OBJECTIVE. Our objective is to discuss neonatal spine sonography with emphasis on imaging pitfalls and normal variants that may simulate disease and to distinguish them from true spinal disorders.

CONCLUSION. Sonography of the neonatal spine is now accepted as a highly sensitive, readily available screening study that can be used to evaluate various anomalies of the lumbar spine in most infants younger than 4 months.

Although MRI has been considered the imaging gold standard, recent advances in sonography have allowed its image quality to improve significantly enough that its diagnostic value is equal to that of MRI [1]. Sonography can now characterize nearly all spinal anomalies sufficiently in the first days of life. This allows the clinical determination of whether the lesion requires urgent intervention or whether further radiologic evaluation with studies such as MRI can be delayed until therapeutic intervention is more imminent. In part 1 of this pictorial essay, we discuss lumbar spine embryology, sonography techniques and indications, normal anatomy, and developmental variations and pitfalls that may simulate disease. Part 2 covers abnormal entities.

Embryology
To understand spine anomalies, knowledge of embryonic development is necessary. The CNS starts to form during the third gestational week, beginning with the process known as neurulation (Fig. 1A). Next, canalization occurs at the distal end of the neural tube in the caudal cell mass, resulting in an ependyma-lined neural tube that unites with the rest of the spinal cord to form the conus medullaris and ventriculus terminalis (Fig. 1B). Finally, at 38 days of gestation, retrogressive differentiation occurs (Fig. 1C), forming the filum terminale [2–5].

Technique and Indications
Images are obtained in the longitudinal and transverse planes using a linear 5–12-MHz transducer (Fig. 2). The vertebral level is determined by counting down from the 12th rib and confirmed by counting up from the L5–S1 junction or the tip of coccyx. If the vertebral level is unclear, correlation with radiographs (possibly with a marker) may help. Color or power Doppler sonography may be used as an adjunct to better characterize soft-tissue masses found on the skin or in the spinal canal.

Normal Variants That May Simulate Disorders
Several common normal variants that may be confused with disorders on lumbar spine sonography will be discussed, including ventriculus terminalis, filar cyst, prominent filum terminale, cauda equina pseudomass, pseudosinus tract, and dysmorphic coccyx. Familiarity with these variations can prevent
misinterpretation and referrals for unneeded additional clinical or imaging evaluation.

**Ventriculus Terminalis**

The ventriculus terminalis, often seen on sonography and MRI in children younger than 5 years, is due to incomplete fetal regression of the embryonic terminal ventricle in the conus medullaris [6, 8] (Fig. 3).

**Filar Cyst**

The so-called filar cyst is an interesting incidental finding that has only recently been studied, perhaps at least partly because of being detected more often with improved sonographic equipment. Although this lesion has been scantily described in the radiology literature, it is often visible on sonography. There is no autopsy description of a filar cyst, which begs the questions of its origin and its validity as an entity [3, 4]. In addition, the nomenclature for this lesion is confusing in that it has been termed both “ventriculus terminalis” and “filar cyst” by various authors [6–8]. We prefer the latter term, filar cyst, to specify the filar location from the conus medullaris location of the ventriculus terminalis.

Possible explanations for the origin of the filar cyst include that perhaps the normal arachnoid reflections form a pseudocystlike structure or that it is a true ependyma-lined cystic embryonic remnant (possibly indistinguishable from the ventriculus terminalis) that is disrupted by the act of opening the dura during autopsy. Regardless of its origin, it is a normal variant that alone has no known clinical significance and that does not require additional imaging [4]. If MRI is performed, in our experience, the filar cyst is less reliably visible than on sonography.

Strict imaging criteria for filar cysts should be applied (location midline, within filum, just below conus; fusiform shape, well-defined, hypoechoic appearance of a simple cyst) to avoid the potential for underdiagnosing a true disorder (Figs. 4 and 5).

**Prominent Filum Terminale**

A prominent filum terminale may cause concern when it stands out as particularly echogenic in comparison with other nerve roots. It is distinguished as normal by its thickness and typical midline course [1] (Fig. 6).

**Pseudomass due to Positional Nerve Root Clumping**

Positional clumping of the nerve roots occurs when an infant is scanned in the decubitus position. Rescanning the child prone will cause the “mass” to disappear as the nerve roots return to their normal position (Fig. 7).

**Pseudosinus Tract**

Another common normal variant is a pseudosinus tract, which is seen on sonography as a residual cordlike region composed of fibrous tissue extending from a skin dimple to the coccyx (Fig. 8). True dermal sinus tracts rarely occur at the tip of the coccyx and are typically found in a more cranial location. However, a careful search should be made for any mass or fluid along the course of the fibrous tract. If CSF is draining via a dimple, then a true sinus tract is likely, and MRI is the imaging technique of choice.

**Dysmorphic Coccyx**

The tip of the coccyx can vary widely in shape, and in some cases may mimic a mass when palpated on physical examination (Fig. 9).

