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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.

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ACR–AIUM–SPR–SRU PRACTICE PARAMETER FOR THE PERFORMANCE OF NEUROSONOGRAPHY IN NEONATES AND INFANTS

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 care¹. 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

The clinical aspects contained in specific sections of this practice parameter (Introduction, Specifications of the Examination, and Equipment Specifications) were developed collaboratively by the American College of Radiology (ACR), the American Institute of Ultrasound in Medicine (AIUM), the Society for Pediatric Radiology (SPR), and the Society of Radiologists in Ultrasound (SRU). Recommendations for physician requirements, written requests for the examination, documentation, and quality control vary among the 4 organizations and are addressed by each separately.

This practice parameter has been developed to assist physicians performing sonographic studies of the brain in neonates and infants. For the purpose of this practice parameter, infants are defined primarily as those in whom the anterior fontanelle remains open. Neurosonography should be performed only when there is a valid medical reason, and the lowest possible ultrasonic exposure settings should be used to gain the necessary diagnostic information. In some cases, additional or specialized examinations may be necessary. Although it is not possible to detect every abnormality, adherence to the following practice parameter will maximize the detection of most abnormalities of the brain in neonates and infants that can be imaged with ultrasound.

II. INDICATIONS/CONTRAINDICATIONS

Indications for neurosonography in preterm or term neonates and infants include, but are not limited to, the following:

- Evaluation for hemorrhage or parenchymal abnormalities in preterm and term infants¹⁻⁵
- Evaluation for hydrocephalus¹⁻⁵
- Evaluation for the presence of vascular abnormalities²⁻⁸
- Evaluation for possible or suspected hypoxic ischemic encephalopathy^{2-5,9-12}
- Evaluation and follow-up of patients on hypothermia, extracorporeal membrane oxygenation (ECMO), and other support machines
- Evaluation for the presence of congenital malformations²⁻⁵
- Evaluation of signs and/or symptoms of central nervous system disorder, eg, seizures, facial malformations, macrocephaly, microcephaly, intrauterine growth restriction (IUGR)^{2-5,13}
- Evaluation of congenital or acquired brain infection²⁻⁵
- Evaluation of trauma, eg, complications of fall, cephalohematoma, or subgaleal hematoma including fracture, subdural hematoma, and/or subarachnoid hemorrhage^{2-5,14,15}
- Evaluation for craniosynostosis¹⁶
- Follow-up or surveillance of previously documented abnormalities, including prenatal abnormalities²⁻⁵
- Screening prior to surgical procedures

There are no contraindications to neurosonography.

III. QUALIFICATIONS OF PERSONNEL

Each organization will address this section in its document. ACR language is as follows:

See the ACR–SPR–SRU Practice Parameter for Performing and Interpreting Diagnostic Ultrasound Examinations.

IV. WRITTEN REQUEST FOR THE EXAMINATION

Each organization will address this section in its document. ACR language is as follows:

The written or electronic request for neurosonography 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)

V. SPECIFICATIONS OF THE EXAMINATION

(Also see section VII, Equipment Specifications)

Standard Imaging Examination of the Neonate and Infant ²⁻⁵

The coronal view, by convention, should have the patient's right side on the left side of the image. Representative *coronal views* should be obtained by sweeping through the entire brain, from anterior to posterior, using the anterior fontanelle as a sonic window. Coronal views should include the following, sequentially:

