis-related, tumor-related, post-traumatic, and treatment failed trigeminal neuralgia. Typical trigeminal neuralgia commonly is associated with neurovascular contact, particularly by the superior cerebellar artery. Neurovascular contact with the trigeminal nerve can be graded by MR imaging based on severity. Aneurysm, arteriovenous malformation, dural arteriovenous fistula and verteobasilar ectasia can be grouped as other vascular causes to be considered in imaging assessment. Benign tumors like schwannoma, meningioma, epidermoid cyst and lipoma involving the course of trigeminal nerve display characteristic MR findings. Perineural spread of the branches of trigeminal nerve from head and neck and other cancers need to be evaluated carefully for clinical management. Benign inflammatory and infectious conditions like sarcoidosis, herpes and Lyme disease can present with trigeminal neuralgia symptoms, which can be assessed by MR. Sella and cavernous lesions extending into the Meckel’s cave include entities like vascular, benign and malignant conditions. Pontine lesions like multiple sclerosis, glioma, infarction, metastasis, hemorrhage and cerebrovascular disorders should be considered in the association of brain stem lesions and trigeminal neuralgia.

SUMMARY/CONCLUSION
MR imaging features can delineate various clinical forms of trigeminal neuralgia.

KEY WORDS: Trigeminal neuralgia imaging

Electronic Scientific Exhibit 037
Subcortical Low-Intensity on Long-Time of Repetition Images of the Brain: a Pictorial Review

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PURPOSE
Subcortical low-intensity on long-time of repetition images (SLI-longTR) has been reported as an uncommon finding at magnetic resonance imaging (MRI) of the brain in a wide range of acute and chronic conditions. The purpose of this exhibit is to discuss pertinent physiopathology, and clinical implications of SLI-longTR by presenting longTR images, gradient-echo (GE), diffusion-weighted imaging (DWI) with mean apparent diffusion coefficient (DWI-ADC), and susceptibility-weighted imaging (SWI) in a wide range of diseases, at both diagnosis and follow up.

APPROACH/METHODS
We present SLI-longTR in seizures, hypotension, ischemia, venous thrombosis, gliomas at both diagnosis and disease progression/relapse, leptomeningeal metastases, and osteodural lymphoma. SLI-longTR may be focal, perilesional, or diffuse, unilateral or bilateral, iso to hypointense at both GE images/SWI and DWI with normal to decreased mean ADC when compared with values obtained from the normal white matter. Generally, SLI-longTR does not show gadolinium enhancement. SLI-longTR may be reversible.

FINDINGS/DISCUSSION
SLI-longTR is observed in a wide variety of acute and chronic meningeal, cortical, and subcortical diseases. This suggests that a common causative factor may exist in various diseases even if this is not proved yet. Notably, the precise pathogenesis is still uncertain, as well as its clinical and therapeutic implications. A shortening effect on T2 relaxation time may result from calcium, high proteinaceous or high cellular content, demyelination, heme and nonheme iron, and free radicals. Calcifications, high proteinaceous or high cellular content, and hemorrhage are easily ruled out by comparison with computed tomography findings, or other MRI sequences and/or follow up. Abnormal iron accumula-
tion resulting from disruption of axonal transport of iron has been proposed in cerebral ischemia and infarction. This seemed consistent with the possible DWI findings, i.e., hypointensity on isotropic DWI despite low mean ADC values; the presence of a paramagnetic substance rather than cytotoxic edema may explain these findings. However, iron accumulation alone might not be enough, since it usually does not occur in a short period and is not reversible. Therefore production and accumulation of free radicals have been considered as the most likely hypothesis. A sufficient concentration of free radicals and ferric iron produced during a disease course along with inadequate amount of free radical scavengers or iron chelators may explain SLI-longTR images. Free radicals are paramagnetic because of their unpaired electrons thus shortening the T2 relaxation time and alternating mean ADC values. This theory explains the presence of SLI-longTR in reversible conditions such as seizures. More recently, an increased amount of deoxyhemoglobin from venous stasis has been advocated to explain SLI-longTR in spontaneous intracranial hypotension. This might also explain this finding in other meningeal diseases leading to venous stasis including neoplasms or venous thrombosis.

**SUMMARY/CONCLUSION**

Further studies are needed to evaluate if SLI-longTR is more frequent than it has been described. Serial MRI in larger cohorts of patients are needed, possibly including measurements of additional MR parameters, such as susceptibility-weighted imaging, magnetization transfer ratios, T2 relaxation times, or MR spectroscopy and pathologic studies, in order to determine clinical significance and therapeutic implications of SLI-longTR.

**Electronic Scientific Exhibit 038**

Melanocytic Lesions in Central Nervous System

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**PURPOSE**

To review radiologic aspects of melanocytic lesions in central nervous system (CNS), describing typical and atypical features, diagnostic challenges, with clinical and pathologic correlations.

**APPROACH/METHODS**

The brain and spine magnetic resonance imaging (MR) and computed tomography (CT) scans of patients with melanocytic lesions were analyzed retrospectively and grouped according to two main diagnostic categories: congenital lesions (e.g., neurocutaneous melanosis) and tumors (benign primary, malignant primary and metastatic lesions). Literature was reviewed and imaging findings were described and correlated to clinical and pathologic data.

**FINDINGS/DISCUSSION**

Typical melanocytic lesions are hyperdense in CT and have shortened T1 signal (hyperintensity) in MR due more commonly to the paramagnetic effect of melanin, probably related to stable free radicals. Many patients however may have isodense CT lesions, atypical signal intensity in MR or unremarkable scans. Hemorrhage is not uncommon and is a frequent feature related to metastases. Disease in CNS may present as parenchymal or leptomeningeal involvement; or both. Parenchymal and leptomeningeal benign involvement is seen in neurocutaneous melanosis, a congenital phakomatosis characterized by multiple or giant cutaneous melanocytic nevi (GCMN) and excessive proliferation of melanocytes cells in CNS, typically involving amygdala and cerebellum. Asymptomatic infants with GCMN may have unsuspected brain or meningeal lesions and should be screened with MR. Malignant melanoma may involve both parenchymal and leptomeningeal compartments as primary or metastatic lesions, and tends to have concomitant involvement of unusual locations as subcutaneous tissue and choroid. Other primary pigmented tumors of the leptomeninges are rare and include pigmented meningioma, meningeal melanocytoma, melanotic schwannoma, melanoblastosis, and primary leptomeningeal melanomatosis, a rare malignant condition. Unlike parenchymal melanoma, benign parenchymal lesions do not have postcontrast enhancement. Nevertheless leptomeningeal involvement usually presents as focal or diffuse enhancement that tends to be heterogeneous or associated to parenchymal invasion in more aggressive pathology. Growth, edema, or necrosis are signs of primary malignant or degeneration of a benign disease. Differential diagnosis of T1 hyperintense lesions includes lipid-rich nodules (lipomas, dermoids) and acute/subacute hemorrhage. Diffuse or focal leptomeningeal enhancement is relatively unspecific and could delay definite diagnosis since other causes such as nonmelanotic carcinomatosis, infectious meningitis and non-infectious inflammation should be rule out.

**SUMMARY/CONCLUSION**

Melanocytic diseases in CNS are relatively rare and may have unspecific radiologic aspect, particularly regarding leptomeningeal involvement. Some presentations however are more typical and suggest some specific diagnostics, such as the common location of brain lesions in neurocutaneous melanosis and the classical appearance of meningeal melanocytic involvement. Otherwise, radiologic evaluation is essential in work up of individual patients such as in the screening of asymptomatic infants with GCMN, in the staging of malignant disease and in the follow up of focal lesions.

**KEY WORDS:** Melanocytic lesions, central nervous system, imaging
Meckel's Cave: What Hides Within?

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PURPOSE
1. To discuss the anatomy and review various lesions within the Meckel’s cave including primary and metastatic tumors, infectious processes, and masses that may involve Meckel’s cave. 2. To illustrate characteristic imaging findings that may assist differentiating various lesions. 3. To describe typical clinical history and epidemiology of Meckel’s cave lesions.

METHODS
The goal of this computerized scientific exhibit is to provide a structured approach to discuss lesions within the Meckel’s cave. We will present a variety of cases including tumors (e.g., schwannomas and meningiomas), granulomatous processes (e.g., sarcoidosis), perineural spread of tumor mimicking primary lesions (including from the nasopharynx), congenital touch me not lesions (e.g., petrous apex cephaloceles), and infectious processes, among others. The anatomy of the Meckel’s cave will be delineated through high-resolution imaging and correlated with anatomical sketches. Pathologic correlation of select cases also will be presented. Disease progression and treatment as well as clinical data will be discussed. Symptoms associated with Meckel’s lesions also will be reviewed (e.g., trigeminal neuralgia, diplopia, ptosis, headache and abducens nerve palsy).

FINDINGS/DISCUSSION
The Meckel’s cave is an often underrepresented structure in the brain. A cerebrospinal fluid- (CSF) filled pouch that houses the trigeminal ganglion, it is in close proximity to the cavernous sinus and temporal lobe. As a result, primary and secondary lesions may affect it. Head and neck tumors also may present after perineural spread along the divisions of the trigeminal nerve. Given the growing use of radiation therapy for trigeminal neuralgia (“Gamma knife therapy”), it is important to understand the variety of processes that can occur in this location to avoid incorrect interpretation. Radiology pathology correlation also will provide a helpful adjunct in developing an understanding of these lesions.

SUMMARY/CONCLUSION
It is important for neuroradiologists to be familiar with the anatomy and lesions of the Meckel’s cave given its proximity to critical structures. Identifying and differentiating tumors, infections and mass lesions within the Meckel’s cave are important for patient management and treatment. Identifying perineural spread of tumor into Meckel’s cave in head and neck cancer is helpful for staging and prognosis.

KEY WORDS: Meckel’s cave
Amygdala Lesions: Differential Diagnosis with Anatomical and Functional Implications

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PURPOSE
To review radiologic anatomy of the amygdala and to describe pathologic processes involving the amygdala, depicting best diagnostic evidences to identify them.

APPROACH/METHODS
Computed tomography (CT) and magnetic resonance imaging (MRI) scans of patients with pathologic amygdalar involvement were analyzed retrospectively. Main diagnostic categories were: congenital [e.g., Urbach-Wiethe syndrome (UWS), neurocutaneous melanosis (NM), cortical focal dysplasia (CFD)]; neoplastic [e.g., dysembryoplastic neuroepithelial tumor (DNET)]; epileptic [e.g., mesial temporal sclerosis (MTS)]; infectious/inflammatory [e.g., herpetic encephalitis (HE), limbic encephalitis (LE)]; degenerative [e.g., Alzheimer disease (AD), Creutzfeldt-Jakob disease (CJD)]; toxic-metabolic [e.g., preterm hypoxic ischemic encephalopathy (HIE)]; and neuropsychiatric [e.g., Kluver-Bucy syndrome (KBS)]. Literature was reviewed. Clinical picture and pathologic findings, when available, were correlated to radiologic features. A systematic radiologic approach to amygdalar lesions was proposed.

FINDINGS/DISCUSSION
The amygdala is an ovoid mass of gray matter in the superomedial portion of temporal lobe constituted by three groups of nuclei: basolateral - inhibitory and reflective of external environment -, centromedial - excitatory and reflective of internal environment -, and cortical. Major bundles of fibers with bidirectional connections between amygdala and cortex, brain stem, basal ganglia, thalamus, hypothalamus, and hippocampus are the stria terminalis and the ventral amygdalofugal pathway. As part of limbic system, it is thought to play a role in modulation of perceptual sensitivity and emotional memory. The systematic approach of amygdalar involvement was based in the following criteria: unilateralism/bilateralism, symmetry, focial/multifocal disease, and special features as calcifications, volume, and morphology. Urbach-Wiethe syndrome - a rare autosomal recessive disorder - and NM are both neurocutaneous conditions associated with bilateral and symmetrical involvement of the amygdala. Despite marked differences between dermatomal manifestations, central nervous system lesions in UWS are characterized focal and calcified; while in NM multifocal involvement of meninges and other brain sites commonly presents as T1-hyperintense lesions, related to abnormal proliferation of melanocytes. Cortical focal dysplasia and low-grade neoplasms as DNET are usually focal and unilateral processes, with increased cortical volume, but more often with faint T2 hyperintensity of CFD and “bubbly” appearance of DNET. Both could occur isolated, combined or be associated with MTS - a seizure-related unilateral or bilateral hippocampal gliosis, sometimes with radiologic visible secondary amygdalar volume loss. Limbic encephalitis and HE usually are associated with unilateral or bilateral mesial temporal lobe enlargement and MR signal abnormalities in acute phase and atrophy in chronic phase, frequently affecting amygdala but also other limbic structures. Other lesions as restricted water diffusion in CJD, atrophy in AD or T2 hyperintensity in preterm HIE involving amygdala are not specific or typical. Neuropsychiatric symptoms frequently are related to lesions in amygdala, but only few unique disorders as KBS, a constellate of behavioral changes after bilateral temporal lobe severe damage or resection, may present detectable structural lesions.

SUMMARY/CONCLUSION
Several conditions can pathologically involve amygdala. Some radiologic patterns may narrow differential diagnosis pointing to specific etiologies. Knowledge of typical findings in some particular diseases and uncommon involvement in other conditions is important to logical approach of these lesions in neuroradiologic practice.

KEY WORDS: Amygdala, imaging, Urbach-Wiethe

Prospective Multicenter Evaluation of Patients with Chronic Kidney Disease Undergoing Gadolinium Contrast-Enhanced MRI Imaging

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PURPOSE
To evaluate the incidence of nephrogenic systemic fibrosis (NSF) in patients with stage 3-5 chronic kidney disease (CKD) undergoing MR imaging (MRI) with gadobenate dimeglumine or gadoteridol.

APPROACH/METHODS
Patients with no history of gadolinium (Gd) exposure within 1 year referred for clinically indicated MRI and who had stage 3 to 5 CKD based on estimated glomerular filtration rate (eGFR; MDRD method) from serum creatinine values obtained within 24 hours prior to MRI were enrolled into one of two studies: Study 1 (beginning 09/2007) comprising patients undergoing CE-MRI with 0.1 mmol/kg gadobenate dimeglumine; Study 2 (beginning 09/2007) comprising patients undergoing CE-MRI with 0.1 mmol/kg gadoteridol. A similar population with no known Gd exposure within 10 years was studied as a control population; Study 3 (beginning 06/2008) patients in studies 1 and 2 were stratified into two cohorts: eGFR of 30-59 mL/min/1.73 m2 (Cohort 1) or < 30 mL/min/1.73 m2 (Cohort 2). In Study 3, only patients with eGFR < 30 mL/min/1.73 m2 were enrolled. Patient follow up by means of scheduled telephone calls and office visits was undertaken for up to 2 years. Patients presenting with symptoms possibly indicative of NSF were referred to a study dermatologist for consultation and deep skin tissue biopsy.
Purpose
To date, 857 patients have been enrolled of which 842 met entry criteria: 303 in Study 1 (266 in Cohort 1; 37 in Cohort 2), 142 in Study 2 (130 in Cohort 1; 12 in Cohort 2), and 397 in Study 3. As of September 30, 2010 no cases of NSF have been identified in any enrolled patient.

Summary/Conclusion
In three prospective studies evaluating incidence of NSF in a control population with stage 4-5 CKD or in patients with stage 3-5 CKD undergoing MRI with gadobenate dimeglumine or gadoteridol, no cases of NSF have been identified to date. Follow up is ongoing in all three studies and complete results will be presented. The prospective methodology used in these studies to determine the incidence of NSF in patients with CKD may shed light on the risk of NSF in patients with CKD undergoing MRI.

Key Words: NSF, gadoteridol, gadobenate

Electronic Scientific Exhibit 043
Imaging Patterns and Lesions Related to Drugs Used in Clinical Practice
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Purpose
To review the full range of brain MR imaging (MRI) abnormalities related to administration of different drugs.

Approach/Methods
A retrospective analysis of brain MRI findings related to use of different drugs prescribed at our institution and review of literature were performed.

Findings/Discussion
Findings were classified according to imaging patterns and to type of drugs administered. By imaging patterns: • Focal lesion in the splenium of the corpus callosum, which usually show transient restricted diffusion, is described with the use of carbamazepin, dilantin, vigabatrin, valproic acid and phenobarbital. • Toxic leukoencephalopathy, with a wide range of findings from mild reversible white matter alterations to necrotizing leukoencephalopathy should be considered in patients with acute onset of neurologic deficit and exposure to immunosuppressants, chemotherapy agents, antimicrobials and/or methadone. The clinical history is not directly correlated with the MRI findings. • Posterior reversible encephalopathy syndrome includes typical and atypical forms with different types of hemorrhage. This pattern has been related mainly with the use of immunosuppressants and chemotherapy agents. • Brain atrophy has been found with the use of steroids and valproic acid. Phenytoin is sometimes related with cerebellar atrophy. By type of drugs administered: • Antiepileptic drugs are associated with focal lesion of the splenium of the corpus callosum, as well as brain and cerebellar atrophy. • Immunosuppressive agents like cyclosporine and FK-506 are associated with posterior reversible encephalopathy syndrome; chronic glucocorticoid therapy with cerebral atrophy; intravenous immunoglobulin with acute encephalopathy, and metronidazole with cerebellar toxicity. • Chemotherapy agents are probably the group with more brain abnormalities described including: chronic and acute methotrexate-induced leukoencephalopathy, dural venous thrombosis, posterior reversible encephalopathy syndrome, hemorrhage and brain atrophy. • Monoclonal antibodies natalizumab and rituximab which are used for multiple therapies including multiple sclerosis, have been associated with the development of progressive multifocal leukoencephalopathy.

Summary/Conclusion
The large and increasing number of drugs used in clinical practice could be associated to a wide range of clinical and brain MR imaging abnormalities from mild and reversible to permanent and severe findings. Recognition of these drug-related to MRI findings is critically important, because symptoms may be confused with metastatic disease, tumor progression, paraneoplastic disorders, or opportunistic infections, and not with the use of the drug by itself. Discontinuation of the offending drug may prevent irreversible central nervous system injury.

Key Words: Medication, brain, abnormalities

Electronic Scientific Exhibit 044
Bullet to the Brain: Radiology of Penetrating Neurotrauma, from Beirut to Chicago
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Purpose
Case-based educational exhibit focusing on the imaging findings that change prognosis and management in patients with penetrating neurotrauma.

Approach/Methods
The exhibit will focus on penetrating trauma only but will cover the gamut of neuroradiology including head, neck and spinal canal. Cases, predominantly CT/CTA, will be taken from two large level 1 trauma centers in Chicago and Lebanon.

Findings/Discussion
Using a case-based approach with self assessment in the form of multiple choice questions, the following will be discussed: Scope of the problem: Penetrating trauma statistics in the United States and Lebanon. Source of the problem: Penetrating weapons - Properties and Physics [including ballistics (ex guns), hand drives objects (ex knives)]. Seeing the problem: Role of imaging in penetrating trauma. Case-based review of penetrating trauma focusing on the findings that change management and prognosis (selected case examples in brackets). Skull and maxillofacial: (commminated fractures); Scalp: (subgaleal hematoma, foreign bodies); Brain:
[hemoorrhage (subdural, subarachnoid, intracranial)], herniation (uncal, subfalcine), diffuse axonal injury]. Spine: (spectrum of fractures, cord injury); Neck: [zone 1/2/3 structures and complications (extravasation, pseudoaneurysm)].

**SUMMARY/CONCLUSION**
Penetrating trauma is an important cause of ER visits in many parts of the United States and the world. Neuroradiology has a central role to play in patients with penetrating trauma to the head, neck and spine. Understanding the properties and physics of common projectiles responsible for penetrating neurotrauma is helpful in understanding how they damage the neuraxis and their imaging appearance. Timely recognition of the imaging findings that alter prognosis and management of the patient with penetrating neurotrauma is critical to their outcome and recovery.

**KEY WORDS:** Penetrating, trauma, gun-shot wound

**Electronic Scientific Exhibit 045**
Retrospective Blinded Comparison of the Radiographic Diagnosis of Acute Central Nervous System Injury on a Portable Handheld Device and OsiriX to Traditional High-Resolution LCD Monitors

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**PURPOSE**
The iPads display resolution is 480 x 320 which is higher than many sequences on MR imaging (MRI). The iPad with its many applications offer user versatility and portability. If specific CT and MR sequences can be interpreted accurately on these portable devices when compared to the traditional stationary LCD display and system, then a radiologist can provide the same turnaround time as if he were onsite which can be crucial for emergent studies. Hypothesis: The iPad’s display resolution is adequate for specific low-resolution CT and MR sequences. Data selection with inclusion and exclusion criteria. Number: The anticipated number of patients is approximately 50 patients. Inclusion Criteria: The study will include those patients with MRI brain and CT perfusion studies. Exclusion Criteria: The study will exclude those patients with neoplastic brain lesion.

**APPROACH/METHODS**
Investigator initiated, single site, retrospective, nonrandomized.

**FINDINGS/DISCUSSION**
Protocol Summary: Each radiologist independently interpreted specific CT and MR sequences for approximately 50 patients on traditional high-resolution LCD monitors, portable handheld devices, and OsiriX for a period of 1 week. OsiriX is an imaging software DICOM viewer for the Mac and the studies for 50 patients are filed and ready for review. Each radiologist documented his results into positive for stroke, negative for stroke; positive for bleed, negative for bleed; and positive for fracture, negative for fracture. After 2 weeks, the same sequences for the 50 patients were interpreted again independently by the same radiologist to allow for intrarater reliability. Subsequently, the results of each radiologist for each patient were compared to allow for inter-rater reliability. All personal identifiers were removed from the data spreadsheets such that there were no links between the information and the individual patients. The collected de-identified data were tabulated on a spreadsheet. Statistical methods, such as averaging and t-test comparisons, were utilized.

**SUMMARY/CONCLUSION**
The data and statistical analysis demonstrated that portable handheld devices such as the Apple Ipad displays adequate resolution on CT and MRI sequences to accurately diagnose acute central nervous system (CNS) injuries and to allow referring physicians an ability remotely to analyze the severity of these findings to determine if acute surgical management is necessary.

**KEY WORDS:** OsiriX

**Electronic Scientific Exhibit 046**
Time-Resolved 4D CT Angiography of the Brain: Technique and Clinical Applications

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**PURPOSE**
To present the clinical applications of time-resolved four-dimensional CT angiography (TR-4D CTA) of the brain with tips for protocol optimization.

**APPROACH/METHODS**
The role of 4D CTA of the brain will be presented focusing on clinical applications in a variety of vascular disease states. Integration with perfusion imaging in the assessment of stroke and steno-occlusive vascular pathology will be highlighted. Protocol details will be provided along with tips for radiation dose management.

**FINDINGS/DISCUSSION**
Time-resolved volumetric imaging of the brain provides anatomical, physiologic and dynamic angiographic information. Clinical applications of this new imaging technique include steno-occlusive cerebrovascular disease, vascular malformations, and aneurysms. The added dynamic dimension of TR-4D CTA provides advantages over conventional CTA modalities that can change clinical management and/or prevent the need for additional imaging.

**SUMMARY/CONCLUSION**
Current time-resolved 4D CTA imaging techniques, clinical applications and advantages over conventional CTA are reviewed.

**KEY WORDS:** Time-resolved CTA, 4D CTA, intracranial vascular pathology
Incidental Fenestrations on MR Angiography: *Shedding Light on these “Windows”*

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**PURPOSE**

Fenestration or segmental duplication of cerebral arteries can result from incomplete fusion of paired primitive embryologic vessels or incomplete obliteration of anastomoses. This exhibit illustrates various intracerebral arterial fenestrations and the associated findings.

**APPROACH/METHODS**

Cerebral magnetic resonance angiography (MRA) reports of the brain performed from 2002-2010 at our institution were searched for the keyword "fenestration". Fenestrations were classified by locations and the presence of coexisting vascular abnormalities.

**FINDINGS/DISCUSSION**

A total of 165 fenestrations were present in 163 patients with a mean age of 49 years (range: 1-98 years, median: 50 years). The majority of fenestrations were noted in females (n = 98, 60%) and within the posterior circulation (n = 104, 63%). The locations of fenestrations included A1 (11%), A2 (3.5%), ACOM (19.5%), M1(2.5%), basilar (55%), and vertebral (5.5%) arteries. PCOM, PCA, AICA, and SCA fenestrations were each less than 1%. Associated small aneurysms were identified, in a minority of cases, adjacent to (n = 8, 5%) and remote from (n = 12, 7%) the fenestrations. No other vascular anomalies were seen in these patients. In the group with fenestrations but no associated aneurysms (88%), very few vascular anomalies were noted (n = 4, azygous, dural a-v fistula, fetal origin).

**SUMMARY/CONCLUSION**

The word fenestration is derived from the latin word “fenestra” or window, and represents the segmental duplications of the lumen into two distinct endothelium lined channels. Fenestrations are not uncommon findings on routine MRA. Though the exact clinical significance is unknown, recognition of these normal variants is significant in differentiating them from other pathology, to exclude associated aneurysms, and for neurosurgical planning. This exhibit illustrates examples of fenestrations in various locations and associated findings, thereby serving to raise awareness and improve accurate detection of these variants.

