Neonatal Lumbar Puncture (LP) - are traditional clinical landmarks of lumbar anatomy accurate when compared with ultrasound assessment

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Aims and objectives

Lumbar puncture (LP) is a commonly performed procedure in neonates that allows a sample of cerebrospinal fluid (CSF) to be obtained. This may be used diagnostically to investigate for infection of the central nervous system and inborn errors of metabolism but also as therapeutic intervention to reduce intraventricular pressure in communicating hydrocephalus. Unsuccessful or traumatic lumbar punctures can lead to neonatal discomfort, diagnostic ambiguity and potentially prolonged hospital stays with unnecessary antibiotic use.

Current best practice for neonatal lumbar puncture involves placing the neonate in the left lateral position, identifying the intercristal line, a hypothetical line (also known as Tuffier’s line) joining the most superior and posterior aspects of the right and left iliac crests, palpating one intervertebral space above or below and inserting the needle at a 45 degree angle.

This technique has its foundations in adult practice where the intercristal line is used to identify the 4th lumbar vertebra where siting the LP needle one space above or below this region avoids potential needle trauma to the spinal cord which is thought to end at L1 vertebral level.

In the neonatal population it has been reported to cross the midline at a level between L5 and S1 but this remains an area of debate.

To the best of our knowledge there are no studies in the literature that have investigated whether manual palpation reliably allows accurate differentiation between vertebrae and intervertebral spaces in neonates.

Ultrasonography is well recognized to be a useful investigation of the anatomy of the infant spine. It allows accurate assessment of the position of vertebrae and intervertebral spaces and also the depth from skin to dura.

In this prospective study we aimed to use ultrasonography to investigate the vertebral level crossed by the intercristal line as determined by manual palpation of anatomical landmarks and secondly the ability of manual palpation to reliably identify a specified intervertebral space in neonates. The level of the conus medullaris was also recorded.
Methods and materials

This was a single centre, prospective blinded study at a district general hospital in the United Kingdom.

Over a ten month period, beginning April 2013, a total of 30 neonates were recruited from either the postnatal ward or the Special Care Baby Unit (SCBU).

Inclusion criteria were; term neonates (37-42 weeks gestation), informed consent from infant's parent/guardian, study personnel available to be present during data collection, no contra-indication to the use of ultrasound jelly, clinically well subjects thought to tolerate handling. Exclusion criteria included spinal/lumbosacral anomalies (spina bifida, sacral dimples) and valid consent not obtained or withdrawn.

After discussions with the research and development department this piece of research was deemed a service evaluation and thus did not require formal ethics committee approval.

At recruitment the study was explained to parents verbally and an information leaflet given. Written consent was obtained and documented. Parents were invited to be present during the marking and ultrasonography if they wished.

Paediatricians selected to examine the neonates were specialist registrar level and above. Examiners were selected by their presence on the unit that day, if more than one paediatrician fitted the criteria they were chosen at random by pulling a name out of a box. A researcher was always present during neonatal examinations to ensure the correct methodology was adhered to and to file the documented results.

All senior paediatricians from the department who agreed to take part in the study were assigned a randomized identification code prior to the commencement of the study in order to facilitate blinding from the consultant radiologist who performed the ultrasound on infants. The researcher documented the examiners personal randomized identification code along with neonatal information including; admission weight, age, gender, gestational age and positioning. Examiners were then handed a 'clinician instruction sheet' instructing the marking of the intercristal line and one intervertebral space above. This was marked on a clear plaster on the infants back.

The radiologist was blinded from the paediatrician marking the neonate and thus was not present during marking. The member of the research team present ensured that there
was no contact between the examiner and the radiologist. The consultant radiologist was then provided with a sheet for completion allowing documentation of; the vertebral level of the marked intercristal line, the vertebral level of the second marking, whether it was one intervertebral space above as requested of the examining paediatricians, whether the second mark was within the intervertebral space and finally the level of the conus medullaris.

The examination and marking of the subject was performed with the subject on a resuscitaire, held in the left lateral position. Neonates were held on the resuscitaire in the same position by the same person for ultrasonography. Infants were released from the left lateral position between marking by the paediatrician and scanning by the consultant radiologist if their clinical condition was thought to deem it necessary. No lumbar punctures were performed during the study.

The radiologist was provided with an envelope in which to put the examination findings. After examination the envelope was sealed and a number put on the outside of the envelope (1-30). If any abnormality was detected the radiologist was informed to make the researcher aware immediately and inform the service consultant. That neonate would then be removed from the research project.

