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The spread of the ultrasound-guided injectate after a lumbar and thoracic erector spinae plane block. A cadaveric study

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Abstract : *Purpose :* The *erector spinae* plane block is a novel block performed at a thoracic level with a spread via the thoracolumbar fascia. The objective of this cadaveric study is to evaluate the spread of the injectate after a lumbar *erector spinae* plane block.

Methods : Four lumbar erector spinae blocks were performed in two non-embalmed cadavers with 20 ml of a methylene blue or black ink solution injected in a plane between the transverse processes and the *erector spinae* muscles. After dissection, the extent of the dye spread, and the staining of neuronal structures were documented. Laminectomy was performed to determine the epidural spread. A thoracic *erector spinae* plane block was also performed in both cadavers to determine the epidural spread of dye.

Results : In the lumbar region, the craniocaudal dye spread underneath the *erector spinae* muscle varied between two and five intervertebral levels. The staining of the spinal nerves was limited to the level of the intervertebral foramina in one cadaver. Dye was also observed at the inner side of the *ligamenta flava* at the lumbar region. An epidural spread was present after both thoracic *erector spinae* blocks, with an extension to the contralateral side in one of them.

Conclusion : A lumbar *erector spinae* block (ESB) can spread over multiple vertebral levels in the proximity of the neuroforamen and the spinal nerves and, potentially to the epidural space. This may suggest analgesia for lower spine surgery. A thoracic ESB may spread epidurally and contralaterally. Further research is desirable.

Keywords : *Erector spinae* block ; ultrasound guidance ; spine surgery ; postoperative analgesia ; locoregional anaesthesia

Introduction

A suitable locoregional technique for back surgery requires a block of the innervation of the vertebrae and of the paravertebral muscles. Therefore these blocks should include the dorsal rami of the spinal nerves at the levels of surgery (1) . Dorsal ramus blocks can be feasible in chronic pain treatment (2) .

Lately, a series of case reports describe how a bilateral block of the lumbar dorsal ramus nerves lowers pain scores and reduces morphine consumption after spine surgery (3) .

Recently, the thoracic *erector spinae* plane block (ESB) was described as a new, safe and simple technique for acute post-surgical pain and neuropathic pain. With this technique, one single large volume injection of local anesthetic reaches the immediate vicinity of the dorsal and ventral roots of the thoracic spinal nerves at several vertebral levels (4, 5). This substantial coverage is believed to be due to the spread of the injectate via the thoracolumbar fascia.

The thoracolumbar fascia is also present in the lumbar region around the *erector spinae* muscle. Theoretically, this fascia could contribute to the dispersion of the injectate over multiple levels as well, reaching the dorsal rami of the lumbar spinal nerves. To our knowledge, there are no cadaveric nor clinical published trials performing a lumbar ESB with a high-volume injection aiming for multiple vertebral levels. It is essential to comprehend how the local anesthetic spreads after a lumbar ESB and

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to determine if the dorsal rami are reached and how many vertebral levels will be covered.

This anatomical study was performed on fresh human cadavers in order to examine the local anesthetic spread in a craniocaudal and mediolateral direction, after completing an ESB at one lumbar level with a single high-volume injection. As our results suggested a putative epidural spread after a lumbar ESB, this information has also been studied at the thoracic level.

Material and methods

The study conforms to the Declaration of Helsinki and to the guidelines of study ethics in anatomical research within the framework of the Anatomical Quality Assurance Checklist (6). Two non-embalmed fresh frozen female cadavers from the Laboratory of Human Anatomy and Embryology (Department ASTARC, Faculty of Medicine & health science, University of Antwerp) were used. The dissections were performed in December 2017.

For the first cadaver (cadaver 1), an ultrasound guided ESB was performed at the second lumbar intervertebral level at the right side and at the fourth lumbar intervertebral level at the left side. For the second cadaver (cadaver 2), a bilateral lumbar ESB was performed at the third lumbar intervertebral level. After lumbar region dissection, a thoracic *erector spinae* plane block was performed at the T5 level on the right side in both cadavers.

The blocks were performed by the authors D.V.A. and M.B.. The dissections were performed by L.v.N and N.d.J.

