

FIRST YEAR AND/OR FIRST ROTATION

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I. NEURORADIOLOGY EXAMINATION

1. Prior to: Indications & ACR appropriateness, Protocoling
2. During: Safety - contrast material, radiation dose; Quality - adequacy of images
3. Interpretation: Approach, Normal anatomy, Normal variants, & Pathology. (see below)
4. After: Reporting; Medicolegal considerations and responsibilities, including communicating results

II. TECHNIQUE, PHYSICS AND INDICATIONS

1. Understand the basic principles behind and indications for Radiological examinations-
 - a. Radiography
 - b. CT
 - i. CT window and level settings, slice thickness, inter-slice gap
 - ii. CT attenuation of normal and abnormal structures.
 - iii. Dose measures for CT, i.e. CT dose index (CTDI) values, and strategies for radiation dose reduction.
 - iv. Multiplanar Reformations and 3D reconstructions
 - c. Contrast- Types of contrast media- identify risks and manage reactions
2. Recommended Supplement for call - CT angiography & CT venography
CT and CTA- helical imaging parameters i.e., pitch, and image reconstruction algorithms (e.g., MPR and 3D).

III. ANATOMY & NORMAL VARIANTS

1. Brain
 - a. Cerebral lobes and surface anatomy, including identification of prominent sulci and gyri
 - b. Basal ganglia and thalamus
 - c. Brainstem and cranial nerves
 - d. Pituitary and pineal glands
 - e. Ventricles and basal cisterns
 - f. Meninges
 - g. Basic skull and skull base anatomy
 - h. Vascular – cervical and intracranial- arterial and venous
 - i. Normal variants, including vascular variants
2. Spine
 - a. Osseous components
 - b. Vertebral anatomy and differences between cervical, thoracic and lumbar spine

- c. Spinal canal and cord- intramedullary, intradural-extramedullary and extradural compartments
- d. Normal variants
- 3. Head and Neck
 - a. Calvarium
 - b. Anatomy of spaces of neck
 - c. Salivary glands, thyroid
 - d. Oral cavity and oropharynx, hypopharynx, laryngopharynx
 - e. Lymph node levels
 - f. Orbits- bony and ocular anatomy
 - g. Sinus anatomy – turbinate and meatal anatomy, the osteomeatal unit (OMU) and normal drainage pathways of the paranasal sinuses
 - h. Normal variants
- 4. Basic MR anatomy
 - a. Brain
 - b. Head & Neck
 - c. Spine
 - d. Normal MRI variants
- 5. CT Angiography and CT Venography

IV. INTERPRETATION APPROACH

- 1. Radiography
- 2. CT
- 3. Brain
- 4. ENT
- 5. Spine

V. BRAIN PATHOLOGY

- 1. Edema- cytotoxic (CVA) versus vasogenic (tumor, inflammation, infection), osmotic and interstitial
- 2. Stroke-
 - a. Ischemic versus hemorrhagic
 - b. Arterial versus venous
 - c. Vascular distributions
 - d. Patterns of ischemic stroke
 - e. Early detection by CT
- 3. Neoplasms-
 - a. Single versus multiple
 - b. Primary versus secondary
 - c. Location: intra-axial versus extra-axial, gray or white matter, supra-versus infratentorial
 - d. Enhancement pattern

- e. Pediatric versus adult
- 4. Trauma-
 - a. Fractures- calvarial, skull base, temporal bone
 - b. Hematomas-
 - i. Extra-axial: Epidural (arterial and venous), Subdural (different ages)
 - ii. Intra-axial: Contusions and shearing injury (grading)
 - c. Non-accidental trauma
- 5. Hemorrhage
 - a. Blood Density evolution – expected evolution and variants
 - b. Type, by location – parenchymal, epidural, subdural, subarachnoid
 - c. Hemorrhagic transformation of infarcts- differentiation from contrast
 - d. Hypertensive bleeds- common sites
 - e. Differentiation of subdural from extradural blood
 - f. Hyperdense noncalcified lesions on CT
 - g. Calcified intraparenchymal lesions
- 6. Hydrocephalus-
 - a. Differentiate atrophy from hydrocephalus
 - b. Distinguish intraventricular vs extraventricular obstructive
 - c. Radiographic acuity/ compensation
 - d. Shunt types
 - e. Shunt follow up- ventricle size measurements
 - f. Complications of shunts- slit ventricle, shunt dependence, trapped ventricle
- 7. Brain herniation patterns
- 8. Calcifications- physiologic versus pathologic, causes
- 9. Postoperative findings on CT
- 10. Vascular disorders –
 - a. Aneurysms, arterio venous malformations
 - b. dissection,
 - c. thrombosis (arterial and venous)
 - d. NASCET criteria

