Use of Ultrasound Guided Serratus Anterior Plane Block for Rib Fractures

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Abstract

Patients who have multiple rib fractures (MRFs) due to various etiologies like road traffic accidents, assault, falls from heights, etc. The morbidity and mortality increase significantly in presence of other injuries, and in elderly patients with comorbidities. Ultrasound (US) guided serratus anterior plane block (SAPB) is a fascial plane block that has been utilized for managing pain after thoracotomy, mastectomy, and fractured ribs. US-guided SAPB is a safe and effective fascial plane block for managing pain in patients who sustain MRFs. Further research in the form of well-designed and adequately powered RCTs is needed to confirm its use in patients with MRFs

Keywords: Ultrasound, Serratus anterior plane block, Rib Fractures

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Introduction

Patients who have rib fractures due to various etiologies like road traffic accidents, assault, falls from heights, etc. The morbidity and mortality increase significantly in presence of other injuries, and in elderly patients with comorbidities [1,2]. Pulmonary complications like pneumonia, flail chest, pneumothorax, hemothorax, acute lung injury requiring non-invasive or invasive ventilation contributes to morbidity, prolonged hospital stay, and thus increased cost of treatment. Poorly controlled pain leads to basal atelectasis, worsening of acute lung injury, non-invasive or invasive ventilation, prolonged hospital stays, and thus an overall increased burden of the cost of treatment [3,4]. Pain management offered for patients with MRFs could be either systemic analgesia (opioids, multimodal analgesia with adjuvants) or regional anesthesia (RA). There are several RA options that can be offered to alleviate pain following MRFs like thoracic epidural analgesia, paravertebral block, intercostal nerve block, serratus anterior plane block (SAPB), or erector spinae plane block [5-10].

Ultrasound (US) guided SAPB was initially described by Blanco et al. in 2013. Blanco et al. described two planes, one superficial to serratus anterior muscle and second underneath the muscle and above the rib (Figures 1,2) [11,12]. When a SAPB is performed, it targets the lateral cutaneous branches of the thoracic intercostal nerves arising from the ventral rami of the thoracic spinal nerves. These nerves traverse through the internal intercostal, external intercostal, and SA muscles to innervate the muscles of the anterolateral aspect thoracic cage. These branches travel through the two potential spaces above and below the SA muscle. At the level of the fifth rib, the superficial plane is defined as the fascial plane formed by the anterior aspect of the SA muscle and the posterior aspect of the latissimus dorsi muscle. The deep plane of the fascial plane is the plane between the posterior aspect of the SA muscle and the external intercostal muscles and ribs. LA injected in either of these planes spreads throughout the lateral chest wall along these fascial planes and thereby providing analgesia from T2-T9 dermatomes of the anterolateral thorax. Due to the ease of identification of relevant structures using the US, the block was extensively utilized for managing postoperative pain after breast surgeries, thoracoscopic non-cardiac surgeries, minimally invasive cardiac surgeries, thoracotomy, and chest trauma including rib fractures, especially at the posterolateral aspect. c

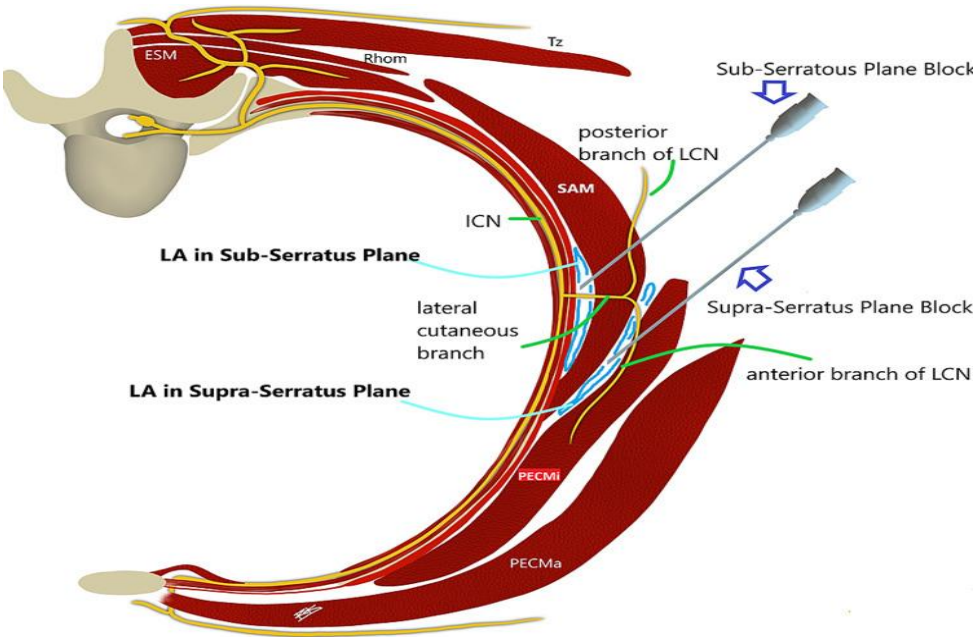

Figure 1: Schematic diagram showing needle placement for ultrasound-guided serratus anterior plane block, in superficial and deep plane [11].

