

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

Revised 2024 (Resolution 30)

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.

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 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

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 [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, 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) [2-5,17]
- Congenital or acquired brain infection [2-5]
- Craniosynostosis [20,21]
- Follow-up or surveillance of previously documented abnormalities, including prenatal abnormalities [2-5]
- Screening before or following surgery

There are no specific contraindications to neurosonography; however, age >6-9months may be a limitation. Depending on the goal of the examination, the study may be compromised or nondiagnostic in an infant with a small open fontanelle.

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 before sonographic evaluation if available.

The appropriate frequency of the transducer should be selected to ensure that superficial and deep structures are well depicted. More than one transducer frequency may be needed for optimal evaluation of the supra- and infratentorial structures, particularly in larger term or older infants. High-frequency linear transducers may be used for additional detail of abnormalities as needed.

Video clips may be obtained for better demonstration of abnormalities, as needed [24]

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. The transducer may be tilted from side to side to image as much of the superficial peripheral surfaces of the cerebral hemispheres as possible.

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) [25]. . Differentiation between subdural hemorrhage and subarachnoid hemorrhage may be performed by identification of inferiorly displaced arachnoid mater and inferiorly displaced bridging veins using color Doppler.

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 and left parasagittal to demonstrate the deep white matter (periventricular regions)
- Right and left parasagittal to demonstrate the lateral ventricles including caudothalamic groove
- Right and left parasagittal to demonstrate the 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.
- Superior sagittal sinus with color Doppler

The mastoid view is primarily used to visualize the posterior fossa and may be obtained from both the right and left mastoid fontanelle as needed, with right or left side appropriately labeled.

Midline anterior cerebral artery pulsed Doppler assessment of resistive index, as needed [26], especially for infants with suspected hypoxic ischemic injury or hydrocephalus.

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 [27]. 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, and microvascular imaging may be useful to evaluate vascular structures. Color or power Doppler as well as microvascular imaging techniques may be useful in cases of suspected dural venous sinus thrombosis and meningitis [28-31]. Spectral Doppler, with angle correction if accurate velocity is important, may be useful such as in patients with hydrocephalus and hypoxic ischemic injury [29].

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].

When clinically indicated, high-resolution linear transducer imaging may be performed to assess any scalp fluid collections.

When there is clinical or imaging concern for vascular abnormality, including malformation or thrombosis, infection, or hypoxic ischemic injury, contrast enhanced ultrasound (CEUS) may be considered to increase the specificity of ultrasound [32-35].

- CEUS examination of the neonatal brain is performed using the standard pediatric weight-based dose of 0.03 mL/kg sulfur hexafluoride lipid microspheres contrast.
- Imaging is performed with a small footprint curved-array mid frequency transducer.
- CEUS is performed by saving coronal and sagittal cinematic clips.
- Once ultrasound contrast has been injected, care must be taken to only image in low mechanical index (MI), thermal index, and lower power output mode to avoid microbubble destruction and potential sonoporation. High MI pulses to clear the field should not be used.
- Imaging may require more than one injection to visualize all relevant anatomy and pathology, depending on clinical indication.

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

Equipment performance monitoring should be in accordance with the [ACR–AAPM Technical Standard for Diagnostic Medical Physics Performance Monitoring of Real Time Ultrasound Equipment](#) [36].

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 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>).

ACKNOWLEDGEMENTS

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

Writing Committee – members represent their societies in the initial and final revision of this practice parameter

ACR

Squires, Judy H MD, Chair
Cohen, Harris L MD
Fung, Christopher MD

AIUM

Epelman, Monica MD
Kirsch, Jonathan D MD

SPR

Faingold, Ricardo MD
Riedesel, Erica MD

SRU

Fordham, Lynn A MD
Rosenberg, Henrietta MD
Williams-Weekes, Terri MD

Committee on Practice Parameters - Ultrasound

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

| | |
|----------------------------|----------------------------------|
| Dahiya, Nirvikar MD, Chair | Azadi, Javad MD |
| Bohm-Velez, Marcela MD | Burgan, Constantine MD |
| Carnahan, Molly MD | Fung, Christopher MD |
| Gabriel, Helena MD | Gunubushanam, Gowthaman MBBS, MD |
| Itani, Malak MD | Melany, Michelle MD |
| Penna, Rupinder MD | Sohaey, Roya MD |
| Squires, Judy H MD | |

Committee on Practice Parameters – Pediatric Imaging

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

| | |
|--------------------------|---------------------------|
| Levin, Terry L MD, Chair | Alizai, Hamza MD |
| Amodio, John B MD | Betz, Bradford W MD |
| Blumfield, Einat MD | Collard, Michael MD |
| Goldman-Yassen, Adam MD | Lai, Hollie A MD |
| Lala, Shailee V MD | Lasiecka, Zofia M MD, PhD |
| Laufer, Adina MD | Li, Arleen MD |
| Maloney, John A MD | Noda, Sakura MD |
| Shah, Summit MD | Trout, Andrew T MD |
| Vatsky, Seth DO | |