**KEY WORDS:** Meningeal, arterial, anatomy
Visualization of Distal Dural Rings Using Fusion Image of MR Cisternography and MRA: Application to Paraclinoid Aneurysm Whether It Is Located at Intradural or Extradural Site

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PURPOSE
1) To illustrate the normal MR anatomy of the parasellar and suprasellar regions including the distal dural rings (DDR). 2) To illustrate the relation of the DDR and paraclinoid aneurysm whether it’s located at intradural or extradural site.

APPROACH/METHODS
Three-dimensional cisternography and MR angiography (MRA) were obtained from normal volunteers and paraclinoid aneurysm patients. Fusion images were made by 3D workstation and analyzed three orthogonal reconstruction images. The DDR was defined as a curved plane passing the ICA into the suprasellar CSF space. To elucidate the configuration of the carotid cave, the medial edge between the ICA and tuberculum sellae space was classified as following types: A, no dent; B, shallow dent in which the depth was below the radius of the adjacent ICA; and C, deep dent in which the depth exceeded the ICA radius. The aneurysmal location was diagnosed as extradural or intradural using these images.

FINDINGS/DISCUSSION
The DDR was visualized clearly by 3D-cisternography. Fusion images with MRA are able to discriminate the artery from other structures on 3D cisternography. Regarding the carotid cave configuration, 43% were classified as type A, 37% as type B and 20% as type C, which was consistent with anatomical study using cadavers. For paraclinoid aneurysm, the locations of aneurysms were divided as intradural, extradural, and transitional by fusion image. Aneurysms with a medial projection (carotid cave aneurysm) were difficult to diagnose as intradural or extradural using only MRA, because of the variation of carotid cave figures. However with fusion images, we were able to make a clear demarcation between intra and extradural location.

SUMMARY/CONCLUSION
Fusion images with 3D cisternography and MRA yielded clear visualization of the DDR. This imaging technique will serve for better understanding the parasellar anatomy and discriminating intradural and extradural paraclinoid aneurysms.

KEY WORDS: Aneurysm, MR cisternography, fusion image

How Do You See It?

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PURPOSE
To describe the visual system and its complex relationships with the rest of the brain by means of morphologic sequences, diffusion tensor imaging (DTI) and functional magnetic resonance imaging (fMRI).

APPROACH/METHODS
We have analyzed morphologic, DTI and fMRI sequences in normal volunteers in a 3 T magnet. Morphologic analysis was done with T2 3D Brain View sequence (TR 2500, TE 219, in plane resolution 1x1 mm, NSA 3), and 3D Venc BOLD sequence (TR 19, TE 26, flip angle 10, NSA 2, in plane resolution 0.7 x 0.7 mm). Diffusion tensor images were acquired as single shot EPI in the axial plane, employing 32 diffusion directions and a b factor of 800. Functional MR imaging sequences were obtained in the 3T system using axial single-shot EPI in a block design (TR/TE 3000/30, NSA 1, 9 blocks).

FINDINGS/DISCUSSION
The visual system processes visual detail, as well as enables several nonimage forming photoresponse functions. It interprets information from visible light to build a representation of the surrounding world. It accomplishes a number of complex tasks, including the reception of light, the identification and categorization of visual objects; assessing distances to and between objects; and guiding body movements in relation to visual objects. First we explain the detail of the anatomy of the visual system from rods and cones to the striate and para-striate cortex (17, 18 and 19 Brodmann areas) in the morphologic sequences. With the help of the DTI we draw the optic radiation and main association fascicles in connection with it, describing the two distinct pathways: the dorsal stream or "where" stream, and the ventral or "what" stream. We use different tasks (checkerboard, faces recognition, semantic discrimination) to identify the visual cortex and associated visual areas.
SUMMARY/CONCLUSION
A thorough knowledge of the visual functional anatomy is mandatory to understand pathology which may affect this area.

KEY WORDS: Visual system, DTI, fMRI

Electronic Scientific Exhibit 051
Anatomical and Functional Review of the Fornix

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PURPOSE
A thorough understanding of the anatomical detail and functional significance of the fornix is critical for recognizing and predicting clinically significant impairments. The dysfunctional consequences of pathologic or surgical lesions of the fornix have been underemphasized despite its ready identification on routine MR imaging.

APPROACH/METHODS
This exhibit addresses the anatomical and functional networks relevant to the fornix in conjunction with other nearby pathways and structures. Detailed discussions will underscore structural morphology and anatomical connectivity, including both microscopic features as well as macroscopic landmarks needed to identify these structures on routine MR imaging. Anatomical drawings, pathway diagrams, and routine MR images are utilized as illustrative aids. Clinical findings associated with injuries to these pathways also are highlighted.

FINDINGS/DISCUSSION
This detailed review will focus on the fornix, which is the main outflow tract (predominantly though not exclusively unidirectional) from the hippocampus. The fornix consists of white matter tracts from the alveus and fimbriae that carries efferent fibers from CA3 and subiculum of the hippocampal formation. The fornix follows an arc-shaped course along the choroid fissure with intimate association with the tela choroidea and choroid plexus. It projects to the mammillary bodies and septal nuclei to form an intricate part of the limbic circuit. As part of the hippocampal extended network, the fornix contributes to episodic recollective memory with verbal and nonverbal memory in the dominant and nondominant hemispheres, respectively. Injury to the fornix correlates with impaired recall performance and antegrade amnesia.

SUMMARY/CONCLUSION
The primary goal of this exhibit is to equip neuroradiologists with an understanding of the anatomical landmarks and functional implications of the fornix for integration into daily radiologic practice.

KEY WORDS: Fornix

Electronic Scientific Exhibit 052
Course of the Facial and Vestibulocochlear Nerve through the Temporal Maze: A Gaze into the Embryology, Normal Anatomy and Common Pathologies

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PURPOSE
Seventh and eighth cranial nerves have a complex relationship and anatomy particularly as they course through the petrous temporal bone. We reviewed the embryology and microanatomy of the facial and vestibulocochlear nerves from its origin in the brainstem to petrous temporal bone in normal subjects and those who had imaging for pathologic conditions.

APPROACH/METHODS
Patients referred from specialist Head and Neck clinic underwent HRCT temporal bone and MR imaging (MRI) brain, skull base imaging. HRCT temporal bone was performed on 128 slice MDCT (Siemens Definition as Plus) with 0.6-0.8 mm slice thickness, coronal and sagittal reformats were done as routine. MR imaging was performed with a 1.5 T MRI system (Siemens Magnetom Symphony Tim Syngo MR B17). Multiplanar T1- and T2-weighted fat-saturated images were obtained followed by high-resolution 0.6 mm T2 SPACE sequence. The bony facial canal, internal auditory canal identified on HRCT was correlated with course of the facial and vestibulocochlear nerves and their branches on MR imaging. Intravenous gadolinium was used to study pathologic conditions. Variations of bony anatomy, topographical relationship and morphology of the neural content were noted.

FINDINGS/DISCUSSION
The topographical relationship of the facial and vestibulocochlear nerves differs among the subjects. Most common pattern seen was the course of the facial nerve was superior
and anterior to the vestibulocochlear nerve as a tubular structure throughout the length of the internal auditory canal (IAC) prior to entrance into the fallopian canal. The facial nerve course through the three segments of the fallopian canal, labyrinthine segment, tympanic segment and mastoid segment, before exiting the stylomastoid foramen was identified. Common variation in the length of the mastoid segment, the site of the stylomastoid foramen and the point of divergence of the chorda tympani were described. The vestibulocochlear nerve enters the internal auditory canal (IAC) as a tubular structure but becomes crescent shaped in cross section in the middle portion of the IAC before branching into the cochlear nerve then the superior vestibular nerve, inferior vestibular nerve and the singular nerve at the lateral portion of the IAC. Different embryogenesis of the inner ear and internal auditory canal may account for various osseous and neural pathologies encountered. Common pathologies related to 7th and 8th cranial nerves like acoustic neuroma, facial schwannoma, Bell’s palsy, etc. were noted and have been presented in pictorial format along with high-resolution CT and MRI anatomy.

SUMMARY/CONCLUSION
Facial and vestibulocochlear nerves have variable topographical relationship but consistent pattern of variance are identified. Understanding of the embryology, anatomy and the normal variants of osseous-neural microanatomy can overcome pitfalls in diagnosis of common pathologies of the facial and vestibulocochlear nerves.

KEY WORDS: Facial nerve, temporal bone, vestibulocochlear nerve

Electronic Scientific Exhibit 053
Cavernous Sinuses: Detailed Anatomy with Advanced MR Imaging and Correlations with Cadaveric Dissections. What the Skull Base Surgeon Needs to Know

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PURPOSE
The cavernous sinuses (CS) are one of the most complex regions of the skull base to evaluate due to their intricate anatomy. Knowledge of anatomical structures in these regions is crucial for adequate presurgical evaluation. In this exhibit, we reviewed the anatomy of the CS with high-resolution imaging and compared it with matching cadaveric dissections emphasizing the landmarks which neurosurgeons consider essential for treatment decisions.

APPROACH/METHODS
Ten CS in five cadavers and four skull bases were fixed in formalin and dissected using a surgical microscope (3X to 40X). We then studied the CS from different subjects using advanced MR imaging (MRI) sequences in similar projections. Cavernous sinuses were depicted with multidetector CT (for evaluation of fine bone structures), three-dimensional (3D) Fourier transformation constructive interference in steady state (CISS) MR imaging and 3D T1-weighted imaging both after intravenous injection of gadolinium.

Anatomical studies were compared with the imaging ones and a skull base neurosurgeon emphasized the areas of knowledge that are critical for a neuroradiologist to transmit in reports.

FINDINGS/DISCUSSION
High-resolution imaging demonstrates relevant structures of the CS and their landmarks in the medial cranial fossa. The most crucial features for presurgical evaluation include the CS walls and their relations to the cranial nerves, bone anatomy and its thickness, internal carotid artery branches and afferent/efferent vessels and venous plexus. The CS walls are well identified by imaging in most cases but when this is not possible landmarks to define them can be inferred from anatomical studies. Anatomical variants that help surgeons decide which approach to use can be established by high-resolution imaging and include pneumatization of the anterior clinoid process, sphenoid sinus septations and optic chiasm position.

SUMMARY/CONCLUSION
The CS contain vital neurovascular structures that are affected by numerous pathologies. Landmarks, anatomical variations and CS contents are depicted with high-resolution imaging and their inclusion in the radiology report helps surgeons with their decision of treatment. Lesions in the CS may distort the anatomy complicating characterization of some of these landmarks. Treatment decisions are based on preoperative imaging studies that identify not only the distorted pathologic anatomy but also normal anatomy and variations of the CS.

KEY WORDS: Cavernous sinus, anatomy
Electronic Scientific Exhibit 054


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PURPOSE
To demonstrate, with optional quiz format, the two- and three-dimensional trajectories of the normal white matter tracts of the healthy human brain.

APPROACH/METHODS
This interactive presentation of the white matter tracts, with optional quiz format, is constructed by overlapping diffusion tensor images with MP-RAGE images. We used diffusion tensor tractography to provide additional relevant anatomical information for conventional MR imaging studies, using multiplanar reconstructions of the main topologic relationships of the brain like, projection, association, limbic and commissural fibers. The anatomical maps illustrate each pathway and anatomical structures by a simple click on the region of interest. In addition, a detailed list of the major anatomical landmarks is provided, allowing the user to navigate in the regions of interest and obtain anatomical information like: Anatomical nomenclature, location, function, and connectivity.

FINDINGS/DISCUSSION
ANATOMY: Hippocampal internal structure is due to 2 U-shaped lamina of gray matter that are interlocked together - the cornu ammonis and dentate gyrus. The amygdala is anterior to the hippocampus. The temporal stem is the white matter containing the uncinate fasciculus that connects the temporal lobe with the basal ganglia and frontal lobe. EMBRYOLOGY: Findings from 13-week specimens demonstrate an unfolded hippocampus, large temporal horn, wide open hippocampal sulcus and a prominent germinal matrix. Sixteen-, 18-, and 24-week specimens show progressive changes consisting of infolding of the hippocampus and reduction in size of temporal horn, hippocampal sulcus, and germinal matrix. VARIATIONS: A number of normal variations may mimic pathologic entities including hippocampal asymmetry, hippocampal shape and orientation, hippocampal sulcal remnant, and temporal horn asymmetry. Incidental findings that may mimic pathologic entities include choroidal fissure cysts and enlarged Virchow Robbin spaces.

SUMMARY/CONCLUSION
MR imaging of fetal and adult specimens provides useful insight into the complex development and anatomy of the temporal lobe. Knowledge of this anatomy and familiarity with developmental anomalies as well as incidental findings is important in order to differentiate these entities from pathologic abnormalities.

KEY WORDS: Temporal, anatomy, embryology

Electronic Scientific Exhibit 055

Understanding the Temporal Lobe and Stem: Embryology, Anatomy, Terminology and Normal Variations

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PURPOSE
To enhance understanding of normal temporal lobe embryology, terminology, anatomy and normal variations as depicted by MR imaging (MRI).

APPROACH/METHODS
Temporal lobe anatomy was investigated by MR imaging and correlative anatomical dissection of adult specimens. Hippocampal embryology was studied by MRI, correlative dissection and correlative histologic analysis of formaldehyde-preserved human fetal specimens. To assess normal variations, 29 normal subjects were imaged.

FINDINGS/DISCUSSION
ANATOMY: Hippocampal internal structure is due to 2 U-shaped lamina of gray matter that are interlocked together - the cornu ammonis and dentate gyrus. The amygdala is anterior to the hippocampus. The temporal stem is the white matter containing the uncinate fasciculus that connects the temporal lobe with the basal ganglia and frontal lobe. EMBRYOLOGY: Findings from 13-week specimens demonstrate an unfolded hippocampus, large temporal horn, wide open hippocampal sulcus and a prominent germinal matrix. Sixteen-, 18-, and 24-week specimens show progressive changes consisting of infolding of the hippocampus and reduction in size of temporal horn, hippocampal sulcus, and germinal matrix. VARIATIONS: A number of normal variations may mimic pathologic entities including hippocampal asymmetry, hippocampal shape and orientation, hippocampal sulcal remnant, and temporal horn asymmetry. Incidental findings that may mimic pathologic entities include choroidal fissure cysts and enlarged Virchow Robbin spaces.

SUMMARY/CONCLUSION
MR imaging of fetal and adult specimens provides useful insight into the complex development and anatomy of the temporal lobe. Knowledge of this anatomy and familiarity with developmental anomalies as well as incidental findings is important in order to differentiate these entities from pathologic abnormalities.

KEY WORDS: Temporal, anatomy, embryology
Lifting the Veil on the Limbic System: Normal Structure and Function and Characteristic Imaging Patterns in Limbic Disease

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PURPOSE
To review the anatomy and function of the limbic system. To discuss pathologic entities which target the limbic structures with specific attention to imaging characteristics and clinical considerations. After viewing this exhibit, viewers should be able to: (1) Identify the components of the limbic system, (2) Understand the role of the limbic system in the central nervous system, (3) Identify imaging findings and their clinical correlation for diseases which affect the limbic system.

APPROACH/METHODS
We begin with an organized review of the anatomy and known functions of the limbic system. This complex system comprises cortical structures including the olfactory cortex, parahippocampal gyrus, hippocampal formation, cingulate gyrus; subcortical structures including the amygdala, septum pellucidum, hypothalamus, anterior thalamic nuclei, mamillary bodies, ventral portions of the basal ganglia; basal forebrain; septal nuclei; and portions of the brainstem. A discussion of the spectrum of pathology which targets limbic structures includes: congenital abnormalities, injury such as contusion and ischemia, vascular lesions, infection/inflammation, epilepsy, neoplastic and paraneoplastic entities, metabolic abnormalities resulting in limbic degeneration such as Wernicke-Korsakoff syndrome, and dementia.

FINDINGS/DISCUSSION
The limbic system is a complex and incompletely understood system made up of multiple central nervous system structures united by an intricate network of communications which play a role in a variety of functions including olfaction, memory, emotion, and homeostasis. High-resolution multiplanar cross-sectional imaging allows in vivo visualization of these structures in normal subjects and in patients with limbic disease, enabling an understanding of both function and pathology affecting this system.

SUMMARY/CONCLUSION
The limbic system is a vital part of the brain which is incompletely understood. Imaging identifies the anatomical components of the system. Understanding the imaging patterns of disease affecting the limbic system is important for the radiologist to formulate a useful differential diagnosis.

KEY WORDS: Limbic system, anatomy, pathology

Honey, I Blew Up the Veins
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PURPOSE
Cases of variant and pathologic intracranial venous dilatation are utilized to illustrate detailed anatomy.

APPROACH/METHODS
The cerebral angiography and neurorintervention database from a group of five neurorinterventionists was reviewed for cases of dural and pial fistulization, arteriovenous malformation and developmental venous anomaly. Images were selected detailing intracranial venous anatomy that was felt to be poorly demonstrated in the angiograms of normal brains. The consistent landmark relationships of venous and brain anatomy were depicted by correlation with MR brain and vascular imaging, as well as by graphic illustration.

FINDINGS/DISCUSSION
Prior to the advent of CT, a knowledge of detailed angio- graphic venous anatomy was most pertinent to the localization and measurement of extrinsic mass effect. Venous drainage patterns remain of particular importance in the grading of AVMs and dAVFs whereas variant venous anatomy, including dVAs may impact neurosurgical approach and the risk of venous infarction or hemorrhage. Although the dural and supratentorial cortical venous anatomy is well demonstrated on normal angiograms and has been the subject of multiple presentations, the deep transmedullary, subependymal and posterior fossa venous patterns are poorly outlined. Venous dilatation due to the above lesions enables a clear depiction of this otherwise subtle anatomy. Multiplanar brain MR is ideally suited to defining the relationship of venous to brain surface anatomy and elucidates the otherwise seemingly complex course of these vessels.

SUMMARY/CONCLUSION
A sound knowledge of detailed intracranial venous anatomy can be achieved by assessing cases of variant and pathologic venous dilatation as presented in this atlas.

KEY WORDS: Venous, anatomy, angiography
**Comparative CT Analysis of Hominid Skulls: Steps to Modernity**

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**PURPOSE**

To illustrate the role of high-resolution MDCT for better understanding the hominid fossil record. We discuss morphometric features and apply craniometric analysis to illustrate changes in form and function. Our exhibit challenges the radiologist to make observations, such as those relating to cranial shape, to facilitate appreciation of paleoanthropology using modern imaging.

**APPROACH/METHODS**

Five museum quality replica skulls, capturing the detail and scientific accuracy of the original specimens, were chosen to represent the hominid record. In chronological order, these are *Australopithecus afrarensis* (“Lucy”), *Australopithecus boisei* (“nutcracker man”), *Homo erectus* (“Peking man”), *Homo neanderthalensis* and an early *Homo sapiens* (“Cro-Magnon man”). We also scanned the skull of a Bonobo chimpanzee, another member of the Hominidae family. Three-dimensional MDCT permitted accurate depiction of the outer skull surfaces, included the supraorbital brow ridge, forehead slope, sagittal crest, and orientation of the face and foramen magnum. The slopes of the maxilla and nasal bones, and mandibular shape and dentition also were considered. Review of the scientific literature helped determine key craniometrics, such as the supraorbital breadth and maxillary prognathism indices and bizygomatic breadth.

**FINDINGS/DISCUSSION**

A journey to Olduvai Gorge, Tanzania, “the Cradle of Mankind” provided inspiration. Until recently, paleoanthropological research was confined to the dig or laboratory. Technological innovations have allowed the field to move into the reading room. MDCT provides virtual anatomy rivaling that of original fossils. Our first specimen, *Australopithecus afrarensis*, at 3.2 million years old (MYO), is believed to be the oldest ancestor of modern *Homo sapiens*. Lucy had a distinctive V-shape jaw, similar to primates, with canines intermediate in size between apes and humans, and large, flat molars, required for a herbivorous diet. The modern U-shaped jaw, on the other hand, includes more dental variation, necessary for the omnivore. Although her brain capacity was small, 375-500 cc (the bonobo chimpanzee, the closest extant relative of humans, has a cranial capacity of 280-380 cc) her pelvis suggested bipedalism. *Australopithecus boisei* (2.3-1.2 MYO; cranial capacity 510 cc), was a highly specialized masticator, with huge mandible, molars and zygomatic arches and prominent sagittal crest. Peking man (125-500,000 YO; cranial capacity 850-1250 cc), had a small, flat face, prominent cheek bones, prominent brow ridge and a rare metopic suture. When the orbits are positioned anterior to the frontal lobe, supraorbital brow ridges may form to bridge the gap. *Homo neanderthalis* (200,000-30,000 YO), with a relatively enormous cranial capacity 1600 cc, had a low vaulted cranium and forehead, projecting face and a pronounced double-arched brow ridge. Our Cro-Magnon skull (30,000-10,000 YO; cranial capacity1600 cc) demonstrates a decreased angle of the forehead, in no small part due to expansion of the frontal lobes, sitting directly above the orbits. Decreased maxillary prognathism reflects the decreased size of the masticator structures.

**SUMMARY/CONCLUSION**

MDCT analysis of the early hominid fossils is a major new tool for paleoanthropology. Three-dimensional reconstruction of morphologic structures permits improved understanding of the similarities and differences in the brain and craniofacial characteristics of early hominids and provides insights into the emergence of modern man.

**KEY WORDS:** MDCT, hominids, craniometrics

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**Electronic Scientific Exhibit 059**

**Utilization of Optimized Nonorthogonal Imaging Planes to More Precisely Define the Spread of Pharyngeal Neoplasms into Adjacent Spaces, Extrapharyngeal Muscles, Vessels and Nerves**

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**PURPOSE**

1. Utilize nonorthogonal CT and MR images obtained along precisely defined anatomical planes to aid in staging of pharyngeal cancer. 2. Better define the pathways of pharyngeal tumor spread between the different portions of the pharyngeal constrictor muscles, along adjacent extrapharyngeal muscles, along the deep cervical vasculature, and cranial nerves to aid in T-staging of pharyngeal tumors.

**APPROACH/METHODS**

1. Use the source data from previously obtained contrast-enhanced neck CT scans in 50 patients with pharyngeal cancer to construct images in optimized nonorthogonal planes perpendicular and parallel to the orientation of the main extrapharyngeal muscles. 2. Use of nonorthogonal imaging planes for prospective MR evaluation of 15 patients with known pharyngeal cancer on 1.5 and 3.0 T scanners.

**FINDINGS/DISCUSSION**

We found that using imaging planes perpendicular and parallel to the orientation of the normal course of the extrapharyngeal muscles allowed us to better define the pharyngeal anatomy and relationship of pharyngeal tumor spread outside the pharynx to adjacent extrapharyngeal muscles, adjacent spaces, and other structures. These imaging planes provided us with additional information in many cases that allowed more accurate T-staging of the patient’s pharyngeal cancer.
SUMMARY/CONCLUSION
Accurate T-staging of pharyngeal cancers (nasopharyngeal, oropharyngeal, hypopharyngeal) is crucial in that it may affect both treatment and prognosis. The use of optimized nonorthogonal images obtained parallel and perpendicular to the adjacent extrapharyngeal muscles allows one to better define the relationship of tumor spread and more accurately T-stage pharyngeal cancers.

KEY WORDS: Pharyngeal neoplasms, pharyngeal muscles

Electronic Scientific Exhibit 060
Imaging of the Developing Skull Base: Evolution from the Newborn to Adulthood

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PURPOSE
1. Provide an interactive review of basic embryologic concepts of skull base development. 2. Illustrate evolution of skull base maturation on CT and MR. 3. Highlight developmental concepts of common skull base lesions.

APPROACH/METHODS
Utilize multiplanar CT and MR imaging from the neonate through adulthood.

FINDINGS/DISCUSSION
Understanding the complex anatomy of the skull base is critical to thorough evaluation of this region. This review will highlight important developmental concepts and demonstrate changes to the bony and soft tissue elements as highlighted on CT and MR imaging from the neonatal period to adulthood. The role of embryology in common skull base pathologies also will be discussed.

SUMMARY/CONCLUSION
This interactive review will provide the viewer with an imaging-based approach to important concepts of skull base development, anatomy, and their relationship to common skull base pathology.

KEY WORDS: Skull base, development

Electronic Scientific Exhibit 061
Revisiting the Pterygopalatine Fossa and its Communications: A Conceptual Approach with CT Correlates

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PURPOSE
To simplify understanding and visualization of the complex three-dimensional (3D) anatomy of the pterygopalatine fossa with its communications and neurovascular connections.

