Serratus plane block and erector spinae plane block in the management of pain associated with rib fractures in chest trauma: a brief report from a single-center

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Key words: pain; chest; trauma; rib fracture; block; serratus; erector spinae.

Contributions: FS: project administration, investigation; ADS: conceptualization, methodology, editing, investigation; MM: writing-original draft, investigation; RV: supervisor, validation; SC: writing-review, investigation; AT: visualization; FC: validation, editing, investigation; ES: data curation, investigation; CS: software, investigation; SDB: resources. All authors critically revised the manuscript and approved the final version for submission.

Conflict of interest: all authors declare that they have no conflicts of interest.

Ethics approval: ethics approval was not required for this study.

Informed consent: written informed consent was obtained from the patients for their anonymized information to be published in this article.

Funding: this research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Availability of data and materials: the data that support the findings of this study are available from the corresponding author, upon reasonable request.

Received: 6 March 2023.
Accepted: 3 July 2023.

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Advances in Anesthesia and Pain Medicine 2023; 1:11
doi:10.4081/aapm.11

Abstract

Pain harms the clinical course of individuals with rib fractures. Patients with more than three fractured ribs are more likely to have lung problems because pain can impede lung ventilation and secretion clearance due to difficulty coughing, resulting in atelectasis and hypoxia. Systemic analgesia to invasive regional anesthesia procedures such as thoracic epidural, paravertebral catheters, intercostal nerve blocks, and fascial plane blocks are all alternatives for analgesia in chest trauma. The study's goal is to evaluate the analgesic efficacy of erector spinae plane (ESP) and serratus anterior plane (SAP) blocks in chest injuries, as well as their effect on improving respiratory metrics. For this objective, fifteen cases of isolated thoracic trauma resulting in rib fractures were reviewed retrospectively. All patients were at least 18 years old, spontaneously breathing, and had received a chest wall fascial plane block for pain relief. All patients reported practically instantaneous pain alleviation, with the onset occurring around 10 minutes after the block operation. One patient required oxygen therapy, but the rest were quickly weaned due to improved respiratory mechanics. Our findings suggest that chest wall anesthetic blocks are a safe and effective therapy for pain caused by rib fractures. At admission, the median NRS was 7 (RF 6:26.7%; 7:26.7%; 8:26.7%; 9:13.3%; 10:6.7%), with a minimum of 6 and a maximum of 10 (IQR: 1.5, CV: 0.2). All patients reported immediate pain relief that began around 10 minutes after the block was done; the average decrease in NRS was 6.8 points. They have also been shown to be effective and beneficial in improving respiratory parameters and lowering oxygen support.

Introduction

Rib fractures in chest trauma patients are among the major sources of pain, as the ribs are innervated by pairs of intercostal nerves, which are located along their lower margins. Patients with three or more fractured ribs have an increased risk of lung complications.[1-2] Pain can impair ventilation and the ability to eliminate secretions due to difficulty coughing, which can cause atelectasis and hypoxia. Up to 1/3 of patients develop nosocomial pneumonia and mortality has been reported up to 16%. Therefore, the general objectives of the management of chest trauma include pain control, chest physiotherapy, mobilization, and possible oxygen therapy or ventilator support.[3-4] Analgesic options in chest trauma range from systemic analgesia to invasive regional anesthesia techniques such as thoracic epidurals, paravertebral catheters, intercostal nerve blocks, and blockages of the fascial plane.[5] For a selected group of

patients with the most significant lesions, surgical fixation of the ribs may be appropriate if the mechanics of the chest wall is sufficiently impaired.[6-7]

Thoracic epidural analgesia (TEA) has particular benefits in terms of the subjective score of pain,[8-9] improvement of respiratory parameters including functional residual capacity (FRC), lung compliance, PaO2, vital capacity, and reduced incidence of drowsiness, gastrointestinal disorders and respiratory depression.[10] In addition, the positioning of TEA provides multi-level and bilateral coverage. Because of these advantages, it has traditionally been considered the gold standard regional technique for treating patients with multiple rib fractures.[11-12] However, TEA presents more risks and contraindications compared to fascial plane chest wall blocks, since the latter are performed under direct ultrasound vision and, in expert hands, they are related to less procedural risks.[13-14]

