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Successful emergency pain control for posterior rib fractures with ultrasound-guided erector spinae plane block

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ABSTRACT

The Eastern Association for the Surgery of Trauma and Trauma Anesthesiology Society Guidelines recommend prompt and effective multimodal analgesia for rib fractures that combines regional anesthesia (RA) techniques with pharmacotherapy to treat pain, optimize pulmonary function, and reduce opioid related complications. However, RA techniques such as epidurals and paravertebral blocks, are generally underutilized or unavailable for emergency department (ED) patients. The recently described serratus anterior plane block (SAPB) is a promising technique, but failures with posterior rib fractures have been observed. The erector spinae plane block (ESPB) is conceptually similar to the SAPB, but targets the posterior thorax making it likely more effective for ED patients with posterior rib fractures. Our initial experience demonstrates consistent success with the ESPB for traumatic posterior rib fracture analgesia. Herein, we present the first description of the ESPB utilized in the ED.

1. Introduction

Management of traumatic rib fracture pain is a vexing problem with significant clinical implications. While effective, traditional regional anesthesia (RA) techniques such as epidurals, paravertebral, and intercostal injections, are generally time-consuming, technically complex, and are associated with significant potential complications. In 2010 Truitt et al. introduced a novel technique whereby local anesthetic (LA) infiltration superficial to the posterior ribs via tunneled catheters successfully controlled rib fracture pain [1,2]. Since then, multiple thoracic RA techniques have been developed that use ultrasound-guided (USG) LA injections into fascial planes from the thoracic spinal lamina to the sternum to anesthetize various regions of the thorax [3-8]. Because these USG thoracic plane blocks are superficial, they are safer and easier to perform, making them suitable for emergency practitioner (EP) utilization. Clinical experience suggests a simple algorithm—anterior and lateral rib fractures should be treated with a SAPB, and posterior fractures with the ESPB.

The serratus anterior plane block (SAPB), involves injecting LA at the mid-axillary line either just above or below the serratus anterior muscle. Not surprisingly, this block is most effective for trauma of the lateral and anterior chest wall. However, there is unreliable coverage for posterior rib fractures which is consistent with anatomic studies that show relatively limited posterior spread of LA with SAPB [5-10]. The erector spinae plane block (ESPB), moves the injection point to be more anatomically aligned with posterior traumatic injury by injecting LA 3 cm lateral to midline just below the erector spinae muscle. At this point the posterior rami and innervation to the posterior thorax is better targeted. Additionally, injection in this region shows evidence of cephalocaudal and paravertebral LA spread that reaches the origin of the intercostal nerves resulting in dense hemithorax anesthesia [5,8-11]. The original Truitt catheters were tunneled in a similar location, 3–7 cm lateral from midline, deep to the erector spinae muscles and superficial to the ribs adjacent to the vertebral transverse processes (TPs). However, the ESPB requires only a single USG injection, making the technique much simpler and less invasive.

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Such considerable thoracic analgesia with a relatively superficial LA injection has multiple potential applications in emergency medicine, particularly for posterior or extensive thoracic trauma. Herein, we present the first technical description and clinical response to USG ESPBs placed by emergency practitioners (EPs) for pain control in the management of posterior rib fractures.

2. ESPB background and anatomic basis

Fractured ribs and adjacent injured tissues are primarily innervated by the thoracic spinal nerves, which branch into ventral and dorsal rami after arising from the spinal cord and passing through the intervertebral foramen. The ventral rami become the intercostal nerves that provide the bulk of the innervation of the lateral and anterior chest wall. The dorsal rami exit the paravertebral space and innervate the posterior chest wall [5].

The ESPB targets the erector spinae plane (ESP), which lies in the chest wall between the anterior surface of the cephalocaudal-oriented erector spinae muscles and the posterior surface of the spinal TPs. LA spread in the ESP anesthetizes the dorsal rami as they traverse this plane, providing anesthesia to the posterior chest wall. Additionally, LA injected into the ESP spreads anterior and cephalocaudal. Anterior spread anesthetizes the ventral ramus and intercostal nerves. This provides anesthesia not only directly to the fractured ribs and periosteum, but also to a large portion of the lateral and anterior chest wall via the lateral and anterior branches of the intercostal nerves [6-12] (Fig. 1A). Cephalocaudal spread in the channel-like ESP extends anesthesia at least 3 vertebral levels above and 4 vertebral levels below the injection point resulting in extensive thoracic anesthesia from a single injection [6,8-11,13] (Figs. 1B, 2).

