Revised 2022 (Resolution 23)*

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

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[1]. 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.

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).

[1] Iowa Medical Society and Iowa Society of Anesthesiologists v. Iowa Board of Nursing, 831 N.W.2d 826 (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.

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 allows for multidimensional 2-D and 3-D reconstructions and offers a high degree of clinical 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; therefore, it has greatest utility in evaluating the osseous spine, as opposed to soft-tissue structures, such as the spinal cord. 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. Adult Spine Trauma
   CT of the spine is considered a primary imaging evaluation of acute spine trauma in adults [1,2]. Meta-analysis of blunt thoracolumbar trauma has demonstrated that CT is more accurate than radiographs for detecting thoracic and lumbar spine fractures [3]. CT with intrathecal contrast (CT myelography) may be used to evaluate spinal canal pathology related to trauma when MRI is contraindicated.

   CT can be used for evaluating vertebral compression/insufficiency fractures in both acute and chronic clinical situations [1,4-17]. Advances such as dual-layer spectral CT have demonstrated higher accuracy in detection of acute osteoporotic vertebral body fracture bone marrow edema compared to conventional CT images [18].

2. Pediatric Spine Trauma
   CT is the primary modality of choice for pediatric patients who are obtunded or with low neurological score with multiple sites of injury and/or high risk of mechanism of injury [19]. In some institutions, brain CT will include C1 to C3 of the cervical spine in pediatric patients with multiple injuries [19,20]. Other practices advise obtaining a separate cervical spine CT with a lower dose than head CT if there is clinical concern of spinal injury. Given that the majority of cervical spine injuries in children <8 years old (especially those <3 years old) are of soft tissue rather than bone, 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 younger pediatric patients as an alternative or complement to a targeted CT of the area of concern.

3. Degenerative Changes
   CT is often used to study the spine for conditions such as spinal stenosis or in evaluating disc degeneration when MRI is contraindicated. CT with intrathecal contrast (CT myelography) is better at delineating the spinal canal and neural foramina in degenerative conditions. CT provides superior osseous delineation and may be complementary to MRI for surgical planning [21]. For more information on CT myelography, see the ACR–ASNR–SPR Practice Parameter for the Performance of Myelography and Cisternography [22]. Additionally, in evaluating these conditions, CT may be helpful for presurgical planning and is complementary to MRI.
4. Inflammatory Conditions
   CT shows the presence and extent of osseous structural changes of the spine in the evaluation of inflammatory lesions and deposition diseases [23,24]. Structural changes of the bone in inflammatory spondyloarthropathies are well delineated on CT [25]. In ankylosing spondylitis, for example, CT is sensitive for syndesmophytes [25] and ankyloses [26], fracture, and Andersson lesions [27]. Progression of syndesmophytes in ankylosing spondylitis can be assessed on CT, which can contribute to sagittal malalignment [28]. CT for this application can be performed with the additional use of an intrathecal contrast agent to better delineate spinal canal or neural foraminal encroachment (see number 3).

5. Bone Mineral Density
   CT number measurements (in Hounsfield unit) on CT images reflect bone mineral density [29-34]. Opportunistic CT number measurements on abdominal CT images obtained for other reasons [35-38] or on CT scans obtained of arthropathy [39,40], degenerative disease [41], or for sacral fractures [42] can identify patients with osteoporotic bone mineral density without additional radiation exposure or cost. In patients with sacral insufficiency fractures, there is lower regional volumetric bone density of the sacrum when compared to a cohort without fracture; this local sacral volumetric bone density as measured by CT is independent from the areal bone mineral density (BMD) as measured by dual-energy X-ray absorptiometry of the lumbar spine [43]. Furthermore, deep learning can be used to predict BMD of lumbar vertebrae from unenhanced abdominal CT images [44]. In degenerative lumbar spine surgery, measurements with higher CT number results are associated with lower rates of pseudarthrosis [45]. Despite the opportunistic utility of lumbar spine CT number measurements in identifying osteoporosis in patients undergoing single-level fusion, these measurements have not been shown to be useful in adult spinal deformity patients [46]. Other CT related modalities for quantitatively measuring bone metabolism include areal bone mineral density measurement based on dual-layer spectral CT scout scans [47], quantitative bone SPECT/CT [48] and quantitative CT or spectral detector CT, which is a 3-D method that can measure the trabecular and cortical bone compartments [32,34,49-52].

