Ultrasound-Guided Serratus Anterior Plane Block for Rib Fracture-Associated Pain Management in Emergency Department

Subhankar Paul, Sanjeev Kumar Bhoi, Tej Prakash Sinha, Gaurav Kumar
Department of Emergency Medicine, All India Institute of Medical Sciences, New Delhi, India

Abstract

Context: Traumatic rib fractures are common and painful conditions to present in the emergency department. Ultrasound-guided serratus anterior plane block (SAPB) is a newer technique which is being used for managing postthoracotomy, thorascopic surgery, or post mastectomy pain by the anesthetists. However, we have recently started utilizing this novel technique in our emergency department for rib fracture patients with severe pain. Settings and Methods: We present a case series of 10 patients of multiple rib fractures (MFRs) with persistent Defense and Veterans Pain Rating Scale (DVPRS) 7 or more even after intravenous analgesics where this block was applied by trained emergency physicians (EP). Results: Following SAPB median (± IQR) pain score reduction was 5 (±4) at 30 min and 7.5 (±2) after 60 min of administering the block. There were no incidences of block failure or block-related complications in our series. Conclusions: Ultrasound-guided SAPB can be used safely by trained EP in the emergency department to relieve acute severe analgesic-resistant pain in MFR patients.

Keywords: Regional anesthesia, rib fractures, serratus anterior plane block, ultrasound

INTRODUCTION

Rib fractures are among 10% of all injured patients presenting to the emergency department and results in significant morbidity and mortality, especially in the elderly. Uncontrolled pain due to rib fracture leads to impaired ventilatory function, atelectasis, and pneumonia. The effective and continuous analgesia is one of the key components of rib fracture management. Opiates have been the mainstay of pain management, which have significant side-effects, including respiratory depression, depressed cough reflex, and delirium. Hence, multimodal analgesia such as thoracic epidural analgesia and regional nerve blocks has been used.

Thoracic epidural analgesia has been standard of definitive pain therapy for multiple rib fractures (MFRs). However, it is technically difficult and usually not performed in the emergency department. Regional nerve blocks such as intercostals nerve blocks and paravertebral block are time-consuming, involve multiple injections and necessitate patient repositioning.

Ultrasound-guided serratus anterior plane block (SAPB) has recently gained the interest of the anesthesiologists and pain physicians due to its efficacy, relative ease, single-injection method with limited side-effect profile. SAPB is being used in controlled environment such as OT or ICU for various breast surgeries and thoracotomy pain control by the anesthesiologists. However, there is limited literature regarding its feasibility and efficacy in the emergency department by the emergency physicians (EP) for acute pain. We are presenting here a case series of ultrasound-guided SAPB in 10 patients with MFRs in the emergency department by EP.

METHODS

Patients with 3 or more rib fractures who had persistent Defense and Veterans Pain Rating Scale (DVPRS) of 7 or more even after intravenous analgesics where this block was applied by trained emergency physicians (EP).
after NSAIDS and Opioids administration were recruited for the block. Patients were recruited consecutively regardless of their body habitus or severity of injuries. ED pain team comprised of trained nurses who were not included directly in the block procedures, assessed pain scores of the patients before and after the blocks. The used pain assessment tool was DVPRS which utilized a combination of numerical rating scale with pictorial facial expressions, functional word descriptors, and color coding according to the level of pain. Authors performed SAPB as described by Blanco et al, and in few cases, deeper plane method was adopted as the body ergonomics was not conducive. The details of the procedure are being described.

The patient was recruited after informed consent and shifted to a monitored bed with intravenous cannula in situ.