3. Cases

a. Patient 1: 79 year-old female sustained a ground level fall onto a concrete step resulting in fractures of her right 9th–11th posterior ribs. Despite receiving multimodal analgesia with morphine, ibuprofen, and gabapentin, she reported persistent 10/10 pain. She also experienced nausea, vomiting, dysphoria, and decreased oxygen saturations after medication administration. ESPB was performed with 20 mL of 0.5% bupivacaine + 5 mL of normal saline (NS).
b. Patient 2: 38 year-old female sustained fractures of her right 7th–9th posterior ribs after falling into a gulley while skiing. ESPB was performed with 20 mL of 0.5% bupivacaine + 10 mL of NS.
c. Patient 3: 61 year-old male sustained a 10th posterior rib fracture after falling backwards from a ladder. ESPB was performed with 20 mL of 0.5% bupivacaine + 10 mL of NS.

All patients had severe chest wall pain prior to ESPB. Within 30 min of performing an USG ESPB, all patients had effective analgesia, restoring the ability to inspire deeply, cough, laugh, and perform trunk movements with minimal pain.

4. Description of technique

a. Pre-assessment

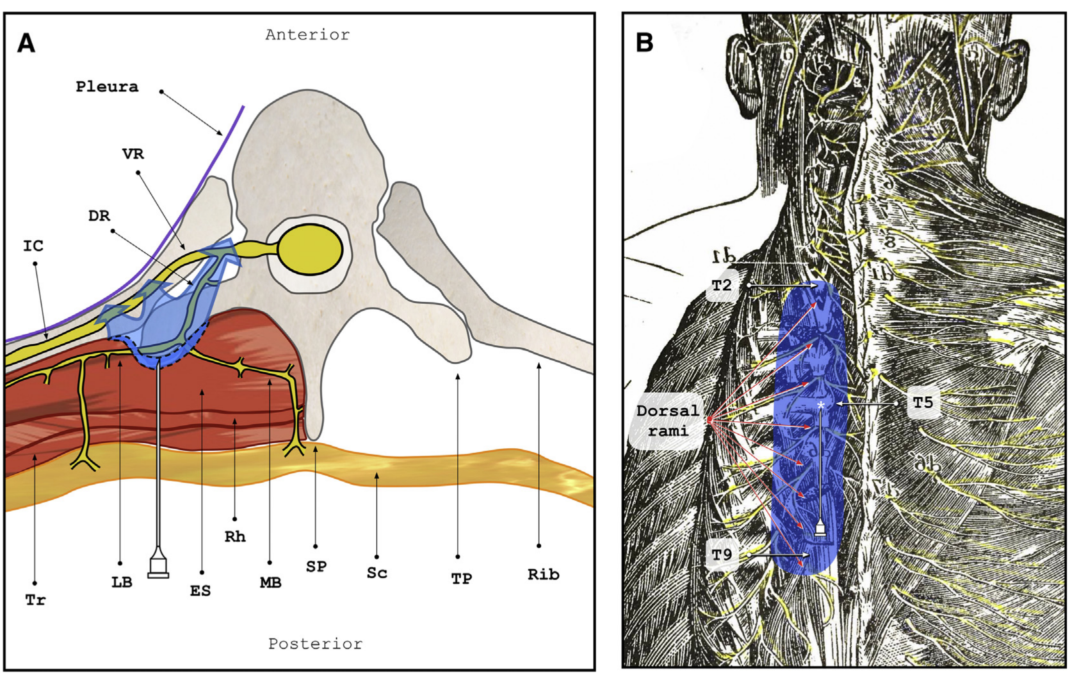

Fig. 1. Local anesthetic spread with ESPB. A. Cross section of posterior thorax at the level of the 5th thoracic vertebrae. The block needle is shown injecting local anesthetic (LA) into the erector spinae fascial plane (ESP), which lies in the chest wall between the anterior surface of the cephalocaudal-oriented erector spinae muscles and the posterior surface of the spinal transverse processes. LA spread in the ESP anesthetizes the dorsal rami as they traverse this plane, providing anesthesia to the adjacent injured muscle and soft tissues that contribute to posterior rib fracture pain. Additionally, LA injected into the ESP spreads anterior, anesthetizing the ventral rami where they become intercostal nerves. This intercostal nerve anesthesia provides analgesia directly to the fractured ribs and periosteum, and to the lateral and anterior chest wall via the lateral and anterior branches of the intercostal nerves. DR = dorsal ramus, VR = ventral ramus, IC = intercostal nerve, dark blue shaded area = LA within the ESP, light blue shaded area = anterior LA spread to the IC and VR, LB = lateral branch of the DR, MB = medial branch of the DR, TP = transverse process, SP = spinous process, Tr = trapezius muscle, ES = erector spinae muscle, Rh = rhomboid muscle, Sc = subcutaneous tissue. B. View of the posterior thorax with tissues posterior to the TPs dissected away. The block needle is again shown with the tip adjacent to the 5th thoracic TP. Cephalocaudal spread in the channel-like ESP extends anesthesia at least 3 vertebral levels above and 4 vertebral levels below the injection point allowing for extensive thoracic anesthesia from a single injection. T2, T5 and T9 = left transverse processes of the 2nd, 5th, and 9th thoracic vertebrae, respectively. Dark blue = T2 through T9 level cephalocaudal spread of LA with injection at T5 level TP. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

