

## The Erector Spinae Plane Block: A Review of Current Evidence

Originally published as Anaesthesia Tutorial of the Week

Araz Pourkashanian\*, Madan Narayanan, Arun Venkataraju

\*Correspondence email: [araz.pourkashanian@nhs.net](mailto:araz.pourkashanian@nhs.net)

### Summary

- From the evidence we have available, the ESP block should be considered an alternative analgesic option for patients with acute or chronic pain of the trunk
- Most of the favourable data for the ESP block relies on its use as part of a multimodal analgesic package, and this should be considered when planning a patient's care.
- Further research needs to be conducted to determine its true effectiveness compared with other regional techniques as well as optimal dosing regimens.

### KEY POINTS

- The erector spinae plane block is an easy-to-perform regional anaesthesia technique with a wide range of clinical applications.
- Most of the current research has focused on its use in thoracic and trunk surgery.
- Many experts now consider the erector spinae plane block an alternative analgesic option to thoracic epidural analgesia and paravertebral blocks, especially where these techniques are contraindicated.
- The block has a good safety profile with very few reported complications.

### INTRODUCTION

Interfascial plane blocks are the current hot topic in regional anaesthesia. The 19th-century German surgeon Carl Ludwig Schleich is seen by many as the father of infiltration anaesthesia. His work from 1899 titled "Painless Operations. Local Anaesthesia With Indifferent Liquids" described the use of local anaesthetic (LA) agents to relax the muscles of the anterior abdominal wall and provide analgesia to aid surgery.<sup>1</sup> This was the origin of a procedure that is now practiced worldwide, the rectus sheath block. These techniques have had to bide their time for use in clinical care as their safety, efficacy, and reproducibility have been difficult to assess. However, several factors have led to a seemingly exponential growth in fascial plane block research, description, and utility. The advent of readily available ultrasound technology in modern-day health care and the production of longer-acting amide LAs have had a major impact. A greater driver has probably been the desire, and some would argue necessity, to move away from traditional neuraxial techniques used in the perioperative care of patients undergoing thoracic and abdominal surgery. With surgical techniques becoming less invasive, the introduction of enhanced recovery pathways, and the increased use of anticoagulation therapies, the use of epidural anaesthesia has decreased among

many clinical practitioners. In addition, Blanco's 2007 publication of a "no pops" ultrasound-guided transversus abdominus plane (TAP) technique has led researchers to explore various planes for interfascial blocks.<sup>2</sup> Currently, the greatest volume of work produced in this field is focused on truncal interfascial plane blocks, one of which is the erector spinae plane (ESP) block.<sup>3</sup>

This tutorial will look at the current research and evidence in the clinical application of the ESP block. We will explore its inception through to the results of recently published randomised controlled trials and postulate what the future holds for this novel technique. The technique itself will be described in detail in the Anaesthesia Tutorial of the Week article on ESP.

### ESP BLOCK: WHAT IS IT?

The ESP block is a novel interfascial paraspinal plane technique that was initially used by Forero et al<sup>4</sup> for 2 patients with severe chronic thoracic neuropathic pain and 2 patients undergoing video-assisted thoracoscopic surgery. The authors described 2 techniques for this block. One was in a patient with neuropathic pain from metastatic seeding to the ribs,

**Araz Pourkashanian**

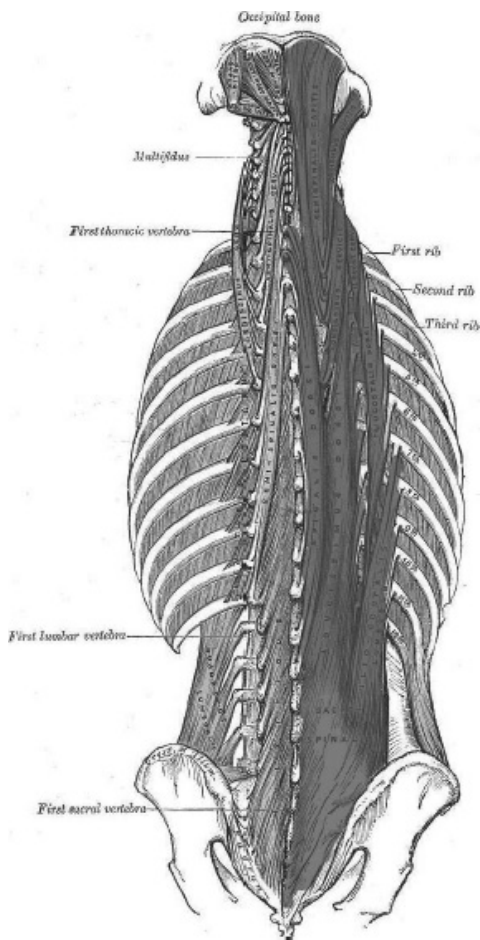
Regional Anaesthesia Fellow  
Frimley Park Hospital  
UNITED KINGDOM

**Madan Narayanan**

Anaesthetic Consultant  
Frimley Park Hospital  
UNITED KINGDOM

**Arun Venkataraju**

Anaesthetic Consultant  
Hampshire Hospital NHS Trust  
UNITED KINGDOM



**Figure 1.** Red highlighted structures indicate the 3 columns of the erector spinae muscles. Medial to lateral: spinalis, longissimus, iliocostalis. Source: Henry Vandyke Carter [public domain], image reproduced from *Gray's Anatomy* (figure 389; "Deep Muscles of the Back"). CC BY 3.0.

where they injected LA into the plane between the rhomboid major and erector spinae (ES; ie, superficial to the ES). The patient had complete resolution of pain. In the other 3 cases, LA was deposited deep to the ES, which similarly produced the desired analgesic effect but also provided a cutaneous sensory block.

