

## The Erector Spinae Plane Block A Novel Analgesic Technique in Thoracic Neuropathic Pain

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**Abstract:** Thoracic neuropathic pain is a debilitating condition that is often poorly responsive to oral and topical pharmacotherapy. The benefit of interventional nerve block procedures is unclear due to a paucity of evidence and the invasiveness of the described techniques. In this report, we describe a novel interfascial plane block, the erector spinae plane (ESP) block, and its successful application in 2 cases of severe neuropathic pain (the first resulting from metastatic disease of the ribs, and the second from malunion of multiple rib fractures). In both cases, the ESP block also produced an extensive multidermatomal sensory block. Anatomical and radiological investigation in fresh cadavers indicates that its likely site of action is at the dorsal and ventral rami of the thoracic spinal nerves. The ESP block holds promise as a simple and safe technique for thoracic analgesia in both chronic neuropathic pain as well as acute postsurgical or posttraumatic pain.

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Neuropathic pain is a common chronic pain condition with many etiologies, including surgery, trauma, and diseases such as herpes zoster, diabetes, and cancer.<sup>1</sup> It is notoriously difficult to manage, and patients often show a poor or limited response to analgesic medications or experience intolerable adverse effects.<sup>2</sup> Interventional procedures targeting the central and peripheral nervous system are an alternative but the current evidence for their efficacy is limited.<sup>3,4</sup> In addition, many of the described techniques (eg, pulsed radiofrequency, spinal cord stimulation, and intrathecal injection of local anesthetic, steroids, and other medications) are invasive, require specialized expertise, and carry the risk of serious complications.<sup>4</sup>

We present the first description of a novel yet simple interfascial plane block, the erector spinae plane (ESP) block, and its successful application in 2 cases of severe thoracic neuropathic pain as well as 2 cases of acute postsurgical pain. We discuss the relevant anatomy and also present evidence from an anatomical and radiological investigation in fresh cadavers for its presumed mechanism of action.

### CASE REPORTS

Written informed consent was provided by all patients for inclusion in this report.

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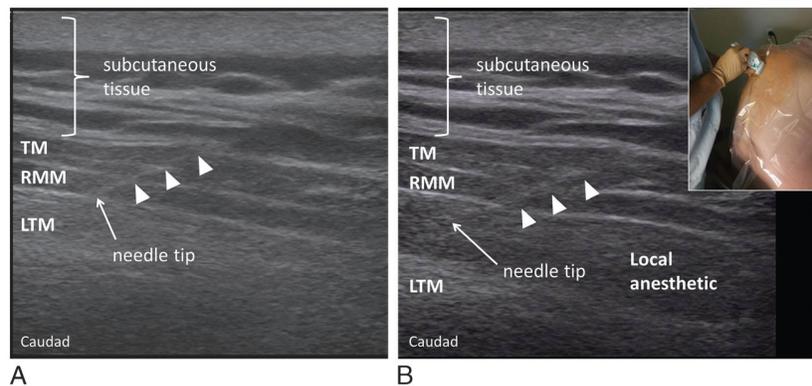
### Case 1

A 67-year-old man, weight 116 kg and height 188 cm [body mass index (BMI), 32.8 kg/m<sup>2</sup>] with a history of heavy smoking and paroxysmal supraventricular tachycardia controlled on atenolol, was referred to the chronic pain clinic with a 4-month history of severe left-sided chest pain. A magnetic resonance imaging scan of his thorax at initial presentation had been reported as normal, and the working diagnosis at the time of referral was post-herpetic neuralgia. He reported constant burning and stabbing neuropathic pain of 10/10 severity on the numerical rating score (NRS), radiating from his spine into the anterior chest wall, mainly at T5 and extending several dermatomes inferiorly. There was significant sleep disturbance and impairment of quality of life. Physical examination revealed allodynia and hyperesthesia over the affected dermatomes with a primary trigger point over the T5 dermatome 3 to 4 cm lateral to the neuraxial midline. Pain management up to that point had included pregabalin (600 mg daily at the time of consultation), nonsteroidal anti-inflammatory drugs, baclofen, fluoxetine, and marijuana with no improvement. Several different opioids had been tried but all had to be stopped due to severe nausea and vomiting. Nonsystemic and nonpharmacologic methods of analgesia had also been attempted without success, including subcutaneous injections of lignocaine and steroid, transcutaneous electrical nerve stimulation, acupuncture, and topical application of lignocaine, heat, and cold therapy.

