NEONATAL ANATOMY RELEVANT FOR LUMBAR AND CAUDAL EPIDURAL BLOCKS

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Introduction

Caudal and lumbar epidural blocks (see Figures 1a & b)are the most widely used regional anaesthetic procedures for any procedure on the lower part of the abdomen and lower limbs, especially in neonates, infants, and certain high risk children [1]. The successful performance of these procedures requires a thorough knowledge of the anatomy of the lumbar vertebrae and sacrum, the spinal cord as well as the position of the dural sac.

Many anaesthesiologists, not used to working with paediatric patients, may lack the knowledge of relative depths or position of key anatomical structures. A thorough knowledge of the anatomy of paediatric patients is therefore essential for safe and successful performance of epidural blocks.

Figure 1a: Caudal epidural block being performed on a young infant at the Red Cross Children's Hospital in Cape Town.
Figure 1b: Lumbar epidural block being performed on a teenager at the Red Cross Children's Hospital in Cape Town.

Aim

The aims of this study were to observe and quantify the important landmarks and structures, associated with both the lumbar and caudal epidural blocks, and to determine the effects that flexion of the patient will have on these structures.

Materials and Methods

The saccococcygeal membrane (covering the sacral hiatus and found between the two sacral cornuae) as well as the lumbar vertebrae and the iliac crests was carefully exposed of 40 neonatal cadavers (mean length: 0.42m ± 0.07m; mean weight: 1.59kg ± 0.85kg) (see Figure 1).

High quality digital photographs were then taken. A scale of known distance was placed on top of the dissected area (without covering any of the relevant structures) in order for digital measurements of the photograph to be possible. The photographs were then imported into UTHSCSA Image Tool version 3 (freeware), which was used to analyse the photographs and make the measurements. Each cadaver was photographed in both a prone (see Figure 2a) and flexed (between 40°-50°) (see Figure 2b) position.

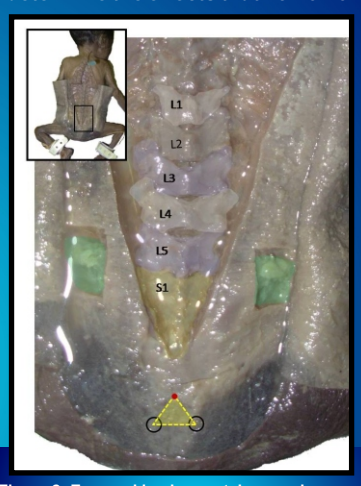


Figure 2: Exposed lumbar vertebrae and sacrum of a neonatal cadaver. Also indicated is the sacral hiatus (yellow triangle), covered by the sacrococcygeal membrane, between the two sacral cornuae (black circles) and with its apex indicated by the red circle. The iliac crests are highlighted in green.

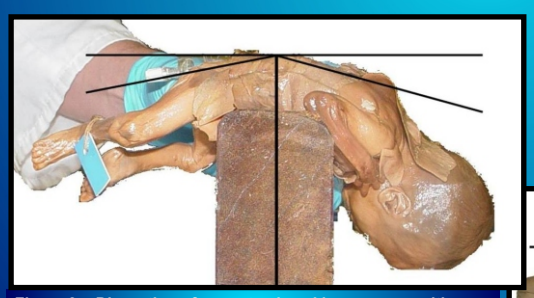


Figure 3a: Dissection of neonate placed in a prone position.
Figure 3b: Neonate flexed between 40° and 50° over a wooden block.