The standard practice for performing an ESP block today uses ultrasound to deposit LA deep to the 3 columns of ES muscles (iliocostalis, longissimus, spinalis), which run the length of the spine from the base of the skull to the medial crest of the sacrum (Figures 1 and 2). They all have attachments to the transverse processes, the level of which is dependent on the specific muscle. Overlying the ES complex are 2 further layers of muscle: the trapezius and rhomboid major (Figure 2).

### HAS THE ESP BLOCK CAUGHT ON? WHAT DOES THE LITERATURE SAY?

Since Forero's publication in *Regional Anesthesia and Pain Medicine* in September 2016,<sup>4</sup> there has been wide interest in the ESP block. In the 2 years that followed, there had been close to 100 relevant publications (Figure 3), and based on a literature search conducted in June 2019 via EMBASE, Medline, and PubMed, that number has far been exceeded.

As with any novel regional anaesthesia technique, the initial interest in the block led to an abundance of clinicians attempting to replicate the effects in their own patients. The result was a wealth of case reports with a wide range of clinical applications. Tsui et al<sup>5</sup> recently performed a pooled review of 242 cases relating to the ESP block. After applying inclusion criteria to their search, they found that 90.5% of publications were either case reports or case series, 5.5% were anatomical cadaver studies, and only 2.4% were randomised controlled trials. Most publications originated from Turkey (25%), with Canada and Japan producing the second and third most articles, respectively.

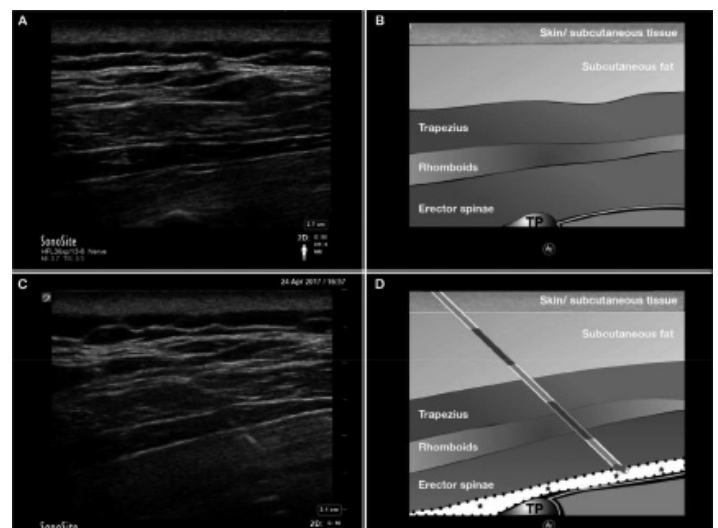
### ANATOMICAL STUDIES AND PROPOSED MECHANISM OF ACTION

As with all fascial plane blocks, the aim of the ESP block is compartmental spread; its efficacy relies on the LA agent passively distributing within the plane to reach target nerves. Absorption and diffusion of LA across tissue planes also appear to play a role in the extent and quality of the block.

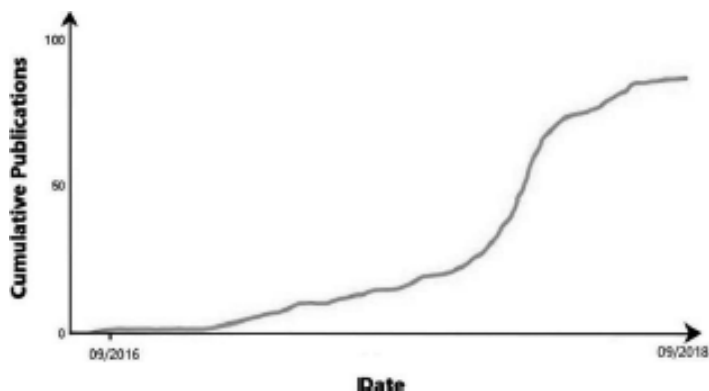
The working theory is that because of the discontinuity of the intercostal muscles, LA diffuses anteriorly to the ventral and dorsal rami of the spinal nerves and through the intertransverse connective tissue to enter the thoracic paravertebral space (Figure 4).