In view of the severity of symptoms, we elected to attempt a regional anesthetic technique in the pain clinic to provide some immediate relief. The cranio-caudal extent of pain made intercostal nerve blocks impractical and thoracic epidural or paravertebral injection was ruled out as being too invasive for the clinic setting, particularly given his body habitus. We considered performing a serratus plane block<sup>5</sup> but were concerned that it would not adequately cover the posterior chest wall. We decided however to use the same principle of local anesthetic spread within an interfascial plane superficial to the transverse processes/ribs, but to perform the injection at the site of the patient's primary trigger area for pain, 3 cm lateral to the T5 spinous process.

This novel interfascial plane block, the ESP block, was performed as follows. The patient was placed in a sitting position and a high-frequency linear ultrasound transducer (GE LOGIQe, Wauwatosa, Wisconsin) was placed in a longitudinal orientation 3 cm lateral to the T5 spinous process. Three muscles were identified superficial to the hyperechoic transverse process shadow as follows: trapezius, rhomboid major, and erector spinae. An 8-cm 22-gauge block needle (EchoStim; Benlan Inc, Oakville, Canada) was inserted in a cephalad-to-caudad direction until the tip lay in the interfascial plane between rhomboid major and erector spinae muscles, as evidenced by visible linear spread of fluid between the muscles upon injection (Fig. 1). A total of 20 mL of 0.25% bupivacaine was injected here.

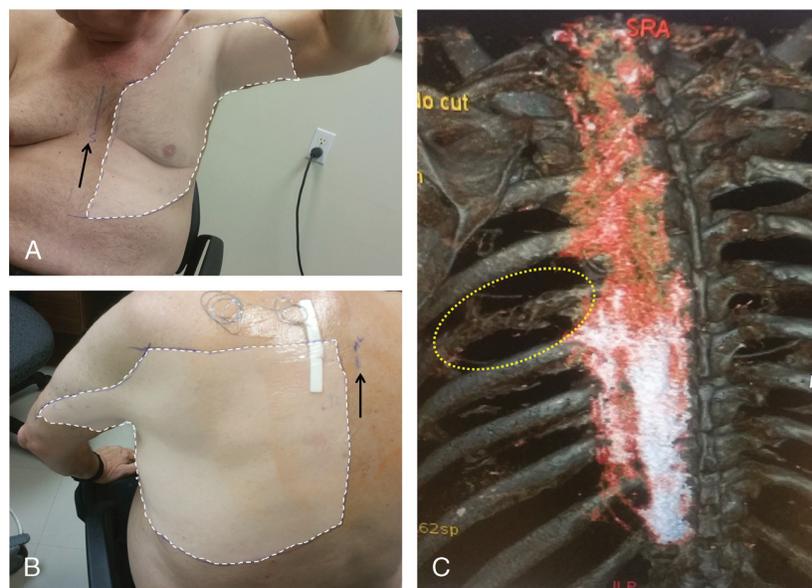
Within several minutes, the patient reported that his pain had diminished significantly, and a full assessment of the extent of the sensory block was performed 2 hours later. By that time, the patient had obtained complete relief of pain, with an NRS of 0/10. There was an area of diminished sensation to pinprick extending



**FIGURE 1.** The ultrasound-guided ESP block performed superficial to erector spinae muscle (ESM) in the first patient of the case series. Inset picture shows patient in seated position with probe placed in a parasagittal plane 3 cm lateral to the midline at the level of the fifth thoracic vertebra. A, The needle (arrowheads) is inserted in a cephalad-to-caudad direction to place the tip between the rhomboid major muscle (RMM) and ESM. B, Injection here creates a linear pattern of local anesthetic spread that displaces the ESM downward.

from T2 to T9 in a cephalocaudal direction, and from a line 3 cm lateral to the thoracic spine to the midclavicular line in an anterior-posterior direction (Figs. 2A, B). The axilla and medial aspect of the upper arm also exhibited sensory blockade. The patient subsequently reported recurrence of the pain 36 hours after the initial block, and the block was repeated twice more in the clinic on consecutive days with 20 mL of 0.25% bupivacaine, which provided complete analgesia lasting about 12 hours on average each time. The patient further reported that his pain, when it did recur, had significantly diminished in severity to NRS 3/10 at rest. The characteristics of his pain had also changed: it no longer radiated into the chest wall and was largely confined to the back, hyperesthesia was reduced, and the allodynia had resolved.

