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 parameters 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 parameters and technical standards will be reviewed for revision or renewal, as appropriate, on their fifth anniversary or sooner, if indicated.

Each practice parameter 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 and approval. The practice parameters 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 parameter and technical standard by those entities not providing these services is not authorized.

Revised 2015 (Resolution 20)*

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

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. 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.

1 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 revised collaboratively by the American College of Radiology (ACR), the American Society of Neuroradiology (ASNR), and the Society for Pediatric Radiology (SPR).

Computed tomography (CT) is a technology that produces cross-sectional images of the body using x-rays. Computed tomography (CT) is utilized extensively in imaging of the brain. This practice parameter outlines the principles for performing high-quality CT imaging of the brain in pediatric and adult patients. There should be an effort to minimize radiation exposure, particularly in children. An alternate modality should be considered when possible.

CT of the brain is superior to magnetic resonance imaging (MRI) for the evaluation of osseous structures, acute intracranial hemorrhage, and the detection of calcification, which can be important for the identification of an abnormality or for refinement of a differential diagnosis. CT of the brain is sufficient and diagnostic in many clinical circumstances such as in acute trauma, nontraumatic intracranial hemorrhage, evaluation of shunt malfunction, and selected postoperative follow-up. However, CT is less useful for certain conditions such as subtle neoplastic, infectious, or inflammatory conditions affecting the cranial nerves, brain parenchyma, and meninges. In combination with the clinical history and physical examination findings, CT of the brain is a useful screening tool for indications such as acute mental status change, seizure, acute neurologic deficit, acute headache, and nonacute headache with neurologic findings. CT is useful as a screening modality for the presence of neoplasm and mass effect, particularly in conjunction with intravenous contrast.

II. INDICATIONS

Indications for CT of the brain include, but are not limited to, the following:

A. Primary Indications
   1. Acute head trauma [1-5]
   2. Suspected acute intracranial hemorrhage [6-8]
   3. Vascular occlusive disease (acute and chronic) or vasculitis (including use of CT angiography and/or venography) [9-25]
   4. Aneurysm evaluation [26-28]
   5. Detection or evaluation of calcification [29]
   6. Immediate postoperative evaluation following surgical treatment of tumor, intracranial hemorrhage, or hemorrhagic lesions [30]
   7. Treated or untreated vascular lesions [31,32]
   8. Mental status change [33]
   9. Increased intracranial pressure [3,4]
  10. Headache [34,35]
  11. Acute neurologic deficits [36]
  12. Suspected intracranial infection [37-43]
  13. Suspected hydrocephalus [44-46]
  14. Certain congenital skull and brain lesions (such as, but not limited to, craniosynostosis, macrocephaly, and microcephaly) [6,47,48]
  15. Evaluating psychiatric disorders [49]
  16. Brain herniation [2,3]
  17. Suspected mass or tumor [50-54]
  18. CT guidance and image integration for neurosurgical, neurointerventional, and other therapeutic procedures [55-64]
  19. Certain skull lesions (such as, but not limited to, fibrous dysplasia, Paget disease, histiocytosis, osteolytic lesions, and skeletal tumors)

B. Secondary Indications
1. When MR imaging is unavailable or contraindicated, or if the supervising physician determines CT to be appropriate [65-67]
2. Diplopia [68]
3. Cranial nerve dysfunction [69-72]
4. Seizures [66,67,73-76]
5. Apnea [77]
6. Syncope [78]
7. Ataxia [79]
8. Suspicion of neurodegenerative disease [80-83]
9. Developmental delay [45,46,84]
10. Neuroendocrine dysfunction [65]
11. Drug toxicity [33,85-87]
12. Congenital morphologic brain abnormalities [88]
13. Abusive head trauma and postmortem forensic investigations [28,34,87,89-91]
14. Brain death [34,92-96]
15. Suspected shunt malfunctions or shunt revisions [44]

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 [97].

III. QUALIFICATIONS AND RESPONSIBILITIES OF PERSONNEL

See the ACR Practice Parameter for Performing and Interpreting Diagnostic Computed Tomography (CT) [98].

IV. SPECIFICATIONS OF THE EXAMINATION

The supervising physician must have complete understanding of the indications, risks, and benefits of the examination, as well as alternative imaging procedures. The physician should be familiar with relevant ancillary studies that the patient may have undergone (See the ACR Practice Parameter for Communication of Diagnostic Imaging Findings [99].). The physician performing CT interpretation must have a clear understanding and knowledge of the anatomy and pathophysiology relevant to the examination.

