Unpredictable Injectate Spread of the Erector Spinae Plane Block in Human Cadavers

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We performed bilateral ultrasound-guided erector spinae plane blocks at the second and eighth thoracic vertebrae in 11 fresh frozen cadavers. Methylene blue dye spread variably and extensively deep to the erector spinae muscles fascia with involvement of the spinal rami and paravertebral space in 1 of 11 cadavers when injected at the eighth thoracic vertebra, and in 4 of 11 cadavers at the second thoracic vertebra, with crossover to the contralateral side of the spine. Our study demonstrates that in cadavers, an erector spinae plane block follows the fascial planes with unpredictable spread, which might explain its varying clinical efficacy. (Anesth Analg 2019;129:e163–e166)

The erector spinae plane block is a regional anesthetic technique, providing analgesia in both acute postsurgical pain and chronic neuropathic pain.[1–8] This ultrasound-guided block is a fascia block whereby local anesthetics are injected below the erector spinae muscles. These muscles run along both sides of the vertebral column from the sacrum or sacral region up to the base of the skull.

Previous studies describing ultrasound-guided erector spinae plane block using computed tomography reconstruction showed extensive cephalocaudal spread of injectate from the first to the eighth thoracic vertebra deep to erector spinae muscle and involvement of epidural, neural foraminal, and intercostal spaces when injected at the fifth thoracic vertebra in cadavers.[1,9] The erector spinae plane block has been performed mainly at the fifth thoracic vertebra because of its use for thoracic analgesia, clinically resulting in loss of sensation ranging from the first to the 10th thoracic vertebra, although alternative injection sites have been used showing a spread from the third cervical vertebra to the third thoracic vertebra when injected at the second thoracic vertebra.[10]

The erector spinae plane block is a fascia block; however, its exact mechanism of action is still unclear. It has been suggested to anesthetize the spinal nerves by passing through the costotransverse foramen of Cruveilhier, accompanying the dorsal ramus and artery to the paravertebal space.[1] In clinical practice, we observe highly variable results of the erector spinae plane block and hypothesize that an unpredictable spread might be the explanation for these results. Therefore, we examined the spread of the erector spinae plane block in 11 cadavers. To maximize the amount of blocks, we injected bilaterally and chose 2 different thoracic levels to evaluate spread to the contralateral side and identify or support possible new indications for the erector spinae plane block.[10] To avoid overlap of dye, we performed an erector spinae plane block at either the second thoracic vertebra or the eighth thoracic vertebra on one side and an erector spinae plane block at the other thoracic level on the contralateral side using methylene blue dye solution.

METHODS

Sixteen fresh frozen cadavers were provided by the Department of Surgery of the Radboud University Medical Center, Nijmegen, the Netherlands. The deceased all chose to donate their bodies to science; therefore, no ethics committee approval was necessary. We placed the cadavers in prone position, with neck and back fully exposed and inspected them for anomalies (eg, scoliosis/scars) indicating previous spine surgery. An ultrasound-guided erector spinae plane block was performed by anesthesiologists experienced in ultrasound-guided regional anesthesia techniques. An 18-gauge Tuohy epidural needle (B. Braun Melsungen AG, Germany) and a Philips ultrasound machine (Xperius Ultrasound System; Philips Ultrasound Inc, Bothell, WA) were used for an in-plane technique, and 20 mL of diluted methylene blue (1 mL of methylene blue dissolved in 19 mL of sodium chloride 0.9%) was injected at the level of the second and eighth thoracic vertebrae on either the right or left side of the spine, with 2 injections per cadaver (eg, if the erector spinae plane block was performed at the second thoracic vertebra at the left side, an erector spinae plane block was performed at the eighth thoracic vertebra at the right side). The level of injection was determined by palpation and counting down from the spinous process of the seventh cervical vertebra. A linear probe was placed paramedian in a longitudinal orientation to identify the transverse process and rib and to visualize acoustic shadows of the skin, subcutaneous tissue, rhomboid muscle, trapezius muscle, and the erector spinae muscle. The needle tip was placed from cranial to caudal beneath the erector spinae muscle, and dye was injected under continuous ultrasound visualization.