Regional anesthesia techniques provide excellent pain control, thus reducing the need for systemic anesthetics and analgesics. In addition, studies have shown that regional techniques can accelerate recovery, decrease intensive care and hospital stays, improve heart and lung function, reduce infection rates and neuroendocrine stress responses, and promote the early return of intestinal function. A well-functioning peripheral nerve block with a long-acting local anesthetic decreases the incidence of dose-related opioid side effects including respiratory depression, increased sedation, confusion, itching, and nausea.[15]

In the context of rib fracture management, two innovative myofascial plane blocks are most frequently used: serratus anterior plane block (SAP) and erector spine plane block (ESP). These procedures offer technical simplicity with a favorable side-effect profile while providing unilateral multi-level pain coverage. Compared to other regional techniques, there is no risk of hemodynamic changes, motor block, vascular penetrance, or involuntary intrathecal injection. In addition, both methods can be used in patients with coagulation disorders.[16,17]

SAP block is performed at the fifth rib level on the mid-axillary line, while the patient is sitting or supine. The ultrasound guide can be used to identify the dorsal latissimus and anterior dentate muscles and local anesthetic (LA) can be injected in both the superficial surface (superficial SAP block) and the deep surface (deep SAP block) of the anterior serratus muscle, providing analgesia to the lateral cutaneous branches of the T2-T9 intercostal nerves. In particular, the SAP block provides adequate analgesia exclusively to the anterior two-thirds of the hemithorax, limiting its usefulness to anterior rib fractures.[18,19] It has been shown that the SAP block is faster and easier to perform than the ESP block, mainly because of the lateral or seated position needed for ESP block procedures.

On the other hand, the ESP block provides analgesia to the anterior, lateral, and posterior areas of the hemithorax. AL is injected above the transverse process of thoracic vertebrae, below the group of muscles known as erector spinae.[20-25] Although several clinical cases have identified its value in patients with multiple rib fractures, showing significant improvement in respiratory mechanics, reduction in pain scores, and opioid needs, there are still no statistically significant differences in terms of outcome between the two techniques.[26]

The study aimed to evaluate ESP and SAP block's analgesic efficacy in chest trauma and their ability to improve respiratory parameters. Primary endpoints were: changes in NRS, change in p\f ratio, possible need for rescue therapy, and need for oxygen therapy or ventilatory support. Secondary endpoints were changes in respiratory parameters at the physical examination (respiratory rate, heart rate, signs of respiratory fatigue such as paradoxical breathing or accessory muscles activation) and length of stay in the hospital.

Materials and Methods

A retrospective observational study was conducted at the Trauma Center of the A.O.R.N. Cardarelli Hospital in Naples, extending from November 2021 to November 2022, enrolling patients with rib fractures due to thoracic trauma who received a chest wall fascial plane block within 8 hours from admission to the hospital for pain management.

Patients affected by confounding factors, such as serious pre-existing respiratory diseases or lesions in other districts, were excluded from the study as these would have affected the reliability of pre-and post-treatment respiratory assessments and altered pain perception. We also excluded patients who had already received ineffective opioid analgesia.

Data were collected from electronic medical records.