APPROACH/METHODS
The pterygopalatine fossa is conceptualized as a room, its communications as hallways and the foramina as doors. This approach simplifies the three-dimensional understanding of the adjacent communications and their contents in the medial, lateral, anterior, posterior, superior and inferior directions. Initially, simple computer-enhanced hand-drawn illustrations were created with proper perspective view to provide the "big picture" of the architecture. Subsequently, graphics design software, Autodesk 3D Studio Max 9.0, was used to create hollow volumetric virtual models with appropriate surface rendering, lighting and shadowing to facilitate viewing the interior aspect the conceptualized pterygopalatine fossa, its communications and their contents. Users can rotate their view as a "camera view" as if physically present within the pterygopalatine fossa and are able to see the connections and structures. Macromedia Flash is used to create these modules, which are inherently web-compatible. A quiz is provided in the end, describing scenarios where user is asked to imagine walking through the previously mentioned spaces while turning in different directions to enter and recognize the nearby connections. Correlative axial and coronal thin-slice CT images of the structures also are provided.
**Findings/Discussion**

The pterygopalatine fossa is an important space as it communicates with the middle cranial fossa, orbit, nasal cavity, oral cavity, pharynx, foramen lacerum and the infratemporal fossa via eight foramina and canals. These include sphenopalatine foramen, foramen rotundum, pterygoid canal, greater and lesser palatine foramen, inferior orbital fissure, palatinovaginal canal, and the pterygomaxillary fissure. Each of these contains important neurovascular components. The fossa itself can play an important role in the spread of infection and tumor. Therefore, understanding this intricate anatomy can prove essential in understanding the routes of spread of disease, the extent and at times in planning radiation treatment. This knowledge also can serve as a reference point when attempting to understand and learn the surrounding anatomical spaces and neuroanatomy. The correlative CT images help apply the learned concepts and solidify the knowledge of the actual anatomical appearance of the discussed structures.

**Summary/Conclusion**

An alternative approach to learning the intricate three-dimensional anatomy of the pterygopalatine fossa and its communications was designed. This interactive method can be used in teaching similar anatomy within the skull where direct visualization within the cadaver is difficult, if not impossible, due to the small size and complexity.

**Key Words:** Pterygopalatine fossa, 3D, ganglion

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**Electronic Scientific Exhibit 063**

**Ultrasound of the Oral Cavity: Technique, Imaging Appearances and Correlation with Other Cross-Sectional Studies**

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**Purpose**

The purpose of this educational exhibit is to demonstrate the ultrasound anatomy of the oral cavity in correlation with CT and MR anatomy. The oral cavity is a challenging area to evaluate for radiologists. Streak artifacts from dental fillings often obscure detail anatomy on CT. Diagnosis and treatment of pathology relies on accurate assessment of multiple complex structures. Oral cavity is accessible by ultrasound via submental intraoral approach. Familiarization with the ultrasound appearance of normal structures of the oral cavity is crucial in order to appreciate and delineate pathology.

**Approach/Methods**

This educational exhibit aims to review technical aspects, pros and cons and demonstrate ultrasound appearance of oral cavity structures. The technical aspects of ultrasound procedure for oral cavity, such as transducer selection, use of patient landmarks, and orientation of transducer will be reviewed. Sonographic appearances of oral cavity anatomy will be demonstrated and correlated with CT and MR imaging (MRI).

**Findings/Discussion**

Imaging of oral cavity lesions usually includes CT (computed tomography), MRI (magnetic resonance imaging) and/or PET (positron emission tomography). Although these tests are excellent for defining disease, they have certain limitations, including: 1) Ionizing radiation (CT); 2) Intravenous contrast administration for CT and MRI; 3) Motion artifact (swallowing, tongue movement); 4) Degradation of image quality by dental metalware. Ultrasound evaluation of oral cavity structures has multiple advantages that compliment CT and MRI. It is a noninvasive test, which has no ionizing radiation for patient. It is relatively inexpensive and fast to perform. It is a real-time examination, which means it is less compromised by motion artifact. It has excellent spatial resolution of small structures. Images are affected less by dental hardware.
SUMMARY/CONCLUSION
Ultrasound has not been utilized extensively in evaluation of pathology of the oral cavity. It offers many advantages that complement CT and MRI. Thorough understanding of the ultrasound appearance of oral cavity structures is essential before applying the technique to the patient population. By the end of this educational exhibit, the participant should be able to recognize the appearances of normal oral cavity anatomy, have in-depth understanding of the approach to the ultrasound scan in regards to probe selection, scan approach, and standard reference planes using anatomical landmarks as well as appreciate the correlative appearances of oral cavity structures on MRI and CT. Coronal ultrasound of the floor of mouth and tongue is an example of the anatomical detail that can be achieved.

KEY WORDS: Ultrasound, oral cavity, normal appearances

Electronic Scientific Exhibit 064
Imaging of the Common Peroneal Nerve with 3 T Magnetic Resonance Neurography: Normal Anatomy and Common Neuropathies

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PURPOSE
Common peroneal nerve (CPN) is the most commonly injured nerve in the lower extremity and it may be involved in a variety of pathologies. Injury to the CPN is also the most common cause of foot drop. This electronic exhibit will provide an introduction to the technique for obtaining high quality, high resolution 3 T MR neurography (MRN) images of the CPN. The MRN appearance of normal and diseased CPN will be demonstrated.

APPROACH/METHODS
1. Gain knowledge of technical considerations for high-resolution 3 T MRN of CPN. 2. Familiarize with the normal anatomy of CPN and its branches. 3. Learn the MRN imaging appearance of various pathologies that can affect the CPN.

FINDINGS/DISCUSSION
1. MR neurography imaging characteristics of various direct and indirect peroneal nerve pathologies, such as, nerve sheath tumors, perineuroma, ganglion, peroneal tunnel entrapment, neurapraxia, axonotmesis, neurotmesis, entrapment by adjacent mass lesions and involvement in posterolateral corner injury of the knee, etc., will be shown with case examples. Relevant electrodiagnostic and surgical correlations also will be presented.

SUMMARY/CONCLUSION
3 T MRN is an excellent noninvasive tool for evaluation of CPN anatomy as well as its pathology in great detail. This exhibit will help the radiologist become familiar with normal imaging findings and the most commonly occurring injuries/pathologies involving CPN and its branches.

KEY WORDS: Common peroneal nerve, MR neurography, neuropathy

Electronic Scientific Exhibit 065
Case-Based Illustrative Review of the Extra-Axial Spaces at the Junction of the Skull Base and Upper Cervical Spine

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PURPOSE
To define and illustrate the anatomy and physiopathology of the extra-axial spaces of the junction of the skull base and cervical spine. To facilitate identification and early diagnosis of extra-axial lesions occurring within these spaces.

APPROACH/METHODS
Review of literature and selection of cases during interpretation session from 2009-2010, identifying studies where pathologic findings illustrate the boundaries of the extra-axial spaces of the skull base and cervical spine and their relationships. Cases with lesions of the upper cervical spine extending into the posterior cranial fossa and with lesions of the posterior cranial fossa extending into the upper cervical spine, as well as lesions originating at the level of the foramen magnum and craniocervical junction are depicted with didactic illustrations.

FINDINGS/DISCUSSION
A case-based comprehensive review of the anatomy of the extra-axial spaces of the skull base and upper cervical spine and its transition through the foramen magnum is not found in the radiologic literature. Multiple cases are identified and
presented which, through physiopathology and imaging appearance, illustrate these spaces. The understanding of the anatomy of the craniocervical junction allows for prediction of the location and extent of lesions in different compartments, facilitating identification and appropriate classification.

SUMMARY/CONCLUSION
Different cases illustrating extra-axial lesions through the foramen magnum are presented and discussed. Understanding the anatomical boundaries and relationships of these spaces allows for proper diagnosis of extra-axial skull base lesions.

KEY WORDS: Extra-axial, skull base, craniocervical

Electronic Scientific Exhibit 066

MR Perfusion of Squamous Cell Carcinoma of the Tongue at 3.0 T

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PURPOSE
1. Role of neoangiogenesis and the clinical impact of increased microvessel density in squamous cell carcinoma (SCC) of the tongue. 2. Evaluate the technique of head and neck MR perfusion at 3.0 T. 3. Discuss the perfusion pattern of squamous cell carcinoma of the tongue. 4. Current challenges and future directions.

APPROACH/METHODS
At 3.0 T, MR perfusion of the head and neck region was done following dynamic administration of a gadolinium-based contrast agent using a three-dimensional T1-weighted spoiled gradient-echo sequence over a duration of 4 minutes. The wash-in, maximum enhancement and wash-out rates of the primary SCCs of the tongue and metastatic adenopathy were plotted and assessed using a quantitative analysis software. The results of the MR perfusion analysis finally were interpreted in lieu of the unenhanced T1- and T2-weighted images, and the diffusion images.

FINDINGS/DISCUSSION
Quantitative analysis of the MR perfusion pattern of SCCs of the tongue revealed a rapid arterial phase enhancement with very slow wash out of contrast at about 4 minutes.

SUMMARY/CONCLUSION
Dynamic gadolinium-enhanced MR perfusion imaging of the tongue at 3.0 T is a valuable tool to identify and localize primary SCCs, assess nodal disease for metastases and evaluate tumoral response to therapy.

KEY WORDS: MR perfusion, squamous cell carcinoma, 3.0 T
Electronic Scientific Exhibit 068
Panoramic Radiography: Analysis and Interpretation for the Medical Radiologist

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PURPOSE
Panorex or orthopantograph exams often are used in hospitals and emergency rooms for evaluation of dental, maxillofacial, and mandibular conditions. Image interpretation requires understanding the technical properties of this technique, as well as familiarity with normal anatomy, nomenclature and classification of dental and periodontal disorders.

APPROACH/METHODS
Content: - Introduction; - The Panorex or panoramic x-ray. Technical overview; - Normal anatomy and dental nomenclature; - Dental Pathology; - Infection; - Trauma; - Benign tumors, cysts and expansile lesions; - Malignant lesions; - Conclusion.

FINDINGS/DISCUSSION
Panorex imaging is a useful modality for detecting and diagnosing various lesions within the region of the maxilla and mandible.

SUMMARY/CONCLUSION
Understanding of the imaging principles, anatomy and regional pathology is essential for appropriate image interpretation.

KEY WORDS: Panorex, mandible

Electronic Scientific Exhibit 069
Imaging the Smile: A Pictorial Review of Dental and Periodontal Disease for the Everyday Radiologist

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PURPOSE
While dental CT is not routinely performed at hospital imaging centers, dental and periodontal disease can be recognized with standard high-resolution maxillofacial computed tomography (CT) and sagittal and coronal reformations. The implications of diagnosing dental and periodontal disease can have a significant impact on not only the dental health of patients but diseases of the sinuses and jaw bones. This educational exhibit serves to review dental and periodontal anatomy and distortion of normal anatomy that indicates disease.

APPROACH/METHODS
It is well established in the literature that curvilinear and orthoradial multplanar high-resolution dental CT is extremely reliable in evaluating dental anatomy in preparation for presurgical planning, but not all institutions possess the software, nor is it practical to use such technology in all situations. In this exhibit, standard reformations from maxillofacial CT performed to evaluate odontogenic processes as well as for other purposes where dental disease is incidentally found, will be included as educational examples to recognize a gamut of dental and periodontal disease and the implications of these findings.

FINDINGS/DISCUSSION
Recognition of dental and periodontal disease on standard maxillofacial CT is imperative to diagnose to help direct immediate management, preclude further complications, and address foreseeable sequelae of odontogenic disease. A patient with facial pain or trauma, for example, may receive a maxillofacial CT and an etiologic odontogenic process may be recognized if careful survey and inspection of the alveolar processes is routine. Such diseases can have significant impact on patient well being. The smile is one of the most recognizable and attractive features of the human face, and unfortunately often disease-ridden. While promoting dental hygiene is beyond the scope of a diagnostic radiologist, identifying early disease to prevent complications cannot be overemphasized.

SUMMARY/CONCLUSION
Dental disease incurs a large financial burden on our healthcare system and diagnostic radiologists can play a role in limiting future complications by diagnosing early periodontal disease and/or involvement of the bony jaw. It is crucial to understand the anatomy of the teeth, their intimate relationship with the maxilla and mandible and close apposition to the maxillary sinus in the case of the maxillary molar teeth. Early diagnosis and therefore prevention of complications such as chronic apical periodontitis, osteomyelitis, oroantral fistulization and inferior alveolar nerve destruction should be in the diagnostic armamentarium of the everyday radiologist. Preserving a patient’s smile and preventing chronic infectious processes and avoiding costly endodontic repair is truly a worthwhile endeavor.

KEY WORDS: Dental, periodontal, CT

Electronic Scientific Exhibit 070
Facial Palsy and Hemispasm: What the Neuroradiologist Needs to Know: A Review of the Anatomy and Potential Etiologies

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PURPOSE
Facial palsy and hemispasm are clinical conditions caused by various etiologies, ranging from upper motor neuron to distal facial nerve pathology. The facial nerve comprises motor, sensory and parasympathetic divisions. Understanding the anatomy of the upper and lower motor neuron pathways is crucial in being able to evaluate potential etiologies for facial paralysis and hemispasm. The purpose of this exhibit is to review the gross and radiologic anatomy of the facial nerve and various pathologies that can cause facial paralysis and hemispasm. Because the facial nerve has a long course from its origin in the brainstem to its peripheral branches, CT and MR imaging (MRI) are complimentary imaging modalities used to evaluate...
this large area. The radiologic and pathologic features of the most common conditions causing facial paralysis and/or hemispasm at each specific anatomical level will be discussed in this exhibit.

**APPROACH/METHODS**

Illustrations and cross-sectional imaging (CT and MRI) examples of the anatomy and pathology of the different parts of the facial nerve will be described and reviewed. This includes the location of the nuclei, the course of the intratemporal segments, the extraosseous pathologies, and the greater superficial petrosal nerve (GSPN) and chorda tympani branches.

**FINDINGS/DISCUSSION**

Representative examples of causes and pathology involved in facial palsy will be reviewed. This includes lesions along the corticobulbar fibers, lesions within the brainstem, neurovascular compression at the root entry zone of the facial nerve, infection, inflammatory processes like multiple sclerosis, Bell’s palsy, facial nerve canal trauma, and masses like meningioma, schwannoma, hemangioma and perineural spread of cancer (often from parotid gland). We will present other benign and rare congenital entities like facial nerve canal duplication, facial canal meningocele, and persistent stapedial artery. We will describe the pertinent imaging findings in each with their differential diagnoses.

**SUMMARY/CONCLUSION**

In order to fully evaluate for potential etiologies of facial nerve paralysis and hemispasm, a thorough understanding of the relevant anatomy and clinical symptoms related to malfunction is essential. Neuroimaging plays a vital role in the diagnosis of these patients, to localize the lesion and evaluate for benign versus malignant etiology.

**KEY WORDS:** Facial, nerve, palsy

**Electronic Scientific Exhibit 071**

**Imaging of Extraocular Muscle Dysfunction**

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**PURPOSE**

To demonstrate the imaging features of cranial nerve and orbital lesions causing extraocular muscle dysfunction.

**APPROACH/METHODS**

MR imaging, CT, MRA, CTA and conventional cerebral angiography are the imaging modalities used to assess cranial nerve and orbital lesions causing extraocular muscle dysfunction. In this exhibit, we will demonstrate cranial nerve and orbital lesions presenting with extraocular muscle dysfunction occurring at various levels from the origin in the brainstem to the muscles themselves.

**FINDINGS/DISCUSSION**

Extraocular muscle dysfunction can be due to third, fourth and sixth cranial nerve lesions as well as intrinsic orbital or systemic conditions with manifestations in the orbit. Cranial nerve lesions can be classified based on anatomical locations as follows: brainstem nucleus, fascicles, subarachnoid space, petrous apex, cavernous sinus, orbital apex and orbit. Brain stem lesions include infarction, hemorrhage, tumor, demyelination and arteriovenous malformations. Complete ipsilateral third nerve palsy with contralateral ptosis is due to midbrain third nerve nucleus lesion as the levator subnucleus is a single central caudate nucleus. Third nerve nuclear or fascicular lesions present with characteristic syndromes based on specific midbrain locations like cerebral peduncle, red nucleus, substantia nigra and superior cerebellar peduncle. MR imaging is the best imaging modality to assess brain stem lesions. Subarachnoid space lesions are typically isolated nerve palsies and may present with headache or orbital pain. The etiologies are aneurysm, ischemia, trauma, infections like tuberculosis, Lyme disease, cryptococcal infection, inflammatory lesions like vasculitis, sarcoidosis, carcinomatous meningitis, neoplasms including meningioma, ependymoma, hemangioblastoma and metastasis. Raised intracranial pressure can cause fourth and sixth nerve palsies. In acute setting, aneurysm assessment is crucial in management of third cranial nerve lesions. Posterior communicating artery aneurysms are characteristic for third cranial nerve involvement. Aneurysms in other locations also can involve cranial nerves. Third cranial nerve dysfunction can be internal or external based on pupillary or external ocular muscle involvement. Internal and external dysfunction can be complete or incomplete. The risk of aneurysm causing third cranial nerve palsy is high in complete or incomplete internal dysfunction with complete or incomplete external muscle dysfunction. The risk of aneurysm is low without external muscle dysfunction. MR imaging, MRA, CTA or conventional angiography is used for aneurysm assessment. The choice of investigation is based on institutional practice. Cavernous sinus lesions can be associated with Horner’s syndrome and cranial nerve palsies of third, fourth, sixth nerves, ophthalmic and maxillary branches of fifth cranial nerve. Thrombosis is an important consideration which can be evaluated with thin slice CT or MRI. MR imaging has added advantage of assessing dural venous sinuses. Tumor, inflammation, carotid aneurysm, ischemia and arteriovenous fistula can involve the cavernous sinus. Petrous apex lesions may present with sixth nerve palsy. Orbital apex and orbital lesions can be due to trauma, tumor, infection, inflammatory disorders like pseudotumor, thyroid ophthalmopathy and chronic progressive external ophthalmoplegia. CT and MRI can be used for evaluating such lesions based on clinical presentation.

**SUMMARY/CONCLUSION**

Imaging of extraocular muscle dysfunction should be planned carefully based on clinical presentation, age and associated signs and symptoms.

**KEY WORDS:** Extraocular muscle dysfunction
Three-Dimensional Volume-Rendered MDCT with Surface-Shaded Display for Preoperative Evaluation of Orbital Tumors

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PURPOSE
Surgical intervention for primary and metastatic orbital tumors requires intricate resection and complex reconstructive procedures. The purpose of this study is to demonstrate our initial experience utilizing three-dimensional volume-rendered MDCT (3D-MDCT) with surface-shaded display (SSD) in the preoperative evaluation of the orbit in patients with orbital tumors.

APPROACH/METHODS
Three-dimensional MDCT with SSD images were reconstructed from source axial CT data obtained in patients with orbital tumors. The 3D-MDCT and SSD data were compared and evaluated for assessment of bony anatomy and relationship of orbital contents to the tumors.

FINDINGS/DISCUSSION
Surface-shaded display images may be rotated along multiple axes, and viewed from 360 degrees in any plane deemed necessary. This allows visualization of the orbit from its interior and from the exterior including the intracranial compartment to evaluate the orbital roof. The relation of areas of bone destruction to the orbital foramina, and of the tumor to the intraorbital contents is demonstrated. This technique complements visualization of these relationships to information obtained from orthogonal MDCT.

SUMMARY/CONCLUSION
Accurate assessment of the integrity of the bony orbit, the relation of bone destruction to the orbital foramina and of tumor to the intraorbital contents is imperative for the surgical planning of patients in whom complex resection and reconstruction is performed. Three-dimensional volume-rendered MDCT with surface-shaded display may aid neuroradiologists, ophthalmologic surgeons and neurosurgeons in the preoperative assessment and mapping of orbital tumors by providing a multidimensional view of the orbit.

KEY WORDS: Volume rendering, orbit, tumor
Electronic Scientific Exhibit 074
Magnetic Resonance Imaging of IgG4-Related Sclerosing Disease in the Head and Neck and Brain

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Purpose
Based on a concept proposed from Japan in 2001 and published in New England Journal of Medicine by Hamano, et al, IgG4-related sclerosing disease is recognized as the extensive infiltration of mainly exocrine tissue by IgG4-positive plasma cells and elevated levels of serum IgG4 that is characteristic of autoimmune pancreatitis. IgG4-related sclerosing disease is a systemic disease involving various organs, including retroperitoneal fibrosis, sclerosing cholangitis, interstitial nephritis, interstitial pneumonia, mediastinal fibrosis and inflammatory pseudotumor of the liver or lung. In the past multifocal fibrosclerosis was reported to be a rare disease before IgG4-related sclerosing disease was defined, but it is accepted now as being closely related to this disease. Further, Mikulicz’s disease was confused as a subtype of the pathologically distinct Sjögren syndrome. However, today Mikulicz’s disease is recognized to be a clear equivalent of IgG4-related sclerosing disease. IgG4-related sclerosing disease also may complicate lesions of the head and neck (HN), and brain. Previously few reports of IgG4-related sclerosing disease in the HN and brain were available, but have increased since the establishment of the concept of the disease. We consider diagnostic imaging to be essential for the detection of lesions in the HN and brain. The aim of our study was to define and exhibit the imaging features of IgG4-related sclerosing disease in the HN and brain.

Approach/Methods
We retrospectively reviewed MR images, from our and other institutes, of 13 cases with IgG4-related sclerosing disease proved by pathologic or serological tests.

Findings/Discussion
Review of the MR images revealed: related enlarged lacrimal glands - 9; orbital pseudotumor - 4; cranial nerve swelling - 6; enlarged pituitary gland - 5; and thickening of the dura mater - 4. Low signals on T2-weighted images are considered characteristic of these lesions. Cranial nerve swelling was most typical of the trigeminal nerve. Of the branches of the trigeminal nerve, swelling was observed especially in the infraorbital nerve. Pituitary gland lesions wipe out the high signal of the posterior gland and are accompanied with swelling of the pituitary stalk. Thickening of the dura mater was recognized as diffuse or nodal with or without enhancement effect.

Summary/Conclusion
IgG4-related sclerosing disease is a prolonged process requiring long-term management. Lesions are polyphasic and can be found concurrently in various organs and exocrine tissue. In cases of pancreatopathy, aortopathy or disorders of other regions, it is important to conduct diagnostic imaging of the HN and cranial regions to search for related lesions. Further, when detecting enlargement of the lacrimal glands, trigeminal nerve swelling, enlarged pituitary gland or thickening of the dura mater, the risk of IgG4-related sclerosing disease must be considered and extensive follow up is necessary.

Key Words: IgG-related sclerosing disease, head and neck, brain

Electronic Scientific Exhibit 075
Sight for Sore Eyes: Imaging of Ocular and Ophthalmologic Infections

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Purpose
After viewing this teaching module the user will have learned the following information regarding ocular and ophthalmologic infections: • Key anatomical structures that limit and facilitate the spread of infection; • Imaging features and common clinical presentations; • Potential complications and routes of spread.

Approach/Methods
Key anatomy will be reviewed using diagrams and corresponding cross-sectional images. Cases, selected from institutional teaching files, are presented in a quiz format to stress the imaging findings of common infections and their mimics. In addition to the imaging findings, the clinical presentation and treatment are discussed.

Findings/Discussion
Cases to be presented include: • Preseptal cellulitis vs abscess. • Postseptal cellulitis vs abscess. • Subperiosteal abscess. • Episcleritis. • Endophthalmitis. • Dacryoadenitis. • Dacryocystitis. • Optic neuritis. • Mucormycosis. • Thyroid ophthalmopathy. • Idiopathic orbital inflammatory syndrome. • Superior ophthalmic vein thrombosis. • Cavernous sinus thrombosis. • Pott’s Puffy tumor.

Summary/Conclusion
Knowledge of the anatomy, patterns of spread and potential complications are essential to limit the potential sight-threatening and life-threatening complications associated with infections of the eye and orbit. Upon the completion of this module the user will have a systematic approach to the imaging evaluation of patients with ocular and ophthalmologic infections.

Key Words: Ophthalmologic, infections, complications
Electronic Scientific Exhibit 076

MR Spectroscopy of Head and Neck

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PURPOSE
MR spectroscopy is a noninvasive imaging technique that can detect metabolic changes of head and neck tumors. Performance of MR spectroscopy of head and neck is technically difficult with great challenge. Recent advances in post-processing techniques of MR improve the results of MR spectroscopy of head and neck.

APPROACH/METHODS
1) To describe the different techniques of MR spectroscopy of head and neck. 2) To review the normal spectrum of MRS of head and neck. 3) To illustrate the potential application of MR spectroscopy in patients with head and neck tumors. 4) To describe the merits and limitations of this method.

FINDINGS/DISCUSSION
MR spectroscopy has been used for differentiation of malignant head and neck cancer from benign tumors and infections as well as it can differentiate squamous cell carcinoma from normal muscles. It helps in characterization of cervical lymph nodes. Also, it can be used for prediction of treatment outcome, differentiation of recurrent tumors from post-treatment changes and monitoring patient after treatment.

SUMMARY/CONCLUSION
MR spectroscopy of head and neck has an important role in management of patients with head and neck cancer. It helps in differentiating malignant head and neck tumors from benign lesions, characterization of cervical lymphadenopathy and monitoring patients with malignancy after therapy.

