The American College of Radiology, with more than 30,000 members, is the principal organization of radiologists, radiation oncologists, and clinical medical physicists in the United States. The College is a nonprofit professional society whose primary purposes are to advance the science of radiology, improve radiologic services to the patient, study the socioeconomic aspects of the practice of radiology, and encourage continuing education for radiologists, radiation oncologists, medical physicists, and persons practicing in allied professional fields.

The American College of Radiology will periodically define new practice guidelines and technical standards for radiologic practice to help advance the science of radiology and to improve the quality of service to patients throughout the United States. Existing practice guidelines and technical standards will be reviewed for revision or renewal, as appropriate, on their fifth anniversary or sooner, if indicated.

Each practice guideline and technical standard, representing a policy statement by the College, has undergone a thorough consensus process in which it has been subjected to extensive review, requiring the approval of the Commission on Quality and Safety as well as the ACR Board of Chancellors, the ACR Council Steering Committee, and the ACR Council. The practice guidelines and technical standards recognize that the safe and effective use of diagnostic and therapeutic radiology requires specific training, skills, and techniques, as described in each document. Reproduction or modification of the published practice guideline and technical standard by those entities not providing these services is not authorized.

Revised 2011 (Resolution 34)*

ACR–ASNR–ASSR–SPR PRACTICE GUIDELINE FOR THE PERFORMANCE OF COMPUTED TOMOGRAPHY (CT) OF THE SPINE

PREAMBLE

These guidelines are an educational tool designed to assist practitioners in providing appropriate radiologic care for patients. They are not inflexible rules or requirements of practice and are not intended, nor should they be used, to establish a legal standard of care. For these reasons and those set forth below, the American College of Radiology cautions against the use of these guidelines in litigation in which the clinical decisions of a practitioner are called into question.

The ultimate judgment regarding the propriety of any specific procedure or course of action must be made by the physician or medical physicist in light of all the circumstances presented. Thus, an approach that differs from the guidelines, standing alone, does not necessarily imply that the approach was below the standard of care. To the contrary, a conscientious practitioner may responsibly adopt a course of action different from that set forth in the guidelines when, in the reasonable judgment of the practitioner, such course of action is indicated by the condition of the patient, limitations of available resources, or advances in knowledge or technology subsequent to publication of the guidelines. However, a practitioner who employs an approach substantially different from these guidelines is advised to document in the patient record information sufficient to explain the approach taken.

The practice of medicine involves not only the science, but also the art of dealing with the prevention, diagnosis, alleviation, and treatment of disease. The variety and complexity of human conditions make it impossible to always reach the most appropriate diagnosis or to predict with certainty a particular response to treatment. Therefore, it should be recognized that adherence to these guidelines will not assure an accurate diagnosis or a successful outcome. All that should be expected is that the practitioner will follow a reasonable course of action based on current knowledge, available resources, and the needs of the patient to deliver effective and safe medical care. The sole purpose of these guidelines is to assist practitioners in achieving this objective.

I. INTRODUCTION

This guideline was developed collaboratively by the American College of Radiology (ACR), the American Society of Neuroradiology (ASNR), the American Society of Spine Radiology (ASSR), and the Society for Pediatric Radiology (SPR).

Computed tomography (CT) is a technology using ionizing radiation to generate images resulting from differential X-ray absorption of the specific tissues examined. CT produces cross-sectional displays and multidimensional 2D and 3D reconstructions and therefore offers a well-accepted high degree of clinical capability and utility for examining the spine. This guideline outlines the principles for performing high-quality CT imaging of the pediatric and adult spine.

II. INDICATIONS

The complete clinical evaluation of spinal disorders may require the use of several different imaging modalities. Depending on the nature of the disorder, CT may be the primary modality used or it may complement other modalities such as radiography, magnetic resonance (MR), ultrasound (US) or nuclear imaging studies. The strength of CT lies in the detailed depiction of bone, and

therefore it has greatest utility in evaluating the bony spine, as opposed to the spinal cord or other soft tissue structures. Additionally, CT may also play an important role in performing and monitoring invasive diagnostic and therapeutic procedures.