6. Alignment
   Abnormalities related to alignment or orientation of the spine, such as scoliosis or spondylolysis, can be demonstrated by CT multiplanar reformations, recognizing that the CT is obtained in the supine position, which can affect alignment [53,54].

7. Postoperative Evaluation
   CT has shown utility in evaluating postoperative patients for accurate evaluation of osseous detail, implant/bone graft position, fusion, and spinal instrumentation integrity [55]. CT myelography may be useful for spinal canal and neural foraminal assessment in the setting of extensive hardware [56-59]. Quantitative CT can show decreased volumetric BMD in adjacent levels [60]. Integrated bone SPECT/CT is a useful problem-solving modality in evaluating patients with persistent or recurring pain after spinal surgery to identify areas of pseudarthrosis, adjacent segment degeneration, hardware failure, and/or segmental motion [61,62]. SPECT/CT can also provide structural and functional information to help identify pain generators in spine-related pain [63-66], which can guide treatment [67].

8. Infectious Processes
   Infectious processes of the spine and paraspinal tissues can be evaluated on CT, recognizing that osseous changes usually trail the clinical presentation [68]. Contrast-enhanced CT can be performed to demonstrate the extent of soft-tissue involvement, particularly when MRI is not feasible. CT is complementary to MRI in demonstrating osseous involvement and features that can optimize image-guided biopsy [69] and those that are associated with poor clinical outcome [70]. Bone and gallium SPECT/CT is complementary to MRI in the diagnosis of infectious spondylodiscitis [71].

9. Neoplastic Conditions and Complications
   CT can provide valuable information in the evaluation of primary or metastatic neoplasms of the spine, including marrow-replacing conditions such as multiple myeloma. MRI and CT are often complementary in evaluating the bone lesions. It can also provide valuable information in relation to complications of neoplastic disease, including malalignment and pathologic fractures [72,73], and can provide important information about osseous integrity to guide treatment planning.

10. Image Guidance
   CT of the spine can be used for imaging guidance before [74], during, and after various spine interventions (eg, biopsy [69,75,76], aspiration, radiotherapy, stereotactic surgery [77], and spine injection) [78-80]. CT with intrathecal contrast (CT myelography) may be helpful for preoperative planning. Vascular imaging with CT arteriography can be used to identify critical vascular structures that may be affected by a surgical approach [81]. Intraoperative CT-guided navigation has shown to improve the safety, accuracy, and

reliability of pedicle screw placement [82,83] and to have a lower rate of malpositioned hardware and unplanned returns to the operating room [84-86]. Studies have also shown that intraoperative CT-guided navigation enables adequate neural decompression [87-89] and maximal tumor resection [90]. Additionally, intraoperative CT may reveal nonspinal findings during spine instrumentation surgery [91].

11. Developmental Spine Abnormalities
    CT can provide valuable information in the evaluation of the osseous components of developmental spinal anomalies and delineate developmental variants that might mimic fractures, complementary to MRI, which is typically the first line of imaging in these evaluations [92]. Three-dimensional surface rendering images can aid in visualization of these anatomic differences [93].

    Depending on the age of the pediatric patient, CT may aid in identifying variations in ossification centers in the setting of trauma or pain to rule out fracture [19].

Evaluation of intradural spinal canal pathologies, such as intradural metastases or arachnoid adhesions, is performed using CT with intrathecal contrast (CT myelography) in situations in which MRI is contraindicated. Primary spinal cord pathologies such as syrinxes are better assessed by MRI, but when MRI is contraindicated, CT with intrathecal contrast (CT myelography) may provide some limited information [94].

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 [95].