KEY WORDS: Spectroscopy, neck, malignancy

Electronic Scientific Exhibit 077

High-Resolution Imaging of the Suprahyoid Neck Using Surface Coils at 3.0 T

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PURPOSE
Evaluate the role of surface coil imaging at 3.0 T in evaluating the suprahyoid neck.

APPROACH/METHODS
The entire neck is screened for adenopathy using a large field of view head and neck coil. A surface flex coil then is placed on either side of the suprahyoid neck of patients, with a permissible field of view of 120 cm. High-resolution imaging of the neck is performed using the following protocol: T2TSE coronal, sagittal and axial images (3 mm slice thickness), T1TSE coronal axial images (3 mm slice thickness), DW imaging (b = 0, 500), MR perfusion (1.5 mm slice thickness, 16 NEX, 4 min 30 sec), postgadolinium T1TSE fat-suppressed axial, coronal and sagittal images (3 mm slice thickness). The scan time is approximately 45 minutes.

FINDINGS/DISCUSSION
The combination of surface coil imaging at 3.0 T produced significant increase in the signal-to-noise ratio and image resolution. This allowed the radiologist to easily identify anatomical landmarks, accurately identify pathologies and stage tumors in this region.

SUMMARY/CONCLUSION
Surface coil imaging at 3.0 T is a useful imaging technique for evaluation of the suprahyoid neck.

KEY WORDS: Surface coil, suprahyoid neck anatomy, 3.0 T

Electronic Scientific Exhibit 078

Imaging Pattern of Calvarial Lesions

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PURPOSE
Calvarial lesions often present themselves as clinically silent findings on skull radiographs or as palpable masses that may cause localized pain or soreness. A variety of neoplastic, inflammatory, congenital and traumatic etiologies can give rise to such lesions. Neuroradiology textbooks only briefly discuss the role of CT and MR imaging (MRI) in their diagnosis (if at all) and very few papers have been published on the subject. Moreover, to our knowledge, little attention has been paid to correlating the imaging findings of calvarial lesions to the histopathologic diagnosis. Our objective is to design a computerized self-teaching module that will ultimately assist radiology residents in establishing a differential diagnosis for calvarial lesions and allow them to evaluate their knowledge through self-assessments.

APPROACH/METHODS
The computerized self-teaching module has four specific aims: (1) Introduce the resident to the clinical aspects of calvarial lesions and the advantages of each imaging modality; (2) Describe the imaging characteristics of the most common lesions; (3) Design quizzes and present mystery cases in order to permit the resident to evaluate his knowledge of calvarial lesions; (4) List the most helpful and pertinent literature. In developing this website, we reviewed the records of 141 patients of the Montreal Neurological Institute and Hospital with radiologically documented calvarial lesions between 2001-2009.

FINDINGS/DISCUSSION
A website was designed by the authors and a medical graphic designer, and is available on the World Wide Web under the domain name www.calvariallesions.com. It is organized under Introductory domain name www.calvariallesions.com. It is organized as follows: Lesions; Self-Assessments; and About. Under Introductory Pages can be found the purpose of the module, an introduction to calvarial pathology, the calvarial anatomy, imaging principles of the calvaria with a focus on dural enhancement, and a history of the calvaria. Thirteen common calvarial lesions are
described within the Lesions heading. Each lesion includes clinical features, radiologic features, a multicolored computer-designed graphic, and an average of three representative cases. Under Self-Assessment, there are three quizzes and four mystery cases.

**SUMMARY/CONCLUSION**

This new website should allow radiology residents to improve their understanding of calvarial pathology. By completing this learning module and evaluating their knowledge through the self-assessments, they should be more comfortable in establishing an appropriate differential diagnosis for calvarial lesions.

**KEY WORDS:** Calvarial, skull vault, lesion

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**Electronic Scientific Exhibit 079**

Pictorial Review of the CT Features of External Auditory Canal Dysplasia

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**PURPOSE**

To present a pictorial review of the spectrum of CT findings in patients with external auditory canal (EAC) dysplasia.

**APPROACH/METHODS**

We retrospectively identified all patients diagnosed at our institution over the last 5 years. We reviewed the high-resolution, thin-section CT of the temporal bones obtained in these patients, and recorded CT features associated with EAC dysplasia. We particularly emphasize the features of the milder forms of this disorder and commonly associated minor middle ear anomalies.

**FINDINGS/DISCUSSION**

Congenital aural atresia (CAA) is the failure of the development of the EAC, due to deficient canalization of a segment of the first branchial cleft. Patients most often suffer from conductive hearing loss. Given intact sensorineural hearing, surgical restoration of conductive hearing can be achieved. External auditory canal dysplasia may be categorized as incomplete or complete; as well as membranous, bony, or mixed. Associated malformations may be present including microtia, middle ear including ossicular abnormalities, and aberrancy of the course of the facial nerve. A higher incidence of cholesteatoma also has been associated. Due to differences in development, inner ear anomalies are less commonly present. Several classification systems exist for the staging of the degree of atresia and associated abnormalities.

**SUMMARY/CONCLUSION**

High-resolution, thin section CT imaging is a key examination in patients with EAC dysplasia as it allows to evaluate temporal bone anatomy and to assess for evidence of other congenital abnormalities including syndromic findings, which may preclude surgery. It is critical for the radiologist to be familiar with the spectrum of imaging findings, and in particular to recognize the milder degrees of dysplasia of the EAC and middle ear cavity, for the purpose of accurate counseling of the family and surgical or alternative procedural planning.

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**Electronic Scientific Exhibit 080**

Branchial Cleft Cyst Anomalies: A Pictorial Review of Their Embryologic, Anatomical and Radiologic Appearance Along with Treatment Options

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**PURPOSE**

Branchial cleft cyst anomalies although benign are common causes of head and neck masses, as well as a cause of morbidity, either from super infection and/or mass effect. Appropriate diagnosis is facilitated by thorough understanding of the embryologic and anatomical branchial relationships.

**APPROACH/METHODS**

Selected cases of branchial cleft anomalies and comprehensive review of the literature were used for this electronic educational exhibit. Certain images highlighting branchial cleft cyst from ultrasound (US), computed tomography (CT), and magnetic resonance imaging (MRI) were chosen for this presentation. Correlative endoscopy and intraoperative findings are included to highlight the importance of our role as radiologists.

**FINDINGS/DISCUSSION**

During the 4th week of embryonic development there are four pharyngeal arches that are separated by clefts and pouches externally and internally respectively. Branchial cleft cyst anomalies arise from incomplete mesenchymal obliteration of one of the four ectodermal lined branchial clefts. The 1st branchial cleft normally develops into the external auditory canal (EAC). There are two classifications to a 1st branchial cyst which compose of 1% of all branchial cysts. Type 1...
branchial cysts are duplication of EAC which are composed of ectoderm lining only. They course laterally to the facial nerve and present near the auricle. Type 2 cysts are more varied in their position as they course medial to the facial nerve and can be found either as preauricular, infraauricular, or postauricular swellings or inferior to the angle of the mandible. Type 2 cysts are composed of ectoderm and mesoderm. There are four classification types to 2nd branchial cyst anomalies, which account for the 95% of the branchial malformations. They are found in the lower, anterolateral neck in the supratonsillar fossa between the sternocleidomastoid muscle (SCM) and the pharynx. The 3rd branchial cysts are rare and can be found deep to the SCM at the superior pole of thyroid coursing between the hypoglossal nerve (H) and the glossopharyngeal nerve through the thyrohyoid membrane ending at the lateral side of the piriform sinus. Fourth branchial cysts are the rarest of the branchial cyst and are seen in the lower third portion of the neck. They course parallel to the recurrent laryngeal nerve to the piriform sinus apex from either around the aorta on the left or around the subclavian artery on the right. The majority of these lesions may be surgically addressed, however for instance, in those complicated by infection, planned procedures may include minimally or less invasive techniques.

**SUMMARY**

At the conclusion of this exhibit, the attendee will have a comprehensive understanding of the imaging features of branchial cleft anomalies, its embryologic developmental origin and treatment options.

**Electronic Scientific Exhibit 081**

**Assessment of Obstructive Sleep Apnea Syndrome with MR Imaging**

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**PURPOSE**

Obstructive sleep apnea syndrome (OSAS) is a common disorder characterized by repetitive pharyngeal collapse during sleep. Obstructive sleep apnea syndrome has gained increasing attention in the literature. MR imaging (MRI) has been used for evaluation of patients with OSAS.

**APPROACH/METHODS**

1. To review the pathophysiology of obstructive sleep apnea syndrome. 2. To review technique of MR imaging used for diagnosis of OSAS. 3. To illustrate structural and functional abnormalities of upper airway in patients with OSAS with different imaging modalities. 4. To review role of imaging in patients with OSAS after treatment.

**FINDINGS/DISCUSSION**

Imaging techniques have increased our knowledge of the pathophysiology of OSAS. The cross-sectional areas of upper airway of OSAS patients were smaller than that of the control. Anatomical and functional MR imaging can detect the level, degree and cause of obstruction in the upper airway that guides the clinical diagnosis and treatment. Also, imaging may be used for follow up of patients with OSAS after treatment.

**SUMMARY/CONCLUSION**

We concluded that anatomical and functional MR imaging is essential for diagnosis of OSAS. It can detect the cause, level, degree and anatomical site for upper airway obstruction. This information is essential for treatment planning as well as for monitoring patients with OSAS after therapy.

**KEY WORDS:** Sleep, MR imaging, apnea

**Electronic Scientific Exhibit 082**

**Imaging and Interpretative Pitfalls in Head and Neck Cancer**

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**PURPOSE**

This pictorial review is to demonstrate common pitfalls in head and neck cancer imaging identified in our weekly tumor board discussions. Radiologic and clinical finding correlation is emphasized to increase diagnostic accuracy in both pre and post-treatment necks.

**APPROACH/METHODS**

It is estimated that 36,540 people will be diagnosed with and 7,880 people will die of head and neck cancer in 2010. Delineating the anatomical extent of the cancer is one of the most important keys in achieving a successful outcome. American Joint Committee of Cancer (AJCC) 7th Edition is used as a standard guideline for staging. However, there are common pitfalls occurring during image acquisition, processing and interpretation that hinder diagnostic accuracy. This presentation is illustrated by using CT, MRI, PET/CT, clinical and endoscopic images. The resources come from 250 cases in our head and neck cancer registry from January to December 2010.

**FINDINGS/DISCUSSION**

The presentation covers pre and post-treatment necks in each anatomical subsite including oral cavity, pharynx and skin. Examples of common pretreatment imaging pitfalls are: 1. Missing a lesion due to inappropriate imaging techniques or artifacts (beam hardening artifacts, motion artifacts, thick CT slice, lack of IV contrast, lack of three-plane reconstruction on CT); 2. Missing a superficial or mucosal lesion in a clinically obvious location (buccal space, soft palate, hard palate, retro-molar trigone, floor of mouth, true vocal cord); 3. Mistaking normal variants as lesions such as asymmetric palatine or lingual tonsils; 4. Tumor extension into certain location is very difficult to assess by imaging alone and needs panendoscopic correlation such as retrocricoid and prevertebral invasion of laryngeal cancers; 5. Infection and benign neoplasm can appear destructive simulating malignant neoplasm clinically and radiologically; 6. Normal-sized lymph nodes can be metastatic while a completely cystic level IIa lymph node can be mistaken as a branchial cleft cyst. Examples of post-treatment imaging pitfalls are: 1. Failure to recognize post-treatment changes due to inadequate history or lack of comparison; 2. Follow up with incorrect imaging modalities making com-
parison and interpretation very difficult; 3. Misinterpreting expected post-treatment changes as residual/ recurrent disease or vice versa; 4. Under detecting a secondary primary tumor obscured by post-treatment changes; 5. Common false positive and false negative findings of PET/CT.

**SUMMARY/CONCLUSION**
Knowing anatomy, recognizing common pitfalls as well as correlating radiologic and clinical findings are crucial steps in accurate staging and following patients with head and neck cancers.

**KEY WORDS**: Head and neck cancer, imaging, pitfalls

**Electronic Scientific Exhibit 083**

**It's Not Just Another Nasal Mass**

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**PURPOSE**
Considerable overlap exists in imaging features of nasal masses, which often limits the ability of the radiologist to narrow the differential diagnosis. We will illustrate the imaging appearances of a variety of nasal masses and emphasize the imaging findings that the otolaryngologist needs to know prior to surgery.

**APPROACH/METHODS**
Computed tomography and magnetic resonance imaging of a wide range of nasal masses will be presented along with details regarding clinical presentation and management. Imaging will be correlated with intraoperative photographs and pathologic specimens. Overlapping imaging features and distinguishing characteristics will be discussed. We also will review the underlying pathology, as currently described in the literature.

**FINDINGS/DISCUSSION**
Masses centered in the nasal cavity frequently share many generic features with overlapping appearance on cross-sectional imaging studies. The lack of pathognomonic features does not permit the radiologist to confidently predict a single diagnosis in most cases. The primary role of the radiologist in assessing these masses is to define local extent and regional spread, evaluate effects on surrounding structures, such as intracranial extension and orbital involvement, or obstruction of the sinus drainage pathways, or in the case of malignant lesions to evaluate for perineural spread or nodal disease. Enhancement and signal characteristics are often nonspecific. When possible, particular imaging features of nasal lesions can be used to narrow the differential diagnosis. Intraoperative photographs and pathologic specimens will be used to correlate with the radiologic findings to reinforce pertinent imaging characteristics of a wide range of nasal masses. Finally, we will discuss pertinent findings with regard to nasal masses that will help otolaryngologists in further work up and management of these patients.

**SUMMARY/CONCLUSION**
Nasal masses frequently lack distinguishing characteristics, and can be a confusing topic to radiologists. By correlating clinical, imaging, surgical, and pathologic findings present in a wide range of masses centered in or originating from the nasal cavity, we hope to help radiologists generate an appropriate and clinically useful differential diagnosis. We also will reinforce important imaging findings in preoperative evaluation.

**KEY WORDS**: nasal mass

**Electronic Scientific Exhibit 084**

**Complicated Pranasal Sinusitis: From Normal Anatomy, Clinical Manifestation to Pathologic Conditions**

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**PURPOSE**
1) To describe the anatomy of paranasal sinuses and adjacent structures. 2) To describe the spectrum of complicated paranasal sinusitis. 3) To illustrate the CT and MR imaging findings in complicated paranasal sinusitis. 4) To discuss the clinical significance of complicated paranasal sinusitis, especially on intracranial and vascular involvement.

**APPROACH/METHODS**
1) Anatomy of paranasal sinuses: Location, adjacent structure, drainage orifice of maxillary, ethmoid, sphenoid and frontal sinuses. 2) The complications of paranasal sinusitis including meningitis, cerebritis, subdural empyemas, Pott's puffy tumor, skull osteomyelitis, cavernous sinus thrombosis, internal carotid arterial stenosis, internal carotid artery rupture, intraorbital infection, facial cellulitis. 3) Multiplanar CT and MR images may demonstrate the anatomical relationship between primary infected sinuses and secondary spreading to adjacent structures. MR imaging combined with MRA and MRV are more sensitive in detection of intracranial and vascular involvement. 4) Intracranial and vascular involvement of complicated sinusitis may lead to severe morbidity.

**SUMMARY/CONCLUSION**
The main teaching points of the exhibit are: 1) Knowledge of paranasal sinal anatomy. 2) Paranasal sinusitis may lead to a variety of complications. 3) The relation between anatomical structures and complications of paranasal sinusitis may be well depicted with CT and MR images. 4) Complications of paranasal sinusitis are potentially risky when great vessels of the neck or intracranial organs are involved.

**KEY WORDS**: Sinusitis, vascular complication, paranasal
We present commonly encountered facial bone fractures in a
facebook.com style format with groups and profiles of specific fracture patterns. This now familiar format allows for facial fracture patterns to be presented in an intuitive and simple design. Each individual fracture pattern has a 3D CT reconstruction profile picture, checklist to identify characteristic radiologic features, and multiple example photos. Specific neurologic complications and treatment approaches for each facial bone fracture pattern are discussed. The facebook.com format is used to reinforce the radiologic patterns of common facial bone fractures.

Findings/Discussion
Each of the commonly encountered facial bone fracture patterns is presented in a simple format with groups and profiles of individual fracture patterns using a design similar to facebook.com. Groups of fracture patterns include: orbital, nasal, tripod, Lefort, smash, and mandibular. The orbital group includes the profiles of orbital rim, frontal sinus, orbital floor, and orbital blowout fracture patterns. The nasal group includes isolated nasal bone fractures and the overlapping nasoorbitoethmoid fracture pattern involving the medial canthal ligament. The tripod group of zygomaticomaxillary complex fractures includes examples of varying degrees of separation of the three zygomatic sutures and occasional TMJ secondary involvement. The Lefort group of maxillary fractures involving the pterygoid plates describes the individual profiles of the classical Lefort I, II, and III fracture patterns. The smash group includes examples of facial fractures in patients with high-speed motor vehicle collisions and gunshot wounds where fractures do not conform to specific craniofacial anatomical buttresses. The mandibular group includes fractures of the mandibular symphysis, body, ramus, coronoid process, and condyle. The importance of systematically identifying each fracture pattern is discussed, with attention to specific complications and surgical treatment approaches for the particular fracture profile.

Summary/Conclusion
Facial fractures frequently are encountered in the trauma setting and present a diagnostic challenge to the radiologist. Accurate classification of facial fracture patterns is essential as individual patterns have specific complications and surgical management approaches. Imitating the simple and intuitive design of facebook.com, we present a review of common facial bone fracture patterns.

Key Words: Facial fractures

Electronic Scientific Exhibit 086
Imaging Algorithm of Petrous Apex Lesions

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Purpose
The purpose of this exhibit is to present a computer interactive algorithmic approach to differentiate lesions involving the petrous apex.

Approach/Methods
We retrospectively reviewed the CT and MR images of lesions involving the petrous apex. We categorized these lesions based on the MR findings and subsequently made an algorithm to differentiate these lesions.

Findings/Discussion
The petrous apex is that part of the temporal bone lying anteromedial to the inner ear and lateral to the petro-occipital fissure. In the imaging evaluation of petrous apex lesions, CT is superior to assess bone involvement while MR is mainly used for lesion characterization. Both modalities are complementary to each other. On the basis of the MR appearance, lesions were divided into broad categories: 1) lesions with high signal intensity on T1-weighted (W) sequences; 2) lesions with low T1 and high T2W signal intensities; 3) lesions with low signal intensity on both T1 and T2W sequences; 4) lesions with intermediate signal intensity on both T1 and T2W sequences. These categories are shown as different arms of the algorithm. Each arm is further divided according to the appearance of lesions on different MR sequences. Computed tomography is discussed, wherever appropriate. The final goal is to arrive at a correct diagnosis.

Figure 1 represents the imaging algorithm. We review the imaging algorithm in a highly interactive way where the viewer can select one arm of the algorithm which will lead to mul-
tiple differentials and then ultimately derive the correct diagnosis with the help of different imaging characteristics. Finally, each diagnosis is discussed, briefly, along with the images.

**SUMMARY/CONCLUSION**
The petrous apex is a small portion of the temporal bone but it is a location for a number of pathologies. Our goal is to provide a computer interactive imaging algorithm to help differentiate lesions involving the petrous apex. After reviewing this exhibit, the viewer will develop an algorithmic approach to diagnose petrous apex lesions.

**KEY WORDS:** Petrous apex

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**Electronic Scientific Exhibit 087**
Pictorial Review of Cases of Dissecting and Blister Aneurysms Causing Subarachnoid Hemorrhage

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**PURPOSE**
To present a pictorial review of cases of subarachnoid hemorrhage due to dissecting and blister intracranial aneurysms, and discuss treatment options and dilemmas.

**FINDINGS/DISCUSSION**
Dissecting and blister aneurysms are an uncommon and difficult to manage cause of subarachnoid hemorrhage. This exhibit presents a pictorial review of these cases using selected images from computed tomography angiography, magnetic resonance angiography, and digital subtraction angiography. This is accompanied by a discussion of potential treatment strategies with an emphasis on the recent trend towards vessel preserving endovascular management using stent devices.

**SUMMARY/CONCLUSION**
With the help of this exhibit we hope to improve the recognition and knowledge of intracranial dissecting and blister aneurysms.

**KEY WORDS:** Blister aneurysm, dissecting aneurysm

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**Electronic Scientific Exhibit 088**
Recognition and Management of Vascular Complications Encountered in Interventional Neuroangiography

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**PURPOSE**
1. To discuss vascular complications seen during interventional neuroangiographic procedures with emphasis on imaging recognition. 2. To review treatment options for each complication with focus on immediate and long-term measures aimed at reducing morbidity and mortality.

**APPROACH/METHODS**
Vascular complications during interventional neuroangiography: • Groin hematoma and retroperitoneal bleeding (including pseudoaneurysm/arteriovenous fistula formation); • Thromboembolism; • Dissection and vascular occlusion; • In situ stent thrombosis; • Coil migration; • Coil stretching; • Aneurysm rupture; • Vessel rupture; • Glue migration; • Knotted catheters; • Broken catheter tip

**FINDINGS/DISCUSSION**
Incidence and imaging recognition of each vascular complication will be discussed with illustrated case scenarios. For example, dissection and thromboembolism during cerebral angiography can appear subtle on imaging and require recognition of prolonged transit time and delayed washout of contrast. In addition, management of each complication with immediate and long-term measures will be explained in detail.

**SUMMARY/CONCLUSION**
• Timely recognition of vascular complications occurring during interventional neuroangiography with appropriate management is essential for minimizing morbidity and mortality. • Knowledge of the multiple factors influencing complication rates including age, comorbidities, endovascular approach, lesion and perilesional anatomy is essential for safe, efficacious treatment.

**KEY WORDS:** Complications, angiography, management

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**Electronic Scientific Exhibit 089**
Computer Fluid Dynamics: All You Have to Know about Its Applications in Cerebral Aneurysm Flow Simulations

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**PURPOSE**
To give a complete review of computer fluid dynamics (CFD) basics and its use in aneurysm flow simulations.
**Approach/Methods**
We review the concepts of CFD, its origins, mathematical basis, analysis methodologies, parameters, and its uses for aneurysm evaluations. We present our data of analyzed cases with real patient data.

**Findings/Discussion**
In the last years CFD has become a very interesting tool for simulating aneurysm flow. One of the main questions when facing an aneurysm is why they rupture? Or when will they rupture? Several parameters as the wall sheer stress (WSS), wall pressure, impingement zone, vortex and morphology, have been related with aneurysm growth and rupture. These could be determined by CFD with data obtained from 3D angiographs. We have analyzed 100 real aneurysms, finding that rupture is associated mainly with low WSS and morphology. Our findings are consistent with others reported in the literature.

**Summary/Conclusion**
Computer fluid dynamics has been positioned as a valid tool for the evaluation of flow in cerebral aneurysm. We believe that in the near future it will be an essential technique for the decision-making process in this disease.

**Key Words:** Computer flow dynamics, aneurysm, rupture

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**Electronic Scientific Exhibit 090**

**Imaging Management of Patients Undergoing Neurointervention: What You Need to Know**

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**Purpose**
Technological and procedural advances have led to a rapid rise in the number of endovascular neurointerventions being performed for the treatment of cerebrovascular disease, and improvements in neuroimaging techniques have allowed for more rapid, accurate, and safer monitoring of patients undergoing neurointervention. Herein we review advances in neurointerventional techniques and describe state-of-the-art MR imaging (MRI) for diagnosis, peri- and postprocedural patient evaluation, and longer term patient follow up.

**Approach/Methods**
Conventional angiography is invasive and costly, and therefore not optimal for the often repeat imaging required in such patients. Both computed tomography angiography (CTA) and magnetic resonance angiography (MRA) with contrast provide excellent depiction of vessels; however, MRA may be preferable following neurointervention due to device-related artifacts at CTA. In addition, MRA lacks ionizing radiation and the use of potentially nephrotoxic contrast, and generally is considered safer than CTA for repeat follow-up examinations.

**Findings/Discussion**
Highly sensitive imaging is essential for presurgical evaluation and following up of patients after neurointervention. The use of parallel imaging techniques increases the temporal resolution of MRI while higher field strength imaging improves signal intensities (SI). Together, they provide a robust, fast, accurate imaging method, providing high intravascular SI in the small caliber vessels of the head and neck, as well as excellent morphologic depiction of soft-tissue masses and surrounding parenchyma. The use of higher relaxivity gadolinium (HR-Gd) agents such as gadobenate dimeglumine further increases SI and obviates the need for higher Gd doses. HR-Gd has shown benefit in follow up of treated aneurysms, evaluation of the supra-aortic vessels, including detection of severe intracranial stenoses; identification and classification of vascular malformations, including dural arteriovenous fistulas and angiomias; and for guiding treatment in patients with brain tumors.

**Summary/Conclusion**
Advanced MR imaging sequences and contrast agents improve the management of patients undergoing neurointerventions.