Abbreviations: LA - local anesthetic, ICN - intercostal nerve, LCN - lateral cutaneous nerve, Rhom - rhomboids muscle, ESM - erector spinae muscle, Tz - trapezius muscle, SAM - serratus anterior muscle, PECMa - pectoralis major muscle, PECMi - pectoralis minor muscle

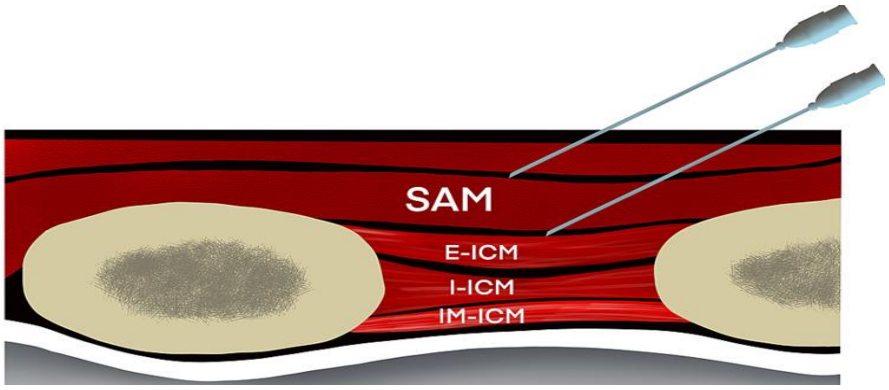

Figure 2: Schematic diagram showing needle placement for superficial and deep serratus anterior plane block along with various relevant structures [11].

Abbreviations: R - Rib, LD - latissimus dorsi muscle, E-ICM - external intercostal muscle, I-ICM - internal intercostal muscle, IM-ICM - innermost intercostal muscle, SAM - serratus anterior muscle

The SAPB is a technically easy alternative to neuraxial blocks that has grown in popularity in recent years as it is safe to use in most patients that a neuraxial block is contraindicated. The SAPB involves the insertion of a needle underneath the anterior edge of the latissimus dorsi muscle, LA is then injected between the serratus muscle and the latissimus dorsi. Both single and continuous injections of LA are used [13-15].

Anatomy and physiology

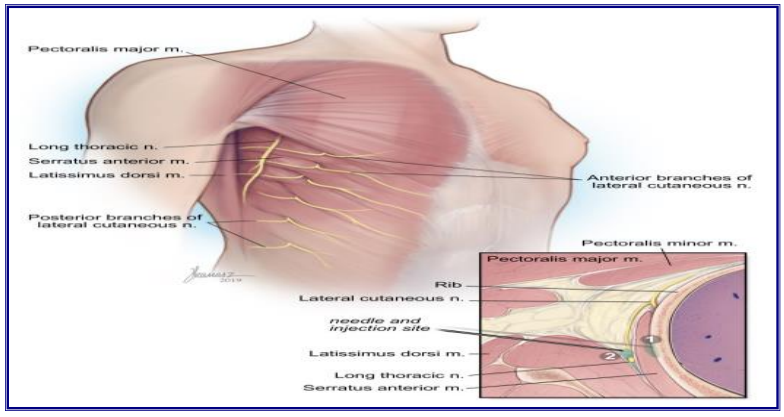

Fig. (3): Lateral cutaneous branches of the thoracic intercostal nerves [13].

The serratus anterior muscle originates from the anterior aspect of ribs 1 through 7-10 and inserts on the medial border of the scapula. It consists of 7 to 10 serrated tendinous projections that originate on each rib and is innervated by the long thoracic nerve. Deep and superficial potential spaces bound the serratus anterior. At the level of the fifth rib, the superficial plane forms from the anterior aspect of the serratus anterior and the posterior aspect of the latissimus dorsi muscle. The deep plane forms from the posterior aspect of the serratus anterior and the external intercostal muscles and ribs. Either plane

will achieve analgesia to the anterolateral chest wall with reportedly similar efficacy and an equivalent area of cutaneous sensory loss [16].