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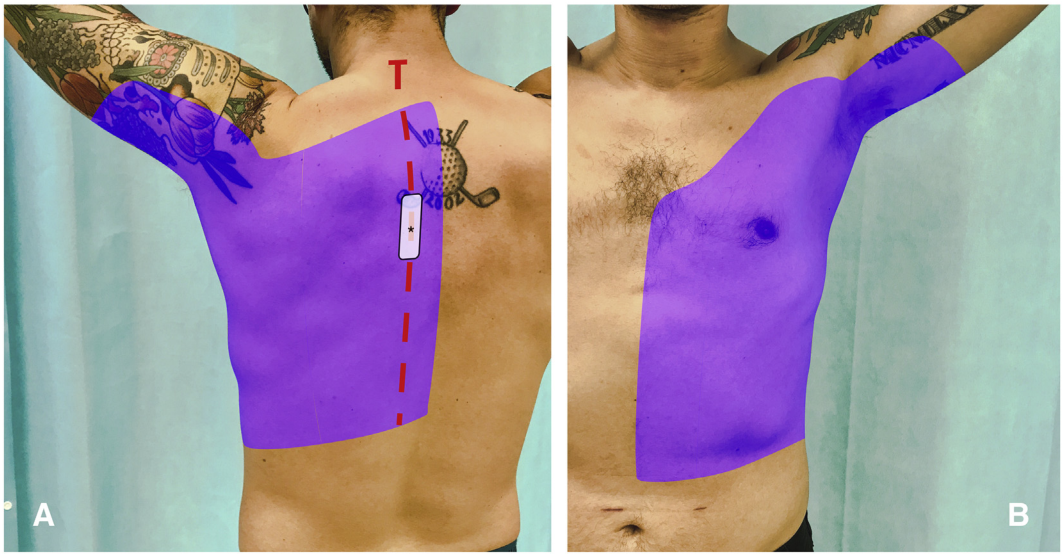

Fig. 2. Area of expected anesthesia with an ESPB at the T5 level left TP. A. Posterior view. B. Anterior view. Dashed red line labeled "T" = transverse processes. Rounded rectangle = ultrasound transducer footprint centered on the T5 level left TP, asterisk = injection target for an ESPB at the T5 level left TP, purple shading = area of anesthesia (T2–T9). Injections at higher or lower TPs will have areas of expected anesthesia shifted higher or lower respectively. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Inspect the back for evidence of overlying infection or excessive soft tissue at the injection target. Patients having more than 5 cm from skin surface to TP on survey ultrasound scan or showing signs of skin infection overlying injection target area are poor candidates for ESPB.

b. Positioning

Expose the posterior thorax by placing the patient prone, in lateral decubitus, or leaning forward in a seated position. For the prone position, stand at the head of the bed with the ultrasound system on either side of the bed at the level of the patient's thighs. For the lateral decubitus position (with patient lying on their unaffected side), sit at the side of the bed facing the patient's back with the ultrasound system on the opposite side of the bed (anterior to the patient). For the seated position, seat the patient on the edge of the bed leaning forward onto a side table in a position similar to the seated lumbar puncture position. Stand behind the patient with the ultrasound system located on the opposite side of the bed anterior to the patient. For all positions, elevate the bed to a level where the needle, probe, and ultrasound screen can all be viewed in direct line-of-site with minimal head movement. We favor the prone or lateral decubitus position for this block as the seated position can be uncomfortable for the patient with acutely fractured ribs.

c. Identifying the optimal location for block placement

The substantial LA spread associated with this block allows for flexibility in block placement location. For rib fractures, the TP should be targeted that approximately coincides with the area the patient finds most painful.

d. Survey scan

Key bony structures (spinous process, TP, and rib) can be differentiated by their shapes and relative depths as the transducer is moved laterally from midline. At the targeted vertebral level, place a high-frequency linear transducer in cephalocaudal orientation over the midline of the back to identify the vertebral spinous process (Fig. 3A, B).

