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Erector spinae plane block for pain management in blunt chest trauma in military prehospital medicine, an interventional study

Karim Ahmed Ramadan Basyouny[a], Mohamed Abd Elraaouf Abd Elkader[b], Maher Fawzy Mahmoud[b], Bassant Mohamed Abdelhamid[b] and Mohsen Mohamed Elsayed Waheeb[b]

[a]Anaesthesiology, Surgical Intensive Care and Pain Management Department, Faculty of Medicine, Egyptian Military Medical Services, Cairo, Egypt; [b]Anaesthesiology, Surgical Intensive Care and Pain Management Department, Faculty of Medicine, Cairo University, Cairo, Egypt

ABSTRACT

Background: Erector spinae plane block (ESPB) was presented in previous studies as a simple and safe technique with an excellent analgesic profile and improvement in respiratory function in multiple rib fractures. The purpose of this study was to investigate the efficiency of performing ESPB in the primary care unit for pain alleviation for individuals with blunt chest traumas.

Methods: This prospective interventional work was performed on 54 patients ranging in age from 20 to 50 years old, both sexes, American society of anesthesiology class I and II diagnosed with multiple rib fracture following blunt chest trauma. ESPB were performed using 20 mL of 0.25% levo-bupivacaine.

Results: The median (IQR) numeric rate scale was 9 (8–9) before block application and was significantly reduced to 1 (0–1) till it was 0 (0–1) in the 12th hour. After 24th hour, the median pain score was 2 (1–2), ($p < 0.00$). The mean arterial blood pressure and heart rate have significantly decreased following the block. Regarding complications of morphine, two patients only experienced mild vomiting. There were no other complications (local anesthetic toxicity, hematoma formation and pneumothorax).

Conclusion: Prehospital administration of ESPB for blunt chest trauma improved the pain scores, decreased the opioid administration without negative consequences on the hemodynamic state or occurrence of complications among participants.

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1. Introduction

Blunt chest trauma is among the most prevalent injuries that have been seen during military operations because of blast injury due to proximity to the blast radius, collision from the blast or after vehicle rollover [1,2].

Multiple rib fractures account for up to two thirds of the cases of chest trauma subjecting the patients to decreased lung volumes, atelectasis and inadequate ventilation because of thoracic splinting from pain and mechanical instability [2,3].

The main objective of care should be to restore mechanics of chest wall by providing sufficient pain relief. Although intravenous (IV) opioids are often utilized, their drawbacks include sedation and respiratory depression promoting respiratory complications. On the other hand, nonsteroidal anti-inflammatory medicines are only useful for minor multiple rib fractures pain and may increase bleeding in people with vascular damage or those taking anticoagulant prescribed drugs [3,4].

Regional analgesic procedures, including epidural injections, intercostal nerve blocks and thoracic paravertebral blocks have been investigated effectively in previous studies for early management in acute trauma patients demonstrating superiority to systemic opioids and nonsteroidal anti-inflammatory drugs (NSAIDS) [5–7].

Several other regional block strategies were shown to effectively decrease pain intensity either in the field or during transportation to the hospital. The determination of this option should be based on the proficiency of the physicians caring for the patient, together with the characteristics and severity of the injuries [8–10].

Erector spinae plane block (ESPB) has been presented in previous studies as a simple and safe technique with an excellent analgesic profile and improvement in respiratory function in multiple rib fractures [11–13]. Ibbotson et al. [14] successfully used single-injection ESPB in the context of aeromedical retrieval. Moreover, landmark guided ESPB is

CONTACT Karim Ahmed Ramadan Basyouny karimbasyouny89@icloud.com Anaesthesiology, Surgical Intensive Care and Pain Management, Faculty of Medicine, Egyptian Military Medical Services, Town house n.281, El-montazah compound, October Gardens, Giza 31511, Egypt

a straightforward, feasible and easy to conduct block especially in settings where ultrasound equipment is unavailable [15,16].

To our knowledge, landmark guided ESPB has not been studied as a prehospital tool for pain alleviation among individuals with blunt chest traumas [8].

The purpose of this work was to assess the efficiency of performing ESPB in the primary care unit for pain alleviation among individuals with blunt chest traumas.