### Is the ESP Block a Surrogate for the Paravertebral Block? How Far Does the Injectate Spread?

Further imaging studies have been performed to determine the extent of LA spread as a means of explaining the true mechanism of action. In Forero's publication, the authors expanded on the case series by analysing the spread of injectate both on computerized tomography (CT) imaging and in cadavers.<sup>4</sup> In 1 patient, after 25mL of solution



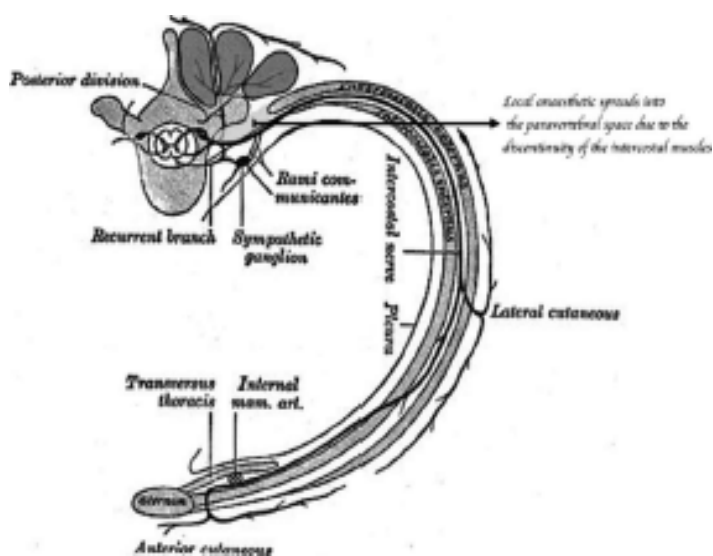
**Figure 2.** (A, B) Demonstration of the muscle layers and bony landmarks seen on ultrasound when performing an erector spinae plane block at the thoracic level. Layers from superficial to deep: skin/subcutaneous fat, trapezius, rhomboids, erector spinae, transverse process. (C, D) Needle entry seen through the muscle layers on the vector from the upper left to lower right of the image. Local anaesthetic has been infiltrated deep to the erector spinae (\*). The hypoechoic area produced as a result is indicated by the white marked area.



**Figure 3.** Graphical representation of the rapid growth in publications relating to erector spinae plane block.

was injected superficially to the ES muscles, CT imaging revealed cephalocaudad spread from T1 to T11 with minimal lateral spread. In their cadaveric work, they injected methylene blue dye superficial to the ES muscle bilaterally in one cadaver and deep to ES bilaterally in another. Dissection of the former cadaver demonstrated staining of the lateral branches of the spinal root dorsal rami in a longitudinal fashion but no anterior spread beyond the intercostal muscles. With the second cadaver, and injection deep to the ES muscle, the spread of the dye was much greater and included the area deep to the intercostal muscles, through the costotransverse foramina, and close to the spinal nerve root ventral and dorsal rami.

Chin et al<sup>6</sup> demonstrated in a cadaveric study that with 20 mL of dye injected at the transverse process of T7 (below the ES muscle), spread was seen cranially up to the lower cranial/upper thoracic vertebrae and caudally as low as the third lumbar vertebra.



**Figure 4.** Brown highlighted structures indicate erector spinae muscles. The green highlighted area indicates local anaesthetic (LA) deposited below the erector spinae complex. The LA injection spreads into the paravertebral space because of the discontinuity of the intercostal muscles. Source: Henry Vandyke Carter [public domain], image reproduced from *Gray's Anatomy* (figure 819; "Diagram of the Course and Branches of a Typical Intercostal Nerve"). CC BY 3.0.

The cadaveric work by Adhikary et al<sup>7</sup> analysed the spread of radiocontrast dye deep to the ES muscle complex in 3 fresh cadavers. Their results confirmed that seen with Forero et al<sup>4</sup> with craniocaudal spread up to 9 vertebral levels along the paraspinous muscles and in the intercostal space (Figure 5). There was also dye seen in the neural foramina and epidural space.

The case report by Schwartzmann et al<sup>8</sup> of ESP block using gadolinium clearly showed the spread of contrast into the paravertebral space, through the neuroforamina, and a resultant circumferential epidural spread over 7 thoracic levels (Figure 6).

All of these results suggest that the ESP block may be an alternative analgesia option to the paravertebral block (PVB), with some evidence demonstrating injectate diffusing into the paravertebral space to also exert its analgesic effects.

However, not all cadaveric studies have had such extensive spread of dye. Yang et al observed only minimal spread into the paravertebral space, and Ivanusic et al failed to demonstrate any spread into the paravertebral space.<sup>9,10</sup> Ivanusic et al<sup>9</sup> performed an ESP block deep to the ES muscle with 20mL of dye on 10 cadavers (ie, 20 total injections). Like previous studies, there was extensive lateral and craniocaudal spread of dye around the ES complex. But only 1 of the injections led to staining of the ventral rami, and there was no spread anteriorly to the paravertebral space. They did, however, acknowledge the tissue tension limitations of cadaveric studies in replicating the spread of LA in vivo and postulated that the intrathoracic pressure changes present in the living may explain the anterior spread into the paravertebral space.