VI. SPINE PATHOLOGY

- 1. Trauma-
 - a. Stable versus unstable fractures
 - b. Compression, burst and chance fractures
 - c. Fracture patterns and associated injuries
 - d. Spondylolysis and Spondylolisthesis
- 2. Post-operative spine- x-rays & CTs for assessment of hardware, alignment
- 3. Spinal Hemorrhage-
 - a. Epidural
 - b. Subdural

c. Subarachnoid

VII. HEAD AND NECK

1. Maxillofacial, mandibular and orbital trauma- fracture classifications
2. Sinusitis- acute and chronic
3. Neck Infections and abscesses- Airway compromise
4. Foreign bodies
5. Thyroid lesions: Dx and management
6. Abnormal lymph nodes: Dx and management
7. Vascular anomalies – vascular compromise, including atherosclerosis, stenosis, clot and occlusion

SECOND YEAR/ROTATION –

Review all materials from 1st rotation plus:

I. TECHNIQUE AND INDICATIONS

1. Understand the basic principles behind and indications for use of methods of MR examinations
 - a. Brain: T1, T2, FLAIR, DWI, SWI, 3D GRE, 3D, post-contrast, fat suppression
 - b. Vascular: TOF MRA, post-contrast MRA, TOF MRV, post-contrast MRV, fat suppression techniques
 - c. ENT: IR, fat sat post-contrast
 - d. Spine: T1, T2, STIR, GRE, 3D, fat sat post-contrast
2. Types of contrast media- identify risks and manage reactions
3. Lumbar Punctures: fluoro-guided LP, myelogram (C/T/L), cisternogram- indications, techniques and perform

II. ANATOMY:

1. Brainstem, cranial nerves, white matter tracts
2. Spine vascular structures
3. Orbits and sinuses
4. Temporal bone
5. Skull base
6. Head and neck- spaces of neck, lymph node levels

III. BRAIN PATHOLOGY- CT and MRI Correlation:

1. Differential diagnosis by location
2. Stroke- Role of CTA, CTP, MRI, MRA, MRP, Evolution of stroke, TIA, vascular occlusion and atherosclerosis
3. Tumor-
 - a. WHO Grading and imaging correlates
 - b. Gliomatosis
 - c. Tumor mimics- subacute infarcts, subacute hematomas, demyelinating lesions
 - d. Ring enhancing masses
 - e. Intraventricular masses
 - f. Tumors crossing corpus callosum
 - g. Cerebellopontine angle tumors and mimics
 - h. Cortical based tumors
 - i. Fat containing masses
 - j. Calcified/hemorrhagic masses
 - k. MR diffusion and MR Perfusion
 - l. Pineal and pituitary tumors
 - m. Nontumoral cysts- Arachnoid, Colloid, Dermoid/Epidermoid, Enlarged VR spaces, Porencephalic cysts
4. Trauma-
 - a. Skull base and temporal bone fractures