The SAPB targets the lateral cutaneous branches of the thoracic intercostal nerves, which arise from the anterior rami of the thoracic spinal nerves and run in a neurovascular bundle immediately inferior to each rib. At the midaxillary line, the lateral cutaneous branches of the thoracic intercostal nerve traverse through the internal intercostal, external intercostal, and serratus anterior muscles innervating the musculature of the lateral thorax. These branches of the intercostal nerves, therefore, travel through the two potential spaces described above. LA inserted into these planes will spread throughout the lateral chest wall, resulting in paresthesia of the T2 through T9 dermatomes of the anterolateral thorax [17].

US- guided SABP technique

SAPB is performed for patients in the lateral position. The probe is placed in a sagittal plane over the midaxillary line of the thoracic wall. Then, the fourth and fifth ribs are identified in the midaxillary line, and the serratus muscle is identified over these ribs. The needle is inserted, using an in-plane technique, into the interfacial area between the serratus anterior muscle and the rib. A 2-mL volume of saline is injected here for correction. Following confirmation of the correct needle position, a 20-mL volume of 0.25% bupivacaine is administered for SAPB [18].

Fig. (4): Administration of serratus plane block [17].

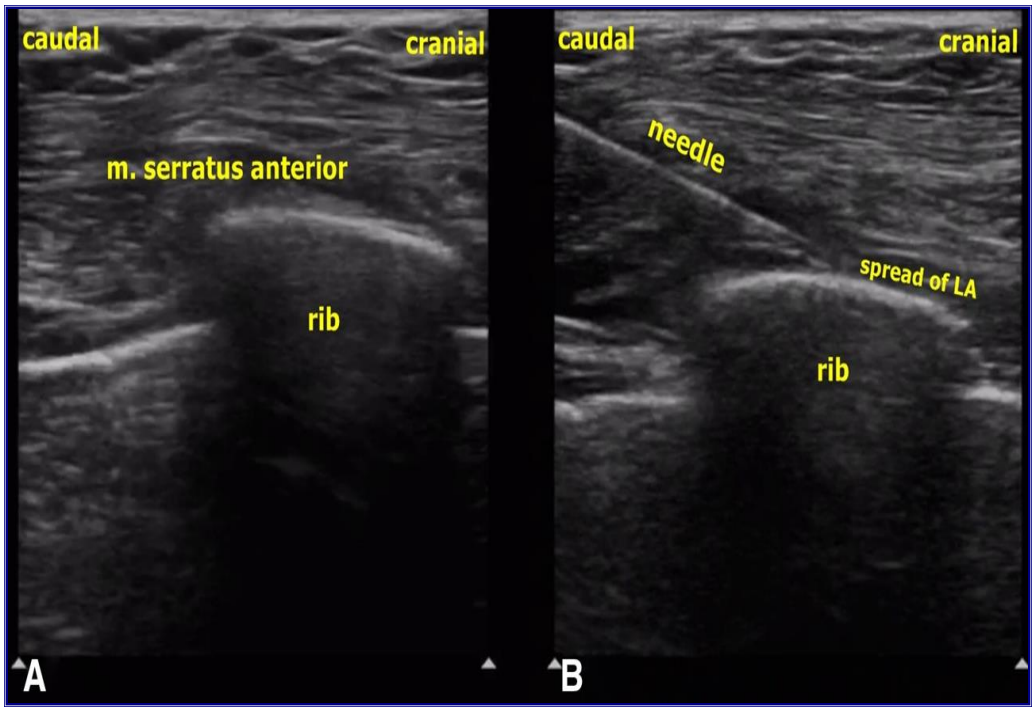

Fig. (5): A) Sonographic anatomy of the SAPB. The serratus anterior muscle and the rib are seen. B) Needle direction, craniocaudal spread of local anesthetic during SAPB [18].

Indication

The SAPB has been used effectively for the management of pain in the context of RFs, rib contusions, thoracoscopic surgery, thoracotomy, breast surgery, and post-mastectomy pain syndrome. In the setting of RFs, the block is effective in providing analgesia for lateral RFs but may be ineffective for anterior and posterior RFs [18].

Contraindications

Absolute contraindications to the SAPB include allergy to LA medications or soft tissue infection in the area of the procedure. Relative contraindications include any anatomical variation that makes sonographic visualization of landmarks difficult. These include scarring and fibrosis due to prior thoracic surgery [19].