At this point, given the dramatic improvement in symptoms and quality of life, we inserted a 19-gauge epidural catheter (FlexTip Plus; Teleflex, North Carolina) 5 cm into the interfascial plane superficial to erector spinae muscle (using the same ultrasound-guided technique and needle approach described previously) to facilitate a course of intermittent boluses of local anesthetic. The catheter was inserted through a 17-gauge Tuohy needle after a bolus injection of 20 mL of 0.25% bupivacaine to open the interfascial plane. The catheter was retained for 5 days in total with the patient returning to the clinic daily for a bolus injection of 20 mL of 0.25% bupivacaine. A sensory block over the T2 to T9 dermatomes and complete analgesia was consistently obtained within 20 minutes after each injection. The course of injections



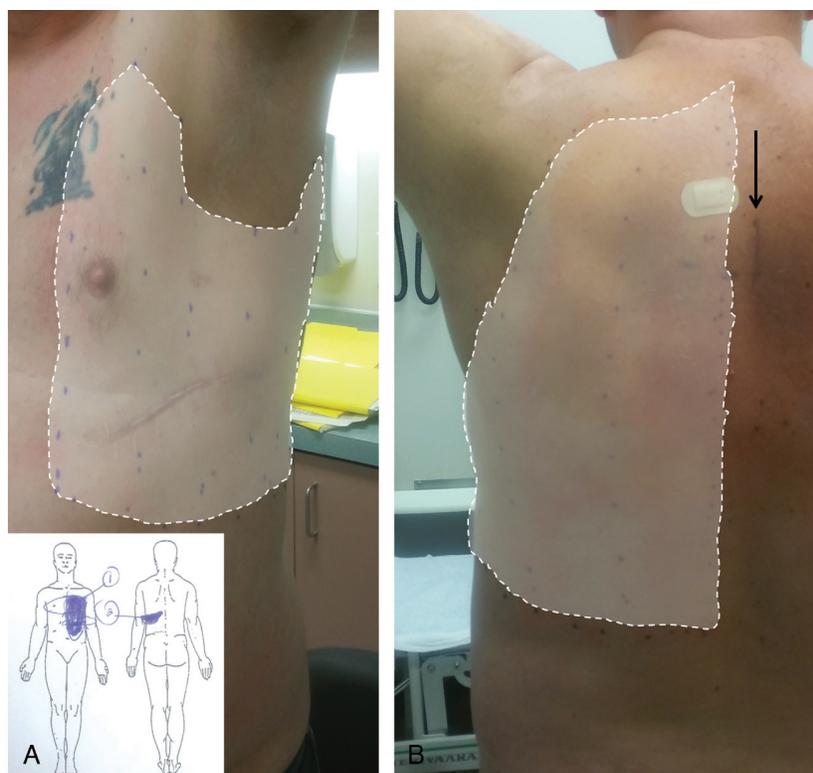
was combined with initiation of gabapentin and amitriptyline therapy, which was titrated to 800 mg 3 times daily and 100 mg at bedtime, respectively, over the same period. After the initial course of nerve blocks and titration of his analgesic medication, the patient reported that he had little to no pain at rest and pain on arm movement that peaked at 8/10 severity. However, he was able to cope using nonpharmacologic strategies and was highly satisfied with the improvement in his quality of life. Further optimization of his analgesic medication was continued, including the addition of carbamazepine.

The patient returned 2 weeks later to the chronic pain clinic for reassessment. Pain at rest remained tolerable but pain on arm movement had increased to 10/10 in severity. We therefore repeated the ESP block with 20 mL of 0.5% bupivacaine plus 5 mL of contrast and performed a computed tomography (CT) scan to try and elucidate the mechanism of action of the block. The patient again rapidly obtained complete relief of his dynamic pain after the block. The CT scan demonstrated extensive cephalocaudad injectate spread between T1 and T11 vertebrae with medial spread toward the midline but limited lateral spread (Fig. 2C). However, the CT scan also revealed a hitherto undiagnosed lytic lesion of the left sixth rib (Fig. 2C), and this, not postherpetic neuralgia, was deemed the likely cause of the patient's neuropathic pain. A subsequent magnetic resonance imaging scan confirmed the presence of multiple lytic lesions in the patient's cervical vertebrae, left fifth and sixth ribs, with a rapidly enlarging soft tissue mass around the lesion in the left sixth rib. These were eventually diagnosed as metastases from primary bladder carcinoma.