The written or electronic request for CT of the brain 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)

A. General Considerations

CT protocols for brain imaging should be designed to answer the specific clinical question. The supervising physician should be familiar with the indications for each examination, relevant patient history, potential adverse
reactions to contrast media, exposure factors, window and center settings, field of view, collimation, slice intervals, slice spacing (table increment) or pitch, dose reduction (eg, iterative reconstruction), and image reconstruction algorithms. Protocols should be reviewed and updated at least periodically to optimize the examination [100-110].

B. Brain Imaging

CT brain imaging may be performed with a sequential single-slice technique, multislice helical (spiral) protocol, or multidetector multislice algorithm [111,112]. For CT of the brain, contiguous or overlapping axial slices should be acquired with a slice thickness of no greater than 5 mm. In the setting of trauma, images should be obtained and/or reviewed at window settings appropriate for demonstrating brain and bone abnormalities as well as small subdural hematomas or other sites of hemorrhage and soft-tissue lesions (subdural windows). For imaging of the cranial base, an axial slice thickness as thin as possible, but no greater than 3 mm with spiral techniques and 2 mm with multidetector and nonspiral techniques, should be used for 2-D reformatting or for 3-D reconstruction. Specially tailored protocols may also be considered, however, if clinical circumstances warrant, and under the direction of the supervising physician.

C. Contrast Studies

Certain indications require administration of intravenous (IV) contrast media or intrathecal contrast (eg, cisternography) during imaging of the brain. Intravenous contrast enhancement should be performed using appropriate injection protocols and in accordance with the ACR–SPR Practice Parameter for the Use of Intravascular Contrast Media [113]. Cerebrospinal fluid (CSF) contrast administration requires the use of nonionic agents approved for intrathecal use and should be performed using appropriate protocols as outlined in the ACR–ASNR–SPR Practice Parameter for the Performance of Myelography and Cisternography [114].

D. Advanced Applications

In addition to directly acquired axial images, reformatted images in coronal, sagittal, or other more complex planes may be constructed from the axial dataset to answer specific clinical questions, or the images may be manipulated to allow selective visualization of specific tissues such as in CT perfusion, CT volumetry, CT angiography/venography, multimodality image fusion, and mapping techniques. Such applications are better performed with helical, volume, or dual-energy datasets rather than routine axial sequential data [8-10,18,23,27,55,61,103,115-132]. Also see the ACR–ASNR–SPR Practice Parameter for the Performance of Computed Tomography (CT) Perfusion in Neuroradiologic Imaging [133] and the ACR–ASNR–SPR Practice Parameter for the Performance and Interpretation of Cervicocerebral Computed Tomography Angiography (CTA) [134].

V. DOCUMENTATION

Reporting should be in accordance with the ACR Practice Parameter for Communication of Diagnostic Imaging Findings [99].

VI. EQUIPMENT SPECIFICATIONS

A. Performance Standards

To achieve acceptable clinical CT scans of the brain, the CT scanner should meet or exceed the following specifications:

1. Scan times: per slice or image not more than 2 seconds

2. Slice thickness: minimum slice thickness 2 mm or less
3. Interscan delay: not more than 4 seconds (may be longer if intravascular contrast media is not used)

4. Limiting spatial resolution: must be measured to verify that it meets the unit manufacturer’s specifications. Limiting spatial resolution should be >10 lp/cm for a <24 cm display field of view (DFOV).

5. Table pitch: no greater than 2:1 for most CT scanners

6. For advanced applications (eg, perfusion imaging or CTA), cine-capable scanners are preferable with tube rotation ≤1 second and continuous cine imaging ≥60 seconds. See the ACR–ASNR–SPR Practice Parameter for the Performance of Computed Tomography (CT) Perfusion in Neuroradiologic Imaging [133].

B. Patient monitoring equipment and facilities for cardiopulmonary resuscitation, including vital signs monitoring equipment, support equipment, should be immediately available.

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 or sizes in the patient populations.

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 emergencies such as cardiopulmonary arrest.
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) [1]


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).

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).

For specific issues regarding CT quality control, see the ACR Practice Parameter for Performing and Interpreting Diagnostic Computed Tomography (CT) [98].

Equipment monitoring should be in accordance with the ACR–AAPM Technical Standard for Diagnostic Medical Physics Performance Monitoring of Computed Tomography (CT) Equipment [135].

In addition to CT radiation safety and quality control, appropriateness studies, utilization review, and outcomes studies facilitating best practices for CT brain imaging should also be considered and encouraged as part of a comprehensive continuous quality improvement program [35,89,136-147].

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 ([http://www.acr.org/guidelines](http://www.acr.org/guidelines)) 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 and the SPR.

**Collaborative Committee**
Members represent their societies in the initial and final revision of this practice parameter.

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5. Schachar JL, Zampolin RL, Miller TS, Farinhas JM, Freeman K, Taragin BH. External validation of the New Orleans Criteria (NOC), the Canadian CT Head Rule (CCHR) and the National Emergency X-


*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.

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