Complications

Rebound pain is possible since the analgesia provided by bupivacaine typically lasts around six hours. Local anesthetic systemic toxicity (LAST) is a potential complication of regional anesthesia. For this reason, dilute anesthetic is used, and a maximum dose of 2 mg/kg of bupivacaine is the recommendation. Pneumothorax is a potential complication but would entail catastrophic error since the fascial planes targeted in this block are superficial to the ribs, and the pleural line can be visualized clearly on US. If a pneumothorax is suspected, US can help to confirm lung sliding

immediately after the procedure. Nerve injury is unlikely given the needle is not steered directly at nerves, but instead towards the plane through which the nerves run [20].

The only RCT was the one by Tekşen et al. in which the authors randomized 60 patients into two groups: in one group single US-guided SAPB was performed using 30 mL of 0.25% bupivacaine and the control group was on PCA tramadol [14]. Patients were monitored for pain scores over 24 hours and pain scores were compared. The mean score was 1 in the SAPB group, and 2.7 in the control group. Patient satisfaction scores were not documented. Lack of blinding, allocation concealment, and heterogenicity were limitations of this RCT. In a series of 10 patients, Paul et al. performed a single US-guided SAPB in patients with three or more unilateral rib fractures having pain scores of about 9/10 on arrival. They injected up to 40 mL of 0.25% ropivacaine depending upon the body weight of the patient. The mean pain score at 30 min was 4 and at 60 min was 2.1. There were no block-related complications [15]. Schnekenburger et al. conducted a pilot study in 20 patients with MRFs by performing single-shot US-guided SAPB. Mean scores at baseline and 4 hrs were 6.5 (6-8) and 3 (2-5) [16]. In another retrospective study by Diwan et al. involving 72 patients out of which 38 patients received continuous SAP infusion via an indwelling catheter. The authors retrospectively compared analgesic efficacy and 24 hr fentanyl consumption of continuous SAPB with fentanyl infusion [17]. On analysis, authors found that there were statistically significant lower pain scores in patients of SAPB group when compared to that of fentanyl and in also in 24 hrs fentanyl consumption in patients who received continuous SAPB versus that in fentanyl group (p=0.001). However, the study was retrospective and had a small sample size. There was also significant heterogenicity in terms of age and other associated injuries. There were several case reports and series which were identified on literature search. Papers in which SAPB was performed in critically ill patients with multiple injuries were not analyzed as they did not fulfill the inclusion criteria [18,19].

There was only one RCT that was available for review which had several limitations. There was no random sequence generation or allocation concealment done which led to selection bias. Blinding of participants and personnel is important to avoid performance and detection bias which was not possible in the selected studies [20]. Attrition and reporting bias is due to incomplete reporting data and selective reporting, respectively [21]. As the data analyzed in this review was mostly from case reports and series, there was no attrition data or reporting bias as such. As fewer studies were included, the funnel plot was not evaluated for publication bias. A quantitative analysis of data or meta-analysis was not performed due to limited sample size, heterogenicity, and reporting bias. Quantitative analysis of non-comparative case series does not produce relative association measures such as odd's ratio or relative risks. There was only one RCT in the review, which had limitations like allocation concealment and blinding. Therefore, it was not performed in this review. For this reason, the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) assessment was not done.

Biswas et al. demonstrated in a cadaveric study that SAP performed superficial or deep did not influence the spread of injectate either in anteroposterior or craniocaudal direction [22]. Being a fascial

plane block, a higher volume of LA (around 30 mL or more) is expected to provide a better quality of analgesia [23,24]. A volume of 30-40 mL LA is required to achieve sensory loss from dermatome T2-T9 in SAPB [25]. On reviewing the results, we observed that patients with MRFs who received either a single shot or continuous SAPB have better pain scores from baseline. However, the absence of a control group was a big limitation. Therefore, we could not conclude if pain scores with intervention and pain scores with analgesics like opioids or any combination of multimodal analgesia would be comparable or better. Patient satisfaction scores were also not consistently mentioned in the papers published. The GRADE of evidence could not be performed in our review due to several reasons. Most of the articles included were case reports or case series due to which the sample size was very small. There was no standardized way of reporting pain scores, LA volume/concentration was inconsistent thus leading to significant heterogenicity. We agree with the fact that a review of case reports or case series cannot be placed at the top of the hierarchy in a pyramid that depicts validity [25]. It is not possible to randomize patients with fracture ribs into different groups due to several reasons. The rib fractures are not always unilateral. In situations when patients present with unilateral MRFs, there is a possibility that there could be other injuries as well. A group of patients will require surgery for abdominal/head/long bones trauma and thus will be excluded from intervention. Lastly, there can be ethical concerns in randomizing patients with multiple injuries

No Conflict of interest.

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