2. Materials and methods

This prospective interventional work was performed on 54 patients aged from 20 to 50 years old, both sexes, American society of anesthesiology class (ASA) I and II diagnosed with multiple rib fracture following blunt chest trauma. The work was performed following permission from the Ethics Committee Institutional Review Board and Faculty of Medicine, Cairo University, Cairo, Egypt. All participants provided well-informed written consent.

Exclusion criteria were life threatening conditions of chest trauma (simple pneumothorax, flail chest, haemothorax, pulmonary contusion, blunt cardiac damage, traumatic aortic disruption, traumatic diaphragmatic injuries and blunt oesophageal rupturing), Glasgow Coma Scale (GCS) less than 15, patients with hemodynamic instability or shocked patients, traumatic brain injury and spine injury, unstable pelvic fracture, abdominal injuries, obesity (body mass index (BMI) more than 35), infection at the needle insertion site, coagulopathy and recognized allergy to any of medications under the study.

2.1. Based on the latest advanced trauma life support guidelines 2018

The primary survey is the assessment and management of trauma treatment, focusing on the ABCDEs while simultaneously restoring vital capabilities and to exclude life threatening conditions and the above-mentioned exclusion criteria by following this specific order: airway maintenance while limiting movement of the cervical spine [17]. Ventilation and breathing: Supplemental oxygen was given. Circulation: two 18-gauge cannula were applied to the antecubital vein with Ringer lactate infusion. Physical examination to exclude other injuries and any potential source of haemorrhage. Disability (assessment of neurologic status): by assessing the GCS. Exposure/environmental control. Standard monitoring application (electrocardiogram, pulse oximetry and non-invasive blood pressure monitoring). AMPLE history was taken (Allergies, Medications, Past Medical Histories, Last Oral Intake, Events Preceding the Incident). Chest and pelvic X- ray were performed to exclude any source of bleeding. Pain assessment before and after the injection using a numeric pain rating scale (NPRS) for 0 (no pain) to 10 (worst imaginable pain).

2.2. Intervention (ESPB technique)

Under aseptic conditions, one millilitre of lidocaine 2% was injected into the skin using an insulin syringe as a local infiltration. Next, to contact the transverse process of the vertebra, a spinal needle with a gauge of 22 (Spinocan; B. Braun Melsungen AG, Melsungen, Germany) was introduced and progressed in all planes perpendicular to the skin. The needle was placed precisely between the erector spinae (ES) muscle and the transverse process. After removing the spinal needle's stylet, a 5-mL syringe containing local anesthetic was attached to the needle (to reduce the amount of resistance encountered when using a larger syringe). Once each needle was placed and aspirated negative, 20 mL of 0.25% levo-bupivacaine was administered in increments. During injecting the local anesthesia (LA), in the event of encountering any opposition (perhaps because the needle orifice is blocked by bone), the bevel of the spinal needle is turned to find the point of least resistance. After finishing the injection, the spinal needle is extracted, and a sterilized bandage is placed to the injecting site.

When a patient's pain levels were high enough to warrant it, rescue analgesics in the form of 3 mg boluses of IV morphine were introduced. Total morphine administration for a certain time was tracked. The highest safe morphine dosage is 0.5 mg/kg per day. If the participant needs over two dosages of rescue analgesia within the initial hour after receiving the block, the block was considered unsuccessful. Immediately upon arrival, 30 min, 2, 4, 6, 8, 12, 16, 20 and 24 h after ESPB, the patient's heart rate (HR) and mean arterial blood pressure (MAP) were documented. Opioid adverse effects were noted and included nauseousness, vomiting, drowsiness, hallucinations and respiratory depression (respiratory rate 10 cycles/min). Patients taking morphine were asked to rank its side effects on a quadruple verbal scale (none = absence of nausea, mild = presence of nausea without vomiting, moderate = occurrence of one episode of vomiting, severe = occurrence of many episodes of vomiting). Patients with moderate or severe vomiting were administered IV ondansetron at a dosage of 0.1 mg/kg.

The primary outcome was the difference in the NPRS before and 30 min after ESPB application. The secondary outcomes were NPRS at 2, 4, 6, 12 and 24 h after ESPB, time elapsed from end of injection to start of pain relief, total dose of morphine in 24 h required, respiratory rate, and depth, HR, MAP, and oxygen saturation (SpO_2), prevent problems associated with local anesthetic toxicity, hematoma development, pneumothorax, and scores of nauseas and vomiting.

