Ultrasound examination of the neonatal spine

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Introduction

With technological advances in ultrasound, the quality of imaging is becoming equivalent to MRI. MRI at present is still considered the gold standard for imaging the neonatal spine in infants with spina bifida aperta, post spinal surgery and with cerebrospinal fluid (CSF) excreting lesions. There is a high risk of infection in these conditions, which is a major contraindication for an ultrasound examination. Ultrasound is generally the preferred modality in cases of occult spinal dysraphism or suspected spinal cord anomaly.

A spinal ultrasound examination should take place within the first three months of life. It is possible to scan the spine after three months of age but due to the ossification of the spinal processes it becomes much more difficult to image the spinal cord. However, if there is delayed ossification or a defect in the vertebral column, ultrasound may still be possible even after six months.

Clinical indications

Common clinical indications for neonatal spinal ultrasound include: atypical sacral dimple, palpable subcutaneous sacral mass, hair tuft, skin tag, haemangioma, sinus tract, skin pigmentation and in neonates with multiple congenital anomalies such as cloacal exstrophy and anorectal atresia.

Preparation

A good neonatal ultrasound examination should always start with an explanation of the procedure to the parents and/or guardian(s) and obtaining a relevant patient and family history.

The neonate should be examined in a warm environment and all its clothing be removed. The neonate is placed in a prone position over a rolled towel or pillow with legs flexed. Good spinal flexion provides an ideal acoustic window through the spade spinous processes. The head however, should be elevated to allow CSF to distend the distal thecal sac and possible abnormal sacs. The neonate may also be imaged in a lateral decubitus position. However, it should be mentioned that the spinal cord and nerve roots may gravitate to the left or right within the spinal canal, depending on patient position. Another alternative position when dealing with a distressed neonate, is to place the infant against the guardian’s chest with the infant facing over their shoulder.

An incontinence sheet can be place under the lower half of the neonate’s body. Gloves should be worn in case of any unexpected occurrences.

A linear 17-5 MHz transducer or equivalent high frequency linear transducer should be used. However, depending on the size of the neonate a linear 8-4 MHz transducer or alternative lower frequency transducer maybe more appropriate. A high frequency hockey stick transducer may also be helpful when investigating a sinus tract.

Always use warm coupling gel and use additional gel to form a standoff when visualising superficial structures.

Technique

The neonatal spine should be scanned in both sagittal and axial planes. The coronal plane can be employed for additional quality images in conditions such as diastematomyelia.

When scanning the spine, start in the sagittal plane at the level of the sacrococcygeal region. The coccyx is seen as an non-ossified mass of cartilage. The sacral vertebral bodies, which have begun to ossify, are seen superior to the coccyx.

Identify the filum terminale which normally terminates at the L5/S1 level.

Then, count the lumbar vertebral bodies up from L5 to the level of L1: it may be necessary to count the vertebral bodies down from the lowest rib. Although, it is usual to have 12 ribs, 11 and 13 ribs are not uncommon, so this technique is not as accurate. If the level is indeterminate, mark

Fig. 1: Normal image of the sacrum and coccyx in a sagittal plane.

Fig. 2: Normal image of the L5/S1 level and the filum terminale.
the level of the conus medullaris with a small radiopaque marker and undertake an x-ray of the lumbar spine. If available, previous x-rays may be useful to establish the number of vertebral bodies.

Identify the level of L1/L2 and the tapering tip of the conus medullaris at this level. A normal conus medullaris tip terminates above the L2 level. A low conus medullaris, below the level of L2 is suspicious of a tethered cord. After scanning in a sagittal plane the spinal cord should be imaged in the axial plane. Scan from the level of coccyx to the level of L1. Check the spinal cord is correctly positioned within the spinal canal. Visualise oscillations of the nerve roots. Identify the level of conus medullaris and filum terminale terminations. Also check the structure of the vertebral bodies, in case of a hemivertebra.

Due to the high association of spinal and renal abnormalities, both kidneys should be identified and scanned in longitudinal and transverse planes before finishing the examination.

The ultrasonographic images taken during the examination should include the numbering of the vertebral bodies adjacent to their structure. This is important so that the reporting sonologist can clearly identify and report the correct level. A panoramic ultrasound image although difficult in moving neonates can be helpful.