1. Equipment: A high-frequency (7–12 MHz) linear probe was used
2. Personnel: Blocks were performed by the EP trained in the use of point of care ultrasound and procedural ultrasound under the supervision of consultants of emergency medicine
3. Preparation: The block team, drugs, device, and appropriate nerve block needle were assembled in Red area where full resuscitation equipments including 20% Intralipid were available
4. Positioning: The patient was kept in supine position with the arm abducted or in lateral position wherever feasible. The ultrasound machine was kept opposite to the operator, plugged in with powered on. Sterile technique, including an ultrasound transducer cover and sterile gel was employed [Figure 1]
5. Probe positioning and marking: The probe (7–12 MHz) was placed in the sagittal plane, and the 5th rib in the mid-axillary line was identified first. Latissimus dorsi and serratus anterior muscles were identified overlying the 5th rib. The plane in between these two muscles was further confirmed by locating the thoracodorsal artery with color Doppler in that plane. Point of entry of the needle was marked with skin marker [Figure 2]
6. After antiseptic dressing, a small skin-wheel was made at the marked point with subcutaneous infiltration of 1% lignocaine with adrenaline. A gap of 3–5 min was allowed to ensure the onset of the action of skin anesthesia
7. Injection bupivacaine 0.5% was taken as 1 mg/kg body weight and diluted with equal volume of NS to make it a 0.25% solution while not exceeding a total volume of 40 ml
8. After local anesthetic (LA) infiltration, a 50 mm 18 g Tuohy catheter needle was introduced through in-plane technique from superior-anterior to posterior-inferior direction with negative suction
9. Once reached in the plane in between the serratus anterior and latissimus dorsi, aspiration was done to rule out any vascular puncture. Initially, 2–3 ml LA was injected to confirm hydrodissection between latissimus dorsi and the serratus muscle visible in ultrasound. Rest of the solution was given slowly under continuous ultrasound guidance [Figures 3 and 4]. Throughout the procedure, patient’s vitals, SpO2, and electrocardiography were continuously monitored
10. Initial and subsequent pain scores at 30 and 60 min were noted to assess the adequacy of the block. The definition for block-success was to achieve a DVPRS of ≤4 on movement (coughing and deep breathing) and ≤3 on rest following the procedure. Failure to achieve a pain-score less than 50% of the pre-procedure pain-score after 60 min of the block was considered as the working definition of block failure in ED. Intermittent injection fentanyl was planned for breakthrough pain or block-failure
11. Patients were monitored for 1 h in the resuscitation area particularly for any features of cardiac arrhythmias and LA systemic toxicity (LAST). Thereafter, they were followed up till the patients were in the ED. Serial lung ultrasounds were done to find any new onset or block-related complications.

Results

SAPB was done in 10 patients of MFRs with median (± IQR) pain score of 9 (±1.5) on arrival at the emergency department.

Figure 1: Ergonomics of the serratus anterior plane block

Figure 2: Probe position at the right mid-axillary line over 5th Rib
Majority of our patients had posterior or posterior-lateral rib fractures (66%), and rest had anterior or lateral fractures. Average rib fracture score was 10.1 with a range of 3–43. Following SAPB median (±IQR) pain score reduction was 5 (±4) at 30 min and 7.5 (±2) after 60 min of administering the block. Table 1 summarizes the patient characteristics and the effect of the SAPB block in our series. We did not have any case of block-failure in our series and none of our patients required any rescue analgesics during their stay in the ED. Two patients were discharged from ED with precautionary advice but there was no return to ED for pain or other complications. Other patients were admitted to definitive care units who reported no block-related complications.

**Discussion**

SAPB targets the lateral cutaneous branches of the thoracic intercostal nerves, which arise from the ventral rami of the thoracic spinal nerves and traverse through the internal intercostal, external intercostal, and serratus anterior muscles to innervate the musculature of the anterolateral thorax. These branches of the intercostal nerves, therefore, travel through the two potential spaces above and below the serratus anterior muscle. At the level of the fifth rib, superficial plane is formed by the anterior aspect of the serratus anterior and the posterior aspect of the latissimus dorsi muscle. The deep plane is formed in between the posterior aspect of the serratus anterior and the external intercostal muscles and ribs. LA inserted into these planes thus spreads throughout the lateral chest wall along these fascial planes resulting in paresthesia of the t2-t9 dermatomes of the external intercostal muscles and ribs. LA inserted into these fascial planes in between the posterior aspect of the serratus anterior and the external intercostal muscles and ribs. LA inserted into these planes thus spreads throughout the lateral chest wall along these fascial planes resulting in paresthesia of the t2-t9 dermatomes of the external intercostal muscles and ribs. LA inserted into these planes thus spreads throughout the lateral chest wall along these fascial planes resulting in paresthesia of the t2-t9 dermatomes of the external intercostal muscles and ribs.

