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TITLE:

Ultrasound-Guided Fascial Plane Blocks for Acute Rib Fracture Pain in a Level IV Trauma Center: A Literature Review and Introduction of an Evidence-based Analgesia Algorithm for Uncomplicated Rib Fractures

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Introduction: Rib fractures are a common injury occurring in approximately 75% of all blunt thoracic traumas.^{1–3} Poorly controlled pain reduces inspiratory effort, leading to atelectasis and an increased risk of pneumonia. Bronchiectasis, pulmonary effusion, acute respiratory distress syndrome, and respiratory failure can also occur, contributing to poorer overall outcomes in patients experiencing rib fracture trauma.^{2,4,5} Prompt implementation of effective, high quality pain control allows patients to perform deep breathing exercises, cough, clear secretions, and actively participate in chest physiotherapy, reducing respiratory complications.^{2,4,6}

There are multiple risk factors associated with poor clinical outcomes in patients suffering rib fractures, including the number and location of fractures, bilateral versus unilateral fractures, the presence of pulmonary contusions, and flail chest.⁴ Elderly patients, and those with co-morbidities including obesity, smoking, pre-existing respiratory disease, obstructive sleep apnea, cardiovascular disease and diabetes are also at an increased risk for negative outcomes.⁴

Historically, thoracic epidural (TEA) and paravertebral blocks (TPVB) were considered the “gold” standard regional techniques for acute rib fracture pain.⁷ Epidural analgesia is accomplished by inserting a catheter into the epidural space where local anesthetics act directly

on the spinal nerves located in the lateral portion of the space.¹¹ Complications of this invasive procedure include, hypotension, dural puncture, nerve damage, radicular pain, respiratory depression, and epidural hematoma.^{4,7} Absolute contraindications to epidural analgesia include coagulopathy, spinal pathology, thoracic vertebral body fracture, infection at the insertion site, and drug allergy.^{1,4} Relative contraindications include inability to position patient for the procedure, severe traumatic brain injury, unstable lumbar or cervical fractures, anticoagulant therapy, hypotension, and hypovolemia.¹ Paravertebral blocks provide unilateral blockade of the spinal nerves as they pass through the paravertebral space, providing somatic and sensory loss.^{1,4,6,11} Paravertebral blocks are performed as a single injection or continuous-catheter technique under ultrasound-guidance or landmark identification.^{4,6}

In recent years the publication of new, novel ultrasound-guided fascial plane blocks offers a variety of versatile block options in providing analgesia for rib fracture patients while avoiding complications associated with central neuraxial interventions.^{7,8}

Ultrasound-guided regional anesthesia (USGRA) allows real-time visualization of anatomic structures, needle placement, and local anesthetic (LA) spread.⁸ Ultrasound has been instrumental in the ad-

vancement of fascial plane blocks, where local anesthetic is injected into the space between tissue planes and visualized in real-time under ultrasound guidance.^{4,8} Fascial plane blocks are believed to work by the passive spread of local anesthetic to nerves lying within tissue planes or contained within adjacent tissue compartments.⁸ The use of ultrasound guidance has led to the description of a multitude of fascial plane techniques for perioperative pain management of the chest wall region including serratus anterior plane block (SAPB) and erector spinae plane block (ESPB).¹⁰ SAPB and ESPB have been described for the management of anterolateral and posterolateral thoracic pain, including trauma.¹⁰

Serratus Anterior Plane Block. First described by Blanco et al in 2013 as a novel analgesic technique for chest wall surgery, the serratus anterior muscle originates from the anterior surface of ribs 1-8 and inserts on the medial margin of the costal surface of the scapula.^{1,7,8,11} It provides analgesia from T2-T9 by blocking the lateral cutaneous branches of the intercostal nerves.^{1,7} The long thoracic nerve, intercostal brachial, and thoracodorsal nerves, running in the fascial plane superficial to the serratus anterior muscle, may also be anesthetized.⁸ Local anesthetic may be injected superficial or deep to the serratus anterior muscle. Blanco and colleagues reported a longer mean duration of analgesia when injection occurred superficial to the serratus muscle, which is probably related to vascular uptake differences of local anesthetic between these two compartments.^{1,7,11}