Level	ESP Block		
Cadaver	#1	#2	#3
T1			
T2			
T3			
T4			
T5			
T6			
T7			
T8			

**Epidural Space**

Level	ESP Block		
Cadaver	#1	#2	#3
T1			
T2			
T3			
T4			
T5			
T6			
T7			
T8			

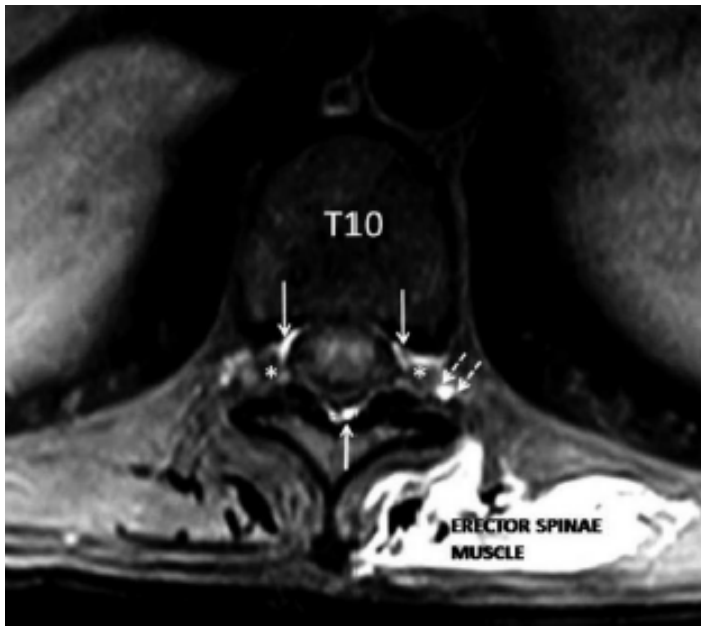
**Neural Foramina**

Level	ESP Block		
Cadaver	#1	#2	#3
T1			
T2			
T3			
T4			
T5			
T6			
T7			
T8			
T9			
T10			

**Intercostal Space**

**Figure 5.** Visible craniocaudal spread of methylene blue dye in cadavers after 20-mL injection at the T5 vertebral level. Good spread (range 5-9 vertebral levels) seen in the intercostal spaces. Dye also visualised in the epidural space and neural foramina in all 3 cadavers. Reproduced from Adhikary SD, Bernard S, Lopez H, Chin KJ. Erector spinae plane block versus retrolaminar block: a magnetic resonance imaging and anatomical study. *Reg Anesth Pain Med.* 2018;43(7):756-762, with permission from BMJ Publishing Group Ltd (license 4614451453587).





**Figure 6.** Gadolinium magnetic resonance image at 45 minutes after left erector spinae plane block. White arrows: circumferential epidural spread. Dashed arrows: paravertebral spread. Asterisks: bilateral neuroforaminal spread. Reproduced from Schwartzmann A, Peng P, Antunez Maciel M, et al. Bilateral erector spinae plane block (ESPB) epidural spread. *Reg Anesth Pain Med.* 2019;44:131, with permission from BMJ Publishing Group Ltd (license 4613860141186).

#### WHAT DOES THE EVIDENCE SAY? (LARGER STUDIES)

Spread of methylene blue dye and contrast medium in cadavers is informative, but do these anatomical studies translate to a meaningful clinical effect? To best answer this question, we need to identify the larger clinical trials. Again, because of the relative infancy of the ESP block, the literature is limited, but below are the key clinical areas that have produced data from randomised controlled trials. Unsurprisingly, much of this work centres on truncal surgery. From the pooled review by Tsui et al<sup>5</sup> of the published literature, nearly 90% of the ESP blocks were performed in the thoracic, 9% in the lumbar, and, 1% in the cervical region. Eighty percent were single shot-techniques, and 20% were catheter techniques.

#### Rib Fractures

Mortality from rib fractures has been reported to be as high as 33%.<sup>11</sup> A dangerous downward spiral results from disruption of respiratory mechanics and pain, culminating in significant morbidity and mortality. For patients with preexisting respiratory comorbidities and/or opioid sensitivity, regional anaesthesia is often life-saving therapy. Thoracic epidural analgesia was long revered as the gold standard for patients with traumatic rib fracture pain, but myofascial plane blocks (eg, serratus anterior, ES) and PVBs have now become alternative options.

A retrospective cohort study at a level 1 trauma centre in Pennsylvania looked at the analgesic outcomes and the effect on respiratory volumes when performing ESP blocks in patients with traumatic rib fractures.<sup>12</sup> For 79 patients, incentive spirometry volumes, 12-hour opioid consumption, and highest numeric rating scale (NRS) static pain scores were recorded at baseline (ie, pre-ESP block)

and up to 72 hours post block. All patients received multimodal analgesia prior to block performance. Most (53%) had between 5 and 7 fractured ribs, and 77% of patients received an ESP catheter to allow a continuous LA infusion into the myofascial plane, with the remaining receiving a single-injection technique. The catheters remained sited until the acute pain team deemed the pain could be managed with oral analgesia alone (mean duration, 3.7 days; range, 0.6-9.3 days). Incentive spirometry volumes nearly doubled from baseline during the first 24 hours, with a mean increase of 545 mL. Moreover, this effect was maintained over 72 hours. Maximum NRS pain scores were statistically significantly reduced, and 12-hour opioid consumption was reduced in patients who received a continuous technique (but this did not reach statistical significance). There was no change in mean arterial blood pressure in any of the patients. Those who had a single-injection ESP block showed less convincing results overall. The authors concluded that the ESP block has become the primary regional intervention for rib fracture patients at their institution. They also suggested its benefit in safety profile for patients with contraindications to neuraxial and perineuraxial techniques (ie, anticoagulated patients).