Barth, Richard MD, Chair, Commission on Pediatric Radiology

Larson, David B MBA, MD, Chair, Commission on Quality and Safety

Nicola, Lauren MD, Chair, Commission on Ultrasound

Comments Reconciliation Committee

| | |
|-------------------------------------|---------------------------------|
| Boyd, David MBA, MD - CSC, Co-Chair | Prosper, Ashley MD - CSC, Chair |
| Amodio, John B MD | Barth, Richard MD |
| Cohen, Harris L MD | Crummy, Timothy MD, MHA - CSC |
| Dahiya, Nirvikar MD | Epelman, Monica MD |
| Faingold, Ricardo MD | Fordham, Lynn A MD |
| Fung, Christopher MD | Gabriel, Helena MD |
| Kirsch, Jonathan D MD | Larson, David B MBA, MD |
| Levin, Terry L MD | Nicola, Lauren MD |
| Riedesel, Erica MD | Rosenberg, Henrietta MD |
| Schoppe, Kurt MD - CSC | Squires, Judy H MD |
| Williams-Weekes, Terri MD | |

REFERENCES

1. Murphy BP, Inder TE, Rooks V, et al. Posthaemorrhagic ventricular dilatation in the premature infant: natural history and predictors of outcome. Archives of disease in childhood. Fetal and neonatal edition 2002;87:F37-41.
2. Rosenberg HK, Viswanathan V, Amodio J. Pediatric Brain. In: McGahan JP, Goldberg BB, ed. *Diagnostic*

- Ultrasound*. Vol 1. 2nd ed. New York, NY: Informa Healthcare; 2008:563-612.
3. Rumack CM, Levine D. Neonatal and Infant Brain Imaging. *Diagnostic Ultrasound*. Vol 2. 5th ed. Philadelphia, PA: Elsevier; 2018:1511-72.
 4. Siegel M. Brain. In: Siegel MJ, ed. *Pediatric Sonography*. 4th ed. Philadelphia, PA: Lippincott Williams & Wilkins; 2011:43-117.
 5. Slovis TL, Bulas DI, Nelson MD. Neonatal Brain Imaging. In: Slovis TL, Coley BD, Bulas DI et al, ed. *Caffey's Pediatric Diagnostic Imaging*. Vol 1. Philadelphia, PA: Elsevier; 2008:398-429.
 6. Intrapromkul J, Northington F, Huisman TA, Izbudak I, Meoded A, Tekes A. Accuracy of head ultrasound for the detection of intracranial hemorrhage in preterm neonates: comparison with brain MRI and susceptibility-weighted imaging. *J Neuroradiol* 2013;40:81-8.
 7. Elkhunovich M, Sirody J, McCormick T, Goodarzian F, Claudius I. The Utility of Cranial Ultrasound for Detection of Intracranial Hemorrhage in Infants. *Pediatr Emerg Care* 2018;34:96-101.
 8. Kersbergen KJ, Groenendaal F, Benders MJ, de Vries LS. Neonatal cerebral sinovenous thrombosis: neuroimaging and long-term follow-up. *Journal of child neurology* 2011;26:1111-20.
 9. Vizcaino-Diaz C, Sanchez-Zaplana H, Ruiz JC, Jimenez-Cobo B. Rupture of intracranial arterial aneurysms in neonates: case report and review of the literature. *Journal of child neurology* 2009;24:208-14.
 10. Wang HS, Kuo MF, Chang TC. Sonographic lenticulostriate vasculopathy in infants: some associations and a hypothesis. *AJNR. American journal of neuroradiology* 1995;16:97-102.
 11. de Vries LS, Cowan FM. Evolving understanding of hypoxic-ischemic encephalopathy in the term infant. *Seminars in pediatric neurology* 2009;16:216-25.
 12. Govaert P. Prenatal stroke. *Seminars in fetal & neonatal medicine* 2009;14:250-66.
 13. van Wezel-Meijler G, De Bruine FT, Steggerda SJ, et al. Ultrasound detection of white matter injury in very preterm neonates: practical implications. *Developmental medicine and child neurology* 2011;53 Suppl 4:29-34.
 14. Epelman M, Daneman A, Kellenberger CJ, et al. Neonatal encephalopathy: a prospective comparison of head US and MRI. *Pediatric radiology* 2010;40:1640-50.
 15. Huang BY, Castillo M. Hypoxic-Ischemic Brain Injury: Imaging Findings from Birth to Adulthood. *RadioGraphics* 2008;28:417-39.
 16. Raets MM, Dudink J, Ijsselstijn H, et al. Brain injury associated with neonatal extracorporeal membrane oxygenation in the Netherlands: a nationwide evaluation spanning two decades. *Pediatr Crit Care Med* 2013;14:884-92.
 17. Glass HC, Bonifacio SL, Sullivan J, et al. Magnetic resonance imaging and ultrasound injury in preterm infants with seizures. *Journal of child neurology* 2009;24:1105-11.
 18. Chamnanvanakij S, Rollins N, Perlman JM. Subdural hematoma in term infants. *Pediatric neurology* 2002;26:301-4.
 19. Trenchs V, Curcoy AI, Castillo M, et al. Minor head trauma and linear skull fracture in infants: cranial ultrasound or computed tomography? *European journal of emergency medicine : official journal of the European Society for Emergency Medicine* 2009;16:150-2.
 20. Soboleski D, McCloskey D, Mussari B, Sauerbrei E, Clarke M, Fletcher A. Sonography of normal cranial sutures. *AJR. American journal of roentgenology* 1997;168:819-21.
 21. Proisy M, Riffaud L, Chouklati K, Treguiet C, Bruneau B. Ultrasonography for the diagnosis of craniosynostosis. *Eur J Radiol* 2017;90:250-55.
 22. American College of Radiology. ACR–SPR–SRU Practice Parameter for the Performance and Interpretation of Diagnostic Ultrasound Examinations. Available at: <https://www.acr.org/-/media/ACR/Files/Practice-Parameters/US-Perf-Interpret.pdf>. Accessed January 13, 2023.
 23. Gupta P, Sodhi KS, Saxena AK, Khandelwal N, Singhi P. Neonatal cranial sonography: A concise review for clinicians. *J Pediatr Neurosci* 2016;11:7-13.
 24. O'Dell MC, Cassady C, Logsdon G, Varich L. Cinegraphic versus Combined Static and Cinegraphic Imaging for Initial Cranial Ultrasound Screening in Premature Infants. *Pediatric radiology* 2015;45:1706-11.
 25. Frankel DA, Fessell DP, Wolfson WP. High resolution sonographic determination of the normal dimensions of the intracranial extraaxial compartment in the newborn infant. *Journal of ultrasound in medicine : official journal of the American Institute of Ultrasound in Medicine* 1998;17:411-5; quiz 17-8.
 26. Gerner GJ, Burton VJ, Poretti A, et al. Transfontanelar duplex brain ultrasonography resistive indices as a prognostic tool in neonatal hypoxic-ischemic encephalopathy before and after treatment with therapeutic