Primary indications for CT of the spine include, but are not limited to:

1. Traumatic injuries, including evaluation of acute injuries and their potential chronic/long term reparative changes. CT of the spine is particularly useful in and is considered a primary imaging evaluation of acute spine trauma in adults. However, given that the vast majority of cervical spine injuries in young children are of soft tissue rather than bone, it should be recognized that the use of CT in this population is of limited utility. If there is a clinical concern for spinal injury, MRI should be considered in pediatric patients. CT may be used when radiographs of a spinal segment (cervical, thoracic, lumbar, and/or sacral spine) are abnormal, equivocal, or nondiagnostic following a traumatic event. CT can be used for evaluating vertebral compression/insufficiency fractures in both acute and chronic clinical situations [1-15].
2. Degenerative conditions and osteoarthritis evaluation. CT is often used to study the spine for conditions such as lumbar stenosis or in evaluating degenerative disc disease, and is the primary evaluation technique when MRI is contraindicated (e.g., the presence of cardiac pacemaker or other implants that are not MRI compatible) [16-28].
3. Postoperative evaluations. CT has shown utility in evaluating postoperative patients with bone graft placement for fusion and/or with spinal instrumentation. The latter is sometimes performed with the additional use of an intrathecal contrast agent [29-30].
4. Infectious processes of the spine and related paraspinal tissues/structures [31].
5. Image guidance. CT of the spine can be used for imaging guidance before, during, and after various spine interventions, including myelography, biopsy, aspiration, stereotactic surgery, and spine injection procedures [32-33].
6. Neoplastic conditions and their complications. CT can provide valuable information in the evaluation of primary or metastatic neoplasms of the spine, to include marrow-replacing conditions such as multiple myeloma. It can also provide valuable information in relation to complications of neoplastic disease, including misalignment and pathologic vertebral compression fractures [34-36].
7. Evaluation of inflammatory lesions and crystal deposition disease, including presence and extent of involvement [37].
8. Congenital or developmental spine abnormalities. CT can provide valuable information in the evaluation of the osseous components of congenital spinal anomalies [38].
9. Abnormalities related to alignment or orientation of the spine, such as scoliosis or spondylolysis with or without spondylolisthesis [39-41].
10. Evaluation of spinal cord syrinxes and other primary processes involving the spinal cord, especially in the evaluation of intrathecal metastases, often in combination with intrathecal contrast use, in situations where MRI is contraindicated.

For the pregnant or potentially pregnant patient, see the ACR Practice Guideline for Imaging Pregnant or Potentially Pregnant Adolescents and Women with Ionizing Radiation.

III. QUALIFICATIONS AND RESPONSIBILITIES OF PERSONNEL

See the ACR Practice Guideline for Performing and Interpreting Diagnostic Computed Tomography (CT).

IV. SPECIFICATIONS OF THE EXAMINATION

A. Written Request for the Examination

The written or electronic request for CT of the spine should provide sufficient information to demonstrate the medical necessity of the examination and allow for its proper performance and interpretation.

Documentation that satisfies medical necessity includes 1) signs and symptoms and/or 2) relevant history (including known diagnoses). Additional information regarding the specific reason for the examination or a provisional diagnosis would be helpful and may at times be needed to allow for the proper performance and interpretation of the examination.

The request for the examination must be originated by a physician or other appropriately licensed health care provider. The accompanying clinical information should be provided by a physician or other appropriately licensed health care provider familiar with the patient's clinical problem or question and consistent with the state's scope of practice requirements. (ACR Resolution 35, adopted in 2006)

B. General Considerations

CT protocols require close attention and development by the supervising physician. They should be tailored to specify indications and to optimize the balance between image quality and radiation dose. See section VII for further information on radiation safety. Protocols should

be reviewed and updated periodically in light of new information, techniques and technology. The supervising physician should be familiar with indications for each examination and the patient history (including potential adverse reactions to contrast media). The supervising physician should also be familiar with the protocol specifications, to include exposure factors, field of view, collimation, slice spacing or pitch, and image reconstruction algorithms**.** These factors should be adjusted to minimize radiation dosage to the minimum level required to adequately perform the specific examination. The location of axial images should be indicated relative to a scout image and/or reconstructed sagittal or coronal images.