**Key Words:** Neurointervention, MR imaging, technique
Electronic Scientific Exhibit 091

Endovascular Management of Symptomatic Cerebral Vasospasm with Transluminal Balloon Angioplasty

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PURPOSE

Delayed cerebral ischemia (DCI) from vasospasm is a major cause of secondary morbidity and mortality following aneurysmal subarachnoid hemorrhage (aSAH). Endovascular intervention via transluminal balloon angioplasty (tBA) and intra-arterial (IA) vasodilator infusion is appropriate for patients who fail medical management or who cannot tolerate sufficient durations of hemodynamic therapy. For proximal vasospasm, tBA is the more reliable of the two modalities although there is marked variability in its utilization. Effective use of this therapy requires early detection of DCI and exclusion of established, irreversible infarct. The purpose of this exhibit is to illustrate indications for tBA in the management of symptomatic vasospasm as well as therapeutic outcomes of the procedure.

APPROACH/METHODS

More than 50 cases of endovascular management for cerebral vasospasm during a 6-year period were reviewed for this exhibit. These cases were accumulated from two institutions, where the senior author practiced during this time frame. Information on patient demographics, clinical presentation, location of vasospasm, mode of treatment, treatment outcome, and procedural complications were examined for each case. Pertinent cross-sectional studies and angiographic images were selected to demonstrate the indications and results of endovascular management.

FINDINGS/DISCUSSION

Successful endovascular treatment of vasospasm was accomplished in all patients with no mortality and a morbidity of less than 5%. Distal lesions were treated with IA vasodilator infusion alone, using verapamil in 2004-05, and nicardipine after 2007. Proximal lesions were addressed with transluminal balloon angioplasty using Hyperform or Hyperglide balloons (ev3 Neurovascular) in most cases. In situations where tortuous anatomy was too difficult to navigate using these systems, small diameter Gateway balloons (Boston Scientific) were an effective substitute. IA infusions were often performed concurrently and likely resulted in better patient outcomes.

SUMMARY/CONCLUSION

When judiciously employed, tBA is a life-saving procedure that can prevent the establishment of infarcts in aSAH patients with symptomatic vasospasm. Procedural complications can be minimized through recognition of congenitally hypoplastic vessels, appropriate balloon catheter sizing, and avoidance of recently clipped vessel segments. IA nicardipine infusion prior to angioplasty may further decrease the risk of acute vessel rupture. With attention to these factors and prudent patient selection, tBA can achieve reliable angiographic and clinical improvement in many cases. It should be considered early in the course of DCI to optimize the amount of salvageable parenchyma. After review of this exhibit, readers should recognize optimal indications for the use of tBA.

KEY WORDS: Balloon angioplasty, vasospasm, subarachnoid hemorrhage

Electronic Scientific Exhibit 092

Paragangliomas of the Head and Neck: Review of Imaging Findings and Endovascular Treatment Strategies

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PURPOSE

Paragangliomas are highly vascular neuroendocrine tumors derived from extra-adrenal autonomic paraganglia that frequently occur in the head and neck, accounting for 0.6% of all head and neck neoplasms. They typically present as painless masses in midlife and occur more frequently in females when presenting in the head and neck. While most are histologically benign, malignant behavior has been noted in approximately 4% of jugulotympanic tumors, 6% of carotid body paragangliomas, and 16% of vagal paragangliomas providing the impetus for treatment of these tumors. Lesions are multiple in 10% of nonfamilial cases and in 25-50% of familial cases. Magnetic resonance imaging findings associated with paragangliomas are characteristic, often strongly suggesting the correct diagnosis and assisting with treatment planning. CT findings are complementary, allowing visualization of the relevant osseous anatomy and extent of bony involvement. In these markedly hypervascular lesions, vascular imaging allows identification of arterial supply and potential sites of venous occlusion. Devascularization, either by endovascular or percutaneous techniques, has assumed an important role in the multidisciplinary management of these
lesions. Our purpose is to review the characteristic imaging findings in patients with head and neck paragangliomas, discuss pertinent neurovascular anatomy and to illustrate the various endovascular approaches to treatment.

**APPROACH/METHODS**
We reviewed the imaging findings, pathology reports and hospital treatment records in 22 patients harboring head and neck paragangliomas referred to our institution for evaluation and treatment from 2003 through the beginning of 2010. The diagnostic imaging studies reviewed include magnetic resonance imaging (MRI), computed tomographic (CT) imaging and digital subtraction catheter-based diagnostic angiographic studies. Illustrative cases are included to highlight the various diagnostic imaging findings, relevant neurovascular anatomy and to demonstrate the various endovascular strategies for treatment.

**FINDINGS/DISCussion**
Paragangliomas of the head and neck region are classified by site of origin into the following categories: carotid body, jugular, vagal, jugulotympanic and tympanic paragangliomas. CT findings included circumscribed mass lesions with homogeneous contrast enhancement, proximity to the major cervical vessels of the neck and bony erosion of the skull base. MR findings included mixed signal intensity but predominately low T1 signal, high T2 signal, homogenous contrast enhancement, and vascular flow voids leading to a pathognomonic “salt and pepper” appearance. Vascular findings associated with paragangliomas included external carotid artery supply most commonly from branches of the ascending pharyngeal artery. Varying degrees of vascular encasement of the internal carotid artery was seen with jugular, vagal and carotid body paragangliomas as well as occlusion of the jugular vein secondary to tumor involvement. Arteriovenous shunting was occasionally present on angiographic studies. Trial balloon occlusion testing was performed when tumor involvement of the internal carotid artery was present, in addition to angiographic evaluation of the intracranial neurovasculature. Devascularization was accomplished using predominately particulate embolization techniques in preparation for subsequent surgical resection.

**SUMMARY/CONCLUSION**
Paragangliomas of the head and neck have characteristic noninvasive imaging findings allowing a relatively specific diagnosis. Cross-sectional and vascular imaging is crucial in planning the multidisciplinary treatment of these lesions, with endovascular therapy or percutaneous devascularization representing an important treatment adjunct.

**KEY WORDS:** Paraganglioma, glomus, endovascular

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**Electronic Scientific Exhibit 093**

**Recognizing and Managing Complications in Neurointervention: "When the Going Gets Tough..."**

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**PURPOSE**
The neurointerventional suite is a highly sophisticated, dynamic and stressful environment. Patients may have multiple comorbidities and/or be acutely ill, thus the risk of procedural complication is high. The prompt recognition and management of complications begins with careful preprocedural communication with patients and families as well as exceptional integration of the entire neurointerventional team. The consequences of intraprocedural complications can range from trivial to devastating, and may negatively impact the quality of life of those involved. Less recognized is the psychological impact on the neurointerventionalist performing the procedure. International meetings are a great platform to address these unique issues faced by neuroradiology. However, political, cultural and reputational issues may be a barrier to acknowledging and sharing these experiences. We believe that the best way to address causing a complication is to understand why they arise and how to react to them. A thorough understanding of the evolution of complications may lead to their avoidance or prevent minor mishaps from progressing into major catastrophes. The aim of this exhibit is to demonstrate both common and uncommon intraprocedural complications encountered during neurointerventional procedures.

**APPROACH/METHODS**
We retrospectively have collected cases of various complications during both diagnostic and neurointerventional procedures in our hospital. We have classified these complications based on the procedures during which they have, or may have, occurred. Specific subheadings include: 1) Vascular access; 2) Treatment of intracranial aneurysms; 3) Embolization of arteriovenous malformations or fistula; 4) Presurgical tumor embolization. We also have assessed the impact of these complications on the performing neurointerventionalist by collecting qualitative evidence, supplemented by a recent literature review.

**FINDINGS/DISCussion**
Each case will prompt the viewer to anticipate and recognize a specific procedural complication. Examples include retroperitoneal hemorrhage, catheter-induced arterial dissection, stroke, vasospasm, aneurysm rupture and inadvertent embolization of a normal vessel. The immediate action required, potential outcomes, and effect on patient prognosis will be discussed.

**SUMMARY/CONCLUSION**
The scope of these procedural complications highlights the complex role of the neurointerventionalist in integrating patient care. Ultimately, these complications can affect the neurointerventionalist in terms of confidence, productivity and desire to continue in the profession. The recognition that complications may be unavoidable even in the best-experi-
Diffuse Cerebral Injury and Edema in Children: Imaging Findings, Etiology, and Outcomes

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**Purpose**

To define and demonstrate the key CT imaging features of diffuse brain edema/injury in children, identify common pitfalls in interpretation, and assess outcomes relative to the imaging findings.

**Approach/Methods**

Cases of diffuse cerebral edema/injury were identified by searching the RIS for Head CT dictations with the terms “cerebral edema”, “hypoxic ischemic”, “cerebral swelling”, “herniation”, “sulcal effacement”, “brain swelling”, or “brain edema” from January 1, 2008 to December 31, 2009. All exams were reviewed and exams excluded if the edema/injury was localized, related to a mass, hemorrhage, or hydrocephalus, or was not definitive on second review. If there were previous or multiple exams, the initial exam describing the findings of diffuse edema/injury was noted as the index case for assessment. Multiple findings of diffuse cerebral edema/injury were assessed in each case: generalized sulcal effacement, vertex sulci visibility, cistern and fissure effacement, loss of cortical or basal ganglia differentiation, herniation, small ventricular system, and presence of defined hypodensity. In each case, the medical record was reviewed and outcome was classified as: full neurologic recovery, disability, or death. Etiologies were determined by best clinical judgment after chart review.

**Findings/Discussion**

There were 86 index CT exams that met inclusion criteria (mean age: 5.8 years, age range: 1-19 years). The most common etiologies were: Hypoxic ischemic (56%), accidental trauma (17%), nonaccidental trauma (14%), metabolic disorder (13%), seizure related (7%), and infection (4%). Overall outcomes were: Full recovery (17%), disability (34%), death (41%). Eight per cent were lost to follow up but no death was documented. Based upon imaging pattern, three groups were analyzed: Those with only cerebral swelling (CS), 29, those with loss of cortical or basal ganglia differentiation without defined hypodensity (CBD), 24, and those with defined hypodensity visible (H), 33. Outcomes were significantly different between the CS and CBD/H groups with neurologic recovery occurring in 45% of the CS group vs 3% of the CBD/H group and death occurring in 7% of the CS group vs 58% of the CBD/H group. (p < 0.001). Twenty-five subjects had previous CT studies within 4 days of the index case. In 7/25, subtle findings of cerebral edema/injury were overlooked on initial interpretation. Subtle loss of cortical differentiation was the most common overlooked finding in these cases (6/7). Multiple examples of diffuse cerebral edema/injury will be presented with key imaging findings outlined. A search pattern approach is emphasized. Additional information regarding age, imaging group, and etiologic relationships to outcome will be presented.

**Summary/Conclusion**

The finding of diffuse cerebral edema/injury on CT has significant prognostic implications in children. Early CT findings can be subtle and may be overlooked. Although hypoxic/ischemic disease is the most common etiology, other conditions can cause this pattern in children and should be considered in the appropriate clinical scenario.

**Key Words:** Cerebral edema, cerebral ischemia

Patterns in Development and Maldevelopment of the Neonatal and Infant Brain

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**Purpose**

Provide an interactive, case-based review of early pediatric neuroimaging, with focus on myelination patterns in the normal neonatal and infant brain, cases of delayed myelination, dysmyelination, and metabolic disorder. Emphasis also will be placed on self-assessment to allow for reinforcement of concepts and patterns, to allow gauging of appropriate myelination.

**Approach/Methods**

Cases will be interactive and will take advantage of the unique didactic medium of Powerpoint.

**Findings/Discussion**

For many neuroradiologists, the interpretation of pediatric neuroimaging is an uncommon or infrequent occurrence, and so, when encountered, is done with hesitation and trepidation. This reluctance is magnified with regard to imaging of neonates and early infants with a diagnosis developmental delay. It is the goal of this educational exhibit to try to alleviate the hesitancy of interpreting early pediatric brain imaging, by providing a review of normal brain development. This will be accomplished by going through basic embryology and development of major sulci, myelination, and typical changes in water diffusion and in location of specific brain activities. Emphasis will be placed on how to assess appropriate myelination and how to evaluate the patient with developmental delay.

**Summary/Conclusion**

A neuroradiologist must possess a thorough understanding of typical imaging developmental milestones in early pediatrics. It is our hope that upon completion of this exhibit, the
reader will be able to keenly scrutinize the appropriate anatomical structures on early neonatal or infant brain MR, so as to gauge appropriate development. Moreover, we hope this will develop a renewed and deeper appreciation of the normal maturation patterns of the pediatric brain, and how to assess for abnormalities in both myelination and morphology.

**KEY WORDS:** Myelination, pediatrics, patterns

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**Electronic Scientific Exhibit 096**

**Rarely Seen Congenital Pediatric Central Nervous System Anomalies**

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**PURPOSE**
Congenital anomalies of the central nervous system (CNS) often present a diagnostic challenge to the interpreting radiologist. In addition to the inherent complexity of these cases, the rarity of many of these diagnoses can contribute to a lack of recognition. The purpose of our educational presentation was to develop an interactive case-based review of pediatric brain and spine anomalies with explanation of the differential diagnosis.

**APPROACH/METHODS**
A sampling of cases representing uncommon pediatric congenital anomalies was selected from cases encountered at our institution. An interactive presentation of these cases then was created using Microsoft PowerPoint with the goal of engaging the user more than in a traditional didactic format. Following each case, we provide a discussion of the etiology, clinical presentation, imaging findings and management as applicable, with options for the user to view similar cases or additional facts.

**FINDINGS/DISCUSSION**
Our presentation provides 11 cases of congenital anomalies of the pediatric brain and spine not routinely encountered in clinical practice with discussion about the differential diagnosis of each of these conditions. By creating an interactive experience for the user, we hope to make relevant information about these diagnoses easier to learn and remember.

**SUMMARY/CONCLUSION**
Our presentation provides a case-based review of pediatric brain and spine anomalies in an interactive format using Microsoft PowerPoint with detailed discussion of findings, the disease entity and possible differential diagnostic considerations.

**KEY WORDS:** Pediatric, congenital

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**Electronic Scientific Exhibit 097**

**An Unusual Case of Giant Open Lip Schizencephaly and Review of the Cortical Developmental Malformations**

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**PURPOSE**
We report a case of giant open lip schizencephaly, an unusual presentation that may be mistaken for hydranencephaly if one is not alert to key distinguishing features. In order to provide a more complete appreciation of the scope of this and related disorders, we then broaden our discussion to encompass the spectrum of cortical developmental malformations.

**APPROACH/METHODS**
We present the clinical and radiographic findings (US, CT, and MR) of a neonate with giant open lip schizencephaly. Theories of pathogenesis are reviewed, together with clinical presentations and associated syndromes, such as septo-optic dysplasia and Perisylvian syndrome. We demonstrate how cortical developmental abnormalities may be categorized according to embryology and etiology, focusing on anomalies of neuronal proliferation, migration, and organization. Although many of these disorders are inherited, a critically timed deleterious event, such as an ischemic or infectious insult, can interfere with normal early development. A diversity of cases is illustrated as we highlight clinical issues, useful imaging modalities, and differential diagnoses.

**FINDINGS/DISCUSSION**
A 23-year-old healthy Hispanic female presented at our clinic for routine obstetrical ultrasound at 18 weeks gestational age, with follow up at 31 weeks. The latter examination was notable for a marked interval change, with nonvisualization of most of the supratentorial fetal brain parenchyma. This finding, together with the distinct unfused thalami and the complete posterior fossa structures suggested hydranencephaly. Although neonatal head CT obtained after an uncomplicated vaginal delivery at 35 ½ weeks gestational age showed bilateral massively dilated CSF spaces, the persistence of portions of the frontal lobes and lateral ventricles rendered our initial diagnosis unlikely. MR imaging (MRI) demonstrated huge gray matter lined clefts and MRA showed patency of the bilateral internal carotid arteries and intracranial vasculature, confirming schizencephaly. The spectrum of cortical malformations is broad, and the diverse clinical features usually include seizures, mental retardation and focal neurologic deficits. Those entities resulting from abnormal neuronal and glial proliferation include tuberous sclerosis, focal cortical dysplasia and hemimegalencephaly (a dysplastic hamartomatous overgrowth of a cerebral hemisphere). Malformations of abnormal neuronal migration may be generalized or focal and include the lissencephaly spectrum, pachgyria, and an assortment of heterotopias (band and nodular). Malformations due to abnormal cortical organization include polymicrogyria/schizencephaly, including Perisylvian syndrome. MR is the imaging modality of choice for its multiplanar capabilities, excellent gray-white matter differentiation, and the ability to produce 3D surface rendered images.
Cortical developmental abnormalities represent a complex and interrelated spectrum of pathologies. It is imperative for the neuroradiologist to understand the underlying embryologic mechanisms of these diseases and to learn how they are classified. Our featured case of giant open lip schizencephaly highlights the potential pitfalls of diagnosis and the need to be familiar with unusual appearances. Understanding the utility of the various radiologic modalities, both pre and postnatally, is essential to help establish the correct diagnosis and to better visualize morphology.

POSTERIOR FOSSA MALFORMATIONS

Malformations of the Posterior Cranial Fossa: Revisited

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PURPOSE
To describe and illustrate the developmental malformations of posterior cranial fossa, including embryologic and genetic basis, classification schemes and characteristic imaging findings.

APPROACH/METHODS
This exhibit will illustrate various cystic and noncystic developmental malformations of the posterior cranial fossa. Understanding of this complex topic would be facilitated by brief discussion on the embryologic basis and proposed genetic causes of some of these malformations. We also will discuss the proposed classification schemes either based on embryologic/morphology or imaging. Characteristic imaging findings of these malformations and associated other central nervous system (CNS) abnormalities also will be discussed and illustrated. Fetal MR imaging (MRI) is frequently used in these malformations for prenatal diagnosis, assessment of severity and detection of other associated CNS abnormalities. These have key roles in predicting the prognosis. We also will illustrate fetal MRI findings in some of these malformations.

FINDINGS/DISCUSSION
Posterior fossa malformations are common CNS developmental abnormalities. Dandy-Walker malformation is the most common of these abnormalities and seen in approximately 1 in 25,000-30,000 births. It is also the cause of 4-12% of all cases of infantile hydrocephalus. Other cystic malformations include Dandy-Walker variant, persistent Blake’s pouch, mega cisterna magna and posterior fossa arachnoid cyst. Noncystic malformations include Paleocerebellar hypoplasia (Rombencephaloschisis, Rombencephalosynapsis), Neocerebellar hypoplasia (cerebellar agenesis (total/subtotal), pontocerebellar hypoplasia, unilateral hemispheric apalasia/hypoplasia) and Cerebellar cortical malformation (cortical dysplasia, granular layer aplasia, Lhermitte-Duclos-Cowden syndrome) and Isolated brainstem hypoplasia. Different classification systems and overlapping nature of some of these malformations makes it a challenging area of pediatric neuroimaging. Understanding the embryologic basis of these malformations improves the understanding of these malformations and creates a conceptual approach towards the diagnostic imaging. Apart from the degree of the posterior fossa parenchymal hypoplasia, associated CNS anomalies are the most important predictor of the long-term prognosis in these patients. Therefore, knowledge and review of these associated anomalies is also of paramount importance.

SUMMARY/CONCLUSION
Posterior fossa developmental malformations remain a challenging area of pediatric neuroimaging. Review of the embryologic basis, classification schemes, characteristic imaging findings and associated CNS anomalies would improve the understanding, create a conceptual diagnostic approach and help in better assessment of prognosis.

KEY WORDS: Posterior fossa malformation, Dandy-Walker malformation, posterior fossa cyst

Posterior Fossa Malformations, Common to Obscure: A Pictorial Review

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PURPOSE
Review the development and anatomy of the structures of the posterior fossa. Review the imaging characteristics and clinical significance of malformations of the posterior fossa.

APPROACH/METHODS
Normal development and anatomy of the posterior fossa and its relevance to the development of posterior fossa malformations will be reviewed. Cases of posterior malformations encountered at our institution will be reviewed with a description of the typical imaging characteristics and the clinical significance of these finding. This will include both common and more obscure malformations of the posterior fossa: Chiari I, II and III malformations; Occipital cephaloceles; Dandy Walker malformations; Blake pouch cysts; Cerebellar hypoplasia; Aqueductal stenosis; Rombencephalosynapsis; Molar tooth midbrain-hindbrain malformations; Lermite-Duclos; Moebius syndrome.

FINDINGS/DISCUSSION
Malformations of the posterior fossa can be encountered commonly in practice, but are often poorly understood. By reviewing the normal development and anatomy of the posterior fossa, one can gain a clearer understanding of these malformations and how there clinical significance is related to the structures that they involve.

SUMMARY/CONCLUSION
By the end of this exhibit, the participants should be familiar with the development of the posterior fossa structures and how it relates to the development of posterior fossa malformations. They also will be able to recognize both common and obscure malformations of the posterior fossa and their clinical significance.

KEY WORDS: Posterior fossa, malformations
**Electronic Scientific Exhibit 100**

**Nevoid Basal Cell Carcinoma Syndrome (Gorlin Syndrome): Neuroradiologic Features and Imaging Strategy**

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**PURPOSE**

We present imaging findings of nevoid basal cell carcinoma syndrome (NBCCS) and discuss feasibility of MR imaging (MRI) to follow-up NBCCS-related odontogenic keratocysts (OKC). We also highlight the importance of recognizing imaging features of NBCCS in patients with medulloblastoma in order to avoid radiation therapy and reduce possibility of inducing secondary tumors.

**APPROACH/METHODS**

We reviewed neuroradiologic imaging findings of six patients with various manifestations of NBCCS, two of which acquired secondary tumors after exposure to radiation therapy for medulloblastoma because the diagnosis of NBCCS was not made initially.

**FINDINGS/DISCUSSION**

Three patients were diagnosed with medulloblastoma, two of which were not recognized initially as having NBCCS and developed multiple meningiomas and nasopharyngeal carcinoma years after radiation therapy. Onset of medulloblastoma at 3 years of age with dural calcifications lead to work up and diagnosis of NBCCS in the third patient. Three other patients presented with odontogenic keratocysts and other clinical manifestations of NBCCS but without history of medulloblastoma. Odontogenic keratocysts were followed with facial MRI in one patient and facial CT in the other two patients.

**SUMMARY/CONCLUSION**

Odontogenic keratocysts and earlier onset of medulloblastoma with dural calcifications should prompt evaluation for NBCCS. The diagnosis of NBCCS will alter treatment of medulloblastoma. MR imaging also can be used in management of odontogenic keratocysts in NBCCS patients in attempt to reduce exposure to ionizing radiation.

**KEY WORDS:** Nevoid basal cell carcinoma syndrome, odontogenic keratocysts, Gorlin syndrome

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**Electronic Scientific Exhibit 101**

**Pontine Tegmental Cap Dysplasia: Diffusion Tensor Imaging and MR Imaging Findings in Six Children**

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**PURPOSE**

To demonstrate neuroimaging findings in six children with pontine tegmental cap dysplasia and ectopic transverse fibers.

**APPROACH/METHODS**

In six unrelated children (4 males and 2 females) an identical brainstem and cerebellar malformation was found on routine MR imaging (MRI). MR imaging findings were reviewed systematically and diffusion tensor imaging (DTI) at 3 T using 32 icosahedric diffusion directions was obtained in two patients to analyze the fiber anatomy of the brainstem.

**FINDINGS/DISCUSSION**

In these children, cerebellar hypoplasia with absent middle and attenuated superior cerebellar peduncles, a flat ventral pons, a vaulted pontine tegmentum (tegmental cap), and absent inferior olivary prominence were demonstrated. Ventral pontine hypoplasia and absence of middle cerebellar peduncles in the present series can be explained by the loss of pontine precerebellar neurons. Routine MR studies suggested an ectopic suprategmental fiber bundle connecting the pons with the cerebellum. Diffusion tensor imaging, using color-coded fractional anisotropy maps and fiber tracking, revealed an aberrant transverse fiber bundle in two patients. The ectopic transverse fiber bundle demonstrated by MRI is in agreement with disordered axonal guidance as the basic process involved. In one patient a prominent mid-pontine fiber bundle was identified connecting ipsilateral pontine nuclei with the cerebellum. In this exhibit an overview of the imaging findings will be presented.
SUMMARY/CONCLUSION
We report on hypoplasia of the ventral pons combined with a dorsal vault projecting in the fourth ventricle. Diffusion tensor imaging revealed an aberrant transverse fiber bundle in two patients and an aberrant midpontine sagittal oriented bundle in one patient, implying a key role for misdirected axonal guidance during the embryonic stage.

KEY WORDS: Anomaly, midbrain, hindbrain

Electronic Scientific Exhibit 102
Cortical Dysplasia in Pediatric Epilepsy: Imaging Findings, Pathology Correlation, Evaluation of MR Imaging Interpretations

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PURPOSE
Cortical dysplasia (CD) is the most common pathology noted after surgical resection for intractable epilepsy in children. Recent pathologic classification schemes have had a significant impact on the treatment and understanding of these complex patients, and recently have been updated by a consensus panel. The finding of an abnormality on MR imaging (MRI) can significantly impact surgical planning and has significant prognostic implications with regards to postoperative seizure freedom. Imaging findings may be subtle and only recognizable after developing significant experience with these patients. This exhibit will provide a review of the imaging spectrum of cortical dysplasia in children with pathologic correlation. An emphasis will be placed on key MRI findings, use of PET including PET/MRI fusion, and relationship of imaging findings to current pathologic grading schemes.