Keeping the probe oriented cephalocaudal, slide the probe approximately 3 cm laterally towards the side to be blocked, identifying the TP injection target (Fig. 3C). To confirm TP identification, slide the probe beyond the target laterally, passing the probe over the costotransverse junction to the rib. The posterior rib adjacent to the costotransverse junction is both lateral and deep to the TP (Fig. 3D). By sliding back and forth over the costotransverse junction, the differentiation between the TP and rib will be clear. The TP will be more superficial, blunter, wider, while the rib will be deeper, rounder and thinner. When satisfied with TP identification, stabilize the probe over the TP and prepare for injection.

e. Injection

With the transducer fixed over the targeted TP, identify a block needle insertion site aligned with the long axis of the ultrasound beam and approximately 1–2 cm away from the probe. (Fig. 4A) The insertion site can be cephalad or caudad to the probe, as the TP can be approached from either direction.

After sterile prep, place a LA skin wheal at the insertion site using a 25–27 g needle. Then insert a block needle (e.g. Tuohy 20 g 90 mm epidural needle) through the skin wheal and advance the needle at a 30–45-degree angle towards the ultrasound beam. After initial insertion of 1–2 cm stop further needle advance and make slight transducer and needle adjustments (keeping the TP in view) until the needle tip is visible. Continue advancing with in-plane ultrasound guidance to the posterior surface of the targeted TP. The operator may feel "fascial clicks" corresponding with the fascia of the trapezius, rhomboid (for blocks at T7 and higher), and erector spinae muscles with a final firm end point upon contacting bone.

Once the needle tip is in the ESP below the erector spinae muscle, we recommend alternating aspiration (to confirm lack of inadvertent vascular puncture) with injection of small aliquots of LA or NS. Anechoic fluid should be seen separating the erector spinae muscle from the TP, confirming spread within the ESP. Once satisfied with the needle position, gradually inject LA until a total of 20–40 mL is

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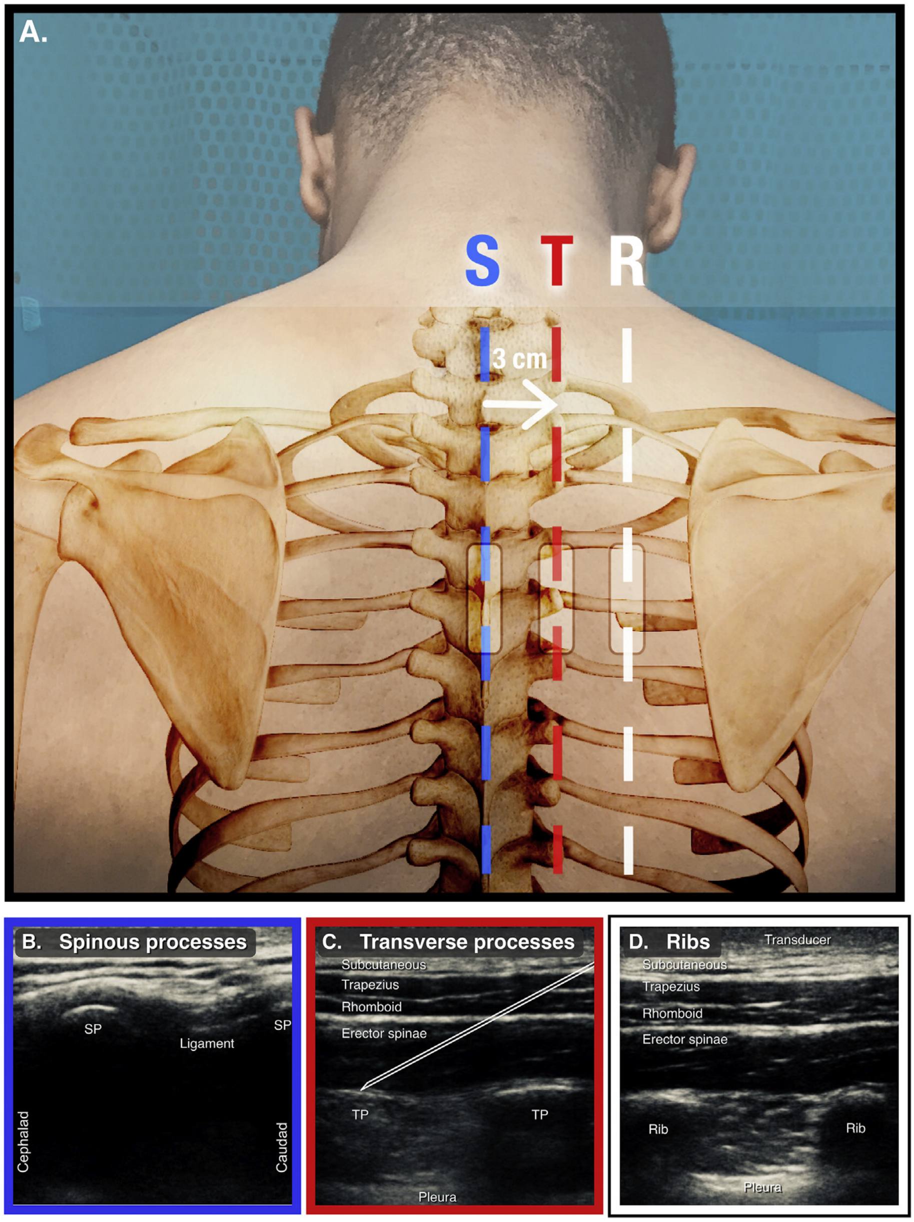

