Revised 2019 (Resolution 28)*

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 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 considering 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 variables such as the condition of the patient, limitations of available resources, or advances in knowledge or technology after publication of this document. However, a practitioner who employs an approach substantially different from the guidance in this document may consider documenting in the patient record information sufficient to explain the approach taken.

The practice of medicine involves the science, and 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 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 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.

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 Qualifications and Responsibilities of Personnel, Written Requests for the Examination, Documentation, and Quality Control and Improvement, Safety, Infection Control, and Patient Education vary among the four organizations and are addressed by each separately.

This practice parameter has been developed to assist physicians and sonographers 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 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, evaluation for the following entities:

- Abnormal increase in head circumference
- Hemorrhage or parenchymal abnormalities in preterm and term infants [1-7]
- Ventriculomegaly (hydrocephalus) [1-5]
- Vascular abnormalities [2-5,8-10]
- Suspected hypoxic ischemic injury (hypoxic ischemic encephalopathy) [2-5,11-15]
- Patients on hypothermia, extracorporeal membrane oxygenation (ECMO), and other support machines [16]
- Congenital malformations [2-5]
- Signs or symptoms of central nervous system disorder (eg, seizures, facial malformations, macrocephaly, microcephaly, intrauterine growth restriction (IUGR)) [2-5,17]
- Congenital or acquired brain infection [2-5]
- Suspected or known head trauma-[2-5,18,19]
- Craniosynostosis [20,21]
- Follow-up or surveillance of previously documented abnormalities, including prenatal abnormalities [2-5]
- Screening prior to surgery

There are no contraindications to neurosonography.

III. QUALIFICATIONS OF PERSONNEL

See the ACR–SPR–SRU Practice Parameter for the Performance and Interpretation of Diagnostic Ultrasound Examinations [22].

IV. WRITTEN REQUEST FOR THE EXAMINATION

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). The provision of 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 scope of practice requirements. (ACR Resolution 35, adopted in 2006 – revised in 2016, Resolution 12-b)

V. SPECIFICATIONS OF THE EXAMINATION

(See also section VII, Equipment Specifications)

Standard Imaging Examination of the Neonate and Infant [2-5,23]

Any prior imaging should be reviewed prior to sonographic evaluation if available.

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.
- Include lateral ventricles at the level of the foramina of Monro (outlining the course of the choroid plexus from the lateral into the third ventricle), interhemispheric fissure, cingulate sulcus (if developed), corpus callosum, septum pellucidum or cavum septi pellucidi, caudate nuclei, putamina, globi pallidi, and Sylvian fissures.
- Lateral ventricles slightly posterior to the foramina of Monro, the point at which 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 and cisterna magna.
- 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: use high-frequency linear transducers to obtain coronal magnification view of extra-axial fluid space, including peripheral brain structures (superior sagittal sinus at level of frontal horns; measure sinocortical distance, craniocortical distance, and width of interhemispheric fissure) [24]. Color Doppler evaluation of the bridging veins may be performed on this view to help differentiate between subarachnoid hemorrhage and subdural hemorrhage.

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 one transducer frequency may be needed for optimal evaluation of the supra- and infratentorial structures. High-frequency linear transducers may be utilized for additional detail of abnormalities as needed.

The sagittal view, by convention, should place the anterior aspect of the brain on the left side of the image. The right side, left side, and midline 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. For the midline view, the transducer should be held in a straight sagittal plane parallel to the midline of the brain. These views should include the following:

- Right and left parasagittal to demonstrate the insula
- Right and left parasagittal to demonstrate the Sylvian fissure
- Right parasagittal to image the 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 the 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 as needed.
- Midline anterior cerebral artery pulsed Doppler assessment of resistive index, as needed [25], especially for infants with suspected hypoxic ischemic encephalopathy.
- Superior sagittal sinus with color Doppler, as needed

The mastoid view is primarily used to visualize the cerebellum and may be obtained from both the right and left mastoid fontanelle as needed.

Additional views, if necessary, may be taken through the posterior fontanelle, any open suture, burr hole, craniotomy defect, or thin areas of the temporal and parietal bones [26]. The transtemporal approach may also be used to visualize the circle of Willis and its major branches. The foramen magnum approach may be used to evaluate the brain stem and upper cervical spine, particularly in infants with known or suspected Chiari 1 or 2 malformations.

For patients with ventricular shunt tubes, additional views should 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. Color or power Doppler may be useful in cases of suspected sinus venous thrombosis [27,28]. Spectral Doppler may be useful in patients with hydrocephalus and hypoxic ischemic brain injury [28].

When there is concern for craniosynostosis, additional imaging may be performed with a high-resolution linear transducer held perpendicular to the expected course of the coronal, sagittal, lambdoid, and metopic sutures [21].

Video clips may be obtained for better demonstration of questionable abnormalities, as needed [29].

VI. DOCUMENTATION

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 should be performed. 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 and/or linear transducers that can fit within and image through the anterior fontanelle with the appropriate settings determined by the depth of penetrability [2-5]. Linear transducers are useful in evaluating superficial structures, such as the skull or scalp. 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 premature babies, neonates, and young infants, and lower frequencies are used in older infants and babies.

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

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 (https://www.acr.org/Advocacy-and-Economics/ACR-Position-Statements/Quality-Control-and-Improvement).

Equipment performance monitoring should be in accordance with the ACR–AAPM Technical Standard for Diagnostic Medical Physics Performance Monitoring of Real Time Ultrasound Equipment **[30].**

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