APPRAOCH/METHODS
Imaging and pathologic data are presented from 53 consecutive surgically treated children who underwent comprehensive presurgical evaluation for intractable localized epilepsy with pathologically proved CD. Detailed MRI, PET and pathologic correlation was performed and forms the basis for this review. Pathologic classification of CD was performed using the standard method of Palmini et al: Ia: isolated cortical architectural abnormalities, Ib - presence of giant or immature neurons, Iia - presence of dysmorphic neurons, and IIb - presence of balloon cells. MR imaging analysis occurred in three stages: Initial exam report (IR), repeat analysis presurgically after comprehensive video EEG, PET, and MEG performance, and finally with knowledge of resection site [final interpretation, (FI)]. MR imaging findings were classified as lesional (L-MR, suggestive of a specific pathology), or nonlesional (NL-MR, nonspecific or normal findings). A comparison was made between the IR and FI to assess for discrepancies.

FINDINGS/DISCUSSION
By highest CD grade, there were 2- Ia, 21- Ib, 26- Iia, and 4- IIb cases. Lesional-MR findings were noted in 0 (0%) Ia, 10 (48%) Ib, 17 (65%) Iia, and 4 (100%) IIb CD cases. Discrepancies between the IR and FI were noted in 15 cases (28%). The majority of these misinterpretations were related to subtle findings of CD including: cortical and/or localized WM increased signal (9), Cortical/WM blurring (3), and unusual sulcal pattern (1). The utility of using PET imaging findings and PET/MRI fusion in improving MRI interpretation will be emphasized. Introduction of the 2010 ILAE consensus classification of cortical dysplasia will be presented and examples given. Role of the neuroradiologist in performing multimodality image fusion for surgical planning will be demonstrated.

SUMMARY/CONCLUSION
Pathologic grading of cortical dysplasia is becoming more standardized with imaging and outcome implications. Knowledge of the spectrum of MR imaging appearances related to this classification is of importance to neuroradiologists. Identification of commonly missed imaging findings of CD in children is important for accurate diagnosis and treatment.

KEY WORDS: Dysplasia, epilepsy, MR imaging

Electronic Scientific Exhibit 103
Intractable Epilepsy: How 3 T Diffusion Tensor Imaging Can Improve Diagnosis

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Firenze, ITALY

PURPOSE
Children with intractable epilepsy may need a surgical treatment in order to improve the quality of life. Aim of this exhibit is to point out different MR imaging (MRI) anomalies such as cortical dysplasia, heterotopia, hippocampal sclerosis and other malformations causing intractable epilep-
sy studied with MRI scans at 3 T and to describe the abnormal fiber connections using diffusion tensor imaging (DTI) and fiber tractography (FT) in children with epilepsy that is refractory to medication. Diffusion tensor imaging and FT are techniques that enable us to demonstrate the orientation and the integrity of white matter (WM) in vivo. Previous studies have shown aberrant WM connections in congenital anomalies of the central nervous system (CNS).

**APPROACH/METHODS**

The studies were performed on a 3T system by using a 8-channel sensitivity encoding (SENSE) head coil. Single-shot spin echo, echo-planar imaging with a navigator echo-phase correction (motion artifacts correction) and a SENSE factor of 2. The slice thickness is 2 mm with no gap (60 slices), 32 diffusion directions. TE = 80 ms, TR = 9914 ms, NSA = 2, b value = 1000 sec/mm². Data are processed on a workstation (Philips Medical System Europe; Extended MR Workspace ver. 6.1.5.4). The analysis of data were done with FACT and FSL. Sixty-three consecutive patients with intractable epilepsy have been studied: five studies were discarded because of motion artifacts; 16 MRIs did not show any alterations; in 21 patients dysplastic lesions were detected; eight patients had brain tumors; 13 patients had other anomalies (heterotopias, polymicrogyria, etc.). Twenty-one lesions were localized on temporal lobes.

**FINDINGS/DISCUSSION**

In cortical dysplasia a decreased anisotropy of WM adjacent to the malformed cortex and an aberrant course of fiber pathways due to the dysplastic WM has been detected. In some cases it has been possible to discriminate dysplasia from tumor. Diffusion tensor imaging can be used to assess gray matter abnormalities like cortical infarction or malformations of cortical development. Diffusion tensor imaging and FT can be used to evaluate the integrity of the white matter adjacent to the dysplastic cortex. In cases where white matter is severely dysplastic, DTI-FT is able to detect an aberrant course of the underlying white matter tract. Subependymal gray matter shows slightly lower FA values. In band heterotopia FT demonstrates the reduced connections between deep white matter and the cortex.

**SUMMARY/CONCLUSION**

Diffusion tensor imaging-FT is a powerful anatomical imaging tool that can demonstrate the gross fiber architecture but not the functional or synaptic connection. Diffusion tensor imaging can demonstrate the integrity of the white matter and allows detection of abnormalities of the brain tissue in an earlier stage than conventional T2- and T1-weighted imaging. The FT technique is operator-dependent and the operator should have a detailed knowledge of neuroanatomy.

**KEY WORDS:** 3 T MR imaging, DTI, intractable epilepsy

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**Electronic Scientific Exhibit 104**

**Neuroradiologic Imaging Findings of the Histiocytosis Syndromes in Children**

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**PURPOSE**

Our purpose is to review the neuroradiologic imaging findings of the three major histiocytosis syndromes in children and adults: Langerhans cell histiocytosis (LCH), histiocytoses of mononuclear phagocytes other than Langerhans cells, and malignant histiocytic disorders.

**APPROACH/METHODS**

In 1987, the Writing Group of the Histiocyte Society created a classification for the histiocytosis syndromes based on presence or absence of Langerhans cells, or presence of a neoplastic disease process.

<table>
<thead>
<tr>
<th>Table 1: Classification of the Histiocytosis Syndromes in Children</th>
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<tbody>
<tr>
<td>I. Langerhans-cell Histiocytosis (LCH) (replaces histiocytosis X, eosinophilic granuloma, Letterer-Siwe disease, Hand-Schuller-Christian syndrome, Hashimoto-Pritzker syndrome, self-healing histiocytosis, pure cutaneous histiocytosis, Langerhans-cell granulomatosis, type II histiocytosis, nonlipid reticuloendotheliosis)</td>
</tr>
<tr>
<td>II. Histiocytoses of Mononuclear Phagocytes other than Langerhans Cells</td>
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<tr>
<td>a. Hemophagocytic lymphohistiocytosis (HLH)</td>
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<td>b. Infection-associated hemophagocytic syndrome</td>
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<td>c. Other histiocytosis syndromes</td>
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<tr>
<td>i. Sinus histiocytosis with massive lymphadenopathy (Rosai Dorfman disease)</td>
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<td>ii. Xanthogranuloma</td>
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<tr>
<td>iii. Reticulohistiocytoma</td>
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<tr>
<td>iv. Miscellaneous/other</td>
</tr>
<tr>
<td>III. Malignant Histiocytic Disorders</td>
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<tr>
<td>a. Acute monocytic leukemia (FAB M5)</td>
</tr>
<tr>
<td>b. Malignant histiocytosis</td>
</tr>
<tr>
<td>c. True histiocytic lymphoma</td>
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</tbody>
</table>

Neuroradiologic findings of the three classes of histiocytosis syndromes in children are discussed through cases that demonstrate their imaging manifestations.

**FINDINGS/DISCUSSION**

Neuroradiologic manifestations of LCH are the direct sequelae of development of granulomas by Langerhans cell histiocytes. Characteristic findings of LCH include lytic skull defects, mastoid destruction and mass lesions, thickening and enhancement of the infundibulum, and absence of the posterior pituitary bright spot. Central nervous system (CNS) imaging findings of histiocytoses of mononuclear phagocytes other than Langerhans cells are demonstrated through multiple cases. The most common imaging findings of hemophagocytic lymphohistiocytosis, including nonspecific periventricular white matter abnormalities, brain volume loss and enlargement of extra-axial fluid spaces, are shown, along with their evolution MR and MR spectroscopy [3, 4]. The spectrum of CNS imaging characteristics of Rosai-Dorfman disease, with findings ranging from cervical...
lymphadenopathy to rare dural based lesions, is presented [5]. Central nervous system imaging manifestations of malignant histiocytic disorders are reviewed through cases of acute monocytic leukemia, malignant histiocytosis, and true histiocytic lymphoma.

Figure 1: Sagittal T1-weighted, contrast-enhanced brain MR in Rosai-Dorfman disease shows multiple, enhancing, dural-based lesions along the midline.

**SUMMARY/CONCLUSION**
The spectrum of imaging findings of histiocytosis syndromes in children vary according to their etiology, as classified by presence or absence of Langerhans cells, or neoplastic origin. Familiarity with CNS imaging findings of the three major classes of histiocytosis syndromes in children aids neuroradiologists in their differentiation and diagnosis.

**KEY WORDS**: Autoimmune, immune, neoplasm

**Electronic Scientific Exhibit 106**

**Pathologies Simulating Herpes Encephalitis: The Not So Good, the Bad and the Ugly!**

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**PURPOSE**
Herpes encephalitis is the most common cause of sporadic encephalitis in the United States, with a predilection for the mesial temporal lobes. If treatment is not started early, it can have devastating consequences. It is therefore one of the cardinal DO NOT MISS diagnosis in radiology. However, there are several conditions other than herpes that can affect the mesial temporal lobe that a radiologist should be aware of, and be able to differentiate from the classical manifestation of herpes. These include cortical neuronal migrational abnormalities, neoplasms, nonherpetic meningoencephalitis, abscesses, cerebrovascular infarct, postical state, paraneoplastic syndrome and neurocutaneous syndromes. The aim of this exhibit is to discuss the myriad abnormalities within the mesial temporal that may mimic herpes encephalitis.

**APPROACH/METHODS**
Presentation is in a quiz-based format. The cases include focal cortical dysplasia, postical state, gliomatosus cerebi, mesial temporal sclerosis, enterovirus meningoencephalitis, west nile encephalitis, limbic encephalitis related to anti-GAD antibody, neurofibromatosis type 1, optic pathway glioma, cavernous angioma, anterior choroidal artery infarct and neurocutaneous melanosis.

**FINDINGS/DISCUSSION**
We will discuss the salient discriminating features of each of these entities, and provide a systematic framework for arriving at the diagnosis when the radiologic findings are viewed in light of clinical history.

**SUMMARY/CONCLUSION**
While it is crucial for a radiologist to raise the possibility of herpes encephalitis in the right clinical context, it is equally important to consider other conditions that may mimic herpes encephalitis. Seizures related to focal cortical dysplasia or mesial temporal sclerosis need surgical intervention. Other mimicking conditions such as paraneoplastic limbic encephalitis require further interrogation to evaluate for the presence of autoantibodies or underlying malignancy. The differential can be narrowed by carefully analyzing the imaging findings to evaluate for hippocampal volume, mass-effect, diffusion restriction, and the extent of edema within the mesial temporal lobes. One can also look for other manifestations in neurocutaneous disorders such as neurofibromatosis type 1 and neurocutaneous melanosis. Finally, an infarct should be high on the differential in patients with risk factors for vasculopathy.

**KEY WORDS**: Mesial temporal lobe, limbic paraneoplastic encephalitis, mesial temporal sclerosis

**Electronic Scientific Exhibit 106**

**Hypoxic Ischemic Brain Injury in Premature Neonates: a Pictorial Essay**

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**PURPOSE**
Hypoxic ischemic injury (HII) is a frequent and important cause of morbidity and mortality in the premature neonatal population. Hypoxic ischemic injury in preterm neonates is difficult to diagnose clinically early on because signs may be lacking or mistaken as a result of developmental immaturity. Therefore, neuroimaging is vital in establishing the diagnosis of ischemic injury; as well as, in evaluating the severity of injury, assessing prognosis, and guiding management. The purpose of this exhibit is to 1) review the physiology of the immature brain; as well as, the pathophysiology of ischemia; and 2) illustrate, by pictorial review, the spectrum of neuroimaging findings seen in hypoxic ischemic injury in premature neonates.
**FINDINGS/DISCUSSION**

Hypoxic ischemic injury in the premature neonate can present with a variety of different imaging findings depending on the severity of the injury. These include damage to the deep gray matter structures and brainstem following a severe HII; and germinal matrix hemorrhage, intraventricular hemorrhage, posthemorrhagic hydrocephalus, or periventricular leukomalacia (PVL) following a mild to moderate HII. Approximately 5% of infants born before 32 weeks gestational age, and up to 19% of infants born before 28 weeks, will develop cerebral palsy. Periventricular leukomalacia is a very important prognostic sign of the neurologic morbidity observed in preterm infants; as more than 50% of patients with PVL will exhibit cognitive and behavioral deficits. Diffuse versus focal involvement in PVL is another important prognostic determination: focal necrotic PVL lesions in the deep cerebral white matter are associated with cerebral palsy; whereas, a more diffuse white matter injury is associated with cognitive/behavioral deficits. Echocardiography is a convenient noninvasive modality for recognition of periventricular leukomalacia, hemorrhage and hydrocephalus. MR imaging is the most sensitive and specific modality for imaging of preterm neonate with HII. Diffusion-weighted MR imaging and proton MR spectroscopy further potentiate the effectiveness of MR imaging as a diagnostic and prognostic tool. Delayed imaging in the subacute phase may be helpful in determining the overall extent of injury and long-term prognosis.

**SUMMARY/CONCLUSION**

The incidence of hypoxic ischemic injury is extremely common in preterm infants. Neuroimaging plays a vital role in the management of these patients. Prompt, comprehensive, and accurate evaluation of HII requires a clear understanding of the various neuroimaging patterns. It is important to have a good understanding of the different patterns of injury, as they can be predictive of cognitive development and may be used to guide long-term prognosis and rehabilitation.

**KEY WORDS:** Pediatrics, hypoxic, ischemic

**Electronic Scientific Exhibit 107**

**Neonatal Brainstem Anatomy in Clinical Practice at 3 T: An Interactive MR Atlas**

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Los Angeles, CA

**PURPOSE**

To provide a detailed and interactive anatomical depiction of the neonatal brainstem at 3 T MR imaging (MRI) including surface anatomy, gray matter structures, and visible white matter funiculi, fasciculi, tracts, and pathways.

**FINDINGS/DISCUSSION**

Relevant multiplanar T1- and T2-weighted 3 T MR images (Phillips Achieva 3.0 T) of the brainstem from morphologically normal premature and term neonates will be provided. Labelled images will be presented initially followed by unlabeled interactive images. The participant will be asked to identify specific normal brainstem structures using the mouse to click on the locations of specific structures.

**SUMMARY/CONCLUSION**

An interactive depiction of normal 3 T MRI neonatal brainstem anatomy will be presented.

**KEY WORDS:** Neonatal MR imaging, pediatrics, brainstem anatomy

**Electronic Scientific Exhibit 108**

**Aspects of Neuroradiology in Pediatric Patients Affected with Langherans Cell Histiocytosis**

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Firenze, ITALY

**PURPOSE**

Langherans cell histiocytosis (LCH) is a clonal proliferative disorder of mononuclear phagocytic and dendritic cells. The reported incidence is 0.2-2.0 cases per 100,000 children under the age of 15 years. It may present as a solitary bone lesion (about 60%) or as a multisystem disorder. Central nervous system (CNS) involvement has been described in about 4-10% of the cases. It is likely a disorder of immune regulation, as evidenced by the presence of other immunologically active cells within the lesions in addition to increase cytokines but since Langherans cell histiocytoses are monoclonal it is not possible to rule out a neoplastic process. Although the CNS involvement in LCH mostly manifests itself in the hypothalamic pituitary region the involvement of cerebellum and brain stem is of particular interest since it can lead to cerebellar signs and cognitive deterioration although this involvement is not necessarily correlated to the symptoms. The purpose of the exhibit is to review the presentation, epidemiology and neuroradiologic findings in patients affected with LCH and to illustrate protocols used to monitor CNS involvement.
**APPROACH/METHODS**
We have studied with MR imaging (MRI) conventional and nonconventional techniques [diffusion tensor imaging (DTI) and MR spectroscopy (MRS)] 18 consecutive patients with LCH showing brain involvement. Studies were performed with 1.5 T (8 patients) and 3 T (10 patients) apparatus. Among these patients eight had solitary lesions. MR spectroscopy was performed in all patients on right centrum semiovallis, right basal ganglia and cerebellum. Diffusion tensor imaging was performed in 12 patients. We have compared our results with those described in literature.

**FINDINGS/DISCUSSION**
In 13 patients cerebellar white matter showed hyperintensity at T2-weighted MRI, in eight patients supratentorial white matter showed signal alterations, in six patients we have found alterations of brain stem and in four of basal ganglia. Overall data for each anatomical region was not significant in the centrum semiovallis and in basal ganglia while we detected a decrease of NAA/Cr ratio and a normal Cho/Cr ratio. The incidence of relapses in patients with CNS involvement is pretty high since 50 percent of our patients underwent to relapse despite aggressive therapies.

**SUMMARY/CONCLUSION**
The major teaching points of the exhibit are: 1. To describe to radiologists the neuroradiologic assessment in pediatric patients with LCH. 2. To describe imaging characteristics on MRI at the onset, during therapy, off therapy and at relapse. 3. Discuss how new MRI techniques (e.g., DTI, MRS) could be helpful in detecting earlier involvement and complications. 4. To suggest protocols to be used in the management of these patients at diagnosis and follow up in order to provide prompt diagnosis and treatment. A better understanding of brain lesions could suggest guidelines for treatment thus improving the quality of life of patients with LCH.

**KEY WORDS:** Langherans cell histiocytosis, MR imaging, pediatric brain

**Electronic Scientific Exhibit 109**
**Imaging Retinoblastoma: Clues for Diagnoses, Prognosis, Treatment Options and Treatment Complications**
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New York, NY

**PURPOSE**
Retinoblastoma is the most common intraocular malignancy in children. The purpose of this educational exhibit is to describe common and uncommon manifestations of retinoblastoma. Emphasis will be placed on specific imaging clues that are useful for tumor diagnosis, prognosis and treatment decisions.

**APPROACH/METHODS**
Cases drawn from a tertiary care cancer center will be presented in an interactive quiz format using CT and MR imaging (MRI) with funduscopic correlations. These cases will illustrate imaging clues that: 1) Help establish the diagnosis of retinoblastoma over other differential possibilities; 2) Are useful for tumor staging and prognostication; 3) Assist with evaluation for treatment options, in particular anatomy of the ophthalmic artery for potential intra-arterial chemotherapy; and 4) Suggest treatment complications during follow up such as second malignancies.

**FINDINGS/DISCUSSION**
Highlighted in each retinoblastoma case are characteristic findings to aid in the differential diagnosis and prognosis of these patients. Common therapies will be discussed, including enucleation, radiotherapy and chemotherapy including intra-arterial chemotherapy. Focus will be placed on imaging criteria that increase tumor staging and necessitate enucleation. Patients with hereditary forms are prone to developing secondary malignancies after treatment; therefore a discussion of the differentiation between hereditary and nonhereditary retinoblastoma and the potential role in determining tumor management is included.

**Figure. Axial fat-saturated contrast T1-weighted images. (A) Enhancing tumor occupies > 50% of the right globe and invades into the optic nerve (arrow). (B) Enhancing tumor in the temporal right globe invades the ciliary body (arrow) and contacts the lens. Both tumors are classified as Group E or extensive retinoblastoma by the International Classification of Retinoblastoma, and both tumors required enucleation.**

**SUMMARY/CONCLUSION**
This educational exhibit illustrates the spectrum of imaging abnormalities in retinoblastoma. Familiarity with these imaging clues is important for tumor diagnosis, prognosis and treatment.

**KEY WORDS:** Retinoblastoma, MR imaging

**Electronic Scientific Exhibit 110**
**Imaging of Murine Medulloblastoma Models on a Clinical MR Scanner: Basic and Advanced Techniques**
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1University of Washington School of Medicine, Seattle, WA
2Seattle Children's Hospital, Seattle, WA
3Fred Hutch Cancer Research Center, Seattle, WA

**PURPOSE**
To investigate MR imaging (MRI) as a multifaceted tool in evaluating murine brain tumor models employing readily accessible 3 T scanners designed for clinical applications.
Medulloblastoma is the most common pediatric posterior fossa tumor associated with significant treatment and tumor-related morbidity. We utilized two tumor models in conjunction with an experimental drug, to evaluate drug efficacy and thereby validate utility of MRI. Much drug development relies on animal tumor models and in vivo multitime-point MRI can increase efficiency and understanding of these studies.

**APPROACH/METHODS**

Preliminary MRI of wild-type nontumor mice, transgenic (focal tumor) and knockout (diffuse tumor) mice was followed by volumetric imaging of both drug-treated and vehicle groups of knockout mice during and following treatment. Comparisons were made with histology (gold standard). Cyclophosphamide derivative IPI-926 was administered via intraperitoneal route using different regimens. Philips Achieva 3 T (Philips Healthcare, Andover, MA) and a custom mouse head coil were utilized for conventional serial imaging in 36 mice and multi spin-echo quantitative T2 mapping in four mice early in treatment course. One hundred and twenty-four scans were postprocessed.

**FINDINGS/DISCUSSION**

MR imaging at 3 T provided a robust way to measure tumor volume change in longitudinal samples. Conventional T2-weighted qualitative imaging yielded volumes that were well correlated to volumes measured at histology, validating this technique. IPI-926 was shown to result in necrosis, change in tumor volume and growth rate. Quantitative T2 pilot imaging early in the treatment time-course suggested that MRI parameters other than volume may be utilized to monitor early drug treatment effects.

**SUMMARY/CONCLUSION**

Ultra-high field strength magnets (>4 T) are not essential in conducting high-quality basic and advanced translational MR imaging of small animals. Using standard 3 T equipment with a well sized head coil, MRI can be used as primary and intermediate endpoint, minimizing the use of study animals and reducing data variability.

**KEY WORDS:** Murine medulloblastoma models, basic and advanced MR imaging

**Electronic Scientific Exhibit 111**

**Diffusion Tensor Imaging and Tractography in Joubert Syndrome, beyond “Molar Tooth Sign”**

Bhuta, S. • Hsu, C. • Kwan, G. • Pincus, D.

1Griffith University, School of Medicine, Gold Coast Hospital, Gold Coast, AUSTRALIA, 2Bond University, Faculty of Health Sciences and Medicine, Gold Coast, AUSTRALIA, 3Pacific Private Clinic, Southport, Gold Coast, AUSTRALIA

**PURPOSE**

To describe the abnormal fiber tracts findings of Joubert syndrome (JS) using diffusion tensor imaging and fiber tractography and review “Molar Tooth Sign”.

**APPROACH/METHODS**

Four patients with clinical and genetic diagnosis of Joubert syndrome underwent MR imaging performed with a 1.5 T MR imaging system (Siemens Magnetom SymphonyTim syngo MR B17). Multiplanar T2- and T1-weighted isotropic volume images, diffusion tensor imaging (DTI). Isotropic diffusion-weighted images, apparent diffusion coefficient (ADC) maps, color-coded fractional anisotropy (FA) maps were obtained. Color vector maps of fractional anisotropy were used to place a region-of-interest seed point for fiber tractography. Healthy age- and sex-matched volunteers with normal structural MR imaging were used as control subjects. Though sample size is small Joubert syndrome is very rare with incidence of 1:100,000.

**FINDINGS/DISCUSSION**

T2- and T1-weighted imaging was performed showed typical “Molar Tooth Sign”. In normal subjects color-coded FA texture maps showed a “red dot” at the level of the inferior colliculi of the midbrain due to decussation of the superior cerebellar peduncles. In JS, the absence of the “red dot” on color-coded FA maps within the midbrain confirms the failure of the superior cerebellar peduncles to decussate. Also seen was horizontal orientation of superior cerebellar peduncles (SCP) fibers (green color) and corticospinal tract (CST) failed to cross in the caudal medulla. In all patients the deep cerebellar nuclei were located more laterally and had a straight configuration. In one patient there was absence of the transverse fibers at the level of the inferior colliculi of the midbrain corresponding to the ventral tegmental decussation (VTD). In normal controls tractography of these three pathways was anatomical.

**SUMMARY/CONCLUSION**

In Joubert syndrome, “Molar Tooth Sign” has been well described but DTI and fiber tracking illustrates that pyramidal tract and the superior cerebellar peduncles do not decussate.

**KEY WORDS:** Joubert syndrome, diffusion tensor imaging

**Electronic Scientific Exhibit 112**

**Cystic and Solid Lesions of the Pediatric Head and Neck**

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**PURPOSE**

Infants and children with neck masses frequently present to the radiologist for further assessment. The role of the radiologist is to differentiate between conditions using imaging modalities such as ultrasound with color Doppler, CT and MR imaging (MRI) based on anatomical location. This presentation provides a pictorial review of common and rare pediatric neck masses and their imaging features.