The radiologist was not permitted to discuss the positioning of the markings with any of the clinical or research team involved.

**Results**

If the limited literature is to be followed, the ICL *should* cross at the upper third of the vertebra of L5 and thus when marking one intervertebral space above this should be L4-5. Of the 30 neonates examined, the level of the marked intercristal line ranged from L2-3 to L5-S1 (Figure 1). No clinician marked the ICL as crossing L5. The majority (50%) of clinicians marked at L4-L5.

The subsequent second marking, one intervertebral space above the ICL, was shown to range between L1-2 and L4-5 (Figure 2). The majority of examiners, 50% would have entered at the L3-4 space. 11 (37%) of examiners would have inserted the needle at a level that would be deemed unsafe in neonates.

The caudal end of the conus medullaris ranged from L1 to L3 with 50% ending at the level of L1-2. In 90% of neonates the conus medullaris ended at L2 or higher (figure 3).
After further analysis looking at individual neonates potential LP site and their documented level of the conus medullaris we generated a scatter graph to represent such data (Figure 4).

The graph shows potential 'collisions' between the LP entry point and conus termination. When considering needles are inserted at a 45 degree angle pointing toward the umbilicus those neonates whose conus terminated, for example at L2, but the needle was inserted at L2-3 may also be at risk.

11 different clinicians marked the neonates, with experience either between 20-50 previous LPs or >50 LPs. We have analysed the results to see if there was one clinician whom repetitively marked incorrectly and would thus skew results - there was no such clinician. There was also no significant difference in accuracy with those clinicians who had greater LP experience.

Images for this section:

![Figure 1) Distribution of the clinical estimate of the ICL by palpation (N=30)](image)

Fig. 1
Figure 2) Distribution of potential LP entry point (one intervertebral space above marked ICL)

Fig. 2
Figure 3) Distribution of the level of the conus medullaris found on ultrasonography

Fig. 3
Fig. 4: Scatter graph to show correlation between LP entry point and the level of the conus.
Conclusion

In our study the level of the ICL was found to be highly variable with the majority of clinicians placing it at L4-5. None of the clinicians marked the ICL to cross the L5 vertebral body as suggested by a recent study which looked at neonatal cadavers in the flexed position\(^4\). The subsequent identification of the LP entry point was not variable. For example, only 2 clinicians marked L5-S1 as the ICL and therefore only 2 clinicians should have come to the conclusion that L4-5 was the next space above. However, four clinicians marked this space as the lumbar puncture entry point. This suggests that not only is the neonatal ICL itself highly variable, but there is also difficulty identifying one intervertebral space above it or even the space itself.

It has been described previously that the ability to palpate a specified intervertebral space using the intercristal line is likely to be inaccurate in adults\(^5\). In 2003 a study involving 100 participants suggested the anticipated intervertebral space is marked one space higher in 51% of cases, thus being more likely to cause trauma. Anaesthetists were shown to be accurate in only 29% of cases\(^6\).

A systematic review and meta-analysis of randomized controlled trials to determine whether ultrasound imaging can reduce the risk of failed lumbar punctures in adults was published in 2013\(^7\).

Ultrasound imaging was shown to significantly reduce the risk of both failed and traumatic procedures along with a reduction in the number of insertion attempts. This review concludes that ultrasound use would be of benefit for LPs in adults.

We assume that a needle placed in or near to the intervertebral space where the conus medullaris terminates in neonates has at least the potential to lead to complications, although we are not aware of any evidence highlighting this in clinical practice.

Our data raises the question whether ultrasonography of the spine perhaps would also be useful in neonates to avoid potential complications and to enhance accuracy of the procedure. It would however also necessitate the availability of ultrasound machines and appropriate training in their use, which is currently not in place in the UK.
In our study we specifically asked clinicians to mark one intervertebral space above the ICL line, which is theory would be higher risk. The results may have been different, not in term of accuracy but in terms of fewer potential 'collisions'.

Our data demonstrates the position of the ICL in relation to spinal anatomy as highly variable. The ability of experienced Paediatricians to palpate spinous anatomy is inaccurate. Due to this inaccuracy there appears to be the potential for harm and diagnostic ambiguity.

The spinal level of the conus medullaris was also highly variable. We question the potential for ultrasonography to aid needle insertion in this vulnerable population. The study is limited by its small sample size.

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