## Case 2

A 48-year-old man, weight 97 kg and height 175 cm (BMI, 31.7 kg/m<sup>2</sup>) presented to the chronic pain clinic with a 3-year history of chronic pain secondary to left-sided fractures of the second to ninth ribs sustained in a motorbike accident. He had extensive neuropathic pain characterized by severe pressure-like pain, electric shock-like sensations, and paresthesia over the left anterolateral thorax (T3–T9) as well as over the site of a thoracotomy incision at T5–6 (Fig. 3 inset). Examination revealed severe hyperesthesia and allodynia over the reported sites of pain. Computed tomography imaging showed malunion of all the rib fracture sites. Before assessment, the patient had tried oral acetaminophen–codeine–caffeine (Tylenol #3) and oxycodone without significant relief and was currently not taking any analgesic medications. We proposed initiating treatment with pregabalin 75 mg bid but also performing an ESP block to provide immediate pain relief and interrupt the pain cycle, to which the patient agreed. A left unilateral ultrasound-guided ESP block was performed as described previously at the level of the T5 transverse process and 3 cm lateral to the midline, with 20 mL of 0.5% ropivacaine injected in the plane between rhomboid major and erector spinae muscles. Within 30 minutes of injection, the patient reported complete resolution of the pain and allodynia. There was, however, no discernable cutaneous sensory block on pinprick testing.

Three hours later, we repeated the ESP block at the same site with another 20 mL of 0.5% ropivacaine to extend the duration of analgesia, but this time the needle tip was advanced further to contact the T5 transverse process. Injection was performed into the



**FIGURE 3.** Extent of cutaneous sensory loss over the anterior (A) and posterior (B) thorax in the second patient in the case series after the second injection of 20 mL of 0.5% ropivacaine deep to erector spinae muscle. The black arrow indicates midline. Inset picture depicts the site of the patient's chronic pain.

interfascial plane deep to the erector spinae muscle and confirmed by visualization of local anesthetic spreading in a linear pattern and between erector spinae and the bony acoustic shadows of the transverse processes (Fig. 4). Assessment 1 hour after the second injection showed sensory loss to pinprick from T3 to T9 over the entire posterolateral aspect of the left hemithorax, extending as far anteriorly as the midclavicular line but sparing the axilla (Figs. 3A, B). The patient continued to experience complete analgesia and subjective numbness over the left thorax at telephone follow-up 7 hours later.

At follow-up 1 month later, the patient reported that he had discontinued the pregabalin after only a few days due to adverse effects but nevertheless remained highly satisfied with his analgesia. Allodynia was no longer present and the pain was well controlled at less than 25% of its original severity without the need for any systemic analgesic medication.

### Case 3

A 75-year-old man, weight 57 kg and height 172 cm (BMI, 19.3 kg/m<sup>2</sup>), presented for video-assisted thoracoscopic wedge resection of the right upper lobe. His medical history included hypertension and previous surgery for rectal carcinoma. A unilateral right ESP block was performed before induction at the level of the T5 transverse process 3 cm from the midline. Twenty milliliters of a 1:1 mixture of 2% lidocaine and 0.5% ropivacaine was injected deep to the erector spinae muscle. The patient received an uneventful general anesthetic for the surgery, during which a total of 250 µg of fentanyl and 1 mg of hydromorphone was administered. In the postoperative care unit he reported a pain score of 0 and required no further opioids. The patient was subsequently placed on intravenous patient-controlled analgesia per institutional protocol and this was discontinued 14.5 hours after the end of surgery, during which time he received a total of only 2.4 mg of hydromorphone. A formal assessment of cutaneous sensory block was not performed but the patient reported a subjective feeling of numbness over the anterior chest up to 24 hours postoperatively.

### Case 4

An 82-year-old woman, weight 47 kg and height 168 cm, presented for video-assisted thoracoscopic right lower lobectomy.

