ACR–AIUM–SPR–SRU PRACTICE PARAMETER FOR THE PERFORMANCE OF AN ULTRASOUND EXAMINATION OF THE NEONATAL AND INFANT 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 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.

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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, Indications, 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 examinations, procedure documentation, and quality control vary between the four organizations and are addressed by each separately.

This practice parameter has been developed to assist practitioners in the performance of neonatal and infant spine sonography and maximize the detection of abnormalities. Sonographic examination of the pediatric spinal canal is accomplished by scanning through the normally incompletely ossified posterior elements. Therefore, it is most successful in the newborn period and in early infancy. In infants more than 3 to 4 months of corrected age [1], the examination can be very limited, although the level of cord termination can often be identified.

Ultrasound of the infant spine is an accurate and cost-effective examination that is comparable with magnetic resonance imaging (MRI) for evaluating congenital or acquired abnormalities in the neonate and young infant. Because of the clinical ease of examination and lack of need for sedation, ultrasound is generally considered the first-line tool for diagnosis, with MRI often reserved for challenging cases in which ultrasound is inadequate or insufficient for diagnosis or exclusion of abnormalities.

II. INDICATIONS/CONTRAINDICATIONS

A. Indications

The indications for ultrasonography of the neonatal/infant spinal canal and its contents include, but are not limited to [2-14]:

1. Lumbosacral stigmata known to be associated with spinal dysraphism and tethered spinal cord, including:
    a. Midline or paramedian masses
    b. Midline skin discolorations
    c. Skin tags
    d. Hair tufts
    e. Hemangiomas
    f. Atypical sacral dimples (high risk; see below)
2. The spectrum of caudal regression syndrome, including patients with sacral agenesis or anorectal malformations such as Currarino Triad, VACTERL association, Cloaca, and OEIS complex
3. Evaluation of suspected spinal cord abnormalities such as cord tethering, diastematomyelia, hydromyelia, or syringomyelia
4. Detection of acquired abnormalities and complications such as:
    a. Hematoma following injury
    b. Infection or hemorrhage secondary to prior instrumentation, such as lumbar puncture
    c. Posttraumatic leakage of cerebrospinal fluid (CSF)
    d. Misplacement of devices and lines
5. Visualization of blood products within the spinal canal in patients with intracranial hemorrhage
6. Guidance for lumbar puncture [12,13]
7. Postoperative assessment for recurrence of cord tethering [15]
8. Evaluation for congenital spine tumors, eg sacrococcygeal teratoma

Please note that there are some indications for ultrasonography of the spine and spinal canal in children outside the neonatal or infant period. The technique for these studies is beyond the scope of this practice parameter but is described in the literature. These indications include, but are not limited to, intraoperative guidance for tumor resection, decompression of Chiari I malformation, and catheter placement for neuraxial analgesia [16,17], neurostimulator device placement and monitoring its positioning, and assessment of lengthening of magnetically controlled growing spinal rods [1].

Sacral dimples associated with a high risk of occult spinal dysraphism include those in which the base of the dimple is not seen, are located >2.5 cm above the anus, or are seen in combination with other cutaneous abnormalities [4]. The examination has a low diagnostic yield in infants with simple, low-lying coccygeal dimples; such patients typically have normal spinal contents [4,8,14,16]. Ultrasound is not considered essential in the workup of simple sacral dimples

B. Contraindications

1. Preoperative examination of an open spinal dysraphic defect. However, in such cases, the closed portion of the spinal canal away from the open defect can be examined for other suspected abnormalities, such as syrinx or diastematomyelia. These latter abnormalities should be identified preoperatively.
2. Examination of the contents of a closed neural tube defect if the skin overlying the defect is thin or no longer intact

III. QUALIFICATIONS AND RESPONSIBILITIES OF PERSONNEL

See the ACR–SPR–SRU Practice Parameter for the Performance and Interpretation of Diagnostic Ultrasound Examinations [18].