Researchers have given mostly superficial plane block except in two cases which was also comparable to others studies. Both Blanco et al. found wider dermatomal spread and better pain control in superficial SAPB group. We have given mostly superficial plane block except in two cases.

**Figure 3:** Normal sonoanatomy of serratus anterior plane block. LD: Latissimus Dorsi Muscle, SA: Serratus Anterior Muscle, white arrow showing 5th Rib, yellow arrow showing pleural line

**Figure 4:** Ultrasound-guided needle tracking and hydrodissection by local anesthetic. LD: Latissimus dorsi muscle, SA: Serratus anterior muscle, White arrow showing needle tip with flow of local anesthetics

Literatures suggest the use of various LAs such as ropivacaine, bupivacaine, and lignocaine. We have used injection bupivacaine (0.25%) which is comparable to Jadon et al., and Kunhabdulla et al., concentration. Camacho and Segura-Grau used (0.25%) levobupivacaine while Bossolasco et al. injected (0.125%) ropivacaine with (1%) lignocaine for rib-fracture analgesia. Hence, we suggest that either bupivacaine or ropivacaine with or without additional lignocaine may be used. We injected up to 40 ml of LA as bolus in fascial plane for better spread and ensuring the safe total dose of bupivacaine (1 mg/kg) with dilution (1:1) as per recommendation by May et al., Durant et al, and Bossolasco et al. used 30 ml of LA as bolus whereas Jadon and Jain, Camacho and Segura-Grau, and Kunhabdulla et al. used 20 ml of LA as bolus followed by continuous infusion through catheter. Hence, bolus of larger volume of LA is recommended for better spread within the fascial plane while ensuring not to exceed the total dose of the anesthetic.

The authors used in-plane approach in the majority of the cases which was also comparable to others studies. Both Blanco et al. and Bhoi et al. found wider dermatomal spread and better pain control in superficial SAPB group. We have given mostly superficial plane block except in two cases.
of bilateral chest injuries where due to technical difficulty and complex positioning, we administered LA into deeper plane following out-of-plane approach. However, we got comparable pain-score reduction similar to the anterior plane block. All of the other case reports for rib-fracture analgesia reported the use of deeper plane method as they had inserted a catheter in the other case reports for rib-fracture analgesia reported the spread of LA to the intercostal nerve-roots. However, Durant et al. reported good pain relief after 15 min of SAPB by observing visual analog scale score 2/10. We have