2.3. Sample size calculation

The sample size was determined according to pilot research, considering the considerable variation in the mean value of NPRS measured before injection (7.12 ± 1.18) and those measured after block (0.36 ± 0.64) in paired *t*-test, with α = 0.05, power of 80%, and an effect size of 0.39. So, a sample size of 54 individuals was needed and the total number of participants was raised to 60 individuals to compensate for a 15% drop-out rate (G-Power 301, ht tp: www.psycho.uni.duesseldorf.de).

2.4. Statistical analysis

The data were encoded and inputted utilizing the statistical software program for the Social Sciences (SPSS) version 28 (IBM Corp., Armonk, NY, USA). The data has been analyzed utilizing the mean and standard deviation for quantitative parameters that were normally distributed, or the median and interquartile range for quantitative parameters that did not have a normal distribution, and frequency (number of instances) and relative frequencies (percentage) for categorical parameters. To compare serial measurements within all groups, a repeated measures ANOVA was employed for normally distributed quantitative parameters, whereas a nonparametric Friedman test was utilized for non-normally distributed quantitative parameters. *P*-values less than 0.05 were considered statistically significant.

3. Results

70 individuals had been evaluated for eligibility (8 individuals did not meet our inclusion criteria), 62 individuals had been enrolled in the work, two individuals did not complete the study (lost in follow-up) and 60 patients completed the study (Figure 1).

The mean age was 22.53 ± 5.02 years. The mean of BMI was 23.93 ± 2.52 Kg/m^2. The ASA was I in 60 (100.0%) patients and II in 0 (0.0%) patients (Table 1).

Before block application (the baseline numeric rate scale (NRS)), the median NRS was 9 and the interquartile range was 8.00–9.00. After 30th minute of the block, the median NRS was significantly reduced to 1.00 median (IQR 0.00–1.00) till it was 0.00 (0.00–1.00) in the 12th hour. After 24th hour, the median pain score was 2.00 (1.00–2.00) ($p < 0.00$) (Table 2).

Time elapsed from end of injection to start of pain relief. (By recording the time needed for NRS to reach < 3) ranged from 5 to 8 min with a median of 6 min. Only two patients needed morphine first dose within 30 min from performing the block, and other two patients needed morphine first dose after 16 h from

Table 1. Demographic data of studied groups.

		N = 60
Age (years)		22.53 ± 5.02
BMI (Kg/m^2)		23.93 ± 2.52
ASA	I	60 (100.0%)
	II	0 (0.0%)

Data are presented as mean ± SD or frequency (%). BMI: body mass index, ASA: American society of anesthesiology.