Fig. 3. Transducer positions and associated ultrasound images as the probe moves from medial to lateral. A. Probe positions over the spinous process, TP and rib. Letters and associated dashed lines represent: S = Spinous processes, T = Transverse Processes, R = Ribs. Rounded rectangles = ultrasound transducer footprints (in this example centered on the 5th transverse process and adjacent spinous process and rib). B. Ultrasound image corresponding to the left transducer footprint above, midline over the spinous process. The spinous process is identified as the very superficial hyperechoic structure in the midline of the back creating a hypoechoic acoustic shadow. SP = spinous process. C. Ultrasound image corresponding to the middle transducer footprint above, over the transverse process. The TP is identified as the next most superficial bony vertebral structure (when compared to the spinous process) approximately 3 cm lateral from the spinous process. It resembles a rib, but has several distinguishing features. It appears more blunted, squared off, thicker and wider than the rounded, thin appearance of ribs. Additionally, the pleura deep to the TP is typically difficult to discern, as opposed to the pleura behind the ribs which is highly visible. Another distinguishing feature of the TP is that it abruptly disappears from view with continued lateral sliding of the probe. Ribs, in contrast, stay visible as the probe is moved laterally. Needle shown at target location for injection into the ESP. Trapezius = trapezius muscle. Rhomboid = rhomboid major muscle. Erector spinae = erector spinae muscle. D. Ultrasound image corresponding to the right transducer footprint above, over the rib. The TP disappears from view as the probe passes laterally over the costotransverse junction, and with continued lateral probe movement, the rounded shadowing ribs and the pleura come into view and remain visible no matter how far the probe is moved laterally.

deposited within the plane (Fig. 4B). In our experience, total needling time is usually less than 5 min and trunk anesthesia develops within 30 min.

5. Discussion

Rib fractures can be exceedingly painful and patients with these fractures are frequently encountered in the ED. Current ED pain management options for these patients are limited. Early and aggressive pain control with regional anesthesia is considered to be a crucial element of rib fracture management in trauma patients, but traditional thoracic RA techniques of epidural anesthesia, paravertebral blocks, and intercostal blocks are not readily available in the ED [14-20]. Instead, these patients are often treated with large doses of opioids until transfer to the inpatient setting where these blocks are generally performed. Unfortunately, opioids are limited by potentially serious, dose dependent, adverse events, such as hypotension, nausea, vomiting, delirium, ileus, urinary retention, suppression of the cough reflex, and respiratory depression. Additionally, traditional thoracic RA techniques risk inadvertent motor blockade, deep vein thrombosis, hypotension, urinary retention, pneumothorax, vascular puncture, and epidural hematoma [14-20].