| Table 1: Patient characteristics and the effect of the serratus anterior plane block |
| Age (years) and sex (male/female) | Diagnosis | Site of break | Rib fracture score | Associated injuries | Dynamic pain score before block | Drug dose and volume | Technique | Dynamic pain score after SAPB (min) |
|----------------------------------|-----------|--------------|-------------------|---------------------|-----------------------------|-----------------|-----------|----------------------------------|
| 30/male                          | Left 2, 4, 5, 6, 7 ribs single point # and 3rd rib two point # | Posterior-lateral | 7 | Left upper and lower lobe contusion, left hemopneumothorax | 10 Bupivacaine 0.25% 40 ml | Out of plane | 5 | 2 |
| 55/female                        | Left 4-8 ribs single point # | Lateral | 6 | Left pneumothorax | 10 Bupivacaine 0.25% 40 ml | Out of plane | 7 | 2 |
| 30/male                          | Right 5-7th ribs single point # | Antero-lateral | 3 | Right pneumothorax, Right anterior column #, right SPR and IPR #, Right acetabulum #, moderate extraperitoneal hemotomia | 10 Bupivacaine 0.25% 40 ml | In-plane | 4 | 2 |
| 50/male                          | Left 7th, 8th, and 12th rib single point fracture, 9th, 11th rib double point fracture, 10th rib 3 point fracture | Posterior and lateral | 12 | Moderate hemopneumothorax associated with collapse left lung | 10 Bupivacaine 0.25% 40 ml | In-plane | 2 | 2 |
| 45/male                          | Right 2-7th ribs single point # | Posterior and anterior | 6 | Right scapula comminuted #, Right clavicle lat end #, Right pneumothorax, Right small postll lung contusion, Right ASIS chip # | 9 Bupivacaine 0.25% 40 ml | In-plane | 7 | 4 |
| 28/male                          | Right 5, 6, 7 ribs single point # | Posterior-lateral | 3 | No hemopneumo thorax, right scapula body # | 8 Bupivacaine 0.25% 40 ml | In-plane | 6 | 1 |
| 57/female                        | Left-sided 2-8th ribs anterior # and 6-9th rib posterior # | Antero and posterior | 43 | Bilateral hemothorax, Multiple dorsal vertebral spinous processes and right transverse process #, Proximal humerus # right side, Segmental # left humerus | 9 Bupivacaine 0.25% 40 ml | In-plane | 4 | 3 |
| 32/male                          | Left 3-6 ribs single point # | Posterior-lateral | 4 | No hemopneumothorax | 9 Bupivacaine 0.25% 40 ml | In-plane | 3 | 1 |
| 65/male                          | Right 2-6th ribs double point #, 7th single point # | Posterior and lateral | 13 | Mild hemopneumothorax, surgical emphysema, minimal air foci in lower mediastinum | 8 Bupivacaine 0.25% 38 ml | In-plane | 2 | 2 |
| 54/male                          | Right 5-7th ribs single point # | Lateral | 4 | No hemopneumothorax | 9 Bupivacaine 0.25% 40 ml | In-plane | 4 | 2 |

#Fracture. ASIS: Anterior superior iliac spine, SPR: Superior pubic ramus, IPR: Inferior pubic ramus, SAPB: Serratus anterior plane block
used DVPRS[27] and also have got adequate levels of pain-score reduction after SAPB (median [± IQR] pain score reduction of 5 [±4] at 30 min and 7.5 [±2] after 60 min).

Previous literature suggested that SAPB would be effective only for anterior Rib-fractures[1,3] sparing the posterior rib periosteum and intercostal muscles.[19] Jain et al.[20] also reported two cases of failed SAPB in posteriorly located MFRs. However, Johnston et al.[23] demonstrated SAP injectate spreading to multiple intercostal nerves up to the medial border of the scapula in a cadaveric model of traumatic hemothorax. In our patients, we had administered SAPB regardless of the site of rib fractures and we have got adequate pain-score reduction though most of our patients had posterior-lateral fractures which was also similar to the results obtained by Rose et al.[20] in isolated posterior rib fractures.

Potential complications of SAPB are pneumothorax, vascular puncture, nerve injury, LAST, and infection.[4] We did not encounter any of the above-mentioned complications similar to the other studies. Another complication is rebound pain as the analgesia provided by bupivacaine typically lasts for 6–8 h.[1] Hence, Camacho and Segura-Graur[18] suggested that continuous SAP block through a catheter in situ would be an effective method for analgesia in MFRs which can easily be accomplished at bedside in the ED. Although we have not tried SAP catheter till now due to technical difficulty and lack of expertise and experience, these case reports imply that continuous infusion through SAP catheter can be inserted in ED by trained EP. Moreover, the learning curve for ultrasound-guided SAPB is short under adequate supervision. This expertise may also be translated among emergency nurses who can deliver continuous pain-free services from ED to the definitive care. This new practice may be a game changer in addressing severe pain associated with MFRs facilitating patient satisfaction and early recovery.

**Conclusions**

Ultrasound-guided SAPB is a technically easy, safe, and effective block which can be performed by the EP as a part of multimodal analgesia in patients with traumatic MFRs.

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**Conflicts of interest**

There are no conflicts of interest.

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