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Neonatal Spine Ultrasound Protocol

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Indications

The indications for ultrasonography of the neonatal spinal canal and its contents include, but are not limited to:

1. Lumbosacral stigmata known to be associated with spinal dysraphism, including but not limited to:
 - A. Midline or paramedian masses
 - B. Skin discolorations
 - C. Skin tags
 - D. Hair tufts
 - E. Hemangiomas
 - F. Pinpoint midline dimples
 - G. Paramedian deep dimples
2. The spectrum of caudal regression syndrome, including patients with sacral agenesis and patients with anal atresia or stenosis.
3. Evaluation of suspected defects such as cord tethering, diastematomyelia, hydromyelia, syringomyelia.
4. Detection of sequelae of injury, such as:
 - A. Hematoma following spinal tap or birth injury
 - B. Sequelae of prior instrumentation, infection or hemorrhage
 - C. Post-traumatic leakage of cerebrospinal fluid (CSF)
5. Visualization of fluid with characteristics of blood products within the spinal canal in patients with intracranial hemorrhage.

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6. Guidance for lumbar puncture

7. Postoperative assessment for cord retethering

Required Images

The examination should be performed with the infant lying in the prone position, although the study can also be done with the patient lying on his or her side when necessary. A small bolster, such as a rolled blanket, may be placed under the lower abdomen/pelvis to help position the patient. The knees may be flexed to the abdomen to allow adequate spacing of the spinous processes and visualization of the spinal canal contents. An infant who has recently been fed will generally lie quietly during the examination. If feeding is not possible, a pacifier dipped in glucose solution will often be helpful in keeping an infant still for an optimal examination. It is important to note that infants, particularly if not full term, have difficulty maintaining normal body temperature. Therefore, the examination should be performed in a warm room, and the coupling agent should be warmed.

The cord should be assessed in the longitudinal and transverse planes, with right and left labeled on transverse images. The examination may be limited to the lumbosacral region in specific cases, such as in patients being evaluated for a sacroccygeal dimple, or in those patients being scanned to look for the presence of hematoma after an unsuccessful or traumatic spinal tap. The entire spinal canal, from the craniocervical junction to the coccyx, may be included in appropriately selected cases.

The normal cord morphology and the level of termination of the conus should be assessed and documented. In order to do this, the vertebral body levels need to be accurately identified and numbered. Once the vertebral bodies are clearly numbered, the level of termination of the conus can be determined. In normal patients, the conus should lie at or above the L2 to L3 disc space. In fetuses and extremely preterm infants the normal conus medullaris may be caudal to the superior endplate of L3. In a preterm infant with a conus that terminates at the L3 midvertebral body, a follow up sonogram after age correction of 40 weeks gestation but before age correction of 6 months is warranted. The level of termination of the conus and its configuration should be documented, as well as any deviations from normal.

The vertebral level can be determined in a number of ways. These include:

- After assessment of the normal lumbosacral curvature to locate the last lumbar vertebra or L5, the vertebral level of the conus is determined by counting the cephalad. This method tends to be more reproducible than the other methods described below, which rely on counting the number of rib-bearing vertebrae or the number of ossified sacral and coccygeal segments and can lead to less reliable results.

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- The first coccygeal segment has variable ossification at birth but, if ossified, can be distinguished by its more rounded shape compared with the square or rectangular shape of the sacral bodies. Counting cephalad from S1 again can help determine the vertebral level of the conus.
- The last rib-bearing vertebra can be presumed to be T12 and the sequential lumbar level can be thus determined.
- 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 under sonographic guidance, followed by and correlated with a spine radiograph.

The level of termination of the cord is important in assessment of tethering. Cord position within the spinal canal and motion of cord and nerve roots are also helpful parameters in assessment for cord tethering. The normal position of the cord within the spinal canal, and deviation from normal, such as apposition to the dorsal aspect of the spinal canal as seen in tethering, should be documented. Cine evaluation can be helpful both in demonstrating anatomy and in showing movement of the distal cord and nerve roots in conjunction with cardiac-related pulsations of the spinal CSF. M-mode can also be very helpful in documenting motion of the cord and nerve roots. The normal nerve roots pulsate freely with cardiac and respiratory motion, layer dependently with variable patient positioning, and are not adherent to each other. Cine can also document changes that occur with head flexion and extension. A stand-off pad or a thick layer of coupling gel may be used, if needed, to follow a tract from the skin surface.

The integrity of the cord should be documented. Areas of abnormal fluid accumulation, such as hydromyelia or syringomyelia, anterior, lateral or posterior meningoceles or pseudomeningoceles, or arachnoid cysts, should be documented and their level identified. Transverse images are essential to identify and document diastematomyelia, with off-center scanning to avoid the potential pitfall of a reverberation artifact creating a lateral duplication, or ghost image.

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

In addition to the termination of the conus, the termination of the thecal sac, typically located at S2, should be documented. The normal filum measures less than 2 mm in thickness. If the filum

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is abnormally hyperechoic or appears thickened, it should be measured and documented. The nerve roots of the cauda equina should be delineated within the thecal sac. In cases of failed lumbar puncture, additional imaging with the child supported in a seated position, bending forward, may be useful to allow gravity to distend the lower thecal sac with CSF.

Upright positioning can be used for image guidance of lumbar puncture or to demonstrate meningoceles or pseudomeningoceles in some patients. Anterior meningoceles or presacral masses should also be scanned from an anterior position.

The vertebral bodies and posterior elements should be evaluated for deformities. Dysraphic defects with open posterior elements should be documented on transverse views.