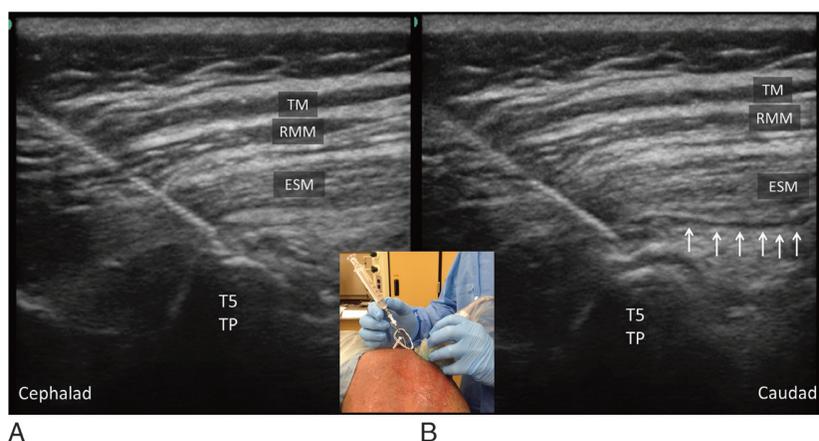
Her medical history was notable for trigeminal neuralgia for which she was taking carbamazepine and transdermal buprenorphine. A unilateral right ESP block was performed with 20 mL of 0.5% ropivacaine injected deep to the erector spinae muscle at the level of the T5 transverse process 3 cm from the midline. Assessment of cutaneous sensory block 20 minutes later showed loss to pinprick and cold sensation from T3 to T9 over the posterior thorax, and T3 to T6 over the anterolateral thorax. She went on to receive an uneventful general anesthetic for the surgery, during which a total of 250 µg of fentanyl and 0.4 mg of hydromorphone was administered. In the postanesthesia care unit, she required 1.8 mg of hydromorphone to manage referred pain in the shoulder and at the site of posterior chest tube insertion at the T9–10 interspace. The patient was subsequently placed on intravenous patient-controlled analgesia and this was discontinued 18.5 hours after the end of surgery, during which time she received a total of 4 mg of hydromorphone.

### Cadaveric Investigation and Data

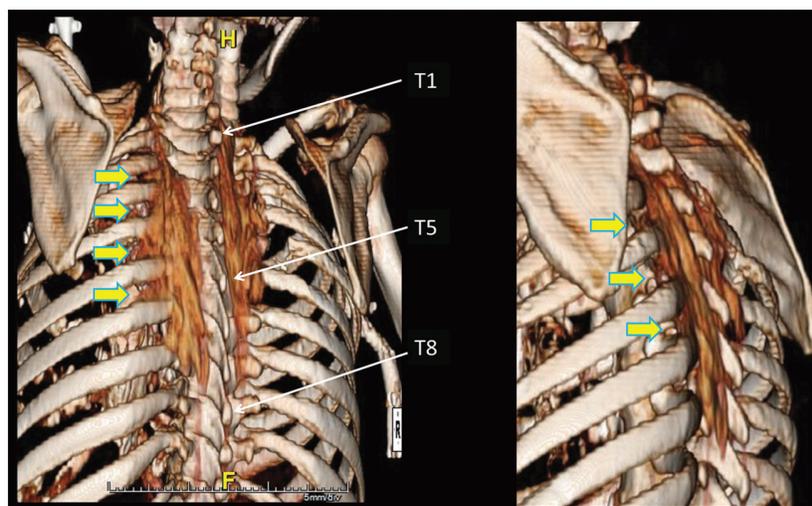
A study of the ESP block was conducted on 2 fresh human cadavers in the Multidisciplinary Lab of Penn State College of Medicine, Milton S. Hershey Medical Center, Hershey, Pennsylvania. The Institutional Review Board of Ethics of Penn State Hershey College of Medicine, Pennsylvania, approved the study for exemption from formal review. All injections were performed by an investigator experienced in ultrasound-guided interventional procedures (S.D.A.). Dissection was performed by a single anatomist (H.L.).

In cadaver 1, bilateral ultrasound-guided ESP blocks were performed at T5 with injection of 20 mL of methylene blue dye between rhomboid major and erector spinae muscles. Dissection showed spread of dye in a longitudinal fashion between erector spinae and trapezius/rhomboid major muscles, with staining of the lateral branches of the dorsal rami of spinal roots. The anterior surface of the erector spinae muscles was also stained but there was however no evidence of dye penetration more anteriorly beyond the intercostal muscles.