C. Spine Imaging

CT scanning provides exquisite depiction of bone detail. CT spine imaging may be performed with a sequential single-slice technique or with single or multidetector helical protocol. For CT of the spine, contiguous or overlapping axial slices with an optimal slice thickness, depending on the spinal segment of interest, are preferred. Spine CT examinations may include a series of multiplanar reformations, preferably in orthogonal planes, such as sagittal and coronal. Additionally, isometric reconstructed images parallel to the disk could be performed.

Images should be reviewed at window and level settings that are appropriate for demonstrating a range of display densities, including soft tissue and bony abnormalities. Given the availability of several different types of CT scanners from different manufacturers, consultation with the manufacturer regarding protocol recommendations is advised in order to optimize spatial and contrast resolution.

It is important that the history be reviewed so that the examination is obtained at the appropriate level where the patient is symptomatic. If the patient's symptoms are limited to a given level, CT of the entire spine segment may not be necessary; for example, if spondylolysis at L5-S1 is suspected from clinical examination and from plain radiographs, CT of the entire lumbar spine from T-12 down is not necessary. This is particularly important in younger and pediatric patients.

1. Cervical spine
   Evaluation of the craniocervical junction and cervical spine requires thin sections for definitive diagnosis. The reconstructed scan width should be no greater than 3 mm. Primary evaluation for the effects of cervical disk or facet degeneration should include 1 to 3 mm contiguous slices or axial reformats aligned to the disk space obtained from pedicle to pedicle for each disk space assessed in both bone and soft tissue algorithms.

2. Thoracic spine and lumbar spine
   Acceptable technique (for all entities except evaluation of spine fusion integrity): Effective slice thickness should be no greater than 3 mm. Diagnostic reformation can be made from these images. The field of view should always be as small as appropriate to improve geometric resolution. For evaluating spine fusion, 1 to 2 mm contiguous slices of the involved spinal segment(s) and at least a portion of the adjacent cranial and caudal normal segments within the acquisition volume will allow a greater degree of certainty in detecting pseudarthrosis. Reformations may be helpful for detecting solid or failed fusion. Primary evaluation for the effects of lumbar disk or facet degeneration may include 2 to 3 mm contiguous slices or axial reformats aligned to the disk space obtained from pedicle to pedicle for each disk space assessed in both bone and soft tissue algorithms.

D. Contrast Studies

Certain clinical indications require the use of intravenous, intrathecal, epidural, perineural, or intra-articular contrast agents. Intravenous contrast administration should be performed using appropriate injection protocols and in accordance with the ACR–SPR Practice Guideline for the Use of Intravascular Contrast Media. Intrathecal contrast administration requires the use of nonionic agents approved specifically for intrathecal use and should be performed in accordance with guidelines outlined in the ACR–ASNR Practice Guideline for the Performance of Myelography and Cisternography.

E. Advanced Applications

In addition to directly acquired axial images, 2D reformatted images in any plane, 3D reformatted images as appropriate, and/or other more complex planes may be constructed from the axial data set to address specific clinical questions, or the images may be manipulated in order to allow selective visualization of specific tissues. Such applications are optimally performed with the original data sets as acquired on a multidetector CT scanner.

V. DOCUMENTATION

Reporting should be in accordance with the ACR Practice Guideline for Communication of Diagnostic Imaging Findings.

VI. EQUIPMENT SPECIFICATIONS

Patient monitoring equipment and facilities for cardiopulmonary resuscitation, including vital signs monitoring, support equipment, and an emergency crash cart, should be immediately available. Radiologists, technologists, and staff members should be able to assist with procedures, patient monitoring, and patient support. A written policy should be in place for dealing with emergency situations such as cardiopulmonary arrest.