Erector Spinae Plane Block. Forero et al first described the ESPB as an analgesic technique for chronic thoracic neuropathic pain.¹² Since then, it has been used successfully to manage pain associated with rib fractures and surgery of the thorax and abdomen.⁷ Depending on the indication, local anesthetic is injected into the fascial plane between the erector spinae muscles and the superior surface of the spinal transverse processes of the cervical, thoracic, lumbar, and/or sacral vertebrae.^{7,8,10} The ESPB is thought to block the ventral and dorsal rami and lateral cutaneous branches of the intercostal nerves, resulting in somatic and visceral analgesia to the posterior, lateral, and anterior chest wall.^{7,8,10,13}

Review of the Literature

A search of the literature was conducted comparing the use of ultrasound guided ESPB and SAPB to the use of thoracic epidural and thoracic paravertebral blocks for acute thoracic pain. CINAHL, PubMed, and Cochrane databases were searched for this review. Keywords

searched include rib fracture, blunt trauma, thoracic injury, thoracic surgery, nerve block, regional anesthesia, analgesia, opioid sparing, and pain. A level of evidence appraisal was performed, with an evidence level rating assigned to each study using the Johns Hopkins research evidence appraisal tool.²⁶

A total of 717 ASA I-III adult patients from 11 studies compared US-RGA fascial plane blocks with TPVB or TEA techniques for analgesic management of rib fractures or acute thoracic surgical pain. Outcome measures of interest included analgesia, opioid consumption, and respiratory function.

Rib Fracture Studies. Five studies focused on rib fractures in this review. Beard et al, a multicenter retrospective observational review, focused on patients who sustained multiple rib fractures and received a continuous catheter regional intervention (TEA, TPVB, or SAPB) for acute pain.²⁸

The case reports in this review included a combination of single-shot and continuous-catheter techniques for the acute management of rib fractures.^{20,22,25,29}

Surgical studies. Six studies focused on acute postoperative thoracic pain.^{30–35} Although the objective of this review is to determine if fascial plane blocks offer non-inferior analgesia in rib fracture patients, the thoracic nerves targeted in these surgical studies are also implicated in rib fracture pain. All of the studies focused on continuous-catheter techniques, except Zhao et al³², which utilized a single-shot injection SAPB for local anesthetic administration.^{30–35}

Discussion

The primary outcome of interest is whether ultrasound-guided fascial plane blocks compared to neuraxial regional techniques result in non-inferior analgesia for the patient experiencing acute thoracic pain. Overall, the studies draw similar conclusions. When assessing pain at different time intervals, three surgical studies found pain scores to be comparable between the ESPB/SAPB groups and the TEA/TPVB groups during the first 12 hours.^{30,33,35} At 24 hours, multiple studies found comparable or decreased pain scores in the fascial plane groups compared to the TEA/TPVB groups.^{25,30,32–35} Similar results were noted in those studies measuring pain at 48 hours.^{31–34} Studies comparing rescue analgesics and respiratory function also had similar conclusions among the intervention groups.

These studies found continuous fascial plane blocks to be comparable overall.^{28,30,31,33–35} Ökmen and Khalil et al^{30,35} conclud-

ed that when compared to thoracic epidural, the serratus anterior plane block had similar outcomes with regard to pain scores and rescue analgesic consumption. Similarly, Hanley et al³⁴ determined SAPB was non-inferior to thoracic paravertebral block in terms of pain scores and opioid consumption (projected mean 48-hr oxycodone requirement of 80 mg with SD of 20 mg in the TPVB group, as defined by the authors. For SAPB block to be deemed non-inferior, 48-hr postoperative oxycodone requirement could not be more than 25% higher than TPVB group).³⁴ Beard et al concluded in their retrospective, observational study that SAPB, TEA, and TPVB all appeared to effectively reduce pain scores and improve respiratory function in rib fracture patients.²⁸ Case reports detailing rib fracture cases all noted a decrease in pain score, opioid consumption, and improved respiratory function (ability to deep breathe, cough and laugh) after both continuous-catheter and single-shot interventions.^{20,22,25,29}

Conclusion

While historically thoracic epidural and paravertebral blocks have been the standard regional technique for acute thoracic pain, these methods are not always feasible. The literature has shown ultrasound-guided fascial plane blocks to be an effective alternative regional analgesic intervention. Implementing an evidence-based assessment tool utilizing ultrasound-guided fascial plane blocks in rib fracture patients provides the anesthesia provider with multiple options for treating acute pain while decreasing variability in patient care and increasing patient satisfaction.

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