Performance of the lumbar ESB

The lumbar ESB was performed with a 5-10MHz curved array probe and a BK flex focus 700 ultrasound machine (BK ultrasound Benelux, Mechelen, Belgium). In a prone position, the intervertebral levels were counted in the paramedian oblique ultrasound view as described by Chin *et al* (7). We visualized the transverse process in a longitudinal paramedian view at the puncture level. A 22 Gauge 55 mm Sonoplex needle (Pajunk Benelux, Geisingen, Germany) was advanced in plane in a craniocaudal direction. The bone contact was achieved with the posterior surface of the transverse process approximately at the midlevel in a mediolateral plane. The needle was slightly retracted (<1 mm) and 20 mL of a methylene blue solution [1 mL methylene blue in a 20 mL aqueous solution of NaCl (0.9%)] was injected between the transverse process and the erector spinae muscle (Fig. 1). For cadaver 2, we used a black ink solution [1 mL pelican black drawing ink in a 20 mL aqueous solution of NaCl (0.9%)].

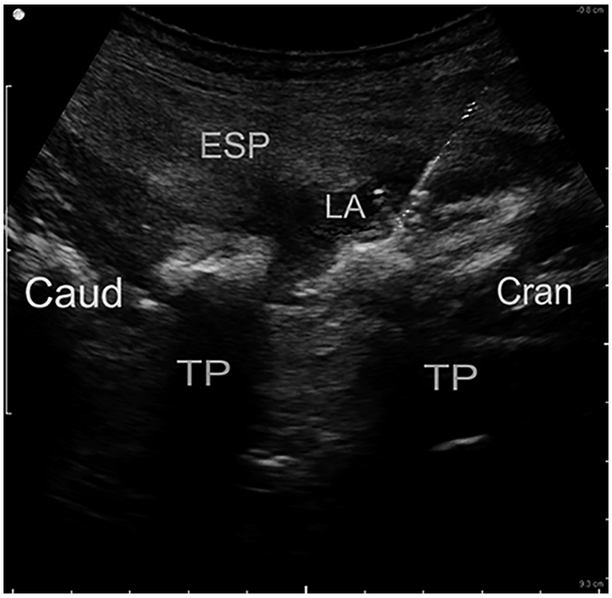


Figure 1.

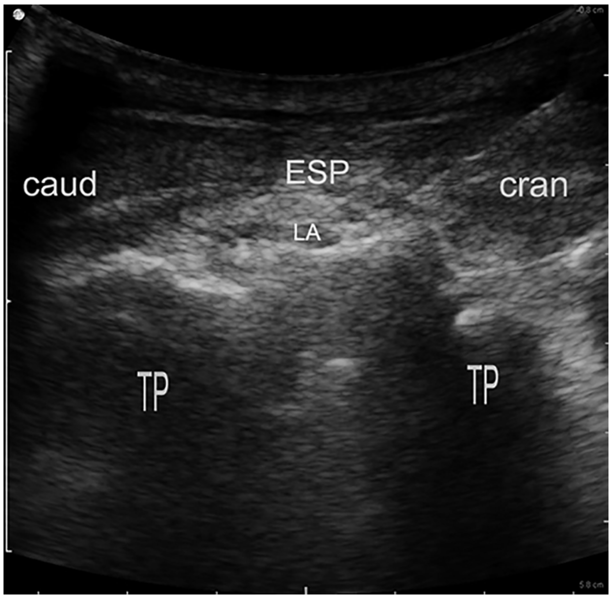


Figure 2.

Performance of the thoracic ESB

The thoracic ESB was performed with a high frequency 6-18 MHz linear array probe and a BK flex focus 700 ultrasound machine (BK ultrasound Benelux, Mechelen, Belgium). In a prone position, the probe was placed in a parasagittal longitudinal view at the level of the fifth thoracic vertebra, according to the description of Chin *et al* (7). A 22 Gauge 55 mm Sonoplex needle (Pajunk Benelux, Geisingen, Germany) was advanced in plane in a craniocaudal direction. The bone contact was achieved with the needle and the posterior surface of the transverse process, approximately at the midlevel in a mediolateral plane. After a slight retraction of the needle (< 1mm), 20 mL of the methylene blue solution was injected between the *erector spinae* muscle and the transverse process (Fig. 2).