In cadaver 2, bilateral ultrasound-guided ESP blocks were again performed at T5 but this time we injected the dye mixture deep to erector spinae muscle with visible fluid spread superficial to the acoustic shadows of the transverse processes (Fig. 4).



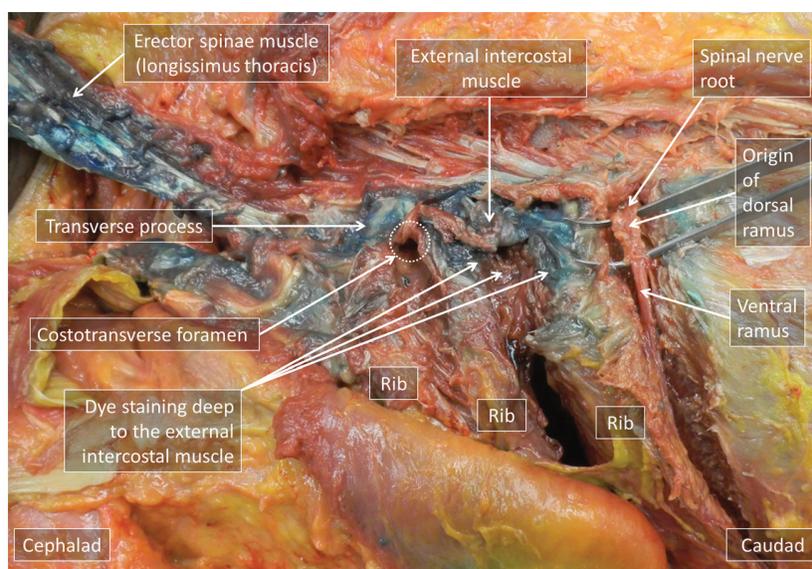
**FIGURE 4.** The ultrasound-guided ESP block performed deep to the erector spinae muscle (ESM) in a fresh cadaver placed in a sitting position (inset). A, The probe is in a longitudinal orientation over the tip of the T5 transverse process (TP) and the block needle is advanced in a cephalad-to-caudad direction through the trapezius (TM), rhomboid major (RMM), and ESM to gently contact the TP. B, Injection into the interfascial plane deep to ESM produces a visible linear pattern of fluid spread (arrows) beneath the ESM.



**FIGURE 5.** Three-dimensional CT reconstruction of injectate spread (darker area) after injection at the T5 level deep to erector spinae muscle. There is visible cephalocaudal spread from T1 to T8. The solid arrows indicate the penetration of dye beyond the costotransverse junction and anteriorly into the intertransverse spaces.

Twenty milliliters of a mixture comprising 10 mL of an iodinated contrast material, iohexol (Omnipaque 300; GE Healthcare, Princeton, New Jersey), diluted in 85 mL of 0.9% sodium chloride with 5 mL of methylene blue dye was injected. Within 20 minutes of completing the injections, cadaver 2 was transferred to a 128-slice multidetector CT scanner (Siemens Flash CT; Siemens Healthcare) where abdominal and thoracic imaging was performed to radiographically assess the distribution of injectate. Images were acquired using routine clinical imaging protocols with the following parameters: kilovolt (peak), 120; effective milliampere-second, 210; rotation time, 0.5 seconds; pitch, 0.8; and detector

collimation, 1.2 mm. Images were reconstructed using a soft tissue algorithm at 3 mm slice thickness at 3-mm intervals. All images were reviewed by a consultant radiologist. Spread of injectate was assessed primarily upon review of the axial image set supplemented with multiplanar images. This showed cranio-caudal spread of injectate from C7 to T8 on the right and T1 to T8 on the left, occurring in a paraspinous gutter bounded by the transverse processes anteriorly and the erector spinae muscle posteriorly (Fig. 5). Lateral spread extended to the tips of the transverse processes at all levels, and slightly beyond the costotransverse junctions at levels T3 to T6 on the right and T4 to T8 on the left.



**FIGURE 6.** Dissection of the right side of cadaver 2 after an ultrasound-guided ESP block and dye injection deep to erector spinae muscle. Trapezius and rhomboid muscles have been removed. The longissimus thoracis portion of the erector spinae muscle has been reflected cranially and dense staining of its anterior (deep) surface is visible. The external intercostal muscle, internal intercostal membrane, and surrounding tissues are also heavily stained. Dye has penetrated deep to these layers and through the costotransverse foramina into the region of the spinal nerves and the origins of the dorsal and ventral rami.