**APPROACH/METHODS**

In this presentation, we will discuss the normal imaging anatomy of the neck. We will review conventional radiographic, gray-scale and Doppler ultrasonographic (US), conventional and three-dimensional computed tomographic (CT), and magnetic resonance (MR) imaging or MR angio-
graphic features of pediatric neck lesions based on the involvement of anatomical compartments of the neck including the retropharyngeal space, retrovisceral space, pretracheal space, prevertebral, carotid sheath, parotid gland, superficial fasciae, submandibular, masticator, pretonsillar, parapharyngeal, posterior cervical, paravertebral, perivertebral, and sternocleidomastoid muscle spaces. Emphasis will be made on a pattern recognition approach to the diagnosis of pediatric neck masses based on anatomical compartments and clinical history.

**FINDINGS/DISCUSSION**

A great majority of neck masses in children are benign. Nonetheless, special attention should be given for the possibility of a malignancy. Pediatric neck masses can be grouped into three general categories: congenital, inflammatory, and neoplastic. The latter includes benign and malignant neoplasm. The patient’s history and an analytical approach to imaging can aid in narrowing down the differential diagnosis.

**SUMMARY/CONCLUSION**

Neck masses are common in pediatric patients and are a frequent cause of seeking medical attention. They can be grouped based on their anatomical location in the neck and imaging characteristics. Ultrasound is the first modality used for investigation as it is readily available and utilizes non-ionizing radiation, unlike CT, and does not require sedation as is usually the case with MRI in children. Ultrasound is extremely useful in assessing thyroid masses, thyroglossal and branchial cysts and parotid lesions. For other causes of neck masses it should still be the first line of investigation, after which CT and MRI can be used to determine the extent of the mass and better define its tissue characteristics. Imaging is not always expected to provide a specific diagnosis but should help narrow the differential diagnosis, thereby helping to guide patient treatment. Recognition of typical and atypical imaging patterns can allow radiologists to more accurately approach the correct diagnosis and aid in better clinical management of pediatric neck masses.

**KEY WORDS:** Pediatric, neck masses, MR imaging

**Electronic Scientific Exhibit 113**

**Pediatric Sinonasal Variants and Lesions: Revisited from Clinical Imaging Perspective**

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Children's Hospital of Wisconsin
Milwaukee, WI

**PURPOSE**

A detailed and thorough understanding of normal anatomy and embryology is vital to the diagnosis and prognosis of congenital and acquired sinonasal abnormalities that present in childhood. The purpose of imaging the paranasal sinuses is to confirm diagnosis, localize disease, characterize the extent of pathology and describe any anatomical variations. In this review, we aim to demonstrate the complex anatomy of the sinonasal cavities, its variations and the imaging techniques appropriate for their evaluation. We will illustrate the wide spectrum of disorders affecting the nasal cavities and paranasal region and we will describe useful imaging features that are important for surgical planning and aid in the differential diagnosis of sinonasal abnormalities.

**APPROACH/METHODS**

All cases presented are selected from our department database. For practical purposes, an anatomical systematization is applied: 1. Lesions originating within paranasal sinuses. 2. Lesions originating within the nasal cavities. 3. Extrinsic lesion with secondary extension to sinonasal cavities. In each group, several entities are presented according to their frequency and/or incidence in different age groups. Important pathologic, clinical and imaging features are emphasized.

**FINDINGS/DISCUSSION**

A wide spectrum of pediatric sinonasal abnormalities is presented. CT has a primary role and MR imaging (MRI) is used as problem solving tool. Congenital sinonasal anomalies are common and the majority are asymptomatic, often incidentally identified. On the other hand, many acquired lesions have nonspecific imaging features, and their diagnosis therefore must be based on the patient’s age and histologic features. Acquired sinonasal abnormalities may be caused by trauma, infection, inflammation, or tumors.

**SUMMARY/CONCLUSION**

Although there is a wide diagnostic range, most often, imaging findings in combination with knowledge of the patient’s age group and clinical presentation, can lead to a specific diagnosis, or will at least restrict the diagnostic possibilities.

**KEY WORDS:** Sinonasal, mass lesion, CT, MR imaging

**Electronic Scientific Exhibit 114**

**A Picture Worth a Thousand Diagnoses!**

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**PURPOSE**

To illustrate the importance of the midline sagittal MR image of the brain in making numerous different diagnoses.

**APPROACH/METHODS**

In this exhibit we will illustrate how a single midline sagittal MR image of the brain alone helps in making several different diagnoses. These could be classified into: 1. Developmental anomalies: Agenesis/dysgenesis of corpus callosum, pituitary hypothalamic anomalies, absent septum pellucidum, septo-optic dysplasia, holoprosencephaly, hydrencephaly, aqeductal stenosis, brainstem/cerebellum hypoplasia syndromes, posterior fossa cystic malformations, Chiari malformations, midline lipoma/arachnoid cyst, hypothalamic hamartoma, nasal/sphenoid encephalocele, dermoid/epidermoid, etc. 2. Vascular abnormalities: Vein of Galen malformation, basilar artery/A-com aneurysm, sylvian/straight sinus thrombosis, pontine cavernous malformation/capillary telangeliectasia, falx sinus, etc. 3. Neoplasms: Midline posterior fossa masses (medulloblastoma, ependymoma, astrocytoma, hemangioblastoma, brain stem glioma), tectal glioma, Pineal masses, pituitary masses,
suprasellar masses (cerebrohypophyseoma, hypotalamo-chiasmatic glioma, etc.), olfactory neuroblastoma, midline teratoma, germinoma, central neurocytoma, skull base/midline meningioma, leptomeningeal metastasis, etc. 4. Metabolic/demyelination/Inflammatory disorders: multiple sclerosis, Marchfava Bignami disease, Wernicke’s disease, pituitary stalk abnormalities (LCH, sarcoidosis, lymphocytic hypophysitis), absent posterior pituitary bright spot, etc. 5. Postsurgical conditions: Assessment of third ventriculostomy, foramen magnum decompression, etc. 6. Miscellaneous: Colloid cyst, perinatal insult and cerebral white matter loss, seizure-related lesions in splenium of corpus callosum, intracranial hypotension, transtentorial/revers transtentorial herniation, etc. 7. Extracranial abnormalities: Marrow infiltrative disorders (leukemia/lymphoma, hemolytic anemias), upper cervical spine malalignment/dislocation/fracture, retropharyngeal/prevertebral fluid collection, atlanto-axial dislocation, skull base anomalies (platybasia/basilar invagination), clival mass, midline sino-nasal disease, choanal atresia, adenoid enlargement/mass, lingual thyroid, macroGLOSSIA (amyloidosis), vallecular cyst, etc. We also will discuss briefly various characteristic imaging features of these entities on the midline sagittal images. These may be helpful in diagnosis and differentiation of these conditions.

**Findings/Discussion**

Midline sagittal image frequently is not given due credit. We believe it is the single most important image in the MR imaging of the brain. Imaging findings on this image may point to various disorders not only confined to the midline but also abnormalities elsewhere in the brain or some extracranial or systemic disorders. These findings may sometimes be incidental and therefore unrelated to the reason for which the exam is performed. Still, frequently these may have significant impact on the patient management and prognosis. Sagittal T1 is the basic sequence acquired with all the brain imaging protocols. We have realized in selected cases sagittal 3D T1 SPGR, 3D T2 or FIESTA/CISS also may be extremely useful in selected cases. We will illustrate such cases as well in this exhibit.

**Summary/Conclusion**

We believe that the midline sagittal image of the brain is the single most important image in the brain MR imaging study. It gives us lots of diagnostic information not only about multiple midline and off-midline brain abnormalities but also numerous extracranial and systemic disorders. In this exhibit we will provide pictorial essay and brief description and imaging differentials of these various abnormalities.

**Key Words:** Midline sagittal brain, midline developmental anomalies, incidentaloma

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**Electronic Scientific Exhibit 115**

**Imaging Approach to Closed Spinal Dysraphisms**

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Seattle Children’s Hospital, University of Washington Seattle, WA

**Purpose**

To review the imaging features of commonly occurring closed spinal dysraphisms (CSDs) with an emphasis on key differentiating points and to propose a simple diagnostic algorithm for magnetic resonance imaging (MRI) of these anomalies.

**Approach/Methods**

Using Z-vision, a PACS-based auxiliary search engine, MR spine studies were searched using keywords like dermal sinus, lipomyelomeningocele, myelocystocele, etc. The results were reviewed by neuroradiologists and classified based on the clinicoradiologic classification proposed by Tortori-Donati, et al. The cases with classical imaging findings were selected for the presentation. A literature review was carried out simultaneously. A small algorithm was developed for diagnostic approach to closed dysraphisms.

**Findings/Discussion**

Following closed dysraphisms are included: I. With subcutaneous mass(cervical & lumbosacral): Lipomyelocele, Lipomyelomeningocele, Meningocele, Terminal myelocystocele. II. Without a subcutaneous mass: Split cord malformations, Caudal regression syndrome, Intradural lipoma, Filum terminale lipoma, Tight filum terminale, Abnormally elongated spinal cord, Dermal sinus, Persistent terminal ventricle. The differentiating features are highlighted with each of the described anomalies. Also the importance of looking for associated lesions like intraspinal dermoids, anorectal anomalies, etc. is underlined. A novel diagnostic approach to CSDs is proposed.

**Summary/Conclusion**

In-depth understanding of the critical diagnostic clues in imaging spinal dysraphisms helps produce an accurate, clinically relevant and impactful report. The proposed universal diagnostic algorithm may be helpful in presurgical evaluation, especially for beginners in pediatric neuroradiology.

**Key Words:** Dysraphism, lipomyelomeningocele, MR imaging
Electronic Scientific Exhibit 116

Pediatric Ultrasound in the Detection of Skin-Covered Spinal Anomalies: Review of the Technique, Embryology and Pathology of Congenital Spinal Disease

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Purpose
Review the development of the spinal canal with 3D interactive illustrations and the resulting spinal dysraphia. Show the technique for spinal pediatric ultrasonography. Demonstrate the normal anatomy and anatomical variants using high-frequency transducers. Show cases of the spinal dysraphisms seen with postnatal ultrasound.

Approach/Methods
This exhibit is intended to give a comprehensive review of the use of postnatal ultrasound for spinal dysraphism. Initially it will review in an interactive way the development of the neural tube and spinal canal, explaining the causes of spinal dysraphism. It then will show a review of the technique used to scan the spinal canal in pediatric patients, demonstrating the normal anatomy and the anatomical variants including transitory dilation, ventriculus terminalis, pseudo arachnoid cyst and pseudo mass of the cauda equina. In the second part of the exhibit, multiple cases of skin-covered spinal anomalies and correlate them with medial illustrations which include: Spina bifida occulta - dermal sinus, spinal lipoma, lipomyelocele, tethered cord, and diastematomyelia; Caudal spinal anomalies - Caudal regression syndrome.

Findings/Discussion
Spinal ultrasound is a technique that has been used routinely in the evaluation of the pediatric spine. The introduction of new technology has increased the sensitivity of this technique to evaluate the neonatal spine. It is important for the radiologist to be familiarized with the images that can be obtained with the new high-frequency ultrasound transducers, to recognize the normal anatomy, the pitfalls and anatomical variants to tell them apart from true dysraphisms.

Summary/Conclusion
Modern ultrasound is a great screening tool with high sensitivity for the detection of occult spinal congenital lesions. The radiologist must be aware of the technique and pitfalls using this imaging modality to correctly characterize spinal pathology.

Key Words: Ultrasound, spine, dysraphism

Socioeconomics
117-119

Electronic Scientific Exhibit 117

Practical Pearls in Radiation Protection in Neuroimaging

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Cincinnati, OH

Purpose
Recent dose accidents primarily in neuroimaging have sparked concerns about radiation safety. In neuroimaging, both interventional and CT are relatively higher dose procedures. Radiation risks in both have been observed primarily deterministic injuries to skin of hair loss and erythema but carcinogenic risks cannot be ruled out. Experience in some centers worldwide has shown that there is scope for prevention. This exhibit reviews the radiation risks in adults and children, draws lessons and provides guidance on management and prevention of radiation effects in neuroimaging.

Approach/Methods
The range of deterministic injuries, methods of monitoring of radiation dose and dose reduction strategies in neuroimaging will be discussed. CT dose reduction using tube current modulation, image post processing and changing CT parameters in different CT protocols will be discussed in detail. Attention will be drawn to new softwares available for dose monitoring and reduction. There will be special focus on CT perfusion protocol to prevent radiation injury.

Findings/Discussion
In the last two decades, deterministic injuries in interventional procedures have been reported. However, relatively recently these injuries secondary to “operator error” in CT perfusion have occurred. By changing parameters in CT perfusion protocols, safe imaging can be emphasized. Practical pearls for dose monitoring both for deterministic injuries (peak skin dose or cumulative air kerma) and for carcinogenic risk (dose/kerma area product), setting on reference levels (DRL) for different procedures and comparison of individual patient dose with DRL will be discussed. A number of dose reduction strategies and softwares in recent years offer greater potential and will be emphasized.

Summary/Conclusion
Radiation risks to patients in interventional procedures and CT require renewed emphasis in view of recent findings and novel methods for dose management.

Key Words: Radiation protection, neuroimaging
**Electronic Scientific Exhibit 118**

**Nephrogenic Systemic Fibrosis: A Portrait in the Medical Literature**

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Bracco Diagnostics Inc.
Princeton, NJ

**PURPOSE**
To identify and analyze all unique cases of nephrogenic systemic fibrosis (NSF) published in the peer-reviewed literature in order to gain an increased understanding of the demographics and risk factors for this disease state.

**APPROACH/METHODS**
All cases of NSF reported in the literature (PubMed 2000-2010) were reviewed and tabulated. For each independent NSF case from the literature, the following was extracted: age, sex, country of origin, degree of renal impairment, details of contrast agent (CA) exposure (including type if known and total cumulative dose prior to onset of NSF symptoms), date of onset of symptoms, and time from last CA exposure to onset of symptoms and the GBCA used.

**FINDINGS/DISCUSSION**
Seven hundred and five cases of NSF were identified in patients from 19 different countries with an average age of 60-69 years. The vast majority of cases reported a degree of renal impairment of stage 4 or 5 chronic kidney disease (CKD), with 1 case of stage 2/3 (eGFR 34.6-69.9), and another of stage 3 CKD (eGFR 40.0 to 58.2). Of the 436 cases for which renal impairment was reported, 14 (3.2%) reportedly suffered from acute renal failure. Patients receiving only Omniscan or Magnevist accounted for 93.3% cases of NSF. In all 705 cases, no unconfounded cases with Dotarem, MultiHance, or ProHance were reported. In most cases, symptoms appeared 1-3 months after the last administration of contrast. Importantly, no cases were identified with an onset of disease symptoms after 2007.

**SUMMARY/CONCLUSION**
A literature review of NSF cases provides a unique profile of a relatively new clinical entity. The epidemiologic evaluation of risk factors, along with rapid implementation of guidelines for patient screening, apparently has halted the development of new NSF cases.

**KEY WORDS**: NSF, gadolinium, risk factors

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**Electronic Scientific Exhibit 119**

**Contrast-Induced Nephropathy: Just Benign Creatinopathy?**

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Burlington, VT

**PURPOSE**
Contrast-induced nephropathy (CIN) is usually thought of as a transient phenomenon with no adverse long-term consequences, a "benign creatinopathy." We explored the relationship between a transient and reversible decrease in renal function and adverse patient outcomes.

**APPROACH/METHODS**
We reviewed the literature on outcomes after CIN as well as our own experience. A number of studies involving both intravenous and intra-arterial contrast agent administration were identified. These studies shed light on the relationship between contrast media use and the development of contrast-induced nephropathy, and were reviewed to explore the possible correlation between short-term decreases in renal function and worse patient outcomes.

**FINDINGS/DISCUSSION**
The short-term events include an increase in need for dialysis, prolongation of hospital length of stay, bleeding, and mortality. Long-term effects of contrast-induced nephropathy include mortality, cardiovascular events and development of end-stage kidney disease. Many of these complications occur many months or years after the exposure to contrast. How these long-term events are related to the acute injury to the kidney is a subject for discussion. The hypothesis that acute kidney injury leads to worsening of chronic kidney disease and exacerbation of nontraditional risk factors for cardiovascular events appear to be sustained by the published literature.

**SUMMARY/CONCLUSION**
The development of CIN after administration of radiocontrast media is associated with worsened patient outcomes, particularly in inpatients. Reasonable strategies to lower the risk of developing CIN should be implemented in all patients at risk of developing this complication.

**KEY WORDS**: Contrast-induced nephropathy, chronic kidney disease, outcomes
MR Imaging Evaluation of Scoliosis: Where Do We Stand and What Do We Need to Know?

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PURPOSE
This exhibit is designed to address the functional utility of MR imaging (MRI), with respect to scoliosis, presented from a clinical imaging perspective. Specifically, we plan to address the essential role of MRI for defining the cause of scoliosis and for presurgical planning. The overriding goal of this exhibit is to arm pediatric radiologists and neuroradiologists with an understanding of the utility of MRI, in a format specifically designed to provide a frame of reference that would be useful in clinical imaging practice.

APPROACH/METHODS
Scoliosis is defined as curvature of the lateral margin of the spine measuring 10 degrees or more. Causes of scoliosis commonly are classified into four major categories: (1) congenital (2) developmental (3) neurologic (4) idiopathic. This study also will include additional causes of scoliosis that should be considered and that are better seen with MR imaging, including: (5) infection (6) genetic causes (7) bone marrow abnormalities and (8) paraspinous masses. MR imaging has advantages over conventional radiography in that it provides better anatomical detail.

FINDINGS/DISCUSSION
In our presentation we will highlight the utility of MRI for the preoperative evaluation of scoliosis and for detection of abnormalities that are not seen on plain films. In particular, we have found 3DT1-weighted MR imaging of the spine to be useful for scoliosis evaluation.

SUMMARY/CONCLUSION
Accurate determination of the cause of scoliosis is essential for presurgical planning. This educational review describes the utility of MRI for the determination of the cause of scoliosis for presurgical planning and treatment. While all abnormal findings are of interest to the surgeon, MRI is clearly indicated for those requiring surgery. In addition, MRI is important to exclude occult causes for scoliosis that cannot be detected on plain film studies and that may be amenable to treatment.

KEY WORDS: Scoliosis, secondary, 3D T1-weighted
Spondylodiskitis: A Pictorial Essay of the Distinguishing MR Imaging Features of Spinal Infection
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Georgetown University Hospital
Washington, DC

**Purpose**
Spondylodiskitis is a potentially devastating and rapidly progressing disease which may result in vertebral collapse, permanent neurologic deficits, or even death. Early diagnosis is essential and relies heavily on recognition of characteristic magnetic resonance features. In this pictorial essay we will display the diagnostic MR imaging features of spondylodiskitis as well as features and patterns that best distinguish spinal infection from common entities with a similar appearance.

**Approach/Methods**
A literature review was performed on the magnetic resonance features of spinal infection as well as common entities within the differential diagnosis. The Georgetown University Hospital picture archiving and communication system database was reviewed from the past 10 years to select those cases and images that exemplified the diagnostic and distinguishing magnetic resonance features of spondylodiskitis.

**Findings/Discussion**
The most sensitive magnetic resonance features of spondylodiskitis include epidural and paraspinous enhancement, T2 hyperintensity and enhancement of the disk space, and poorly defined endplates with loss of the normal low T1 cortical signal. Common entities with similar features include Modic type I degenerative disk disease, normal postoperative changes, and spinal tumors. The key distinguishing feature of degenerative disk disease is a lack of paraspinous and epidural enhancement. Normal postoperative changes are best distinguished by a more focal distribution of signal abnormality within the marrow and endplates. Spinal tumors are best distinguished from spinal infection by their relative preservation of the disk space.

**Summary/Conclusion**
MR imaging is essential in the diagnosis of spondylodiskitis and a clear understanding of the key diagnostic features of spinal infection is essential to the radiologist. Although a number of common entities do exist with similar imaging characteristics, certain criteria may be utilized to favor and more confidently diagnose spondylodiskitis.

**Key Words:** Spondylodiskitis

Spine Infections: Imaging Appearances and Impersonators
Morgan, J. • Bronen, R. A.
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New Haven, CT

**Purpose**
To understand how the pathophysiologic basis of spine infections contributes to their imaging appearances and to utilize characteristic imaging features to differentiate infections from other abnormalities which may impersonate infections.

**Approach/Methods**
We queried our Radiology Information System for spine infections and reviewed imaging appearances of spinal pyogenic, tuberculous, and fungal infections. Classic patterns and imaging variations were categorized and then compared with disorders that mimic infections. Finally, epidural and intramedullary disorders were assessed.

**Findings/Discussion**
We review how the differing pathophysiology of pyogenic and tuberculous/fungal infections leads to different imaging findings. Specific imaging features of focus include enhancement patterns, disk involvement, spread of disease, paravertebral and/or epidural extension, early and late findings, bone mineralization and endplate changes. While there are classic imaging features of spinal infection on MR imaging, there are a number of variations in patterns that radiologists should be familiar with for appropriate interpretation. Other pathologic entities that may impersonate infections, including noninfectious inflammatory, neoplastic and degenerative disease, are presented and distinguishing characteristics are reviewed. Differential diagnosis quizzes are presented.

**Summary/Conclusion**
Radiologists should be familiar with the underlying pathophysiology, imaging patterns, and atypical MR imaging findings of spinal infection and features that may mimic spinal infection in order to form an appropriate differential diagnosis. Knowledge and familiarity of disorders which may mimic spinal infections is important in order to interpret these studies appropriately.

**Key Words:** Infection, inflammatory, spine
Electronic Scientific Exhibit 124

Spinal Neurosarcoidosis: The Mysterious Mimicker: A Review

Krishnan, A. • Hamlin, J. • Wang, A. • Patel, S. • Dulai, M.
William Beaumont Hospital
Royal Oak, MI

PURPOSE
Sarcoidosis has been referred to as a great mimicker of diseases. Neurosarcoidosis, and in particular spinal neurosarcoidosis is even harder to consider when presented with an abnormal spine MR image but with no known history. The aim of this presentation is to describe and display different presentations of neurosarcoidosis of the spine and provide certain imaging and clinical clues that can facilitate the diagnosis.

APPROACH/METHODS
A variety of cases that demonstrate the protean manifestations of neurosarcoidosis will be displayed. Alternative considerations that may have similar imaging characteristics will be compared. Clinical history, lumbar puncture findings, and pathology in select cases will be correlated to better understand the background of this disorder. Case presentations will be provided to understand the clinical and radiologic difficulty in interpreting this condition.

FINDINGS/DISCUSSION
Imaging evidence of neurosarcoidosis is seen in about 10% of cases of systemic sarcoidosis. In about 1% of patients, the nervous system is the only site of involvement. The imaging findings are particularly important to be aware of given the vague clinical history in many of these patients and the often nondiagnostic spinal taps (lumbar punctures). Imaging findings including intradural nodular lesions, leptomeningeal coating of the spinal cord, intramedullary lesions and even osseous lesions will be displayed and discussed.

SUMMARY/CONCLUSION
It is our hope that with this exhibit the practicing neuroradiologist will become familiar with the different presentations of spinal neurosarcoidosis and consider it when presented with spinal lesions. This will facilitate earlier diagnosis of a disorder that is often confusing to many members of the clinical service caring for such patients.

KEY WORDS: Sarcoid, neurosarcoid, intradural

Electronic Scientific Exhibit 125

Diffusion-Weighted Imaging of Spinal and Paraspinal Infection

Moritani, T. • Starkey, J. • Singh, A. • Smoker, W. • Sato, Y.
University of Iowa Hospitals and Clinics
Iowa City, IA

PURPOSE
To demonstrate diffusion-weighted imaging (DWI) of spinal and paraspinal infection and illustrate their mimics and imaging pitfalls.

Electronic Scientific Exhibit 126

Bone Tumors of the Spine: Clivus to Sacrum

Doshi, A. H. • Steinberger, J. • Pawha, P. • Naidich, T. P.
Mount Sinai Medical Center
New York, NY

PURPOSE
The educational exhibit will provide a review of the spectrum of benign and malignant spinal bone tumors extending from the clivus to the sacrum. The exhibit will discuss bone tumors routinely seen in practice such as hemangiomas and metastatic disease, as well as, uncommon primary spinal...
bone tumors. The epidemiology, clinical symptoms and signs, and imaging characteristics of these tumors will be reviewed.

**Approach/Methods**
1. Review of bone tumors extending from the clivus to the sacrum. 2. Review the imaging findings of these tumors and identify characteristics that differentiate tumors. 3. Review the differential diagnosis of lytic spinal lesions, ivory vertebral body, vertebral plana.

**Findings/Discussion**

**Summary/Conclusion**
There are a large number of bone tumors that occur in the spinal column from the clivus to the sacrum. This exhibit highlights the differences in these tumors based on location, epidemiology and imaging findings to help guide the radiologist to a narrowed differential diagnosis.

**Key Words:** Spine, tumor

**Electrical Scientific Exhibit 127**

**Imaging of Postoperative Spine: What the Radiologist Needs to Know and What the Surgeon Wants to Know**

Peri, N. • Lam, F. C. • Hackney, D.