#### Thoracic Surgery

Retraction of ribs and incision of chest wall muscles can make thoracic surgery extremely painful in the postoperative period. The impact on respiratory mechanics is the same as those with rib fractures described above, and these patients will experience the same complications if pain is not adequately managed. Again, currently available evidence leads many clinicians to employ a multimodal analgesic approach with the use of thoracic PVB or neuraxial analgesia (thoracic epidural analgesia [TEA] or intrathecal opioid). However, this will not be appropriate management for every patient, and reported failure rates for PVB and TEA are quoted as high as 15%.<sup>13</sup>

To date, 1 randomized study has been published looking at the use of ESP blocks in adults undergoing video-assisted thoracoscopic surgery (VATS). In their randomized controlled trial, Ciftci et al<sup>14</sup> compared opioid consumption and pain scores of single-shot ESP blocks with a control group (no block). The data showed statistically lower opioid consumption (176.66lg 6 88.83lg vs 717.33lg 6 133.98lg) and pain scores in the ESP group. They also found statistically lower rates of nausea and itching in the ESP group (nausea;  $P = \frac{1}{4}$  .010). This study suggests that the ESP block is a suitable opioid-sparing block for patients undergoing VATS, but pain scores were measured only up to 24 hours, and there are no studies comparing PVB/TEA with this technique in this patient cohort.

For open thoracic surgery, there are several case reports and case series describing the successful use of ESP catheters for posterolateral thoracotomy analgesia.<sup>15,16</sup>

#### Breast Surgery

ESP blocks are showing promise as a regional technique for breast surgery analgesia. Small randomized controlled trials have shown effective analgesia and reduced postoperative opioid consumption when compared with standard care in patients undergoing surgery for breast cancer (including mastectomy).<sup>17,18</sup> However, 1 prospective randomized trial in radical mastectomy surgery showed lower pain scores and postoperative tramadol consumption if a modified

pectoral nerve block was performed rather than an ESP block.<sup>19</sup> Larger comparator studies need to be conducted to assess the true efficacy and benefit for this surgical cohort.

### Cardiac Surgery

Several studies have been performed using ESP blocks for patients undergoing open cardiac surgery. This is a surgical speciality with procedures that require high intraoperative doses of anticoagulant agents, and so regional anaesthesia has traditionally been avoided. Patients undergoing elective cardiac surgery with cardiopulmonary bypass had significantly lower pain scores (up to 12 hours postextubation) if bilateral ESP blocks were performed rather than standard therapy alone with intravenous paracetamol and tramadol.<sup>20</sup> A patient-matched, controlled before-and-after study showed similar results but also found that postoperative adverse events, time to chest drain removal, and time to first mobilization were all significantly lower if ESP blocks were performed.<sup>21</sup> When comparing TEA and bilateral continuous ESP blocks for cardiac surgery, 1 study found comparable pain scores, incentive spirometry, intensive care unit duration, and number of ventilator days.<sup>22</sup>

### Abdominal Surgery

Rectus sheath (RS) catheters have gained huge popularity as an analgesic technique for postoperative midline laparotomy pain. However, this block provides only somatic analgesia to the midline from T6 to T11. For patients who have transverse incisions, stomas, and drains, RS blocks will not provide analgesia. Alternatives that have been explored include TAP blocks and, more recently, quadratus lumborum blocks. A perceived key benefit of the ESP block over other interfascial blocks for abdominal procedures (RS, TAP) is the anterior spread of injectate into the paravertebral and epidural space. This would block not only spinal nerve roots but also rami communicantes transmitting sympathetic fibres, thus leading to relief from visceral pain. This was highlighted in the small case series by Chin et al<sup>23</sup> with significant relief of visceral pain after ESP blocks seen in 3 bariatric patients undergoing laparoscopic abdominal surgery.

The literature points to a wide spectrum of indications for ESP blocks when considering abdominal procedures. These include laparotomy, nephrectomy (laparoscopic and open), renal transplant, radical prostatectomy, percutaneous nephrolithotripsy, herniorrhaphy, gastric bypass, gastrectomy, and caesarean delivery, to name a few.

Tulgar et al<sup>24</sup> performed a double-blinded, randomized, controlled, prospective study comparing ESP and subcostal TAP blocks in laparoscopic cholecystectomy surgery performed at a tertiary university hospital in Turkey. Sixty patients were recruited and randomized into 3 equal groups: bilateral subcostal TAP, bilateral ESP, and control. All patients received standard multimodal analgesia and an intraoperative remifentanyl infusion, and those who received a block had this performed at the end of surgery. A standard mix of 40mL LA was used for all patients. No patients received LA at the surgical site. Tulgar et al<sup>24</sup> found that patients in the 2 block groups had significantly lower rest and dynamic pain scores in the first 3 postoperative hours (P.001) and a lower overall 24-hour analgesic requirement.

Another randomized controlled study, in Egypt, assessed the efficacy of the ESP block for postoperative analgesia in total abdominal hysterectomy.<sup>25</sup> The authors demonstrated that the patients who had blocks had significantly lower fentanyl consumption in the first 24 postoperative hours and significantly lower pain scores in the first 12 hours.