Dissections

Dissections were performed between 20 and 60 minutes after injection to establish the spread of the injectate. The skin was craniocaudally incised (± 5 cm each side) at the midline and the skin flaps were laterally reflected. The thoracolumbar fascia and the medial column of the *erector spinae* muscle (*i.e.* the spinalis muscle) were also craniocaudally incised and laterally reflected. After dissection of the lumbar regions, spread of the dye underneath the erector spinae muscles was measured in a craniocaudal direction (number of vertebral levels). Search for neural structures of the spinal nerves and identification within the injectate spread was completed. Subsequently, a laminectomy was performed to search for putative epidural spread. The primary purpose of the dissections in the thoracic region was evidence of epidural or contralateral spread. In the thoracic region, the skin was incised in a similar way as in the lumbar region. After reflection of the skin flap, the origin of the *trapezius* muscle at the thoracic spinous processes was incised and laterally reflected before incision of the spinalis muscle.

Results

Ultrasound clearly visualized the lumbar and thoracic transverse processes on both sides in both cadavers. The spread of the solution was visualized on ultrasound in all injections. An evident longitudinal spread in a craniocaudal direction underneath the *erector spinae* muscle was observed in both

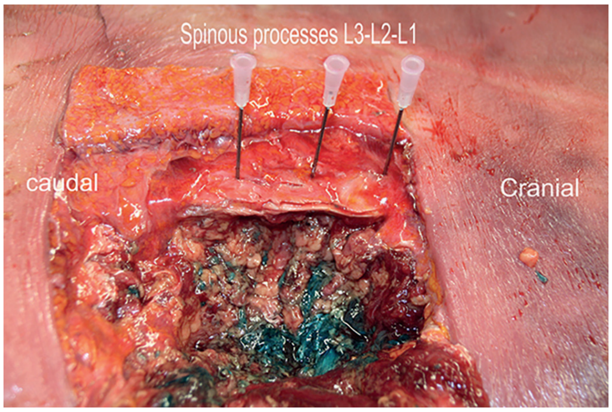


Figure 3

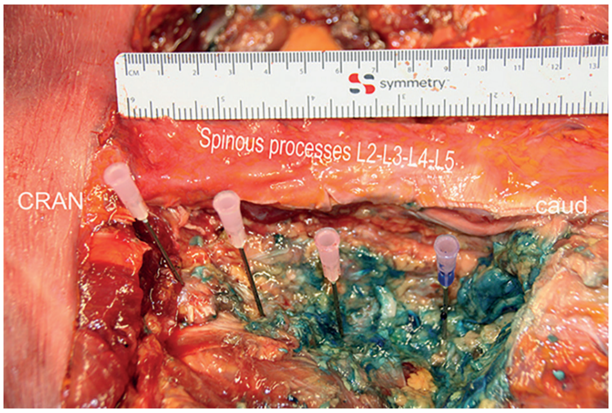


Figure 4

lumbar injections and in one of the two thoracic injections.

Dissection of the lumbar region

The craniocaudal spread of dye underneath the *erector spinae* muscle varied between two and five intervertebral levels (Table 1) (Fig. 3 et 4). After performing a laminectomy and removing the facet joints, the dye was detected at the proximity of the intervertebral foramina, located at the same intervertebral levels as presented in Table 1. In cadaver 1, methylene blue dye was also observed at the inner side of the *ligamenta flava* connecting the removed vertebral laminae (Fig. 5). No evidence

Table 1

Cadaver, side and level of injection and craniocaudal spread

Cadaver	Side	Puncture	Craniocaudal spread	Epidural spread	Contralateral spread
1	right	L2	L1-L2	yes	no
1	left	L4	L2-S1		
2	right	L3	L2-S1	no	no
2	left	L3	L2-L5		
1	left	T5	T2-T9	yes	no
2	left	T5	T3-T7	yes	yes