Beth Israel Deaconess Medical Center
Brookline, MA

**Purpose**
1.To describe the different types of spinal hardware and surgeries and the imaging appearance. 2.To describe the imaging appearance of common and uncommon complications in a postoperative spine. 3. To describe the details that a neuro/orthopedic surgeon will be specifically interested in knowing from the postoperative imaging study performed.

**Approach/Methods**
1. Common types of spinal surgeries and hardware and the imaging appearance on different modalities - plain radiograph, CT and MR imaging (MRI). 2. Common and uncommon complications seen in postoperative spine - (a) early complications (b) delayed complications. Appearance on different imaging modalities - plain radiograph, CT, and MRI. 3. Specific findings and interpretation that the surgeon needs to know to plan further management.

**Findings/Discussion**
Imaging assessment of the postoperative spine is important and can be challenging at times.

**Summary/Conclusion**
This exhibit will provide information to the viewer about imaging of (a) common spinal surgeries and hardware (b) common and uncommon complications - infection, hematoma, myelopathy, arachnoiditis, CSF leak, scar, recurrent disease, etc. (c) specific information (hardware failure, healing, alignment changes, subsidence, etc.) that the surgeon would like to know from the study.

**Key Words:** Postoperative spine, imaging, complications

**Electronic Scientific Exhibit 128**

**State-of-the-Art MR Imaging of Gaucher Disease Type I**

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**Purpose**
Gaucher disease (GDI) is a multisystemic metabolic disorder arising from a deficiency of lysosomal glucocerebrosidase. The predominant clinical manifestations of the disease are hepatosplenomegaly, peripheral blood cytopenia and skeletal disease. Skeletal involvement in GDI is probably the most disabling aspect in patients and shows a slow response to enzyme replacement therapy (ERT). The purpose of the exhibit is to review the presentation, epidemiology and classification of radiologic findings in patients affected with Gaucher disease and to illustrate MR imaging (MRI) features of this disease and protocols used to monitor the treatment with enzyme replacement therapy and substrate subtraction therapy.

**Approach/Methods**
The assessment of skeletal disease in GDI and exactly of bone marrow involvement is performed predominantly by MRI either in the lower extremities and in the lumbar spine using different scoring systems such as bone marrow burden (BMB) or vertebra-disk-ratio (VDR) or Dusseldorf- Gaucher-Score (DGS). Bilateral femurs (hips to knees with proximal and distal femur epiphysis included) are studied on a coronal plane with T1 and T2 images and a STIR sequence. Lumbar spine is studied on a sagittal plane with T1 and T2 images and a STIR sequence. The complete protocol for GDI patients include DXA of lumbar spine and MRI of liver and spleen.

**Findings/Discussion**
The exact incidence of skeletal complications is not known but it is estimated at approximately 80%. There is not necessarily a correlation between severity of bone involvement and severity of any other parameters of Gaucher disease so that skeletal involvement may be the primary symptom.

**Summary/Conclusion**
The major teaching points of the exhibit are: 1. To describe to radiologists the radiologic assessment in Gaucher disease because affecting both the marrow and mineral compartments Gaucher-related bone disease is the most significant cause of morbidity and long-term disability for patients. 2. To describe imaging characteristics on MRI and how to score the bone marrow involvement. 3. Discuss how new MRI techniques (e.g., whole body MRI) could be helpful in detecting earlier involvement of different skeletal segments and complications.

**Key Words:** Gaucher disease, MR imaging, bone marrow
Where Neuro Meets MSK: A Menagerie of Conditions Affecting Both the Axial and Appendicular Skeletal System

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PURPOSE
To explore the compendium of common, unusual and rare conditions which may affect both axial and appendicular skeletal system together. We stress the necessity of searching beyond the spine and cranium in order to better appreciate the extent of the disease process and to assist in formulating an accurate differential diagnosis.

APPROACH/METHODS
We illustrate diverse cases from our neuroradiology, spine and pediatric clinics with imaging findings (plain films, CT and MR) involving both the axial and appendicular skeleton. We review pertinent clinical features and organize entities according to etiology.

FINDINGS/DISCUSSION
Hematologic disorders generally produce narrow infiltration, with bony expansion and widening of the diploic spaces, often with a spectacular radiologic appearance. Red marrow reconversion can be detected readily on T1-weighted MR. Thalassemia may show a characteristic Erlenmeyer flask deformity in the long bones. Sickle cell disease may be associated with extramedullary hematopoiesis, bony infarcts, osteomyelitis and H-shaped vertebrae, as well as dactylitis (hand-foot syndrome) and avascular necrosis of the femoral and humeral heads. Leukemia may generate widened cranial sutures and lucent metaphyseal bands. Skeletal dysplasias are caused by errors in bone formation or remodeling. Achondroplasia is associated with bullet-shaped vertebrae, narrowed interpediculate distances, kyphosis and lordosis, and small foramen magnum. The long bones are short and wide with flared metaphyses. Osteogenesis imperfecta may have wormian bones, basilar invagination, and fragile bones prone to fracture. Spondyloepiphyseal dysplasia is associated with platyspondyly and small irregular ephyses. Connective tissue disorders, such as Marfan and Ehlers-Danlos syndrome, show kyphoscoliosis, spondylolysis, vertebral scalloping secondary to dural ectasia, and joint hypermobility due to ligamentous laxity. Metabolic conditions common to spine and long bones include hyperparathyroidism, rickets and renal osteodystrophy. The phakomatoses include neurofibromatosis (NF1), tuberous sclerosis (TS) and Gorlin syndrome. NF1 demonstrates cranial osseous abnormalities, dural ectasia and sharp kyphoscoliosis, as well as anterior tibial bowing and pseudoarthroses. Tuberous sclerosis may reveal diffuse bone sclerosis with bone cysts in the hands and feet. Gorlin syndrome causes mandibular cysts, bone sclerosis and scoliosis. Chromosomal abnormalities are extensive. Downs syndrome has numerous cervical spine abnormalities (e.g., atlantoaxial subluxation) and unique bony anomalies (e.g., clinodactyly). Caudal regression syndrome, caused by a first trimester insult, may demonstrate spina bifida, stenosis and anterior meningocoeles, with fusion of the lower extremities (sirenomelia). A variety of neuromuscular conditions can cause muscle spasticity or flaccidity with resultant scoliosis. The long bones generally are bowed and gracile. Infectious and inflammatory processes include eosiinophic granuloma (skull, spine and long bones), sarcoidosis (sclerosis, osteopenia and lacy lytic lesions in the phalanges) and tuberculosis (Pott’s disease, gibbus deformity and kyphosis of the spine, and dactylitis and periosteal reaction of the distal extremities). Neoplasms include lymphoma, multiple myeloma and metastases. Nonneoplastic tumor-like conditions are Paget’s disease and fibrous dysplasia, which is uncommon in the spine.

SUMMARY/CONCLUSION
It often is required for the neuroradiologist to move beyond his or her comfort zone when investigating abnormalities of the axial skeleton, to include the appendicular skeleton as well. Multiple seemingly disparate findings, when considered collectively, may reveal the underlying elusive diagnosis.

KEY WORDS: Appendicular skeleton, skeletal dysplasias, phakomatoses

High-Resolution 3 T MR Neurography of Femoral Neuropathy

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PURPOSE
To comprehensively depict femoral nerve pathologies with 3 T high-resolution MR imaging (MRN).

APPROACH/METHODS
Primary interpretation of femoral nerve anatomy and pathology was accomplished on axial T1-weighted (T1W) and T2 SPACE (spectral adiabatic inversion recovery, Siemens, Erlangen, Germany) imaging sequences on a 3 T MR imaging (MRI) unit. Three-dimensional STIR SPACE and 3D T2 SPACE (D-dimensional, STIR-short tau inversion recovery, SPACE- sampling perfection with application optimized contrasts with varying flip angle evolutions) were used as problem solving tools, as they allow isotropic multiplanar and curved planar reconstructions with spin-echo type contrast.

FINDINGS/DISCUSSION
Femoral nerve, the largest branch of the lumbar plexus, can be subject to a variety of pathologies, which may affect the nerve anywhere from the nerve roots to the distal branches. High-resolution MR neurography is being employed increasingly for peripheral nerve evaluation, as it nicely complements information gained from electrophysiological testing. Due to high-resolution and high-contrast imaging possible on higher field MR scanners, normal anatomy and abnormalities of femoral nerve are depicted easily. There are scattered case reports describing femoral nerve pathologies
using MRI. This article comprehensively reviews different types of pathologies involving the femoral nerve and illustrates their 3 T MRN with relevant case examples.

**SUMMARY/CONCLUSION**
Femoral nerve involvement may be seen with numerous pathoetiologies. A high-resolution MRN examination may be used to confirm the clinical suspicion of femoral neuropathy, supplement the information gained from electrodagnostig findings, and exclude other etiologies, such as a compressive mass lesion.

**KEY WORDS:** MR neurography, high-resolution MR imaging, femoral nerve

**Electronic Scientific Exhibit 131**

**If It Quacks Like a Duck, Is It Still a Duck?: A Pictorial Review of Unusual Intrinsic Spinal Cord Lesions**

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**PURPOSE**
Several unusual pathologies can involve the spinal cord, many of which mimic relatively more common benign and malignant entities. It is important for the neuroradiologist to be aware of these entities. In the proper clinical setting, knowledge of these entities can help facilitate correct diagnostic work up and appropriate management. In this educational exhibit, we review a wide spectrum of unusual spinal cord abnormalities. These include benign entities including sarcoidosis, vitamin B12 deficiency, nitrous oxide toxicity, copper deficiency, Sjogren’s syndrome, acute disseminated encephalomyelitis (ADEM), Guillain-Barre syndrome, amyotrophic lateral sclerosis (ALS) and cavernous angioma. We also review imaging findings of spinal cord involvement in the setting of rare infectious diseases such as toxoplasmosis, cysticercosis, HIV, tuberculosis and herpes zoster. Rare intramedullary neoplasms such as glioblastoma, myxopapillary ependymoma, hemangioblastoma, lymphoma, ganglioglioma and metastasis also are illustrated.

**APPROACH/METHODS**
We retrospectively reviewed the imaging findings in patients with unusual pathologic-proved cord lesions over the last 5 years at our institutions. Imaging modalities included predominantly MR imaging (1.5T, Signa, GE Medical Systems, WJ) with CT scan in appropriate cases to further characterize osseous abnormalities.

**FINDINGS/DISCUSSION**
We observed that few entities involve specific portions of the spinal cord that are diagnostic or have other specific imaging features. The vast majority of intramedullary abnormalities have a somewhat nonspecific imaging presentation consisting of high T2 signal in conjunction with focal solid, non-solid or altogether absent enhancement. For this reason, knowledge of the clinical history and correlation with the pattern of signal abnormality and enhancement can help narrow the differential diagnosis. In this exhibit, we present the clinical presentation and imaging findings of these unusual cord pathologies and then review the differential diagnosis.

**SUMMARY/CONCLUSION**
Intramedullary lesions with varying patterns of cord signal alteration, edema and enhancement commonly are encountered. The list of differential considerations for these varied patterns is protean. However, in the right clinical setting, awareness of certain unusual cord pathologies can help the referring physician initiate appropriate work up and treatment.

**Electronic Scientific Exhibit 132**

**Review of MR Spectrum of Spinal Cord Lesions**

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**PURPOSE**
1. To illustrate the MR spectrum of spinal cord lesions in children and adults. 2. To discuss lesion distribution, location and contrast enhancement patterns as a way to help differentiate spinal cord lesions. 3. To review the typical clinical history, epidemiology, and symptomatology of different spinal cord lesions.

**APPROACH/METHODS**
The goal of this electronic scientific exhibit is to provide a clear and structured approach when evaluating spinal cord lesions. We will present different spinal cord lesions with characteristic MRI findings as a case series. We will discuss a wide variety of spinal cord lesions: 1. Trauma (e.g., hemorrhage, edema, transection and syringohydromyelia), 2. Primary spinal cord neoplasm (e.g., astrocytoma, GBM, ependymoma, subependymoma, and hemangioblastoma) and metastasis, 3. Demyelinating disease (e.g., multiple sclerosis and ADEM), 4. Congenital lesions (e.g., caudal regression syndrome, tethered cord, arachnoid cysts, Chiari I and II malformations, syringohydromyelia, diastematomyelia, and spina bifida), 5. Vascular disease (e.g., spinal cord infarction and dural AV fistula associated with venous congestion), 6. Granulomatous disease (e.g., sarcoidosis), 7. Vitamin B12 deficiency, 8. Inflammatory/ immune-related spinal cord disease (e.g., Guillain Barre syndrome and transverse myelitis), 9. Infectious spinal cord disease (e.g., AIDS-associated myelopathy and spinal cysticercosis), 10. Postradiation myelopathy. Using these individual cases, we will discuss how they differ in characteristic lesion distribution, location and contrast-enhancement patterns. Gross pathology and histologic correlation also will be presented in selected cases.

**FINDINGS/DISCUSSION**
A wide spectrum of spinal cord lesions will be presented in a case-based format. Characterization of spinal cord lesions based on lesion distribution, location, and contrast-enhancement pattern will be reviewed to help differentiate these lesions. Gross pathology and histology correlation will provide a helpful adjunct in developing an understanding of these lesions, as well.
**SUMMARY/CONCLUSION**
Familiarity with MRI findings of spinal cord lesions and associated clinical history is critical for radiologists and patient care. After completing this case-based electronic scientific exhibit, the viewer should be able to methodically distinguish spinal cord lesions based on a spectrum of MRI findings.

**KEY WORDS:** Spinal cord lesion

**Electronic Scientific Exhibit 133**

**MR Imaging of the Spinal Cord in Multiple Sclerosis**

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**PURPOSE**
To suggest the most appropriate MR imaging protocol in assessment of the spinal cord in patients with suspected multiple sclerosis. To know the indications of spinal cord MR imaging (MRI) at diagnosis and follow up of multiple sclerosis. To review the typical and atypical MR imaging features of spinal cord multiple sclerosis.

**FINDINGS/DISCUSSION**
The spinal cord commonly is affected in multiple sclerosis (MS). The most sensitive MR sequence for detecting demyelinating plaques within the spinal cord is conventional or fast dual echo-spin echo, and therefore should be considered the sequences of choice for sagittal imaging in suspected MS. The prevalence of cord abnormalities is as high as 74% to 85% in established MS. The lesions can be focal (single or multiple) or diffuse, and mainly affect the cervical cord segment. On sagittal scans, the lesions characteristically have a cigar shape and rarely exceed two vertebral segments in length. On cross section they typically occupy the lateral and posterior white-matter columns, extend to involve the central gray matter, and rarely occupy more than one half the cross-sectional area of the cord. Acute spinal cord lesions can produce a mild to moderate mass effect with cord swelling and may show contrast enhancement. In clinically isolated syndromes (CIS), commonly the first manifestation of MS, the prevalence of asymptomatic cord lesions is lower, although they can be found in 30% to 40% of patients with this condition. The added value of performing spinal cord MR imaging in patients with a nonspinal cord CIS has not been definitively established, but the presence of cord lesions may help to determine dissemination in space according to the 2005 McDonald criteria at the time of diagnosis. MR imaging of the spinal cord can provide important diagnostic information in several clinical settings. Patients initially diagnosed with MS, but showing signs or symptoms of myelopathy, are typically evaluated by spinal cord MR imaging to exclude treatable lesions such as extrinsic compression, neoplasm, or vascular malformation. Moreover, the presence of cord lesions can strengthen the diagnosis of MS in patients fitting the clinical criteria for MS, but with negative or inconclusive brain MRI findings. Similarly, diagnostic certainty can be increased in patients with nonspecific brain findings, particularly those >50 years old, because asymptomatic cord lesions are relatively frequent in MS, but are rare in other white matter diseases.

**SUMMARY/CONCLUSION**
In certain clinical situations, spinal cord MR imaging, performed under adequate technical conditions, may be of great diagnostic value in addition to brain MR imaging at diagnosis and follow up of multiple sclerosis.

**KEY WORDS:** Spinal cord, MR imaging, multiple sclerosis

**Electronic Scientific Exhibit 134**

**Cystic Lesions Encountered in Spinal Imaging: A Pictorial Review and Classification**

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**PURPOSE**
Advances in radiologic technology have allowed the identification of a variety of intraspinal and extraspinal cystic lesions. Failure to appreciate the different characteristics of these cysts has led to confusion in terminology with different terms often being used to describe the same lesion. In an attempt at clarification, the literature is reviewed and a simplified classification of spinal cysts is presented.

**FINDINGS/DISCUSSION**
Spinal meningeal cysts commonly are classified according to a system published by Nabor, et al, which consists of: Type I: Extradural meningeal cyst without neural tissue. Type Ia: Extradural spinal arachnoid cyst. Type Ib: Sacral meningocele. Type II: Extradural meningeal cyst containing neural tissue, (e.g., Tarlov cyst). Type III: Intradural spinal arachnoid cyst. Additionally, various types of neoplastic and non-neoplastic intramedullary cystic lesions will be presented, including congenital and inflammatory lesion with emphasis on distinguishing imaging characteristics. Recommended imaging work up of selected lesions will be demonstrated to limit the differential diagnosis. Lastly, cystic lesions caused by degenerative disease originating from the facets joints (synovial cysts) and Bastrup’s disease will be illustrated. As well as, traumatic spinal cysts relating to injury of the brachioplexus.
**SUMMARY/CONCLUSION**
Nonosseous spinal lesions often are encountered in daily practice. A confident diagnosis can be made if specific imaging features are recognized and proper imaging work up undertaken. Understanding commonly used classification systems should limit confusion in terminology and improve patient management.

**KEY WORDS:** Spine, cysts, classification

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**Electronic Scientific Exhibit 135**

**Spine Tumors and Spine Anatomy on MR Imaging: A Case-Based Approach**

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**PURPOSE**
1. To give an overview of normal spine anatomy on MR imaging (MRI) using multiplanar/volumetric scrollable image stacks with corresponding overlays outlining the relevant anatomy.
2. To demonstrate tumefactive lesions conforming to the varying spaces of the spine (i.e., vertebral body, endplate, posterior element, epidural, intradural, etc.).
3. To illustrate how identification of the "center" of the lesion (in conjunction with other information such as morphology, enhancement, signal changes), assists in constructing an appropriate differential diagnosis, with discussion of the final diagnosis (usually by biopsy) of the above lesion.

**APPROACH/METHODS**
A browser-based presentation consisting of approximately 30 slides will be created, and divided into sections such as "anatomical overview", "unknown cases conforming to anatomical spaces", and "differential diagnoses and actual diagnosis for the unknowns", and "conclusion". The normal anatomy overview and the unknown cases will be presented in an interactive format, using multiplanar (axial, sagittal) MRI sequences (T1, T2, STIR, and contrast-enhanced images) as scrollable "stacks". The scrolling stacks will be implemented with javascript. Ten cases illustrating the anatomical spaces will be presented as "unknowns" and will be scrollable and provided in a format similar to the anatomical overview. An optional "overlay" will be provided to allow easier identification of the borders of the spaces and lesions. There will be commentary with didactic points followed by discussion of the cases and the final diagnoses.

**FINDINGS/DISCUSSION**
Determination of whether a tumefactive spine lesion is worrisome, indeterminate, or benign, is an important and frequent task for the neuroradiologist. Many spine tumors present preferentially in certain spaces of the spine, and diagnosis is made in conjunction with the location of the lesion and the other information available on the scan, in particular morphology and enhancement. This presentation aims to review the most common differentials using unknowns and with "answers", in an interactive, easily-digested, and (hopefully) enlightening manner.

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**SUMMARY/CONCLUSION**
Overview of spine anatomy on MRI with an interactive set of unknown cases illustrating the relevant anatomy and most likely differential diagnoses. Discussion includes the final diagnoses.

**KEY WORDS:** Spine, anatomy, MR imaging

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**Electronic Scientific Exhibit 136**

**Neuromyelitis Optica and Its Mimics: A Detailed Examination of Radiographic, Clinical and Serologic Features of Neuromyelitis Optica**

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**PURPOSE**
Neuromyelitis optica (NMO) is a poorly understood inflammatory demyelinating central nervous system disease associated with optic neuritis and myelitis spanning three or more contiguous spinal cord segments. Neuromyelitis optica often is associated with other autoimmune diseases, such as lupus. Neuromyelitis optica seropositivity is confirmed by the serum autoantibody markers NMO-IgG and anti-AQP4 (target channel aquaporin-4 water channel). Neuromyelitis optica patients with transverse myelitis refractory to steroid pulse therapy often are treated with a wide range of radical therapies that differ from other demyelinating diseases. Therefore, it is critical to suggest NMO in the appropriate clinical context in order to expedite therapy of these complex patients.

**APPROACH/METHODS**
Images from consecutive patients referred for evaluation of demyelinating disease in the spine between January 2008 and November 2010 were reviewed. Cases which illustrated T2 signal hyperintensity were evaluated further. MR images and clinical records were reviewed in each case. Specific features such as sharp or ill-defined borders, symmetry, relationship to white matter or gray matter, intensity of T2 signal, homogeneity, contrast enhancement and restriction of diffusion were analyzed.

**FINDINGS/DISCUSSION**
Multiple documented NMO cases are presented with both intracranial and spinal cord findings (Figures 1 and 2). Potential NMO mimics, including post-traumatic cord contusion, idiopathic transverse myelitis, cord ischemia, presyrinx associated with Chiari I malformation, and subacute combined degeneration also are presented.
Neuromyelitis optica often manifests with multiple exacerbations and is mistaken for more common demyelinating processes, such as multiple sclerosis. However, NMO exacerbations are treated very differently, with treatments ranging from antituberculous therapy to autologous peripheral hematopoietic stem cell transplantation. As many disease processes demonstrate overlapping radiographic features, it is important to understand the wide range of imaging findings within the appropriate clinical context to guide accurate diagnosis. This review emphasizes imaging features that help differentiate NMO from other causes of myelopathy.

**KEY WORDS:** Demyelinating disease, transverse myelitis, spinal trauma

**Electronic Scientific Exhibit 137**

*More than Meets the Spine? Pattern Recognition and Associated Injuries in Spinal Trauma*

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**PURPOSE**

To illustrate the diverse spectrum of nonorthopedic injuries associated with spinal fractures. We emphasize that knowledge of regional anatomical structures and biomechanical considerations can facilitate understanding of patterns of injury.

**APPROACH/METHODS**

We retrospectively reviewed the imaging studies (radiographs, MDCT and MRI) of trauma patients presenting through the emergency department of our Level 1 trauma center during the past 5 years with spinal fractures who had concomitant injuries involving the head, neck, chest, abdomen and pelvis. We excluded extremity fractures from our survey. We classified spine injuries according to the level involved (cervical, thoracic, lumbar, sacral) with additional consideration of transitional zones.

**FINDINGS/DISCUSSION**

Traumatic spinal fractures involve a great expenditure of energy, which should alert the radiologist and clinician to search for other injuries. The majority of injuries were due to motor vehicle collisions. Less common mechanisms included pedestrians struck by vehicles, falls and assaults. Cervical spine fractures are associated most commonly with maxillofacial, intracranial, skull base and vascular compromise. The extreme flexion and extension motions occurring with abrupt blunt impact of the head onto an automobile’s dashboard or windshield may produce multiple brain injuries, including contusions and extra-axial hemorrhages. Upper cervical spine trauma is associated more frequently with maxillofacial and skull-base fractures, such as those involving the occipital condyles. Furthermore, atlanto-occipital dissociation and rotatory subluxations may occur. The relative mobility of the cervical spine allows for considerable torque and shearing forces which predispose to extracranial vascular injuries. These include vertebral and carotid artery dissections and traumatic pseudoaneurysms. The forces generated when the chest impacts the steering wheel place not only the spine, but also the regional anatomy of the lungs, heart and other mediastinal structures at particular risk. Sudden increases in intrathoracic pressure may produce pneumothoraces/pneumomediastinum with accompanying rib fractures. Expeditious diagnosis is essential for management of pseudoaneurysms, aortic dissections and pulmonary
lacerations/contusions. The thoracolumbar junction, a transitional zone, is subject to greater biomechanical stresses during trauma and therefore is more prone to injury than the upper thoracic spine, which is stabilized by the rigid ribcage. At the lower thoracic and lumbar levels, the close proximity of the abdominal viscera to the spine can cause a variety of insults, ranging from contusions and lacerations to devascularization of the liver and spleen. While renal trauma is more frequent at the upper lumbar spine, bowel and mesenteric involvement occurs more often at lower levels. Chance and distraction type fractures, occurring with seatbelt use, and burst fractures, resulting from axial loading (i.e., jumping, falling) have an elevated incidence of intraabdominal injuries with specific patterns. The sacrum and pelvis are not disrupted easily, and when they are, diffuse organ and genitourinary injuries are likely.

**Summary/Conclusion**
In the spinal trauma patient, clinical evaluation is difficult at best. The managing multidisciplinary team must always consider the possibility of associated life-threatening injuries, ranging from the brain and skull to the viscera and vascular structures. Familiarity with the constellation of findings seen with spine injury can help expedite radiologic assessment and diagnosis.

**Key Words:** Spine, trauma, patterns
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