### Lower Limb Surgery

A randomized, controlled, double-blind study looked at the analgesic efficacy of lumbar ESP blocks used for patients undergoing hip and femur surgery.<sup>26</sup> When compared with standard intravenous analgesia, the authors found that the patients with ESP blocks had significantly lower pain scores within the first 6 hours and lower total 24-hour tramadol consumption (control ¼ 226mg 6 35.89mg, ESP block ¼ 130mg 6 50.99mg; P, .001). ESP block was also compared with quadratus lumborum blocks, and both showed similar results overall. The data produced suggest that lumbar ESP blocks may provide effective analgesia for hip and femur surgery as part of a multimodal analgesic strategy.

Given the potential spread of LA into the epidural space, it is feasible that lumbar approaches to the ESP block lead to lower limb weakness. Selvi and Tulgar<sup>27</sup> published a case report describing transient bilateral lower limb weakness after a T11 ESP block.

### Novel Uses

There is an abundance of case reports and small case series in the literature with positive outcomes. Clinicians have investigated the effectiveness of the ESP block on patients undergoing surgery on the upper limbs and spine.<sup>28</sup>

**Table 1.** Weight-Based Local Anaesthetic Concentration and Volume Guide for Erector Spinae Plane Block in Rib Fractures

Drug	Weight-Based Dosing		
	50-kg Patient	70-kg Patient	100p-kg Patient
<i>Unilateral</i>			
0.25% bupivacaine, mL	30	40	40
0.5% bupivacaine, mL	20 (max dose)	20	30
<i>Bilateral</i>			
0.25% bupivacaine, mL	20 per side (40 total)	25 per side (50 total)	30 per side (60 total)
0.5% bupivacaine, mL	Not advised, not enough volume	Not advised, not enough volume	Not advised, not enough volume

There is even a case report suggesting the effectiveness of the technique for a refractory tension headache.<sup>29</sup>

Several articles have suggested the ESP block may be used for chronic shoulder pain and surgery on the upper arm.<sup>30</sup>

## CLINICAL QUESTIONS

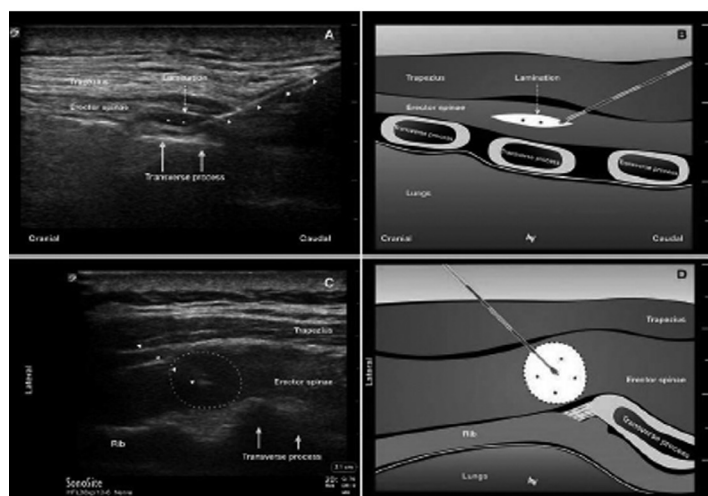
There remain several clinical questions that require further research.

### What Are the Optimal Volume and Concentration of LA?

- Fascial plane blocks rely on a high-volume, low-concentration technique for optimal efficacy.
- In a mini review, De Cassai and Tonetti<sup>31</sup> determined that 3.6 mL of an LA agent per desired vertebral level spread was adequate in ESP blocks. However, at present, there are no data relating this volume to duration of action.
- Luftig et al<sup>32</sup> specifically looked at the volume and concentration used in 16 ESP block articles (49 cases) when indicated for rib fracture analgesia, to determine optimal regimes. Based on the findings, they created a weight-based guide for ESP block in these patients (Table 1).

### Single Level Versus Multilevel

- As shown, cadaveric and anatomical studies show extensive spread of injectate around the ES complex with varied degrees of spread into the neural foramina and epidural space. Further



**Figure 6.** T5 vertebral level parasagittal (A, B) and transverse (C, D) approach to the erector spinae plane block. Needle trajectory indicated by arrow heads. In images A and B, the needle tip is located between the muscle fibers, which run parallel to the ultrasound beam in the parasagittal probe orientation. When fluid is injected here (\*), the ultrasound appearance may replicate that seen with an interfascial injection (also known as lamination), but the result will be an intramuscular injection. With a transverse approach, as shown in images C and D, the needle tip is similarly placed intramuscularly. However, injection in this orientation results in localised circumferential spread of fluid (dotted circle), which is less likely to be confused with interfascial spread. Reproduced from Narayanan M, Venkataraju A. Transverse approach to the erector spinae block: is there more? *Reg Anesth Pain Med.* 2019;44:529-530, with permission from BMJ Publishing Group Ltd (license 4615000311499).

studies will need to clarify the decision to perform the block at 2 levels if a noncatheter technique is being employed.