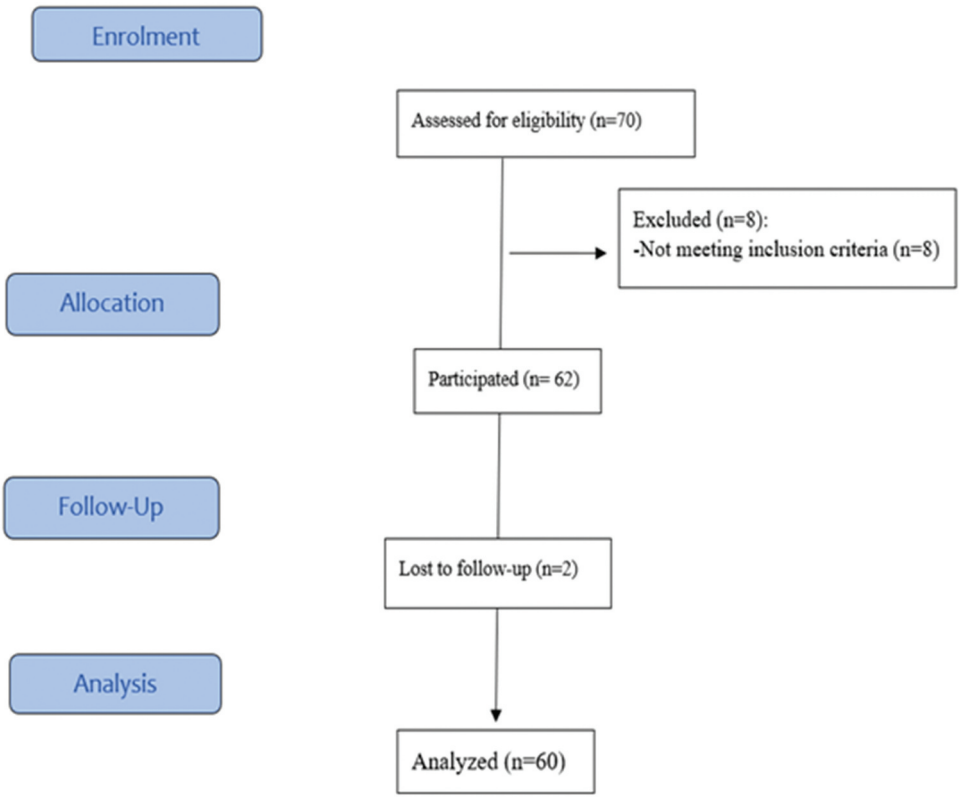

Figure 1. Flowchart of the enrolled patients.

Table 2. Numerical rating scale (NRS).

	N = 60	*P*
Baseline NRS	9.00 (8.00–9.00)	—
NRS 30th min	1.00 (0.00–1.00)	<0.001*
NRS 2nd h	0.00 (0.00–0.00)	<0.001*
NRS 4th h	0.00 (0.00–0.00)	<0.001*
NRS 6th h	0.00 (0.00–0.00)	<0.001*
NRS 8th h	0.00 (0.00–0.00)	<0.001*
NRS 12th h	0.00 (0.00–1.00)	<0.001*
NRS 16th h	1.00 (0.00–1.00)	<0.001*
NRS 20th h	1.00 (1.00–1.00)	<0.001*
NRS 24th h	2.00 (1.00–2.00)	**<0.001***

Data are presented as median (IQR). *Significant *p*value < 0.05, NRS: numerical rating scale.

Table 3. Analgesic characteristics and other complications.

		N = 60
Time to pain relief after the block (min)		6.00 (5.00–8.00)
Rescue analgesia		4 (6.7%)
		56 (93.3%)
Morphine first dose (number of patients)	After 16 h	2 (3.3%)
	After 30 min	2 (3.3%)
	Nil	56 (93.3%)
Morphine 2nd dose (number of patients)	After 6 h	2 (3.3%)
	Nil	58 (96.7%)
Morphine total (mg)	3 mg	2 (3.3%)
	9 mg	2 (3.3%)
	Nil	56 (93.3%)
Vomiting	Mild	2 (3.3%)
	No	58 (96.7%)
Other complications		60 (100.0%)

Data are presented as median (IQR) or frequency (%). *Significant *p*-value < 0.05.

performing the block. Only two patients of them needed morphine second dose after 6 h. Regarding complications of morphine, two patients only experienced mild vomiting. There were no other complications (local anesthetic toxicity, hematoma formation and pneumothorax) (Table 3).

HR has significantly decreased after the block. HR was 120/min before the block but after 30 min it has reduced to 100/min and continued to be decreased to 76.9/min after 24 h. MAP was 103.67 mmHg before the block; then, it has significantly reduced to 91.27 mmHg after 30 min. Then, it continued to decrease till reaching 74.53 mmHg after 24 h. SpO_2 was 89.43% before the block but after 30 min of the block it has reached 97.47%. SpO_2 continued to be between 98% and 99% until 24 h (Figure 2).

4. Discussion

The most important findings in this study are that the prehospital blind ESPB in blunt chest trauma significantly improved the NRS, decreased the opioid administration without any consequences of the patients' hemodynamic or occurrence of complications.

Trauma is a substantial issue in the health of the population, responsible for 30% of the total years of life loss in the US [18]. It is the main reason of mortality among those aged 1–44 years and is the 3rd most common cause of death across all age ranges [19].

There is a substantial mortality and morbidity rate among those who have suffered blunt chest injuries. Blunt chest trauma commonly results in multiple rib fractures, and the chance of sequelae rises with each subsequent rib fracture. Thoracic splinting due to discomfort and mechanical instabilities leads to poor ventilation and respiratory problems with multiple rib fractures [20,21].

