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Ultrasound Evaluation of Lumbar Spine Anatomy in Newborn Infants: Implications for Optimal Performance of Lumbar Puncture

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An ultrasound evaluation of lumbar spine anatomic landmarks relevant for lumbar puncture was performed in 199 newborn infants. Effects of 6 patient positions and gestational age on interspinous process distance, subarachnoid space width, predicted needle entry angle, and needle insertion depth were assessed. Our results identify optimized conditions for lumbar puncture: sitting the infant with hips flexed, a needle entry angle of 65-70 degrees, and proper needle insertion depth (calculated as 2.5 × weight in kilograms + 6 in millimeters). *(J Pediatr 2014;165:862-5).*

Thousands of lumbar puncture (LP) procedures are performed in hospitalized neonates each year. Improvements in the success rate may limit morbidity and improve care. In recent years, ultrasound (US) has been used to assess spinal anatomy and facilitate LP in children and adults[1-6]; however, few studies have been performed in newborns, and most published studies have been hindered by small sample size, nonblinded US measurements for patient position, and limited evaluation of spinal anatomy.[5,7] We aimed to investigate the effects of gestational age and patient positioning on lumbar spine anatomic landmarks and propose recommendations for performing LP in newborns.

Methods

This prospective observational study was conducted in the inborn neonatal unit at University Hospital of León between January 2012 and October 2012 and involved healthy term and preterm newborns. LP was not performed as a part of the study. The study protocol was approved by the hospital's Institutional Review Board, and written parental consent was obtained for each subject. Subject selection was stratified by birth weight blocks of 250 g.

US was performed with the infants in 6 positions, 3 lateral (L1, L2, and L3) and 3 sitting (S1, S2, and S3; **Figure 1**), assigned to 8 different randomized sequences. The occurrence of oxygen saturation <85% or heart rate <80 bpm in each position was recorded. All US studies were performed by the same investigator using a Vivid I portable ultrasound unit (General Electric, Haifa, Israel) with a linear 12-Hz transducer. The medialsagittal plane was used to obtain all images. To ensure consistent placement of the transducer across the cohort of infants, the L4-L5 interspace was marked with a pen on each infant's skin, and the center of the transducer was placed at this point. The skin adjacent to the edges of the transducer also was marked. Images were analyzed offline by a second investigator who was blinded to the patient data, body position, and sequence of image acquisition.

The external interspinous distance (EID) was defined as the distance between the maximum curvature of 2 adjacent posterior spinous processes. This point is the closest to the skin and represents the anatomic landmark for LP on palpation[6] (**Figure 2**). The internal interspinous distance was defined as the distance between the inner facets of 2 adjacent spinous processes[5,8] (**Figure 2**). Needle entry angle (NEA) was measured between the outer edge of the image (considered the skin surface) at the more caudal spinous process and the midpoint of the epidural space (**Figure 2**). Needle insertion depth (NID) was defined as the distance between the outer edge of the image and the midpoint of the medullar canal measured in a line drawn according to the NEA, obtained as above (**Figure 2**). Subarachnoid space width (SSW) was defined as the distance from the dura mater to the posterior surface of the filum terminalis[9-11] (**Figure 2**). All measurements were performed in millimeters using a digital caliper (**Video**; available at www.jpeds.com).

Statistical Analyses

Data were analyzed by repeated-measures ANOVA. The effects of position, gestational age, and gestational age-by-position interaction were assessed. Profile graphs and Bonferroni-adjusted multiple paired comparisons were

CSF	Cerebrospinal fluid
EID	External interspinous distance
LP	Lumbar puncture
NEA	Needle entry angle
NID	Needle insertion depth
SSW	Subarachnoid space width
US	Ultrasound

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Figure 1. Positioning of the infant was stratified as **S1,** sitting with hips in neutral position; **S2,** sitting with flexed hips; **S3,** sitting with flexed hips and neck; **L1,** lateral recumbent with hips in neutral position; **L2,** lateral recumbent with flexed hips; and **L3,** lateral recumbent with flexed hips and neck.

performed to interpret the results. A total of 198 subjects were required for a desired power of 0.9 and a type I error of 0.05.

Results

Of the 247 newborn infants enrolled, 199 completed the analysis. Patient characteristics are presented in the Table. The position had a significant effect on external and internal interspinous process distance, NEA, and SSW ($P < .001$), but not on NID. Gestational age had a significant effect on interspinous distance, NID, and SSW ($P < .001$), with higher values in term infants. In contrast, gestational age had no significant effect on NEA (Figure 3; available at www.jpeds.com). Gestational age-by-position had a significant effect only on EID ($P < .01$). Examination of the profile graphs in Figure 3 aids the interpretation of this result, showing nearly parallel lines for all variables, indicating that the effect of position was similar in term infants and preterm infants (Figure 3).

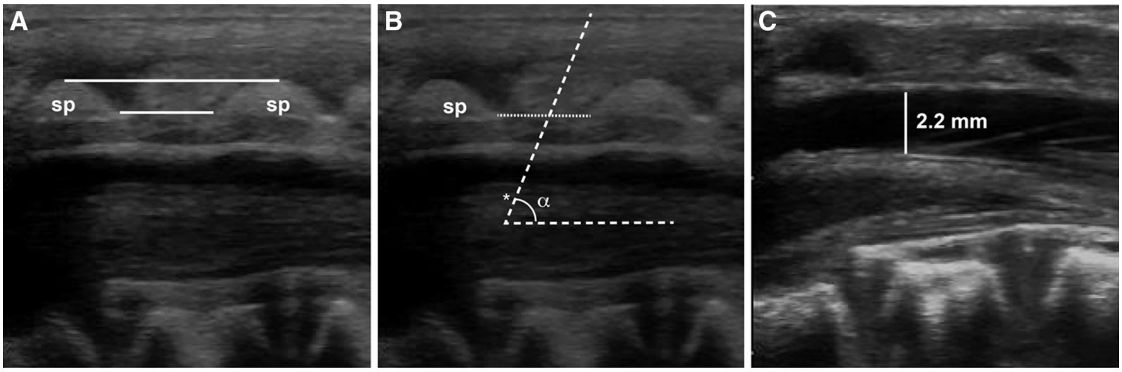

Figure 2. **A,** EID (*upper line*) and internal interspinous distance (*lower line*). This is the location where the needle actually enters the subarachnoid space. **B,** Measurement of NEA. A *line* is drawn from the skin at the closest point to the caudal spinous process that crosses the epidural space at the midpoint between 2 adjacent spinous processes (*short dotted line*). The *asterisk* indicates measurement of NID from the skin surface to midcanal depth according to NEA trajectory. **C,** Measurement of SSW. Conus medullaris is shown. *sp,* spinous process.