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

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### **PREAMBLE**

This document is an educational tool designed to assist practitioners in providing appropriate radiologic care for patients. Practice Parameters and Technical Standards are not inflexible rules or requirements of practice and are not intended, nor should they be used, to establish a legal standard of care<sup>1</sup>. For these reasons and those set forth below, the American College of Radiology and our collaborating medical specialty societies caution against the use of these documents 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 practitioner in light of all the circumstances presented. Thus, an approach that differs from the guidance in this document, 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 this document 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 this document. However, a practitioner who employs an approach substantially different from the guidance in this document 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 the guidance in this document 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 this document is to assist practitioners in achieving this objective.

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<sup>1</sup> *Iowa Medical Society and Iowa Society of Anesthesiologists v. Iowa Board of Nursing*, \_\_\_ N.W.2d \_\_\_ (Iowa 2013) Iowa Supreme Court refuses to find that the *ACR Technical Standard for Management of the Use of Radiation in Fluoroscopic Procedures* (Revised 2008) sets a national standard for who may perform fluoroscopic procedures in light of the standard's stated purpose that ACR standards are educational tools and not intended to establish a legal standard of care. See also, *Stanley v. McCarver*, 63 P.3d 1076 (Ariz. App. 2003) where in a concurring opinion the Court stated that "published standards or guidelines of specialty medical organizations are useful in determining the duty owed or the standard of care applicable in a given situation" even though ACR standards themselves do not establish the standard of care.

## I. INTRODUCTION

This practice parameter 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 2-D and 3-D reconstructions and therefore offers a well-accepted high degree of clinical capability and utility for examining the spine. This practice parameter 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. CT can be used for evaluating vertebral compression/insufficiency fractures in both acute and chronic clinical situations [1-14]
2. Given that the vast majority of cervical spine injuries in young children (especially those <3 years old) are of soft tissue rather than bone and considering the special vulnerability of this patient population to radiation, it should be recognized that the use of CT in this population may be of limited utility. If there is a clinical concern for spinal injury, MRI (by itself or in conjunction with clinical observation) should be considered in pediatric patients as an alternative or complement to a targeted CT of the area of concern.
3. Degenerative conditions and osteoarthritis evaluation. CT is often used to study the spine for conditions such as lumbar stenosis or in evaluating disc degeneration and is the primary evaluation technique when MRI is contraindicated (eg, the presence of cardiac pacemaker or other implants that are not MRI compatible) [15-20]. Additionally, in evaluating these conditions, CT may be helpful for presurgical planning and is complementary to MRI. CT for this application is sometimes performed with the additional use of an intrathecal contrast agent.
4. Evaluation of inflammatory lesions and deposition diseases, including presence and extent of involvement. CT for this application is sometimes performed with the additional use of an intrathecal contrast agent.
5. Abnormalities related to alignment or orientation of the spine, such as scoliosis or spondylolysis with or without spondylolisthesis [21,22]
6. 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 [23,24].
7. Infectious processes of the spine and related paraspinal tissues/structures [25]
8. 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 [26].
9. Image guidance. CT of the spine can be used for imaging guidance before, during, and after various spine interventions (eg intrathecal contrast, biopsy, aspiration, stereotactic surgery, and spine injection procedures) [27,28].

10. Congenital or developmental spine abnormalities. CT can provide valuable information in the evaluation of the osseous components of congenital spinal anomalies.
11. 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–SPR Practice Parameter for Imaging Pregnant or Potentially Pregnant Adolescents and Women with Ionizing Radiation](#) [29].

### **III. QUALIFICATIONS AND RESPONSIBILITIES OF PERSONNEL**

See the [ACR Practice Parameter for Performing and Interpreting Diagnostic Computed Tomography \(CT\)](#) [30].

### **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 the specific indication 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 must include a series of multiplanar reformations, minimally in sagittal and coronal planes orthogonal to the acquired images, often supported by isometric reconstructed images in clinically appropriate oblique plane(s) as well as parallel to each disc level. In the postoperative spine, metal-artifact-reduction imaging techniques may be used, if available [31,32].

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. This can be facilitated by reconstruction of images with soft-tissue and bony algorithms. 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 clinical information be reviewed so that the examination is obtained at the appropriate level where the patient is symptomatic. If the patient's signs and 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 T12 down is not necessary. This is particularly important in pediatric patients [33]. Caution should be applied in the presence of a transitional anomaly.

1. Cervical spine

Evaluation of the craniocervical junction (skull base structures including sella and clivus) 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 disc or facet degeneration should include 1- to 3-mm contiguous slices or axial reformats obtained from pedicle to pedicle for each disc space, assessed in both bone and soft-tissue algorithms. Oblique reformats perpendicular to the long axis of the neural foramina on both sides can sometimes be helpful in the assessment of neural foraminal stenosis.

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 5 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, 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 pseudoarthrosis. Three-dimensional and/or multiplanar reformations may be helpful for detecting solid or failed fusion.