III. QUALIFICATIONS AND RESPONSIBILITIES OF PERSONNEL

See the ACR Practice Parameter for Performing and Interpreting Diagnostic Computed Tomography (CT) [96].

IV. SPECIFICATIONS OF THE EXAMINATION

A. Written Request for the Examination

The written or electronic request for a 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 – revised in 2016, Resolution 12-b)

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, including exposure factors, field of view (FOV), 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

Helical acquisition with reconstruction of contiguous or overlapping axial slices at an optimal slice thickness depending on the spinal segment of interest is required. It is beneficial in spine CT examinations to review multiplanar reformations.

Metal artifacts caused by osteosynthetic material can impair image quality and degrade the diagnostic yield of CT scans. In addition to conventional techniques (increasing tube current and increasing kV and peak voltage, narrow collimation), metal-related artifacts can be reduced to some extent in different image reconstruction algorithms such as iterative and projection-based approaches [97-99]. Other options such as dual-energy techniques [100,101] and raw-data-based metal artifact reduction with iterative or projection-based algorithms reported a significant reduction of metal artifacts and improved evaluation of periarticular soft tissues compared to iterative projections alone [97,99,102-107], when available.

Images should be reviewed at window and level settings that are appropriate for demonstrating a range of display densities, including soft-tissue and osseous abnormalities. This can be facilitated by reconstruction of images with soft-tissue and osseous 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 in which 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 [20]. Caution should be applied in the presence of transitional anatomy. It is also important to be familiar with development variants that might mimic fractures [92].

1. Cervical spine
   Multidetector CT imaging is the first choice modality for evaluation of cervical spine trauma in adults with excellent image quality, up to 99% sensitivity and 100% of specificity for cervical spine fractures [108].

   Evaluation of the craniocervical junction (skull base structures including sella and clivus) and cervical spine requires thin sections for definitive diagnosis. Multiplanar reformations (sagittal and coronal) help identify the exact location and displacement of fractures and define the extent of potential spinal canal, neural foraminal, or vascular compromise. The reconstructed scan width should be no greater than 2 mm [1]. 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 2 mm [1] to allow for diagnostic reformation. The FOV 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 pseudarthrosis. Three-dimensional and/or multiplanar reformations may be helpful for detecting solid or failed fusion. In polytrauma patients, patients may undergo CT scans of the chest, abdomen, and pelvis to evaluate for other traumatic injuries. Current CT imaging capability allows for reformatting to obtain imaging for screening thoracic, lumbar, and sacral injuries without the need for repeat radiation exposure [109], but it needs to be optimized for this purpose.

D. Pediatric CT Spine Imaging

A systematic algorithm approach using a combination of physical examination findings and radiographs can be used to clear the cervical spine while minimizing radiation owing to the low rate of cervical spine injury in young patients [110]. Two major clinical decision rules, the National Emergency X-Radiography Utilization Study (NEXUS) criteria [111] and the Canadian C-Spine Rule [112], were demonstrated to have high negative predictive values (97% and 100%, respectively) to rule out cervical spine injury in adults without the need for imaging. A pediatric validation study showed that no clinically important injuries were missed when the NEXUS clinical decision rule was used [113]. The ACR Appropriateness Criteria® Suspected Spine Trauma – Child [114] uses the Pediatric Emergency Care Applied Research Network study to identify risk factors associated with cervical spine injury in children 3 to 16 years old and the Pieretti-Vanmarcke score for patients <3 years old [115].

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 because of 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. MR 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 [116-123].

MRI is a more suitable investigation when spinal injuries are suspected, providing better information on soft-tissue injuries as well as bone edema related to osseous injury. Although unstable cervical spine injuries are better detected with CT scans, it is unlikely that these will be missed in the initial radiographs, and most of these patients will be subjected to whole-body CT because of the severity of injury on presentation [124]. In children with clinically suspected spinal fracture in the absence of red flag signs/symptoms and with negative radiographs, further discussion between the emergency department, trauma, surgical spinal team (orthopedic or neurosurgery), and radiology department should consider alternative radiation-free assessment or investigations such as an MRI scan or clinical observation if appropriate to reduce the risk of CT-related radiation and its associated hazards [125,126].