IV. WRITTEN REQUEST FOR THE EXAMINATION

The written or electronic request for a neonatal and infant spine ultrasound examination 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 scope of practice requirements. (ACR Resolution 35 adopted in 2006 – revised in 2016, Resolution 12-b)

V. SPECIFICATIONS OF THE EXAMINATION

The examination is usually performed with the patient lying in the prone position, although the study can also be done with the patient lying on their side. When necessary, upright or prone reversed Trendelenburg positioning with resultant CSF distention of the lower thecal sac may permit better delineation of the cauda equina. A small bolster may be placed under the lower abdomen or pelvis to mildly flex the back, which may improve imaging. The knees may be flexed to the abdomen to allow adequate separation of the spinous processes and visualization of the spinal canal contents. Avoid overzealous and excessive flexing that could impede respiration [19]. An infant who has recently been fed will generally lie quietly during the examination. If preprocedural feeding is not possible, a pacifier dipped in glucose solution can be helpful in keeping an infant still, thereby optimizing the examination. The infant may be also positioned in the caregiver's lap, which may have a calming effect, decreasing motion. Positioning the infant semierect also allows for accumulation of cerebrospinal fluid in the lower thecal sac, which widens the interlaminar spaces and creates a better acoustic window. Furthermore, this gravitational cerebrospinal fluid distention may increase detection of any existing lumbosacral meningoceles [1].

It is important to note that infants, particularly if not full-term, have difficulty maintaining normal body temperature. The baby should be kept warm enough to maintain normal body temperature during the procedure, and the coupling agent should be warmed.

The spinal cord should be assessed in longitudinal and transverse planes, with right and left labeled on transverse images. Longitudinal images are ideally obtained in the midline sagittal plane, although in larger or older babies (with greater spine ossification), it may be necessary to obtain images in a slightly off-midline parasagittal plane that is parallel to the spinous processes. Studies are typically limited to the lumbosacral and lower thoracic region as in patients being evaluated for a sacrococcygeal dimple and tethered cord, or when searching for the presence of hematoma after an unsuccessful or traumatic spinal tap. However, the entire spinal canal, from the craniocervical junction to the coccyx, may be included in the examination.

Normal cord morphology and the level of termination of the conus medullaris should be assessed and documented, which requires accurate identification of vertebral body level. The conus normally lies at or above the L2 to L3 disc space [9,20-23]. A normal conus located as low as the mid-L3 level may be identified, especially in preterm infants [23]; this position may be considered the lower limits of normal and is usually without clinical consequence [24]. However, in a preterm infant with a conus that terminates in the region of the L3 midvertebral body, a follow-up ultrasound can be obtained once the infant attains a corrected age between 40 weeks gestation and 4 months of age to document a rise in conus level [9]. The morphology of the conus should be documented as well as any deviation from normal, such as blunting of the tip.

Vertebral body level of the end of the spinal cord can be determined in a number of ways [25,26]. These include:

- Assessment of the normal lumbosacral curvature to locate the lumbosacral junction and thus the location of L5. The vertebral level of the conus medullaris is then determined by counting cephalad from L5. Lumbar vertebral bodies typically lie in a horizontal plane in a prone infant, whereas the sacral vertebral bodies lie at an angle similar to what is seen on lateral radiographs of the lumbosacral spine. This counting method tends to be more reproducible than the other methods described below. Extended field-of-view (panoramic) imaging can often aid in identification of a longer segment of the spine and facilitate identification of the vertebral level, particularly the L5-S1 level. Lumbar spine flexion-extension maneuvers might also allow easier identification of the lumbosacral junction.
- The first coccygeal segment has variable ossification at birth. If ossified, it can be distinguished by its rounder or more triangular shape compared with the square or rectangular shape of the sacral bodies. Counting cephalad from the fifth sacral ossification center can help determine the vertebral level of the conus.
- The thecal sac usually ends at S2 [27]. This level can then be used to count cephalad to determine the location of the conus.
- The last rib-bearing vertebra can be presumed to be T12, and the lumbar level of the conus can then be determined, although this is less reliable because of the variability in the number of ribs.
- When the level of the conus cannot be definitively assessed as normal or abnormal, correlation with previous plain films, if available, is helpful. A radiopaque marker can be placed on the skin at the level of the conus determined by sonographic guidance, followed by a correlative anteroposterior (AP) spine radiograph.