- Frontal lobes anterior to the frontal horns of the lateral ventricles with orbits visualized deep to the skull base
- Frontal horns or bodies of lateral ventricles and interhemispheric fissure
- Lateral ventricles at level of lateral and third ventricles
- Include interhemispheric fissure, cingulate sulcus (if developed), corpus callosum, septum pellucidum or cavum septi pellucidi, caudate nuclei, putamina, globi pallidi, and Sylvian fissures. The foramina of Monro should also be depicted, outlining the course of the choroid plexus from the lateral into the third ventricle
- Lateral ventricles slightly posterior to the foramina of Monro, where the lateral and third ventricles communicate. Include pons and medulla, thalami, and choroid plexus in the roof of the third ventricle and in the caudothalamic grooves.
- Level of quadrigeminal plate cistern and cerebellum. Include cerebellar vermis, cisterna magna posteriorly and inferiorly, bodies of lateral ventricles bordered by caudate nuclei and thalami, and temporal horns.
- Echogenic glomi of choroid plexuses at posterior aspect of the lateral ventricles at level of trigones. Include splenium of corpus callosum at divergence of lateral ventricle and periventricular white matter lateral to posterior horns of lateral ventricles.
- Posterior to occipital horns. Include parietal and occipital lobes and posterior interhemispheric fissure.
- Extra-axial fluid spaces as needed: Use linear high frequency (≥ 9 MHz) transducers to obtain coronal magnification view of extra-axial fluid space, including only peripheral brain structures (superior sagittal sinus at level of frontal horns; measure sinocortical distance, craniocortical distance, and width of interhemispheric fissure) ¹⁷.

The transducer may be tilted from side to side to image as much of the superficial peripheral surfaces of the cerebral hemispheres as possible. The appropriate frequency of the transducer should be selected to ensure that the superficial and deep structures are well depicted. In some larger term or older infants, more than 1 transducer frequency may be needed for optimal evaluation of the supra and infratentorial structures.

The *sagittal view*, by convention, should place the anterior aspect of the brain on the left side of the image. The right side or left side should be clearly annotated. Sequential representative sagittal views are obtained with appropriate degrees of left and right transducer angulation because the frontal horns are somewhat more medial than are the bodies of the lateral ventricles. These views should include the following:

- Right and left parasagittal to demonstrate insula
- Right and left parasagittal to demonstrate Sylvian fissure
- Right parasagittal to image deep white matter (periventricular regions)
- Right and left parasagittal views of lateral ventricles including caudothalamic groove
- Right and left parasagittal views of lateral ventricles, showing choroid plexus
- Additional parasagittal views to include all parts of lateral ventricles
- Midline sagittal views to include corpus callosum, cavum septi pellucidi, and cavum vergae, if present; third and fourth ventricles; aqueduct of Sylvius; brainstem; cerebellar vermis; cisterna magna; and sulci, if present. The branches of the anterior cerebral artery (pericallosal artery and callosomarginal artery) may be visualized.
- Midline anterior cerebral artery pulsed Doppler assessment of resistive index, as needed

Additional views, if necessary, may be taken through the posterior or mastoid fontanelle, the foramen magnum, any open suture, burr hole, craniotomy defect, or thin areas of the temporal and parietal bones¹⁸. The transtemporal approach may also be used to visualize the circle of Willis and its major branches.

The *mastoid view* is primarily used to visualize the cerebellum. On an anterior axial image at the level of the brainstem, the third ventricle, cerebral peduncles, thalamus, and basilar cisterns can also be demonstrated. A more posterior axial image shows the fourth ventricle, posterior vermis and folia of the cerebellar hemispheres, tentorium, and cisterna magna [18,19].

Posterior fontanelle, axial, and sagittal views may be used, as necessary, to clarify abnormalities suspected in the occipital areas, posterior horns of the lateral ventricles, and cerebellum¹⁸.

For patients with ventricular shunt tubes, additional oblique views via the anterior fontanelle and/or axial views may be obtained when a shunt tube and its tip are not visualized on routine scans.

When clinically indicated, spectral, color, and/or power Doppler may be useful to evaluate vascular structures through a fontanelle or a transcranial approach.

VI. DOCUMENTATION

Each organization will address this section in its document. ACR language is as follows:

Adequate documentation is essential for high-quality patient care. There should be a permanent record of the ultrasound examination and its interpretation. Comparison with prior relevant imaging studies may prove helpful. Images of all appropriate areas, both normal and abnormal, should be recorded. Variations from normal size should generally be accompanied by measurements. Images should be labeled with patient identification, facility identification, examination date, and image orientation. An official interpretation (final report) of the ultrasound examination should be included in the patient's medical record. Retention of the ultrasound examination images should be consistent both with clinical need and with relevant legal and local health care facility requirements.