Restricted ventilatory function is linked to pain in acute chest injuries, which can have catastrophic consequences. Analgesic techniques such as epidural catheters, NSAIDS, IV narcotics, patient-controlled analgesics, patches of lidocaine, intercostal blocks and paravertebral blocks were investigated and contrasted in individuals with multiple rib fractures [3].

Since its initial clarification by Forero et al. [22], numerous articles and reports of cases have emerged, highlighting a growing array of applications for the ESPB. These include managing of chronic and acute discomfort, urgent care of fractured ribs [23], alleviation of abdominal surgical pain [24], facilitation of hip arthroplasty [25], and analgesic relief following surgeries for breasts [26]; This serves as an indicator to the rapid expansion of literature on this subject.

To our knowledge, landmark guided ESPB has not been studied as a prehospital tool for pain relief for multiple rib fracture following rib fracture due to blunt chest trauma. Ibbotson et al. [14] demonstrated effectively utilized single-injection US-guided ESBs in the aeromedical retrieval situation, as a component of multimodal analgesics.

On the other hand, a case report from a military retrieval service documents the usage of many injections of an ESB during an extended transport of an individual with chest injuries. (Injection sites at T5, T6 and T7 with 5 ml of 0.5% ropivacaine was introduced at each level). In this study, a larger volume of local anesthetics was injected through a single level injection. Several studies in previous literature demonstrated that ESB was linked to enhanced inspiratory abilities, analgesic results and facilitates weaning off mechanical ventilation following multiple rib fractures, without hemodynamic instability [12,13].

The authors of the first study describing ESPB showed that Injecting into the fascial plane underneath the ES muscle at the T5 transverse process level might offer a broad blockade of sensation that affects several dermatomes. The area that is the target of the ESP, namely the dorsal and ventral rami of the thoracic spinal neurons, was determined by studying fresh cadavers. Based on data from cadavers, LA administered into the tissue layer underneath the ES muscle and above the transverse processes and intertransverse connective tissues enters the front part to numb the spinal nerves [24]. Hamilton and Manickam propose that the method by which LA works is due to its proximity