hypothermia. J Perinatol 2016;36:202-6.

27. Luna JA, Goldstein RB. Sonographic visualization of neonatal posterior fossa abnormalities through the posterolateral fontanelle. AJR. American journal of roentgenology 2000;174:561-7.
28. Grunt S, Wingeier K, Wehrli E, et al. Cerebral sinus venous thrombosis in Swiss children. Developmental medicine and child neurology 2010;52:1145-50.
29. Soetaert AM, Lowe LH, Formen C. Pediatric cranial Doppler sonography in children: non-sickle cell applications. Curr Probl Diagn Radiol 2009;38:218-27.
30. Goeral K, Hojreh A, Kasprian G, et al. Microvessel ultrasound of neonatal brain parenchyma: feasibility, reproducibility, and normal imaging features by superb microvascular imaging (SMI). Eur Radiol 2019;29:2127-36.
31. Hwang M, Haddad S, Tierradentro-Garcia LO, Alves CA, Taylor GA, Darge K. Current understanding and future potential applications of cerebral microvascular imaging in infants. Br J Radiol 2022;95:20211051.
32. Gumus M, Oommen KC, Squires JH. Contrast-enhanced ultrasound of the neonatal brain. Pediatric radiology 2022;52:837-46.
33. Squires JH, Beluk NH, Lee VK, et al. Feasibility and Safety of Contrast-Enhanced Ultrasound of the Neonatal Brain: A Prospective Study Using MRI as the Reference Standard. AJR. American journal of roentgenology 2022;218:152-61.
34. Hwang M, Barnewolt CE, Jüngert J, Prada F, Sridharan A, Didier RA. Contrast-enhanced ultrasound of the pediatric brain. Pediatric radiology 2021;51:2270-83.
35. Hwang M, Tierradentro-Garcia LO. A concise guide to transtemporal contrast-enhanced ultrasound in children. J Ultrasound 2022.
36. American College of Radiology. ACR-AAPM Technical Standard for Diagnostic Medical Physics Performance Monitoring of Real Time Ultrasound Equipment. Available at: <https://www.acr.org/-/media/ACR/Files/Practice-Parameters/US-Equip.pdf>. Accessed January 14, 2023.

*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.

Development Chronology for this Practice Parameter

1991 (Resolution 9)

Revised 1995 (Resolution 36)

Revised 1999 (Resolution 35)

Revised 2004 (Resolution 22)

Amended 2006 (Resolution 35)

Revised 2009 (Resolution 18)

Revised 2014 (Resolution 22)

Revision 2019 (Resolution 28)

Revised 2024 (Resolution 30)