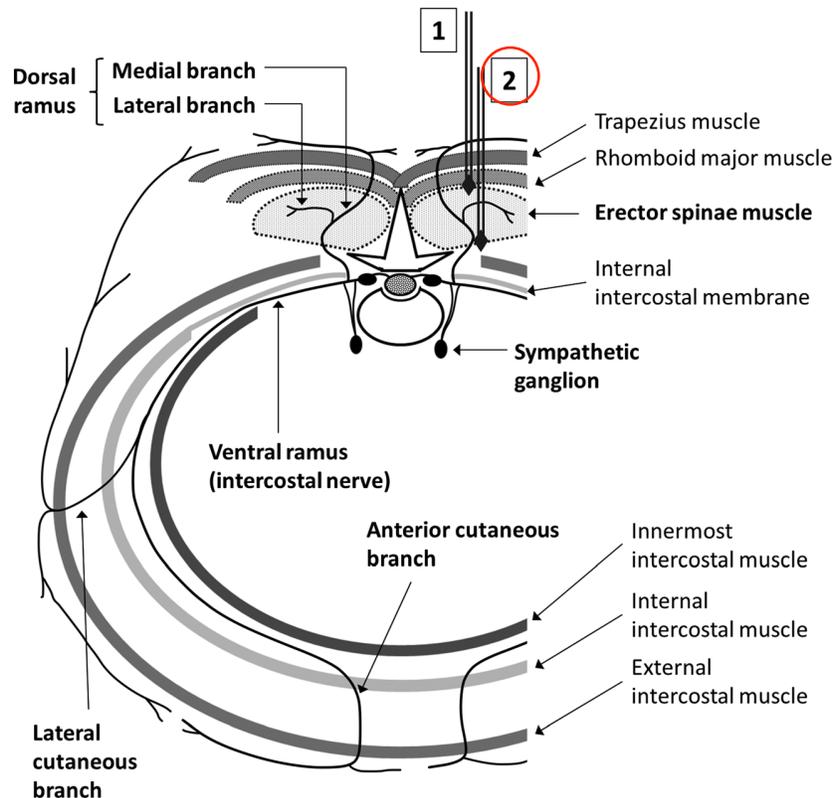
Subsequent anatomical dissection of cadaver 2 confirmed the spread of dye anterior to erector spinae muscle with heavy staining of both erector spinae and intercostal muscles. In addition, there was evidence of dye penetration deep to the intercostal muscles and into the immediate vicinity of the ventral and dorsal rami of the spinal nerve roots (Fig. 6).

## DISCUSSION

The first 2 patients in this report presented with severe chronic thoracic neuropathic pain secondary to bony injury. Although recent reviews conclude that there is a lack of rigorous evidence for the benefit of sympathetic and peripheral nerve blockade in neuropathic pain,<sup>3,4,6</sup> they may be reasonable alternatives when there is a lack of response to topical and oral therapy. The successful use of paravertebral<sup>6,7</sup> and interpleural blocks<sup>8</sup> have been reported, but we decided against performing these more invasive blocks given the outpatient clinic setting and the potential for serious complications. We also ruled out intercostal blocks as impractical given the extent of dermatomal involvement in both cases. Although ultrasound-guided interfascial plane blocks of the chest wall such as the pectoral block<sup>9</sup> and serratus plane block<sup>5</sup> have recently been described, we chose not to use these specific techniques as the available evidence indicates that they mainly

provide analgesia of the anterolateral chest wall and axilla, and would not have covered the affected area in the first patient. We instead performed a similar interfascial plane injection in his primary pain trigger area just lateral to the spinal midline at T5, and were pleasantly surprised to observe both the extensive cutaneous sensory block that was achieved as well as the dramatic relief of the patient's neuropathic pain.