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Immediately after injection, the cadavers were dissected by surgical residents following a standardized method, supervised and checked by a senior surgeon. A vertical midline incision was made from cervical to lumbar level. Thereafter, the fascia and dorsal muscles were bluntly dissected layer by layer starting from the midline and we identified the paravertebral space. The spread of dye was evaluated and photographed. Main outcome parameter was cranial to caudal spread of the injection dye deep to the erector spinae muscle plane. Furthermore, involvement of the dorsal and ventral rami of spinal nerves, paravertebral space, and crossover to the contralateral side was evaluated; however, the amount of vertebral levels at which this occurred was not studied. Paravertebral space was determined by dye spread beneath the erector spinae muscle, posterior to the lung and anterior to the processus transversus.

RESULTS

An erector spinae plane block was performed in 11 of 16 available cadavers (7 females and 4 males), with a mean length of 169.8 cm (±7.6 cm) and a mean weight of 70 kg (±17.9 kg). Five cadavers were excluded due to either subcutaneous emphysema (N = 2), one of which also had scoliosis, or impossibility to perform an erector spinae plane block because the erector spinae muscles were not recognizable on ultrasound (N = 3). The erector spinae plane block was easily performed with visualization of spread of the injection dye beneath the erector spinae muscle on ultrasound.

The Figure shows the detailed spread of injection dye over the vertebral levels for every cadaver, ranging from the fourth cervical to the tenth thoracic vertebra and from the fourth cervical to the first lumbar vertebra when injected at the second and eighth thoracic vertebrae, respectively. Furthermore, it shows that spread of injection dye is variable among the cadavers with more extensive spread when injected at the eighth thoracic vertebra compared to the second thoracic vertebra, which showed more limited and caudal spread of dye. In all cadavers, the injection dye spread on both anterior and posterior surfaces of the erector spinae muscle (Supplemental Digital Content, Figures 1–2, http://links.lww.com/AA/C799).

The Table shows detailed information on the pertinent spaces that were involved and if crossover occurred. It shows that when performing an erector spinae plane block at the second thoracic vertebra, paraspinal structures were more often involved compared to injection at the eighth thoracic vertebra (4 of 11 [36%] vs 1 of 11 [9%]). Furthermore, when the paravertebral space was involved, crossover to the contralateral side was seen when injected at the second thoracic vertebra. After injection at the eighth thoracic vertebra, we observed crossover of dye to the contralateral side without involvement of the paravertebral space in one cadaver, spreading in between the spinous processes at the dorsal side of the ligamentum flavum to the contralateral side (Supplemental Digital Content, Figure 3, http://links.lww.com/AA/C799).

DISCUSSION

This study demonstrates extensive and variable craniocaudal spread of the erector spinae plane block within the fascial plane deep to the erector spinae muscle, corresponding with previous cadaver studies and clinical results in which extensive analgesia was described for different thoracoabdominal procedures and pain conditions.[1,2,4–7,9,11–14] In 4 of 11 cadavers, the dye spread to ventral and dorsal rami and paravertebral space when injected at a high thoracic level. Previous cadaveric studies have shown contradicting results concerning the involvement of these structures. After paravertebral injection, a case report showed a very