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

VII. EQUIPMENT SPECIFICATIONS

Neurosonographic examinations should be conducted with sector or curved linear transducers that can fit within and image through the anterior fontanelle²⁻⁵. Linear transducers are useful in evaluating superficial structures such as the superior sagittal sinus. If the anterior fontanelle is not available, imaging may be performed through available sutural openings or by using a transcranial approach via the thinner squamosal portion of the temporal bone. This approach may require a lower frequency transducer in order to penetrate through the bone. The transducer should be adjusted to operate at the highest clinically appropriate frequency, realizing that there is a trade-off between resolution and beam penetration. Higher frequencies are used in neonates and young infants and lower frequencies in older infants and babies.

Doppler power output should be as low as reasonably achievable to answer the diagnostic question.

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

Each organization will address this section in its document. ACR language is as follows:

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>).

Equipment performance monitoring should be in accordance with the ACR Technical Standard for Diagnostic Medical Physics Performance Monitoring of Real Time Ultrasound Equipment.

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Collaborative Committee

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

ACR

Henrietta Kotlus Rosenberg, MD, FACR, Chair
Beverly E. Hashimoto, MD, FACR

SPR

Harriet J. Paltiel, MD
Carol E. Barnewolt, MD
Judy A. Estroff, MD

AIUM

Teresita L. Angtuaco, MD, FACR
Lynn L. Fordham, MD, FACR
Thomas R. Goodman, MB, BChir

SRU

Dorothy I. Bulas-Kurzok, MD, FACR
Harris L. Cohen, MD, FACR
Brian D. Coley, MD, FACR

Committee on Practice Parameters – Pediatric Radiology

(ACR Committee responsible for sponsoring the draft through the process)

Eric N. Faerber, MD, FACR, Chair
Sara J. Abramson, MD, FACR
Richard M. Benator, MD, FACR
Lorna P. Browne, MB, BCh
Brian D. Coley, MD, FACR
Monica S. Epelman, MD
Kate A. Feinstein, MD, FACR
Lynn A. Fordham, MD, FACR
Tal Laor, MD
Beverly Newman, MB, BCh, BSc, FACR
Marguerite T. Parisi, MD, MS
Sumit Pruthi, MBBS
Nancy K. Rollins, MD

Committee on Practice Parameters – Ultrasound

(ACR Committee responsible for sponsoring the draft through the process)

Beverly E. Hashimoto, MD, FACR, Chair
Sandra O. DeJesus Allison, MD
Teresita L. Angtuaco, MD, FACR
Marcela Bohm-Velez, MD, FACR
Maria A. Calvo-Garcia, MD
Helena Gabriel, MD
Gail N. Morgan, MD
Maitray D. Patel, MD
Henrietta Kotlus Rosenberg, MD, FACR
Sheila Sheth, MD, FACR
Maryellen R.M. Sun, MD
Sharlene A. Teefey, MD, FACR
Jason M. Wagner, MD

Marta Hernanz-Schulman, MD, FACR, Chair, Commission on Pediatric Radiology
Deborah Levine, MD, FACR, Chair, Commission on Ultrasound
Debra L. Monticciolo, MD, FACR, Chair, Commission on Quality and Safety
Julie K. Timins, MD, FACR, Chair, Committee on Practice Parameters and Technical Standards

Comments Reconciliation Committee

Alexander M. Norbash, MD, FACR
Frank J. Lexa, MD, MBA
Teresita L. Angtuaco, MD, FACR
Kimberly E. Applegate, MD, MS, FACR
Carol E. Barnewolt, MD
Dorothy I. Bulas-Kurzok, MD, FACR
Harris L. Cohen, MD, FACR
Brian D. Coley, MD, FACR
Judy A. Estroff, MD
Eric N. Faerber, MD, FACR
Lynn A. Fordham, MD, FACR
Thomas R. Goodman, MB, BChir
Beverly E. Hashimoto, MD, FACR

Marta Hernanz-Schulman, MD, FACR
William T. Herrington, MD, FACR
Deborah Levine, MD, FACR
Debra L. Monticciolo, MD, FACR
Marthe Munden, MD
Harriet J. Paltiel MD
Henrietta Kotlus Rosenberg, MD, FACR
Julie K. Timins, MD, FACR

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