Abbreviations: L=lumbar vertebrae S=Sacral bone

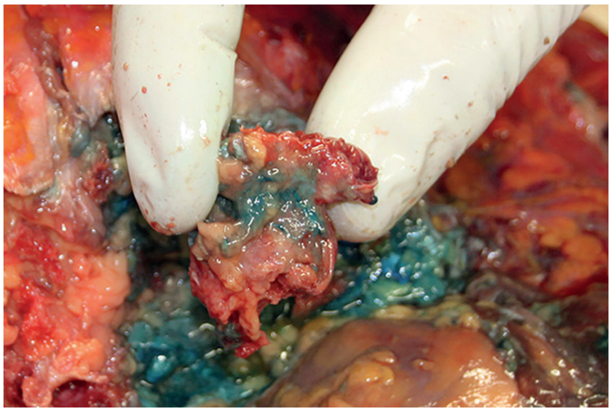
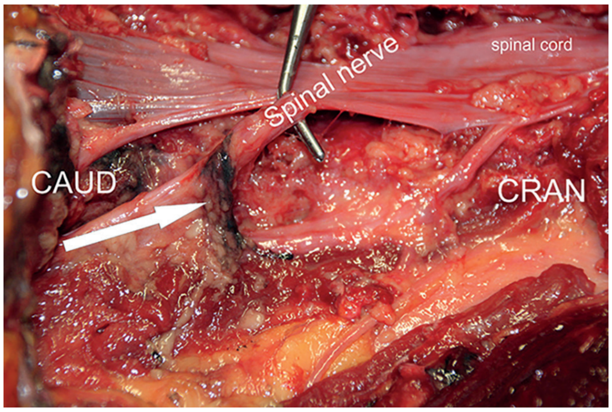


Figure 5



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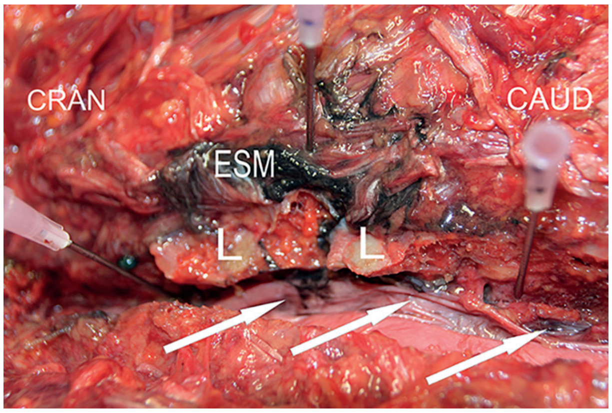

Figure 7

of lumbar epidural spread was observed in cadaver 2. The staining of the spinal nerves was present but limited to the level of the intervertebral foramina (Fig. 6). Neither cadaver showed a ventral spread towards the lumbar plexus.

Dissection of the thoracic region

In cadaver 1, the spread of the black ink was limited in craniocaudal and mediolateral direction. After performing a laminectomy, an evident staining underneath the vertebral *laminae* could be visualized

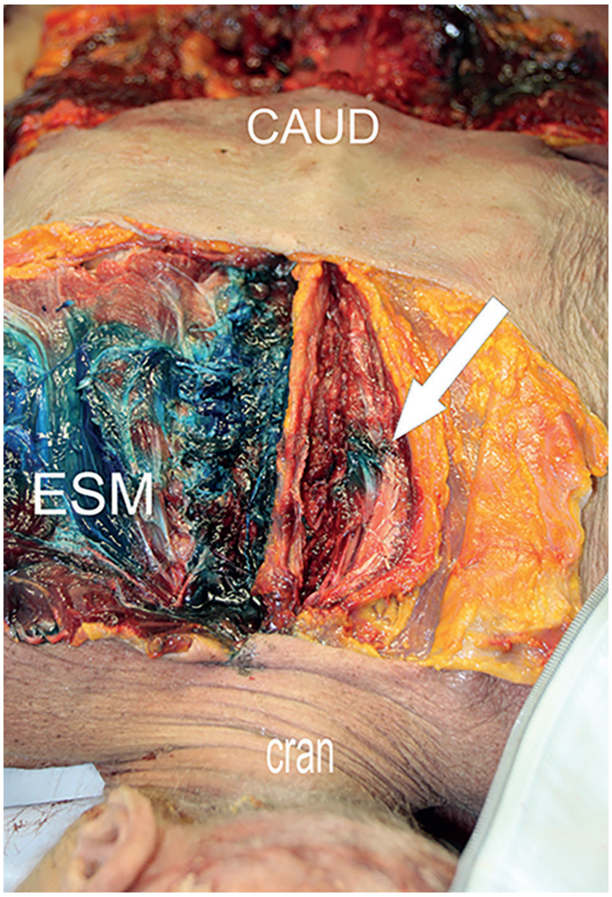

Figure 8

(Fig. 7). In cadaver 2, the spread of methylene blue dye was more extensive in craniocaudal and mediolateral direction. After skin dissection, a distinct staining of the contralateral *erector spinae* muscle was noticed without any superficial spread of the dye on the midline of the cadaver (Fig. 8). The laminectomy revealed a spread of methylene blue via the epidural space towards the contralateral side (Fig. 9).