Pain severity on admission was evaluated by using the Numeric Rating Scale (NRS) and the PIC score (Pain, Inspiration, Cough). The PIC score generates a composite unitless score from a nomogram that aggregates several variables-patient-reported Pain visual analog scale, Incentive spirometry effort, and the perceived adequacy of Cough.[27,28] As to NRS, patients are asked to rate the pain intensity by providing a numerical rating from 0 to 10. Zero indicates no pain and 10 indicates the worst possible pain.[29]

After the anesthetic block, NRS was recorded every 6 hours for the following 48 hours. All patients were treated with paracetamol 1g 3/day. Pulse oximeter saturation (SpO2) and PO2/FiO2 ratio (P/F) calculated by arterial blood gas (ABS) were recorded before the block and 10 minutes after its execution. Primary endpoints were: changes in NRS, change in p\f ratio, possible need for rescue therapy, and need for oxygen therapy or ventilatory support. Secondary endpoints were changes in respiratory mechanics at the physical examination (respiratory rate, signs of respiratory fatigue such as paradoxical breathing, accessory muscles activation) and length of stay in the hospital.

The blocks were performed as an ultrasound-guided technique, using a General Electronics ultrasound linear probe and a 70mm Stimuplex needle (B. Braun). Electrical stimulation was not necessary due to the anatomical characteristics of the fascial plane. A standard LA mixture composed of Ropivacaine 0.375% + Lidocaine 0.5% + Dexamethasone 0.02% (total 20 ml) was administered for each block.

The choice of the technique (ESP block *vs.* SAP block) depended on the different sites of rib fractures: the former was chosen for posterior arch fractures, the latter for isolated anterior arch fractures.

Statistical analysis

Data are summarized by descriptive methods. In particular, categorical variables by estimating relative frequencies; continuous variables are presented as mean and standard deviation, median and interquartile range.

The present study was designed according to the Declaration of Helsinki's guidelines.

Any identity-revealing information was removed from the data.

Results

15 patients were included in the study (4 females and 11 males). The mean age of the patients was 40.2 years (standard deviation SD 10, interquartile range IQR 9.5, Coefficient of Variation CV 0.2) ranging widely from 20 to 60 years. 6 of them received unilateral ESP block, while in the remaining 9 patients SAP block was performed. In all patients, only one analgesic block was needed. At

baseline, the median PIC score was 4 (relative frequencies RF 3: 13.3%; 4: 46.7%; 5:33.3%; 6:6.7%) with a minimum of 3 occurring in two cases and a maximum of 6 in a single case. (IQR: 1, CV: 0.2)

The median value of NRS (Fig. 1) at admission was 7(RF 6:26.7%; 7:26.7%; 8:26.7%; 9:13.3%; 10:6.7%), with a minimum NRS of 6 and a maximum of 10 (IQR: 1.5, CV: 0.2).

All patients experienced rapid pain relief with onset about 10 minutes after the block was performed; the mean decrease in NRS was 6.8 points. NRS decrease then remained less than 3 for the first 30 hours, with a slight but constant increase in the following hours, easily manageable with NSAIDs. In only 4 cases, a rescue dose of anti-inflammatory drugs was necessary after 32 h, while no patients needed to have the block procedure repeated.

The average basal oxygen saturation was 92% (SD 2.3); 3 patients needed oxygen therapy which was administered through nasal cannulae for a maximum of 6l/min. The oxygen flow support globally decreased after the procedure, and only one patient still needed oxygen therapy, while all the others were rapidly weaned due to better respiratory mechanics. No patient needed ventilation support.

The average P/F before treatment was about 219.4 (SD: 10.9), with a consistent post-procedure increase exceeding the threshold value of 300 in all but 4 of the cases.

The average hospitalization time was 6.7 days (SD: 2.8, IQR:1, CV:0.4), with a minimum of 3 days in 2 cases and a maximum of 15 days in a single case, in which infectious complications occurred.

Neither alterations in respiratory mechanics nor subjective dyspnea were recorded on physical examination. No complications related to the anesthetic procedure have been recorded.

An analysis was conducted to investigate the effects of different nerve blocks and levels of the Numeric Rating Scale (NRS) measurement on the response variables. A Type II Repeated Measures MANOVA using the Pillai test statistic was performed. The overall mean of the response variables showed a significant effect ($p<0.001$), indicating that there are variations across the entire dataset. However, the "block" factor did not have a significant effect ($p=0.7$), suggesting that the different blocks of time did not influence the response variables significantly. On the other hand, the "nrs" factor demonstrated a significant effect on the response variables ($p<0.001$), indicating that the different levels of the NRS measurement had a notable impact. The interaction between the "block" and "nrs" factors was not significant ($p=0.14$), suggesting that the effect of the NRS levels did not vary significantly across different nerve blocks.