**Normal ultrasonographic appearances**

Ultrasonographically, a spinal cord appears hypoechoic with an echogenic central canal. The cord is centrally positioned within the spinal canal. The echogenic nerve roots demonstrate oscillation with respiration or infant movement. The tip of the conus medullaris normally tapers and is positioned above L2. The filum terminale is normally echogenic and measures 2 mm or less in thickness. It is located at the L5/S1 level. The spinal cord should remain round in the axial plane through the thoracolumbar region but may become more oval superiorly within the cervical region.

**Normal variants**

There are several spinal variants that are readily demonstrated in a neonatal spine ultrasound. These should be known to the sonographer undertaking the examination to prevent unnecessary additional imaging or stress to the parents and/or guardian(s). Common spinal cord variants include ventriculus terminalis, filar cyst, thickened filum terminale and a fibrous tract from coccyx (pseudosinus tract).

**Filar cyst**

**Spinal pathology and ultrasonographic appearances**

A tethered cord is “a pathologic fixation of the spinal cord in an abnormal caudal location, so that the cord suffers mechanical stretching, distortion and ischemia with daily activities, growth and development.” The ultrasonographic features of a tethered spinal cord include: the low lying position of the conus medullaris below the level of L2; and the spinal cord adhered to the posterior wall or dorsal aspect of the spinal canal which therefore, demonstrates a reduced or absent nerve root oscillation with patient respiration or movement in real-time scanning.

Meningocele is the condition where only the meninges herniate out, through the vertebral column. A myelomenigocele is the herniation of meninges and neural tissue through a defect in the vertebral column. Ultrasound can be useful to differentiate a closed meningocele from a closed myelomeningocele. Ultrasonographically, a meningocele appears as an anechoic sac containing CSF, protruding posteriorly from the spinal canal. It may also contain a few echogenic strands representing the membrane layers of the meninges. A myelomeningocele appears as a sac containing echogenic material representing neural tissue and membranes.

A hydromyelia is the abnormal widening of the central canal by cerebrospinal fluid. This condition may be either focal or diffuse, extending through the entire length of the spinal cord. Ultrasonographically, the echogenic lines of the central canal of the spinal cord appear separated with the central canal appearing widened. It can be associated with several congenital abnormalities including diastematomyelia, Arnold-Chiari malformation, myelomeningocele and lipomenigocele.
A syrinx is the accumulation of fluid within the spinal cord, external to the central canal. It may be impossible to differentiate a syrinx from a hydromyelia. It may result from spinal cord trauma, spinal cord tumour or may be present at birth. If present at birth, it can be associated with other spinal abnormalities. Ultrasonographically, the spinal cord appears widened with an anechoic fluid the central canal is often not seen separately and the blanket term syringohydromyelia has been used as syrinx and hydromyelia often co-exist.

Diastematomyelia is an incomplete or complete longitudinal split or cleft through the spinal cord. The spinal cord divides into two hemi-cords. These hemi-cords may be either symmetrical or asymmetrical but each with their own central canal. At the point of division, there may be an osseous, fibrous or cartilaginous dividing septum. The hemi-cords may reunite caudal to the dividing septum. Ultrasonographically, there appears to be two separate smaller spinal cords within the spinal canal. These hemi-cords are hypoechoic with an echogenic central canal similar to a normal spinal cord, but smaller. They may be located side by side or, more rarely, anterior-posteriorly. The dividing septum may vary from echogenic to hypoechoic, depending on the consistency of the tissue. The septum will be located cephalic to the cleft. The two hemi-cords are optimally demonstrated in the axial and coronal planes. Diastematomyelia is commonly associated with a vertebral column abnormality and a tethered spinal cord.

A spinal lipoma is an encapsulated deposit of fat, neural tissue, meninges or fibrous tissue which extends from the posterior subcutaneous tissue through a midline defect of the fascia, muscle or bone to communicate with the spinal canal or meninges. It may be extradural or intradural. Ultrasonographically, a spinal lipoma appears as an echogenic mass extending from the spinal canal dorsally into the subcutaneous tissues. A lipoma may be associated with a tethered cord and vertebral anomalies.

A dorsal dermal sinus is an epithelial lined tract which extends from the skin surface through to the spinal cord, cauda equina or subarachnoid space. The sinuses are most commonly identified within the lumbar region and are at risk of infection. Ultrasonographically, the sinus appears as an anechoic elongated structure extending superiorly from the skin surface into the spinal canal.

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