The following measurements were taken with the neonate in both a prone and flexed position: (i) the distance of the apex of the sacral hiatus (ASH) to the level of Tuffier's line (defined as the line connecting the two iliac crests) (TL); and (ii) the surface area of the L1/L2 to L5/S1 interlaminar spaces (see Figure 3)

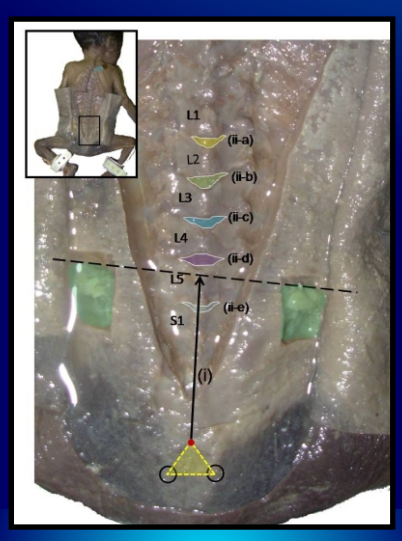


Figure 4: Dissection of neonatal vertebral column. Measurement (i) from the ASG (indicated by red circle) to TL (black dashed line); and (ii.a-e) the surface area of the L1/L2 to L5/S1 interlaminar spaces.

With the neonate in both a prone and flexed position (iii) the distance from the ASH to the end of the DS, and (iv) the distance from the ASH to the end of the spinal cord (conus medullaris or CM) was measured.

There after, the laminae of the lumbar vertebrae were carefully removed in order to expose the content of the vertebral canal. The end of the dural sac (DS) was noted. A midline incision was then made through the dura mater in order to expose the spinal cord (see Figure 4).

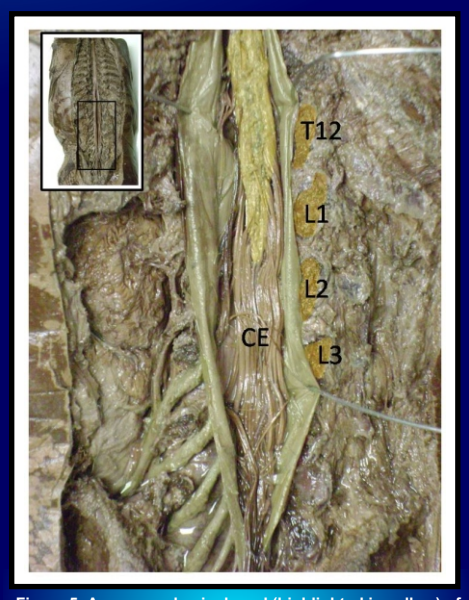


Figure 5: An exposed spinal cord (highlighted in yellow) of a neonatal cadaver. The T12-L3 vertebrae (highlighted in orange) are also indicated. The dura mater (highlighted in green was sectioned and reflected in order to show the spinal cord and cauda equine (CE).

Results & Discussion

Measurement (i):

Table 1: Distance from the ASH to TL and vertebral level of TL in a neonatal sample in both a prone and flexed position

	Distance in mm		% Change	Vertebral level of TL	
	Prone	Flexed		Prone	Flexed
Mean	23.48	24.62		L4/L5	Upper third of L5
SD	4.84	5.12			
CI 95%	2.53	2.01			
Lower	20.95	22.61	1.39	Lower third of L4	L4/L5
Upper	24.57	25.38	8.65	L4/L5	Upper third of L5

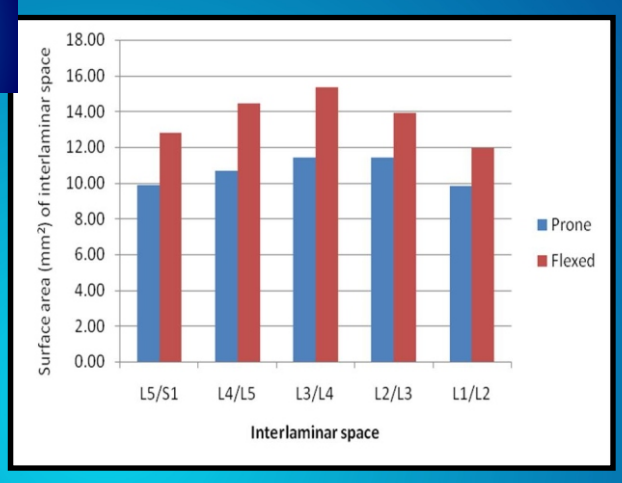
Key:
Lower: Lower range of the Confidence interval with a level of confidence of 95%
Upper: Upper range of the Confidence interval with a level of confidence of 95%
CI 95%: Confidence interval with a 95% confidence level