- b. Evolution of hematomas based on location- Parenchymal vs. SAH vs. SDH/EDH
 - c. Sequelae of brain herniation
 - d. Chronic findings after trauma
 - e. Criteria of brain death
 - f. Chronic traumatic encephalopathy
 - g. Traumatic intracranial and extracranial dissections
 - h. Traumatic carotid cavernous fistula
5. Hemorrhage –
- a. Determining age of hemorrhage on MRI
 - b. Patterns of bleeds- hypertensive, amyloid angiopathy
 - c. When to suspect underlying lesion
 - d. Primary tumors known to hemorrhage
 - e. Hemorrhagic metastases to brain
 - f. Hemorrhagic transformation of infarcts
 - g. Venous infarcts
 - h. Embolic- septic emboli and mycotic aneurysms, fat emboli
 - i. Nontraumatic, nonaneurysmal subarachnoid hemorrhage
6. CNS infections-
- a. Parenchymal versus extra-axial
 - b. Typical (pyogenic abscess) versus atypical (Herpes, Neurocysticercosis, Lyme)
 - c. Infections in Immunocompromised (HIV/ AIDS)
 - d. Chronic granulomatous infections (Tuberculosis, fungal)
 - e. Noninfectious inflammatory conditions (including sarcoidosis)
7. Demyelinating diseases- primary- types of MS, criteria, role of imaging, ischemic, infection
8. CSF dynamics-
- a. Intracranial hypo-and hypertension
 - b. CSF leaks
 - c. CSF diversion procedures
 - d. Normal Pressure Hydrocephalus
9. Vascular-
- a. Basics of CTA, MRA and DSA
 - b. Aneurysms
 - c. Arterial and venous variants
 - d. Arteriovenous malformations (basics)
 - e. Carotid stenosis
 - f. Dissection
10. Epilepsy- Temporal Lobe anatomy, Mesial Temporal Sclerosis

IV. SPINE PATHOLOGY

- 1. Degenerative spine disorders, including lexicon
 - a. Types of disorders –
 - i. Diffuse idiopathic skeletal hyperostosis
 - ii. Disc herniation

- iii. Disc-osteophyte
 - iv. Juxta-articular cysts
 - v. Ossification of the posterior longitudinal ligament
 - vi. Spinal stenosis
 - vii. Spondylolisthesis and spondylolysis
 - b. Disc morphology – bulge, protrusion, extrusion, sequestration
 - c. Lumbar Disc pathology location – central, subarticular, foraminal, far lateral, anterior
- 2. Trauma-
 - a. MRI- criteria of instability
 - b. Ligamentous injuries
 - c. Cord injury
 - d. Epidural, subdural and subarachnoid hemorrhages
 - e. Craniovertebral fractures- Atlanto-occipital dislocation, C1/C2 fractures
- 3. Spine infections and inflammations
 - a. Discitis Osteomyelitis
 - b. Spinal Abscess
 - c. Nonpyogenic infections
 - d. Acute and chronic inflammatory polyneuropathies
 - e. Demyelination- Multiple sclerosis and ADEM
 - f. Transverse Myelitis
- 4. Tumors-
 - a. Extradural
 - b. Intradural extramedullary
 - c. Intramedullary
- 5. Post-operative- CT and MRI for hardware, acute bleeds. Recognizing acute postsurgical complications including acute epidural and hardware associated hemorrhage; misplaced or incorrectly placed hardware. Chronic hardware failure including features of hardware loosening and fractures. Metal artifact reduction techniques for CT and MRI.

V. HEAD AND NECK PATHOLOGY

1. Sinus and osteomeatal unit (OMU) disease- infection, inflammation, tumors
2. Facial and orbital trauma- fracture associations and complications
3. Skull base and temporal bone basics
4. Neck- lymphadenopathy, infections, tumor classification based on location

THIRD YEAR/ROTATION

Review material for R1 and R2

- I. TECHNIQUE AND INDICATIONS** - Understand the basic principles behind and indications for use of methods of examination-
1. CT- CTA, CTV, CT Perfusion- **Dual energy CT**
 2. MRI – Basics of advanced imaging techniques
 - a. Diffusion tensor imaging (principles of DTI)
 - b. Functional MRI (principles of BOLD)**
 - c. MR artifacts
 - d. MR perfusion (use in neoplasms and stroke)
 - e. MR spectroscopy (NAA, Choline, lactate)**
 - f. Susceptibility weighted imaging
 3. Myelography
 4. Cisternography
 5. Digital Subtraction Angiography- Observe, indications, anatomy
 6. Be able to choose appropriate examination types for a variety of clinical situations and recognize strengths and weakness of each type of imaging exam- ACR Appropriateness Criteria® (<http://www.acr.org/Quality-Safety/Appropriateness-Criteria>)