Discussion

The spread to multiple lumbar vertebral levels in this trial might be via the middle thoracolumbar fascia. A multilevel spread (even to T7) has also been shown after a *quadratus lumborum* block (QL2), where the same fascial plane is approached, at a slightly more lateral level (8-10) . After leaving the vertebral foramen, the lumbar dorsal rami pass dorsocaudal between the transverse processes (11) and then divide into medial and lateral branches, which traverse the thoracolumbar fascia. In our dissection, the proximal spinal nerves were stained before this division at several vertebral levels,

The epidural spread could imply sympathetic blockade, but more research is needed to determine

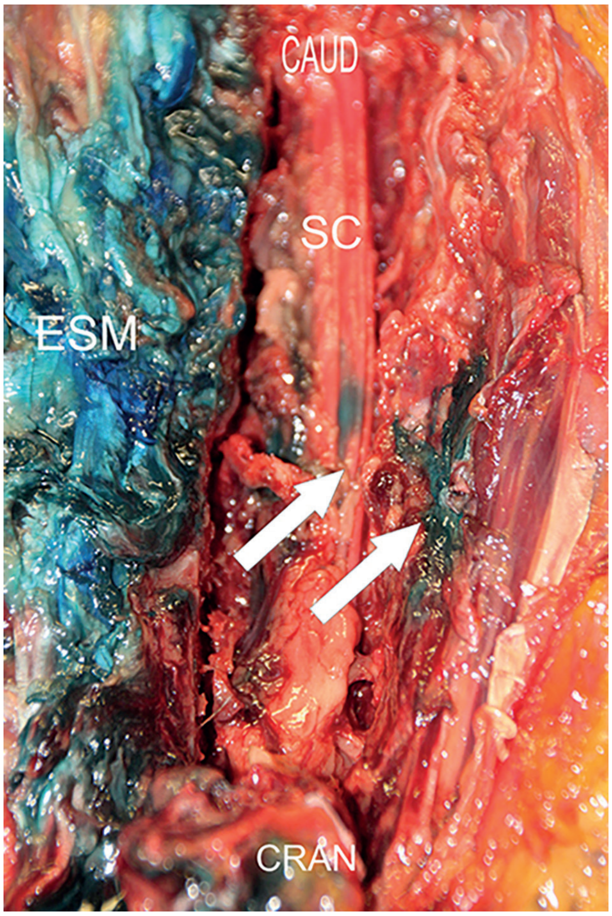

Figure 9

if this is a consistent finding and to get insight into the exact mechanism of this block. Epidural and contralateral spread is described in other lumbar high-volume blocks closed to the vertebral column such as the lumbar plexus block and the suprasacral parallel shift block, with the epidural route as a possible pathway (12-14) .

Our findings of a contralateral and epidural spread of the injectate after a thoracic ESB have, to our knowledge, not been described yet. Extensive craniocaudal spread was already described. However this did not result in the spread of dye anteriorly in proximity to the origin of the ventral and dorsal branches (15) . Epidural spread is known to appear after a thoracic paravertebral block (16) .

All blocks displayed considerable variability in spread along the spinal levels as well as epidural and contralateral dispersion. This variability may be explained by injection deep or superficial to the fascia or by possible layering of the fascial plane with different points of injection. The need to understand the fascial tissue anatomy for all plane blocks was recently emphasized (17) .Two and three layer models have been described (18) . Furthermore, cadaveric factors such as autolysis, age storage, time of death, disease and size could also play a role.

There are several limitations to this trial. Only two female cadavers were used. The extent of inter-individual variation of injected spread in cadaver studies is not insignificant (9) . The thoracic ESB was performed after the lumbar dissection, which may have influenced the thoracic spread due to anatomical disruption of the planes. Although Cadaver results cannot be extrapolated to clinical patients, our findings indicate that a possible epidural spread cannot be excluded after a lumbar and a thoracic ESB.

We conclude that a volume injected between the erector spinae muscle and the transverse process may spread over multiple vertebral levels in the proximity of the neuroforamen and the spinal nerves and also to the epidural space. However, spread after of both lumbar and thoracic ESB varies. The observed spread in our cadavers suggests that a lumbar ESB may provide analgesia for lower spine surgery. A thoracic ESB may spread epidurally and contralaterally. Further research is desirable to understand the clinical implications of the ESB.

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