**Conclusion**

Neonatal spinal sonography is a useful screening technique for occult spinal anomalies; it can characterize normal anatomy and normal variants that may simulate disorders. Familiarity with these findings will prevent misinterpretation and inappropriate referrals.

**References**

Sonography of Neonatal Spine

Fig. 1—Schematics illustrate three stages of spinal cord development.  
A, Neurulation (closure of neural tube) is process of progression from neural plate to neural groove to neural tube. (Reprinted with permission from Sadler T. Langman’s medical embryology, 5th ed. Baltimore, MD: Lippincott Williams & Wilkins, 1985:335 [5])  
B, Canalization occurs when multiple microcysts form and coalesce in caudal cell mass (arrows), which fuses to distal neural tube (arrowheads), forming primitive spinal cord. (Reprinted with permission from Barkovich AJ. Normal development of the neonatal and infant brain, skull and spine. In: Barkovich AJ. Pediatric neuroimaging, 3rd ed. Philadelphia, PA: Lippincott Williams & Wilkins, 2000:624 [2])  
C, Retrogressive differentiation (programmed cell death) is process whereby caudal cell mass and neural tube regress in size to form fetal conus medullaris, ventriculus terminalis, and filum terminale. Note labeled structures. (Reprinted with permission from Barkovich AJ. Normal development of the neonatal and infant brain, skull and spine. In: Barkovich AJ. Pediatric neuroimaging, 3rd ed. Philadelphia, PA: Lippincott Williams & Wilkins, 2000:624 [2])

Fig. 2—1-week-old boy with normal lumbar spine sonogram and history of unilateral renal agenesis.  
A, Transverse lumbar sonogram shows normal anatomy as labeled. V = vertebra, transverse process (arrowhead).  
B, Longitudinal lumbar sonogram shows normal anatomy as labeled. Note central echoic complex (arrowheads), a normal finding that results from interface of central end of anterior median fissure and not central spinal canal.
Fig. 3—1-month-old boy with ventriculus terminalis who was referred for deep sacral dimple and who is developmentally normal at 18 months.

**A.** Longitudinal sonogram of spine reveals distention of distal lumbar spinal canal just above conus medullaris (arrowhead). Size smaller than 5 mm and stability over time distinguish this normal variant from small syrinx.

**B.** Sagittal T2-weighted MR image at age 7 months shows stable distention of distal spinal canal (arrowhead), excluding syrinx.

Fig. 4—Filar cyst in 14-day-old girl with deep sacral dimple and normal motor development.

**A.** Transverse sonogram of proximal cauda equina shows well-defined, midline, cystic collection (arrow). Note normal ventral and dorsal nerve root bundles (arrowheads).

**B.** Longitudinal sonogram reveals well-defined fusiform “cyst” in midline (arrow) just below conus medullaris. Also note prominent echogenic central spinal canal (arrowhead), a normal variant seen in some children.

Fig. 5—Filar cyst in 5-week-old boy with multiple anomalies who had been followed up with MRI at age 2 months.

**A.** Longitudinal sonogram of filum and cauda equina (arrowhead) shows unusually long filar cyst (calipers). Despite its length, it meets criteria for filar cyst: location just below conus medullaris, fusiform shape, well defined, thin walled, and hypoechoic.

**B.** Longitudinal T2-weighted MR image shows ill-defined filar cyst (arrows) that is better seen on sonography.
Sonography of Neonatal Spine

Fig. 6—Prominent filum terminale in 2-week-old boy with asymmetric gluteal crease. Longitudinal sonogram shows hyperechoic filum of normal size (< 1 mm) (arrow) at L5–S1.

Fig. 7—Positional pseudomass in 2-week-old boy with left renal agenesis who was scanned in left decubitus position.
A. Transverse sonogram shows clumping of nerve roots (arrows) on left due to left decubitus position.
B. Longitudinal sonogram also reveals masslike appearance of nerve roots (arrows). Prone images (not shown) were normal.

Fig. 8—Pseudosinus tract in 12-day-old infant with dimple in gluteal crease. Longitudinal sonogram shows cartilaginous, hypoechoic, dorsally curving tip of coccyx (arrowhead), from which hypoechoic cordlike structure (curved arrow) extends caudally and terminates at base of skin dimple (straight arrow).
**Fig. 9**—Misshapen coccyx in two neonatal girls, each with palpable “lump” beneath sacral dimple in gluteal crease.

**A**, Longitudinal sonogram of coccyx in 2-week-old girl shows hypoechoic cartilaginous tip (arrowheads), which is acutely angulated dorsally as it extends toward skin surface. Palpated “lump” was tip of coccyx.

**B**, Longitudinal sonogram of coccyx in 2-week-old girl reveals it is straightened, with loss of its normal ventral curve. Hypoechoic cartilaginous tip (arrowhead) extends dorsally toward skin surface, causing clinically palpable “lump.”

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**FOR YOUR INFORMATION**

The reader’s attention is directed to part 2 accompanying this article, titled “Sonography of the Neonatal Spine: Part 2, Spinal Disorders,” which begins on page 739.

**FOR YOUR INFORMATION**

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