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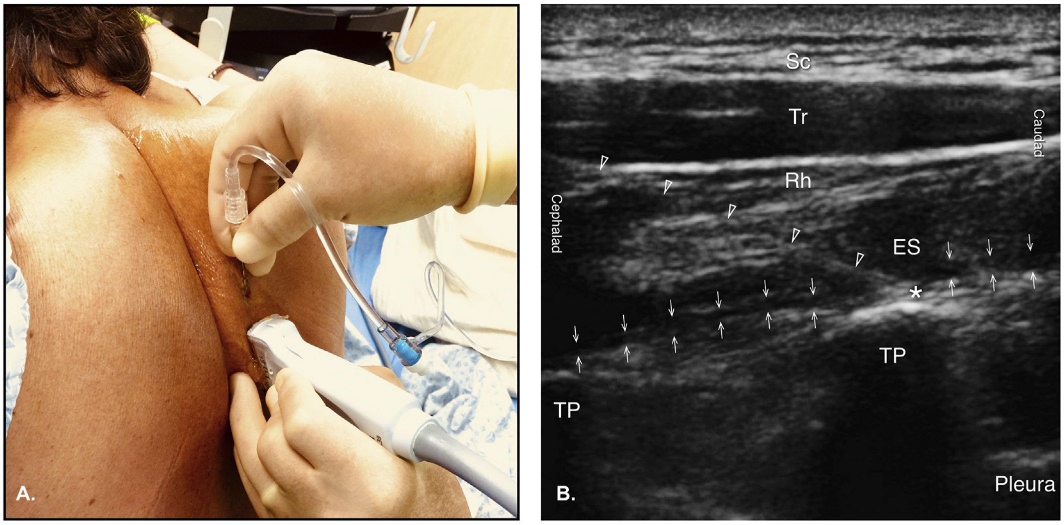

Fig. 4. Insertion site and ultrasound view of the ESPB. A. Insertion site. The transducer is oriented cephalocaudal and held in position over the targeted TP. The needle insertion site is 1–2 cm from the probe, in-line with the ultrasound beam, and either cephalad or caudad to the probe, as the TP can be approached either direction. B. Ultrasound-guided injection into the erector spinae fascial plane. The needle has gently contacted the posterior surface of the TP. Hypoechoic LA is seen lifting the ES muscle away from the TP and spreading across the posterior aspects of adjacent TPs, confirming spread within the ESP. If test injections are seen pooling in the erector spinae muscle instead, make slight adjustments of the needle tip (or rotate the needle so the bevel is facing the TP) until visualizing this planar spread within the ESP. Sc = subcutaneous tissue, Tr = trapezius muscle, Rh = rhomboid muscle, ES = erector spinae muscle, ESP = erector spinae plane, TP = transverse process, triangles = needle, asterisk = needle tip, arrows = LA in the ESP lifting the ES off the TPs.

The ESPB can be performed in the ED and offers a highly favorable efficacy, feasibility and safety profile when compared to these alternatives. It provides profound trunk analgesia, requires only a single extrathoracic injection, and avoids the risks associated with opioids and more invasive traditional thoracic RA techniques. The major risk is local anesthetic systemic toxicity (LAST), which can be avoided by using dilute anesthetic (e.g. 40 mL of 0.25% bupivacaine) and standard precautions. Advancement of the needle could theoretically cause a pneumothorax or puncture into the epidural space; however, this would require substantial operator error as the block target is outside the chest cavity. Additionally, the relatively shallow angle of needle approach allows the broad TPs to function as a formidable shield for deeper structures.

Limitations of ESPB should be kept in mind. Positioning to expose the patient's back is required, which can be challenging in the extensively injured patient. Variability in LA spread can result in regions of anesthesia that are smaller or larger than expected. Patients with extensive tissue between the skin surface and the TPs are poor candidates for this block. Although uncommon, LAST may occur, particularly if standard precautions are ignored or LA is injected beyond weight appropriate dosing. The operator must be familiar with in-plane ultrasound-guidance and never advance the needle unless the tip is clearly visualized by ultrasound since needle insertion into the spinal cord or pleura is possible.

6. Conclusion

Our initial experience suggests the ESPB is technically feasible and highly effective for the acutely injured ED patient with posterior rib fracture pain. Posterior rib fractures are common and the pain associated with them is frequently difficult to manage. Intravenous pain medication alone is often unsatisfactory and more advanced blocks such as epidural, paravertebral, or intercostal blocks are more invasive, increase risk of adverse events, and are typically unavailable in the ED setting. The USG ESPB, with its rapid performance, distance from critical thoracic structures, and extensive analgesia of the hemithorax, may be the ideal technique for EPs to incorporate into the clinical care of patients with posterior rib fractures.

Prior presentations

None

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None

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