Discussion

Historically, systemic opioids have been used as first-line agents for the treatment of rib fractures-related pain. Oral, intravenous (intermittent, continuous, and patient-controlled analgesia), intramuscular, transdermal, and nebulized administration is effective due to the rapid onset of action and ease of administration.[30,31] Morphine is useful in the relief of severe acute pain (NRS 7-10); the dose required to achieve pain relief varies widely from one patient to another and it needs a slow and tailored titration. Paracetamol is indicated only for mild pain (NRS <3), but it produces excellent synergism in association with opioids and non-steroidal anti-inflammatory drugs (NSAID). NSAIDs are indicated for mild and moderate pain (NRS 4-6) since they are limited by the "ceiling effect": maximum efficacy cannot be further improved by increasing doses. Pain management guidelines for blunt chest trauma recommend epidural analgesia as the optimal modality for pain control unless contraindicated. Bulger *et al.* demonstrated that thoracic epidural analgesia is associated with a decrease in the rate of nosocomial pneumonia and a shorter duration of mechanical ventilation.[32]

Chest wall blocks have proved to be relatively safer and simpler to perform compared to thoracic epidural.[33] The primary mechanism of analgesia for chest wall blocks is functional interruption of sensory afferent conduction. The local anesthetic spreads along the fascial plane where it is injected and reaches the nerves that run in that compartment. Moreover, it infiltrates into the muscles and surrounding fascia, which may result in a local effect on peripheral nociceptors.[34-37]

The original description of the SAP block is a modification of type II pectoral nerve block (PECS) in which the obtained analgesia was consistent with coverage of dermatomes T2 to T4 and variably T6, by injecting in correspondence of the anterior axillary line, in a plane between the pectoralis minor muscle and the serratus anterior muscle.[38] Several case reports have demonstrated a reduction in opioid use and an improvement in pain scores after performing SAP block in patients with multiple rib fractures.[39] ESP block, on the other hand, provides analgesia to anterior, lateral, and posterior hemithorax. AL injection is practiced above the transverse process of the thoracic vertebrae, right under the group of muscles known as erector spinae. Many case reports have described its value in patients with multiple rib fractures showing a significant improvement in inspiratory volumes and a reduction in pain scores and opioid requirements.

The present study confirms that chest wall anesthetic blocks are safe and effective techniques in the treatment of pain related to rib fractures. Their early execution allowed us to effectively manage pain avoiding the use of opioids, and then, improving respiratory outcomes. A constant improvement in respiratory parameters, such as saturation and P/F, was observed in all patients. The anesthetic mixture used showed a rapid onset: in about 10 minutes all patients reported consistent pain relief; the duration of effect was remarkable, lasting for about 30 hours.

The study presented some limitations as well, with the chosen inclusion criteria being the most evident: the clinical cases analyzed were mostly young and otherwise healthy patients, with less than 3 unilateral fractured ribs, while severe thoracic traumas or pre-existing lung diseases that could affect the respiratory function were excluded. Notably, these traumas are often underestimated and they are not brought to the attention of the anesthesiologist; consequently, pain is often not properly managed leading to the inability to cough and increasing risk of pneumonia and respiratory failure. The more recent increase in attention to pain issues, in addition to being crucial from a pathophysiological and clinical point of view, is part of an overall process of humanizing.[40]

Conclusions

The present study showed the effectiveness and safety of chest wall blocks for early pain management. Certainly, an early approach has solid scientific foundations, being able to interrupt the mechanisms of genesis and perpetuation of the physiology of pain. However, larger and more systematic research is needed to demonstrate the regional technique's noninferiority compared to the pharmacological approach.

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