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 [127]. 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), *Radiation Risks and Pediatric Computed Tomography: A Guide for Health Care Providers* (https://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 [128]. Intrathecal contrast administration should be performed in accordance with parameters outlined in the ACR–ASNR–SPR Practice Parameter for the Performance of Myelography and Cisternography [22] and the ACR Manual on Contrast Media [129].

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.

SPECT of the spine may be used as a complementary modality to allow more specific anatomic localization of subtle, nonspecific abnormalities on bone scans, such as pars interarticularis fractures [130], facet joint arthritis, or endplate osteophyte formation [131,132]. It can help distinguish compression fractures from severe degenerative disease. Localizing activity in patients who have had spinal fusion can provide insight into the causes of operative failures [61,62,133]. Functional information from SPECT/CT can guide treatment, such as facet joint injection [134,135] or arthrodesis. Gallium SPECT/CT may be helpful in detection of the site of spinal infections [131].

The applications for dual-energy CT in neuroradiology are expanding. Dual-energy CT offers tissue differentiation and characterization, reduction of artifacts, and remodeling of contrast-to-noise ratio (CNR) and signal-to-noise ratio (SNR). Monoenergetic reconstructions can be used in patients with or without metal implants in the brain and spine to reduce artifacts, improve CNR and SNR, or to improve iodine conspicuity [136-138].

V. DOCUMENTATION

Reporting should be in accordance with the ACR Practice Parameter for Communication of Diagnostic Imaging Findings [139].

VI. EQUIPMENT SPECIFICATIONS

A. Equipment

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 [140-142]:

1. Type of scanner: multiple detector row, helical capability
2. Gantry rotation period: 1 second or less
3. Tube heat capacity to allow for study completion
4. Acquisition slice thickness: <1 mm
5. Reconstructed scan width: 1 to 5 mm
6. Beam pitch: no greater than 2:1 Spatial resolution: > 8 LP/cm for Display FOV 32 cm or greater and >10 LP/cm for Display FOV 24 cm or smaller
7. Dose reduction techniques, such as tube-current modulation, variable tube potential, and advanced reconstruction (eg, iterative), should be used to reduce exposure to patients.
8. Radiation monitoring techniques and the equipment to track radiation exposure

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.

Equipment performance monitoring should be in accordance with the ACR–AAPM Technical Standard for Diagnostic Medical Physics Performance Monitoring of Computed Tomography (CT) Equipment [143].

B. Quality Control

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 Qualified 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.

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.

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) and Image Wisely® for adults (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 Quality Control & Improvement, Safety, Infection Control, and Patient Education* on the ACR website (https://www.acr.org/Advocacy-and-Economics/ACR-Position-Statements/Quality-Control-and-Improvement).

ACKNOWLEDGEMENTS

This practice parameter was revised according to the process described under the heading *The Process for Developing ACR Practice Parameters and Technical Standards* on the ACR website (https://www.acr.org/Clinical-Resources/Practice-Parameters-and-Technical-Standards) by the Committee on Practice Parameters – Neuroradiology of the ACR Commission on Neuroradiology and the Committee on Practice Parameters – Pediatric Radiology of the ACR Commission on Pediatric Radiology in collaboration with the ASNR, ASSR, and the SPR.

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*Practice parameters and technical standards are published annually with an effective date of October 1 in the year in which amended, revised or approved by the ACR Council. For practice parameters and technical standards published before 1999, the effective date was January 1 following the year in which the practice parameter or technical standard was amended, revised, or approved by the ACR Council.

<u>Development Chronology for This Practice Parameter</u>
2006 (Resolution 11, 17, 35)
Amended 2009 (Resolution 11)
Revised 2011 (Resolution 34)
Amended 2014 (Resolution 39)
Revised 2016 (Resolution 15)
Revised 2022 (Resolution 23)