Each upper thoracic spinal nerve splits into a dorsal and ventral ramus at its exit from the intervertebral foramen. The dorsal ramus travels posteriorly through the costotransverse foramen (which is a window bordered superiorly by the transverse process, inferiorly by the rib below, laterally by the superior costotransverse ligament, and medially by the lamina and facet joint) (Fig. 6) and ascends into the erector spinae muscle (a common term for the 3 muscles of spinalis, longissimus thoracis, and iliocostalis).<sup>10</sup> Here, it divides into lateral and medial branches; the medial branch continues to ascend through the rhomboid major and trapezius muscles into a superficial location before ending in a posterior cutaneous branch (Fig. 7). The ventral ramus travels laterally as the intercostal nerve, running first deep to the internal intercostal membrane and then in the plane between internal and innermost intercostal muscle on the inner aspect of the rib. The lateral cutaneous branch arises from the intercostal nerve near the angle of the rib and this branch ascends into a superficial location,



**FIGURE 7.** Simplified schematic illustration of the course of a typical upper thoracic spinal nerve. The dorsal ramus arises soon after the spinal nerve emerges from the intervertebral foramen and travels posteriorly through the costotransverse foramen to enter the erector spinae muscle. Here, it divides into lateral and medial branches, with the latter terminating in a posterior cutaneous branch that innervates the skin of the back. The ventral ramus continues laterally as the intercostal nerve, gives rise to a lateral cutaneous branch at the angle of the rib, and terminates in an anterior cutaneous branch. These branches supply the lateral and anterior chest wall, respectively, as illustrated. We recommend performing the ESP block deep (needle approach 2) rather than superficial (needle approach 1) to the erector spinae muscle, so as to deposit local anesthetic closer to costotransverse foramina and the origin of the dorsal and ventral rami (reproduced with permission from KJ Chin Medicine Professional Corp).

emerging near the midaxillary line where it further subdivides into anterior and posterior branches that supply the lateral thoracic wall<sup>11</sup> (Fig. 7). The intercostal nerve terminates in an anterior cutaneous branch that innervates the anterior chest wall and upper abdomen. In addition to these main branches, each intercostal nerve also gives rise to multiple muscular branches innervating the intercostal muscles as well as intersegmental communicating branches.<sup>11</sup>

The complete resolution of bony neuropathic pain and the extensive cutaneous block of the posterior, lateral, and anterior chest wall observed in the first 2 patients strongly suggests that both dorsal and ventral rami of the thoracic spinal nerves must have been affected by local anesthetic. The pattern of CT imaging further suggests that this occurred at a proximal location close to the intervertebral foramina. This is supported by the cadaveric data, which showed penetration of injectate anteriorly through the costotransverse foramen and into the vicinity of the origin of the dorsal and ventral rami when dye was injected into the interfascial plane deep (posterior) to erector spinae muscle. We did not see cadaveric evidence of spread to the ventral rami when injection was performed superficial (anterior) to erector spinae muscle, which is at odds with our initial clinical observations in the first and second patients. We postulate that, in living subjects, there is more dynamic and extensive spread along tissue planes, perhaps following the course of the medial branch of the dorsal rami, which allowed local anesthetic to reach the ventral rami.

Nevertheless, the cadaveric findings and our subsequent clinical experience indicate that the optimal plane for injection in the ESP block is deep to the erector spinae muscle rather than superficial to it, as this will deposit local anesthetic closer to the dorsal and ventral rami. The erector spinae muscle extends along the length of the thoracolumbar spine, and thus, this plane permits extensive cranio-caudal spread and coverage of multiple dermatomes. Furthermore, it is important to perform the injection close to the midline at the tips of the transverse processes, as the costotransverse foramina are located medial to this parasagittal plane. More laterally, the external and internal intercostal muscles may present a significant barrier to local anesthetic spread. The transverse processes also serve as a convenient sonographic landmark and backstop for needle advancement, contributing to the ease and safety of the block.

The most significant advantage of the ESP block, in our opinion, is its simplicity and safety. The sonoanatomy is easily recognizable, and there are no structures at risk of needle injury in the immediate vicinity. The technique also lends itself well to insertion of an indwelling catheter, which can be used to extend the duration of analgesia as needed. It may therefore prove to be a useful intervention in thoracic neuropathic pain where more conventional therapies have had limited success. In addition, there is clearly potential for its application in a much wider range of conditions, including acute pain after thoracic surgery or trauma. We did observe some interindividual variability in the extent of cutaneous block, but this is not unusual in blocks based on local anesthetic spread in tissue planes.<sup>12</sup> The cutaneous sparing of

the sternal area and neuraxial midline in unilateral ESP blockade may also be explained by overlapping innervation from the contralateral side. We recommend that further investigation should focus on confirming the reproducibility of the block, determining the extent of analgesia that can be achieved by varying the site of injection and injectate volume, and quantifying the risk of local anesthetic systemic toxicity by measuring local anesthetic plasma concentrations.

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