#### D. Pediatric CT Spine Imaging

General radiography remains the first-line modality for the traumatized pediatric spine. CT imaging of the spine, especially the cervical spine, can be problematic in the infant due to epiphyseal variants, incomplete ossification of synchondroses, normal ligamentous laxity, and the propensity for ligamentous rather than bone injury. Anatomic and age-related variants may mimic injury and prompt additional, potentially unnecessary, imaging. Cervical spine injury in young children most commonly occurs from the occiput through C3 and typically involves the ligaments to a greater extent than osseous structures. Although CT with multiplanar reconstruction improves the detection of fractures, CT is insensitive to ligamentous, capsular, and soft-tissue injury, and the potential risk from the radiation to the thyroid should be considered. Spinal cord injury may occur without radiographic abnormalities, and a normal CT may result in a false-negative diagnosis after accidental or nonaccidental trauma. Magnetic resonance is therefore the preferred modality in traumatized infants. In older children generally 7 years and older, cervical spine injury has a similar distribution as in adults, and imaging workup strategies should be similar to those employed in adults [34-41].

The effective dose to children from CT of the spine varies significantly depending on age and protocol. One study recorded pediatric variations from 0.6 to 42 mSv [42]. Pediatric CT spine imaging should therefore be limited to regions of radiographic and/or clinical concern and acquired using the lowest possible radiation exposure. A number of public resources are available to medical personnel that stress the importance of dose reduction in children. They include Image Gently ([www.imagegently.org](http://www.imagegently.org)), *Radiation Risks and Pediatric Computed Tomography: A Guide for Health Care Providers* (<http://www.cancer.gov/about-cancer/causes-prevention/risk/radiation/pediatric-ct-scans>), and the FDA Public Health Notification, *Reducing Radiation Risk from Computed Tomography for Pediatric and Small Adult Patients* (<http://www.fda.gov/MedicalDevices/Safety/AlertsandNotices/PublicHealthNotifications/ucm062185.htm>).

## E. 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 Parameter for the Use of Intravascular Contrast Media](#) [43]. Intrathecal contrast administration requires the use of nonionic agents approved specifically for intrathecal use and should be performed in accordance with parameters outlined in the [ACR–ASNR–SPR Practice Parameter for the Performance of Myelography and Cisternography](#) [44].

## F. Advanced Applications

In addition to directly acquired axial images, 2-D reformatted images in any plane, 3-D 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 Parameter for Communication of Diagnostic Imaging Findings](#) [45].

## 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 [46-48]:

1. Type of scanner: single detector row, multiple detector row, helical capability optional, electron beam CT, spectral CT or dual-energy CT optional
2. Gantry rotation period: 1 second or less
3. Tube heat capacity to allow for study completion
4. Reconstructed scan width: 1 to 5 mm
5. Beam pitch: no greater than 2:1 for single-row or multirow detector helical scanners
6. Spatial resolution: minimum of 512 matrix
7. Dose reduction techniques, such as tube-current modulation and iterative reconstruction, should be used to reduce exposure to patients.
8. Radiation monitoring techniques and equipment to track patient radiation exposure preferred

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, registered radiologist assistants, radiologic technologists, and all supervising physicians have a responsibility for safety in the workplace by keeping radiation exposure to staff, and to society as a whole, “as low as reasonably achievable” (ALARA) and to assure that radiation doses to individual patients are appropriate, taking into account the possible risk from radiation exposure and the diagnostic image quality

necessary to achieve the clinical objective. All personnel that work with ionizing radiation must understand the key principles of occupational and public radiation protection (justification, optimization of protection and application of dose limits) and the principles of proper management of radiation dose to patients (justification, optimization and the use of dose reference levels)

[http://www-pub.iaea.org/MTCD/Publications/PDF/Pub1578\\_web-57265295.pdf](http://www-pub.iaea.org/MTCD/Publications/PDF/Pub1578_web-57265295.pdf).

Nationally developed guidelines, such as the ACR's [Appropriateness Criteria®](#), should be used to help choose the most appropriate imaging procedures to prevent unwarranted radiation exposure.

Facilities should have and adhere to policies and procedures that require varying ionizing radiation examination protocols (plain radiography, fluoroscopy, interventional radiology, CT) to take into account patient body habitus (such as patient dimensions, weight, or body mass index) to optimize the relationship between minimal radiation dose and adequate image quality. Automated dose reduction technologies available on imaging equipment should be used whenever appropriate. If such technology is not available, appropriate manual techniques should be used.

Additional information regarding patient radiation safety in imaging is available at the Image Gently® for children ([www.imagegently.org](http://www.imagegently.org)) and Image Wisely® for adults ([www.imagewisely.org](http://www.imagewisely.org)) websites. These advocacy and awareness campaigns provide free educational materials for all stakeholders involved in imaging (patients, technologists, referring providers, medical physicists, and radiologists).

Radiation exposures or other dose indices should be measured and patient radiation dose estimated for representative examinations and types of patients by a Qualified Medical Physicist in accordance with the applicable ACR technical standards. Regular auditing of patient dose indices should be performed by comparing the facility's dose information with national benchmarks, such as the ACR Dose Index Registry, the NCRP Report No. 172, Reference Levels and Achievable Doses in Medical and Dental Imaging: Recommendations for the United States or the Conference of Radiation Control Program Director's National Evaluation of X-ray Trends. (ACR Resolution 17 adopted in 2006 – revised in 2009, 2013, Resolution 52).

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 website (<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 Qualified Medical Physicist 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](#) [49].

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