In addition to the level and location of the cord, motion of the nerve roots is another important parameter in assessment for cord tethering. The cord is normally positioned dependently or centrally within the spinal canal, and any deviation from normal (eg, apposition to the dorsal aspect of the spinal canal) should be documented. Transverse images are extremely helpful to demonstrate a dependent position of the cord. Cine images should be recorded and archived as an aid in demonstrating anatomy and particularly in showing movement of the distal cord and nerve roots in conjunction with normal pulsations of the spinal CSF. The normal nerve roots typically oscillate freely with cardiac and respiratory motion, layer dependently with variable patient positioning, and are not adherent to each other. Cine images can also document changes that occur with head flexion and extension. M-mode ultrasound can also be helpful in documenting motion of the cord and nerve roots. In newborns, diminished or absent motion of the conus and cauda equina due to decreased subarachnoid fluid related to the normal dehydration status has been reported. In these instances, follow-up spine ultrasound may be warranted [28].

Areas of abnormal fluid accumulation within the spinal cord and spinal canal should be documented with their level identified, such as hydromyelia or syringomyelia; anterior, lateral, or posterior meningoceles or pseudomeningoceles; and arachnoid cysts. Transverse images are essential to identify and document diastematomyelia. Off-center scanning may avoid the refraction artifact that creates an apparent lateral cord duplication, or ghost image, that resembles diastematomyelia [29-31].

The subarachnoid space is normally anechoic in appearance, interrupted by normal hyperechoic linear nerve roots and dentate ligaments. The subarachnoid space, dura, and epidural space should be evaluated for abnormalities such as hematoma, lipoma, or other masses.

In addition to the termination of the conus, the termination of the thecal sac, typically located at S2, should be documented [27]. The filum terminale and its thickness should be noted; the filum is normally <2 mm thick [32], although recent studies have suggested a lower cutoff value of 1.1 mm [33]. Increased echogenicity and thickening of the filum may indicate a fatty filum.

Upright positioning can be used for image guidance of lumbar puncture or to demonstrate meningoceles or pseudomeningoceles. Anterior meningoceles or presacral masses can also be scanned from an anterior position, usually through a fluid-filled bladder.

The vertebral bodies and posterior elements can be evaluated for deformities. Open posterior elements in skin-covered dysraphic defects can be documented on transverse views.

Tracts extending from the skin surface should be assessed for connection to the spinal canal. A standoff pad or a thick layer of coupling gel may be used, if needed, to evaluate the superficial soft tissues and skin line for the presence of a tract.

VI. DOCUMENTATION

Reporting and communication efforts should be in accordance with the ACR Practice Parameter for Communication of Diagnostic Imaging Findings [34].

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 should be accompanied by size measurements and/or vertebral level when applicable. The initials of the operator should be accessible on the images or electronically in the electronic medical record (eg, PACS or radiology information software (RIS)). Images should be labeled with the 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 based on clinical need and the relevant legal and local health care facility requirements.

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 [35].

Ultrasound of the infant spine should be performed with real-time scanners using high-frequency linear array transducers, typically ranging from 9 to 12 MHz or higher in neonates [36]. In larger babies, it may be necessary to utilize a lower-frequency probe ranging from 5 to 9 MHz. A curvilinear probe ranging from 3 to 9 MHz may be needed if a larger field of view is desired or the acoustic access is limited, as in older infants. Panoramic views of the entire spinal canal are very helpful in providing an overview of the anatomy by displaying a more global image of the relationship of the spinal cord with the vertebral column and determining the level of the conus medullaris. The use of a split-screen or dual-function technique is similarly useful for obtaining a longer longitudinal image of the cord and spinal column. Images of the craniocervical junction can be obtained with a small vector or curved transducer to accommodate the curvature of the cervical spine.

Clinical protocols should be reviewed to optimize image quality while reducing possible risks due to thermal and mechanical effects.

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 *ACR 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).

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