- Tulgar et al<sup>33</sup> demonstrated lower postoperative pain scores and opioid use in thoracotomy patients if 2-level ESP blocks were performed rather than single-level blocks.
- Multiple published case reports also describe the successful use of a bilevel approach.<sup>34,35</sup>
- There have been no studies to date directly comparing the clinical efficacy of single-level with multilevel injections/catheters.
- Multilevel injections/catheter insertions may have a role when extensive analgesia of the trunk is desired.

### What Is the Optimal Approach?

The classically described approach to the ESP block is a parasagittal ultrasound probe position with in-plane needling. Some clinicians report an out-of-plane technique with the same probe position.

- A documented problem with the parasagittal approach is “lamination”—injection between the muscle fibers producing an ultrasound image consistent with spread within the fascial plane (Figure 7).<sup>36</sup> This occurs because of the longitudinal orientation of the muscle fibers in the ES complex.
- The authors observed this phenomenon to occur more frequently when needling for catheter insertion with 16-gauge Tuohy needles.
- With a transverse approach, lamination will not be seen after intramuscular injection.
- The authors of this article recommend first performing a single-shot ESP block with the transverse approach to create a target space for catheter insertion. The catheter can then be sited using a parasagittal or transverse approach. Block success and correct catheter placement rates may be higher with this technique.

### Caveats

- Publication bias: When the outcome of cases and clinical trials is not in favour of an intervention, they may not be submitted for consideration of publication. This means for a new technique such as the ESP block, the already relatively small pool of evidence may suffer from reporting biases.
- As the technique remains in its infancy with most data coming from case reports, there is currently no consensus on dosing regimes for various indications. This makes comparison between studies more difficult.

## REFERENCES

1. Schleich DL. *Schmerzlose Operationen*. 4th ed. Berlin: Springer Verlag; 1899.
2. Blanco R. Tap block under ultrasound guidance: the description of a “no pops” technique. *Reg Anesth Pain Med.* 2007; **32**:130.
3. Chin KJ, McDonnell JG, Carvalho B, Sharkey A, Pawa A, Gadsden J. Essentials of our current understanding: abdominal wall blocks. *Reg Anesth Pain Med.* 2017; **42**:133-183.
4. Forero M, Adhikary SD, Lopez H, Tsui C, Chin KJ. The erector spinae plane block: a novel analgesic technique in thoracic neuropathic pain. *Reg Anesth Pain Med.* 2016; **41**(5):621-627.