II. ANATOMY

1. **White matter- normal myelination**

III. BRAIN PATHOLOGY

1. Stroke –
 - a. Hypoxic ischemic encephalopathy (HIE)-Preterm, Term and Adults
 - b. Vasculitis
 - c. Posterior reversible encephalopathy syndrome (PRES)
 - d. Risks and benefits of and imaging after thrombolysis/ neurointerventional procedures
2. Tumor- MR Perfusion techniques, **MR spectroscopy, RANO Criteria**
3. Hemorrhage- underlying lesions, active bleeds
4. Vascular- atherosclerosis, vasculopathies, venous thrombosis, arteriovenous malformations, vascular injuries
5. CNS infections-
 - a. Congenital Infections-CMV, Toxoplasmosis
 - b. Fungal and less common infections
 - c. Sequelae of infections
 - d. AIDS and complications
 - e. Routes of spread of non CNS infections to brain
6. White matter-
 - a. Inherited metabolic disorders (limited)
 - b. Demyelinating and dysmyelinating diseases- toxic and metabolic

7. Neurodegenerative- Alzheimer's, metabolic, infectious (Prion disease)
8. Cranial Nerve Pathologies- Schwannomas, leptomeningeal carcinomatosis, perineural spread, infection (Lyme), inflammation (Sarcoid)
9. Congenital/developmental-
 - a. Brain malformations- Chiari 1 and 2, Holoprosencephaly, Dandy Walker spectrum
 - b. Corpus callosum anomalies-agenesis/dysgenesis
 - c. Sulcation and migrational anomalies
 - d. Phakomatoses- NF1, NF2, Tuberous sclerosis, Sturge Weber and von Hippel Lindau
10. Epilepsy- malformations of cortical development
 - a. Hemimegalencephaly
 - b. Heterotopia
 - c. Polymicrogyria, Lissencephaly and schizencephaly
 - d. Focal cortical dysplasia
11. Toxic/Metabolic- Alcoholic, Wilson's, Hepatic encephalopathy, Osmotic demyelination, Chemotherapy, drug abuse

IV. SPINE PATHOLOGY

1. Congenital-
 - a. Neural tube defects-Myelomeningocele, Lipomyelomeningocele, Lipomas, Dermoid, Caudal Regression, Sacrococcygeal Teratoma
 - b. Segmentation anomalies
 - c. Phacomatoses -NF1, NF2
 - d. Congenital/Metabolic/Connective tissue-- Osteogenesis Imperfecta, Marfan's, Osteopetrosis,
 - e. Craniovertebral junction variants-Platybasia, Basilar invagination
2. Spine vascular- infarcts, vascular malformations
3. Miscellaneous- arachnoid cysts, cord herniation, DISH, OPLL, Longus coli tendonitis
4. Spinal manifestations of systemic diseases/Arthritis -Sickle cell, renal/dialysis, Gout/ CPPD, seronegative spondyloarthropathy, rheumatoid arthritis
5. Post procedural imaging and complications- MRI findings- hemorrhage, soft tissue injury, arachnoiditis
6. Nerve plexus- Brachial and Lumbosacral-anatomy and pathology

V. HEAD AND NECK PATHOLOGY

1. Sinonasal tumors- nodal and perineural spread
2. Orbital tumors- Retinoblastoma, Lymphoma, optic glioma, meningioma
3. Orbital Infections and Inflammation-Preseptal versus post septal, endophthalmitis, optic neuritis, pseudotumor, PHPV, retinopathy of prematurity, thyroid orbitopathy
4. Congenital skull base variants and pathologies- nasal masses, meningioma, fibrous dysplasia, chordoma, cartilaginous tumors
5. Pharyngeal and laryngeal tumors-benign and malignant

6. Mandible/maxilla –cysts, infections, tumors, fractures
7. Salivary gland - infections and tumors
8. Temporal bone pathology
 - a. Cholesteatoma and cholesterol granuloma
 - b. Facial nerve & internal auditory canal enhancement differential diagnosis
 - c. Fractures
 - d. Glomus tumors
 - e. Vascular anomalies – Aberrant carotid artery, vascular dehiscence
 - f. EAC atresia
 - g. Otitis Externa
 - h. Coalescent Mastoiditis
 - i. SCCD and EVAS/LESA
 - j. Otospongiosis
9. Neck- pediatric cysts and tumors, venolymphatic malformations
10. Postsurgical/ Post treatment Neck
11. Calvarial Lesions- Craniosynostoses, Fibrous dysplasia, Paget's, Histiocytosis