While the vertebral level of TL moves caudally during flexion, the distance from the ASH to TL increases significantly (p = 0.0061) from 23.48mm ± 4.84mm (mean ± SD) (95% confidence level; range: 20.95mm 24.57mm) to 24.62mm ± 5.12mm (95% confidence level; range 22.61mm 25.38mm). This constitutes a percentage change that ranges between 1.39% to 8.65% (95% confidence level).

Measurement (ii. a-e):

The surface area of the interlaminar spaces of the neonatal cadavers in a prone position and the same sample of cadavers in a flexed position can best be summarised in Figure 6.

Figure 6: Surface area of L1/L2; L2/L3; L3/4; L4/L5 and L5/S1 interlaminar spaces in a sample of neonates in both a prone and flexed position. Average surface area for both samples are shown (blue and red blocks, respectively).



It was found that, when prone, the L2/L3 and L3/L4 interlaminar spaces have the largest surface areas, 9.61-12.68mm2 and 9.73-12.54mm2, respectively. Flexion caused the greatest change (approximately 25.53%) at the L4/L5 interlaminar space. On average there is a 19.01% change in the surface area of the L1/L2 interlaminar space from a prone to a flexed position. The percentage change of the surface area of the L2/L3; L3/L4; and L5/S1 interlaminar spaces are 18.56%, 23.52%, and 23.23% respectively.

Measurement (iii):

In the sample of 40 neonatal cadavers, the mean distance from the ASH to the DS was 10.45mm ± 3.99mm. There is a 95% confidence level that in a neonatal sample, the DS can be found between 8.88mm 11.79mm from the ASH. This is especially important when inserting a continuous epidural catheter via the caudal route. When threading the catheter into the caudal/ vertebral canal there is a very real chance of puncturing the dural mater.

Measurement (iv):

Table 2: Summary of the distance from the ASH to the CM with the cadaver in both a prone and flexed position. The percentage change of this distance between the two positions is also shown. The level of spinal cord termination is also indicated.

	Distance in mm		% Change	Vertebral level of CM
	Prone	Flexed		
Mean	40.62	45.76	11.43	Upper third of L2
SD	11.67	12.16	7.56	
CI 95%	4.58	4.77	2.96	
Lower	36.05	40.99	8.47	L1/L2
Upper	41.61	48.88	12.67	Middle third of L2

Key:
CI 95%: Confidence interval with a 95% confidence level
Lower: Lower range of the Confidence interval with a level of confidence of 95%
Upper: Upper range of the Confidence interval with a level of confidence of 95%

In the sample of forty neonatal cadavers, the mean distance from the ASH to the CM was 40.62mm ± 11.67mm. There is a 95% confidence level that in a neonatal sample, the CM lies between 36.05mm 41.61mm from the ASH in a neonate lying in the prone position. When flexed this distance increases to 45.76mm ± 12.16mm (95% confidence level; range: 40.99mm 48.88mm).
This distance changes between 8.47% - 12.67% (95% confidence level) when the neonate is flexed.
On average the CM can be found at the level of the upper third of the L2 vertebra in neonates (95% confidence level; range: L1/L2 middle third of L2). This is somewhat higher than L3, which is commonly considered the norm for neonates [2].

Conclusion

This study hopes to complement what is already known of the neonatal vertebral column and to shed some light on the changes that occur when the neonate is flexed during the conduction of either single-shot lumbar or caudal epidural blocks, or for the insertion of a continuous epidural catheter via the caudal or lumbar route.

References

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2. Sadler TW. Langman's Medical Embryology (10th ed.). Philadelphia: Lippencott Williams & Wilkens, 2006.

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