For diagnostic quality spine CT, the scanner should meet or exceed the following specifications [42-44]:

1. Type of scanner: single detector row, multiple detector row, helical capability optional, or electron beam CT.
2. Gantry rotation period: 1 second or less.
3. Tube heat capacity to allow for study completion.
4. Reconstructed scan width: 1 to 3 mm.
5. Beam pitch: no greater than 2:1 for single-row or multi-row detector helical scanners.
6. Spatial resolution: minimum of 512 matrix.
7. Tube current modulation, if available, should be used whenever possible, and when study quality will not be significantly compromised.
8. Radiation dose reduction techniques should be used to further reduce exposure to patients in all age groups.

Appropriate emergency equipment and medications must be immediately available to treat adverse reactions associated with administered medications. The equipment and medications should be monitored for inventory and drug expiration dates on a regular basis. The equipment, medications, and other emergency support must also be appropriate for the range of ages and sizes in the patient population.

VII. RADIATION SAFETY IN IMAGING

Radiologists, medical physicists, radiologic technologists, and all supervising physicians have a responsibility to minimize radiation dose to individual patients, to staff, and to society as a whole, while maintaining the necessary diagnostic image quality. This concept is known as "as low as reasonably achievable (ALARA)."

Facilities, in consultation with the medical physicist, should have in place and should adhere to policies and procedures, in accordance with ALARA, to vary examination protocols to take into account patient body habitus, such as height and/or weight, body mass index or lateral width. The dose reduction devices that are available on imaging equipment should be active; if not; manual techniques should be used to moderate the exposure while maintaining the necessary diagnostic image quality. Periodically, radiation exposures should be measured and patient radiation doses estimated by a medical physicist in accordance with the appropriate ACR Technical Standard. (ACR Resolution 17, adopted in 2006 – revised in 2009, Resolution 11)

Decisions regarding the use of CT should take into account the potential adverse effects of ionizing radiation exposure, especially in the pediatric population. Accordingly, the use of other imaging techniques that do not rely on ionizing radiation should be considered where appropriate.

Facilities should have specifically designated, size-appropriate protocols, distinct from adult protocols, for performing CT in pediatric patients.

VIII. QUALITY CONTROL AND IMPROVEMENT, SAFETY, INFECTION CONTROL, AND PATIENT EDUCATION

Policies and procedures related to quality, patient education, infection control, and safety should be developed and implemented in accordance with the ACR Policy on Quality Control and Improvement, Safety, Infection Control, and Patient Education appearing under the heading *Position Statement on QC & Improvement, Safety, Infection Control, and Patient Education* on the ACR web site (http://www.acr.org/guidelines).

A comprehensive CT quality-control program should be documented and maintained at the facility. The program should help to minimize radiation risk to the patient, facility personnel, and the public and to maximize the quality of the diagnostic information. CT facility personnel must adhere to radiation safety regulations when inside the scanner room. Overall program responsibility should remain with the physician, but specific program implementation should be supervised by the medical physicist or service engineer in compliance with local and state regulations, as well as manufacturer specifications. A list of quality-control tests, frequency of performance, and description of the procedure as well as a list of individuals or groups performing each should be maintained. Moreover, the parameters of technique, equipment testing, and acceptability of limits for each test should also be maintained in addition to sample records from each test. Quantitative dose determination should be conducted periodically by a certified medical physicist, in addition to equipment performance monitoring, as per ACR recommendations.

The supervising physician should review all practices and policies at least annually. Policies with respect to contrast and sedation must be administered in accordance with institutional policy as well as state and federal regulations. A physician should be available on-site whenever contrast and/or sedation is administered.

Equipment performance monitoring should be in accordance with the ACR–AAPM Technical Standard for Diagnostic Medical Physics Performance Monitoring of Computed Tomography (CT) Equipment.

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