5. Tsui BCH, Fonseca A, Munshey F, McFadyen G, Caruso TJ. The erector spinae plane (ESP) block: a pooled review of 242 cases. *J Clin Anesth*. 2019; **53**:29-34.
6. Chin KJ, Adhikary S, Sarwani N, Forero M. The analgesic efficacy of pre-operative bilateral erector spinae plane (ESP) blocks in patients having ventral hernia repair. *Anaesthesia*. 2017; **72**:452-460.
7. Adhikary SD, Bernard S, Lopez H, Chin KJ. Erector spinae plane block versus retrolaminar block: a magnetic resonance imaging and anatomical study. *Reg Anesth Pain Med*. 2018; **43**(7):756-762.
8. Schwartzmann A, Peng P, Maciel MA, et al. Mechanism of the erector spinae plane block: insights from a magnetic resonance imaging study. *Can J Anaesth*. 2018; **65**:1165-1166.
9. Ivanusic J, Konishi Y, Barrington MJ. A cadaveric study investigating the mechanism of action of erector spinae blockade. *Reg Anesth Pain Med*. 2018; **43**(6):567-571.
10. Yang HM, Choi YJ, Kwon HJ, O J, Cho TH, Kim SH. Comparison of injectate spread and nerve involvement between retrolaminar and erector spinae plane blocks in the thoracic region: a cadaveric study. *Anaesthesia*. 2018; **73**(10):1244-1250.
11. Pressley C, Fry W, Philp A, Berry S, Smith R. Predicting outcome of patients with chest wall injury. *Am J Surg*. 2012; **204**:910-914.
12. Adhikary SD, Liu WM, Fuller E, Cruz-Eng H, Chin KJ. The effect of erector spinae plane block on respiratory and analgesic outcomes in multiple rib fractures: a retrospective cohort study. *Anaesthesia*. 2019; **74**(5):585-593.
13. Romero A, Garcia JEL, Joshi GP. The state of the art in preventing post thoracotomy pain. *Semin Thorac Cardiovasc Surg*. 2013; **25**:116-124.
14. Ciftci B, Ekinci M, Cem Celik E, Cem Tukac I, Bayrak Y, Oktay Atalay Y. Efficacy of an ultrasound-guided erector spinae plane block for postoperative analgesia management after video-assisted thoracic surgery: a prospective randomized study. *J Cardiothorac Vasc Anesth*. 2019. pii:S1053-0770(19)30407-0.
15. Kelava M, Anthony D, Elsharkawy H. Continuous erector spinae block for postoperative analgesia after thoracotomy in a lung transplant recipient. *J Cardiothorac Vasc Anesth*. 2019; **32**(5):e9-e11.
16. Nath S, Bhoi D, Mohan VK, Talawar P. USG-guided continuous erector spinae block as a primary mode of perioperative analgesia in open posterolateral thoracotomy: a report of two cases. *Saudi J Anaesth*. 2018; **12**(3):471-474.
17. Gürkan Y, Aksu C, Kus A, Yörükoğlu UH, Kılıç CT. Ultrasound guided erector spinae plane block reduces postoperative opioid consumption following breast surgery: a randomized controlled study. *J Clin Anesth*. 2018; **50**:65-68.
18. Altıparmak B, Korkmaz Toker M, Uysal AI, Gümüş Demirbilek S. Comparison of the efficacy of erector spinae plane block performed with different concentrations of bupivacaine on postoperative analgesia after mastectomy surgery: randomized, prospective, double blinded trial. *BMC Anesthesiol*. 2019; **19**(1):31.
19. Altıparmak B, Korkmaz Toker M, Uysal AI, Turan M, Gümüş Demirbilek S. Comparison of the effects of modified pectoral nerve block and erector spinae plane block on postoperative opioid consumption and pain scores of patients after radical mastectomy surgery: a prospective, randomized, controlled trial. *J Clin Anesth*. 2019; **54**:61-65.
20. Krishna SN, Chauhan S, Bhoi D, et al. Bilateral erector spinae plane block for acute post-surgical pain in adult cardiac surgical patients: a randomized controlled trial. *J Cardiothorac Vasc Anesth*. 2019; **33**(2):368-375.
21. Macaire P, Ho N, Nguyen T, et al. Ultrasound-guided continuous thoracic erector spinae plane block within an enhanced recovery program is associated with decreased opioid consumption and improved patient postoperative rehabilitation after open cardiac surgery—a patient-matched, controlled before-and-after study. *J Cardiothorac Vasc Anesth*. 2019; **33**(6):1659-1667.
22. Nagaraja PS, Ragavendran S, Singh NG, et al. Comparison of continuous thoracic epidural analgesia with bilateral erector spinae plane block for perioperative pain management in cardiac surgery. *Ann Card Anaesth*. 2018; **21**:323-327.
23. Chin KJ, Malhas L, Perlas A. The erector spinae plane block provides visceral abdominal analgesia in bariatric surgery a report of 3 cases. *Reg Anesth Pain Med*. 2017; **42**(3):372-376.
24. Tulgar S, Kapakli MS, Kose HC, et al. Evaluation of ultrasound-guided erector spinae plane block and oblique subcostal transversus abdominis plane block in laparoscopic cholecystectomy: randomized, controlled, prospective study. *Anesth Essays Res*. 2019; **13**:50-56.
25. Hamed MA, Goda AS, Basiony MM, Fargaly OS, Abdelhady MA. Erector spinae plane block for postoperative analgesia in patients undergoing total abdominal hysterectomy: a randomized controlled study original study. *J Pain Res*. 2019; **12**:1393-1398.
26. Tulgar S, Kose HC, Selvi O, et al. Comparison of ultrasound-guided lumbar erector spinae plane block and transmuscular quadratus lumborum block for postoperative analgesia in hip and proximal femur surgery: a prospective randomized feasibility study. *Anesth Essays Res*. 2018; **12**(4):825-831.
27. Selvi O, Tulgar S. Ultrasound guided erector spinae plane block as a cause of unintended motor block. *Rev Esp Anesthesiol Reanim*. 2018; **65**(10):589-592.
28. Ueshima H, Inagaki M, Toyone T, Otake H. Efficacy of the erector spinae plane block for lumbar spinal surgery: a retrospective study. *Asian Spine J*. 2019; **13**(2):254-257.
29. Ueshima H, Otake H. Successful cases of bilateral erector spinae plane block for treatment of tension headache. *J Clin Anesth*. 2019; **54**:153.
30. Tsui BC, Mohler D, Caruso TJ, Horn JL. Cervical erector spinae plane block catheter using a thoracic approach: an alternative to brachial plexus blockade for forequarter amputation. *Can J Anesth*. 2019; **66**:119-120.
31. De Cassai A, Tonetti T. Local anesthetic spread during erector spinae plane block. *J Clin Anesth*. 2018; **48**:60-61.
32. Luftig J, Mantuani D, Herring AA, Dixon B, Clattenburg E, Nagdev A. The authors reply to the optimal dose and volume of local anesthetic for erector spinae plane blockade for posterior rib fractures. *Am J Emerg Med*. 2018; **36**:1103-1104.
33. Tulgar S, Selvi O, Ozer Z. Clinical experience of ultrasound-guided single and bi-level erector spinae plane block for postoperative analgesia in patients undergoing thoracotomy. *J Clin Anesth*. 2018; **50**:22-23.
34. Altıparmak B, Korkmaz Toker M, Uysal AI, Gümüş Demirbilek S. Bi-level erector spinae plane block for the control of severe back pain related to vertebral metastasis. *BMJ Case Rep*. 2019;12(6).
35. Balaban O, Aydin T. Ultrasound guided bi-level erector spinae plane block for pain management in Herpes Zoster. *J Clin Anesth*. 2019; **52**:31-32.
36. Narayanan M, Venkataraju A. Transverse approach to the erector spinae block: is there more? *Reg Anesth Pain Med*. 2019; **44**:529-530.