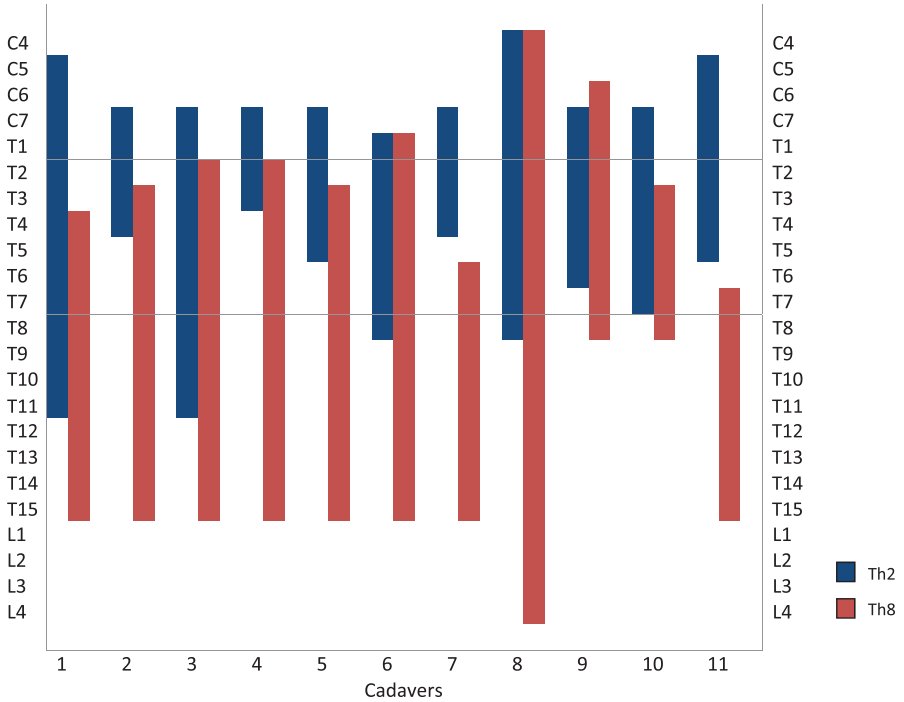

Figure. Craniocaudal spread of injection dye in each cadaver, separately shown for injection at Th2 (blue) and Th8 (red). Th2 indicates second thoracic vertebra; Th8, eighth thoracic vertebra.

Table. Spread of Injection Dye to Structures for Each Cadaver at Injection Level Second and Eighth Thoracic Vertebrae

Injection at Second Thoracic Vertebra				
Cadaver	Ventral Ramus	Dorsal Ramus	Paravertebral Space	Crossover
1	–	–	–	–
2	–	–	–	–
3	–	–	–	–
4	–	–	–	–
5	+	+	+	+
6	–	–	–	–
7	+	+	+	+
8	–	–	–	–
9	+	+	+	+
10	–	–	–	–
11	+	+	+	+
Total, N (%)	4/11 (36)	4/11 (36)	4/11 36)	4/11 (36)
Injection at Eighth Thoracic Vertebra				
Cadaver	Ventral Ramus	Dorsal Ramus	Paravertebral Space	Crossover
1	–	–	–	–
2	–	–	–	–
3	–	–	–	–
4	–	–	–	–
5	+	+	+	–
6	–	–	–	–
7	–	–	–	–
8	–	–	–	+
9	–	–	–	–
10	–	–	–	–
11	–	–	–	–
Total, N (%)	1/11 (9)	1/11 (9)	1/11 (9)	1/11 (9)

unpredictable and nonreproducible block in the same patient.[15] Several studies have shown a limited and variable spread to ventral and dorsal rami and paravertebral space after injection at different thoracic levels, as well as after a retrolaminar block, which is also comparable to the erector spinae plane block.[13,14] However, several studies did show spread to the epidural, paravertebral, or neural foraminal spaces when injected at the fifth thoracic vertebra.[9,12] Possibly, interindividual differences in executing this block and a different diffusion of dye due to defrosting cadavers twice might result in injectate spreading to the paravertebral space instead of only in the interfascial plane. Strikingly, in our study, we also observed that in 4 cadavers (after injection at the second thoracic vertebra), dye crossed over to the contralateral side of the spine. This can happen via a route posterior to the lamina and in between the spinous processes, but we did not observe any dye when we performed the midline incision to the spinous processes. Therefore, we assume that the dye spread via the epidural space to the contralateral side; however, because no laminectomy was performed, a conclusive analysis of epidural spread was not possible. Contralateral involvement only happened when injecting dye at high thoracic (second thoracic vertebra) levels with crossover at cervical level, but not when injected at eighth thoracic vertebra. Differences in anatomical barriers to the erector spinae muscle and paravertebral space with thinner ligamentum flava in the neck region and the transitional anatomy from paraspinal muscles of the thorax to that of the neck in general could provide an explanation.[16]

Limitations to performing an erector spinae plane block on fresh frozen cadavers are as follows: there are differences in tissue integrity; one cannot perform the block in prone position; and there is a lack of physiological influences ([mechanical] ventilation and movement). Furthermore, by choosing a method of blunt dissection, we could not distinguish different patterns of distribution in detail, and we only noted the involvement of spinal nerves and paravertebral space and did not evaluate specific levels at which this occurred, nor compared lateral spread with the rhomboid muscles and intercostal nerves. However, the effect of the erector spinae plane block might be exerted by blocking intercostal nerves and nociceptors in the interfascial plane, explaining its opioid-sparing action, but not always tangible block.[17] Our study demonstrates that in fresh frozen cadavers, an erector spinae plane block follows the fascial planes with unpredictable spread, which might explain the difference in its clinical efficacy. The erector spinae plane block has shown to be an easy and safe intervention that can be performed when epidural or paravertebral analgesia is contraindicated, and is useful in clinical practice for many indications of postsurgical and chronic pain.[17]

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DISCLOSURES

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