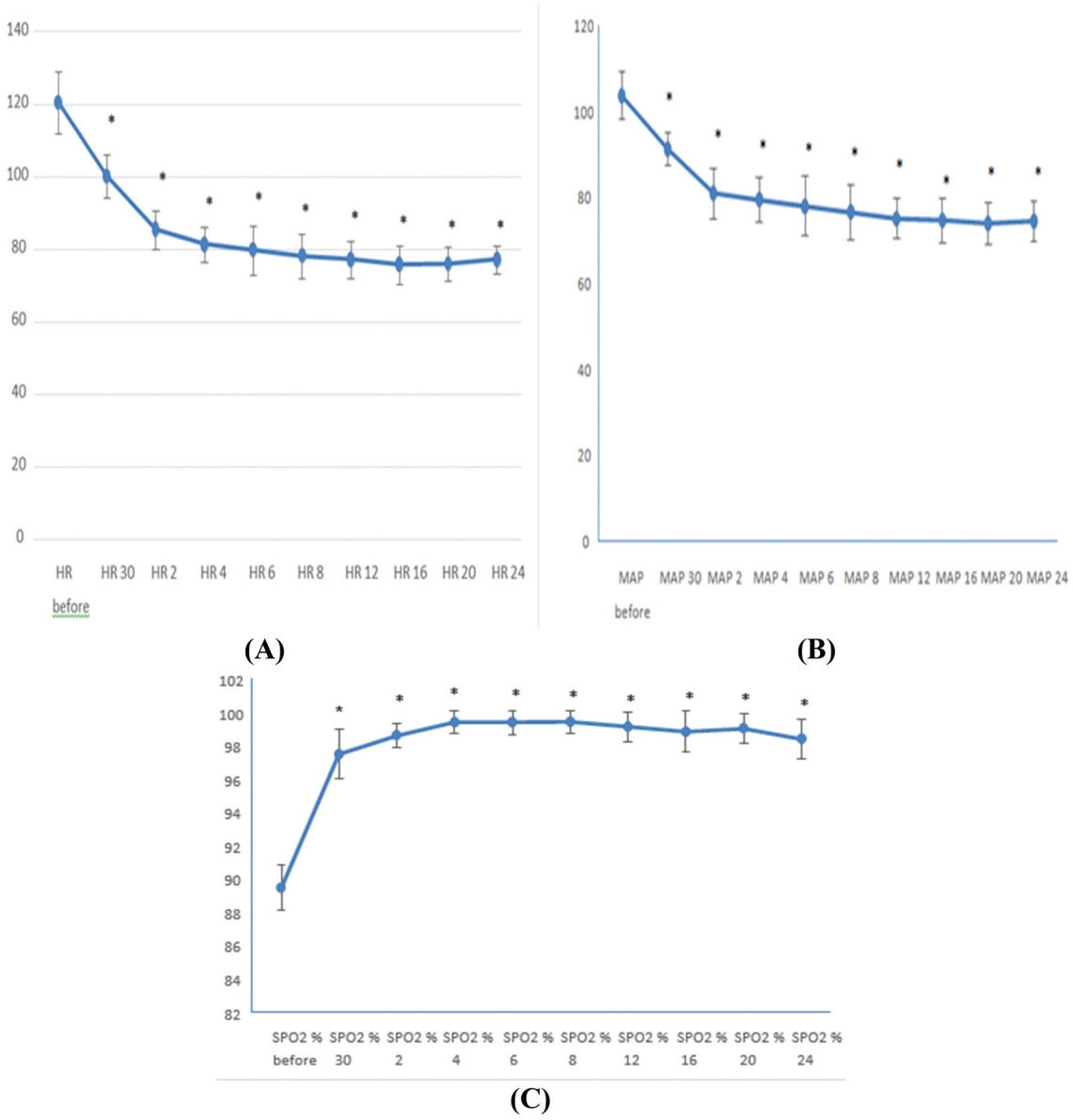

Figure 2. (a) Heart rate (HR), (b) mean arterial blood pressure (MAP) and (c) peripheral oxygen saturation (SpO_2) measurements.

to the costotransverse foramina, that serve as the exit points for the ventral and dorsal rami of the thoracic spinal neurons [27].

Furthermore, they hypothesized that the thoracolumbar fascia, which spans the posterior thorax and abdomen and connects to the nuchal fascia of the neck at its superior end, plays a role in the spread of LA in both directions.

In this study, none of our patients experienced any block related complications of impairment of ventilation. The ESPBs is a more secure, faster, and less intrusive option contrasted to the existing analgesic standards. It is therefore necessary to investigate simpler methods that may be utilized by anaesthetists who rarely utilize an ultrasonic probe in their everyday practice [11].

The ESPB's attractiveness lies in its ability to indirectly reach the paravertebral region and provide analgesia, while avoiding the danger of needle-pleura contact and subsequent pneumothorax. There are not any nearby structures that are at danger of being injured by a needle, which include the pleura, neuroaxis or major blood vessels. Skilled practitioners may safely execute the block on anticoagulated individuals with an acceptable margin of safety [11]. It is important to acknowledge that there is a potential danger of local anesthetic systemic toxicity due to the absorption of the anesthetic in the ESPBs. To reduce it, it is advisable to dilute the anesthesia and include epinephrine in the ESPBs when administering high amounts of local anesthetic [28].

One ought to be mindful of the constraints of ESPB. Repositioning the individual to expose their back is necessary, this might be difficult for individuals with substantial injuries, as highlighted by Luftig et al. [29].

Although the authors did not encounter any challenges with the block approach, Forero et al.

[22] noted that, like other plane blocks, there is some variation among individuals in the effectiveness of the cutaneous block. However, this variation is not uncommon in blocks that rely on the spread of LA in tissue planes [24].

Limitations of our investigation: it is important to consider that the sample size was somewhat small and to be mindful of the limitations of ESPB. Repositioning to expose the patient's back region is necessary, this may be difficult for individuals with substantial injuries. The ESPBs alone offers thoracic analgesia on one side; for incisions extending beyond the midline, bilateral blocks are necessary. Future studies ought to contemplate employing larger sample sizes to yield a more inclusive verdict regarding the effectiveness of ESPB in blunt chest trauma patients. Subsequent studies are encouraged to conduct larger randomized controlled trials to underscore the differential impact of ESPB compared to a control group.

5. Conclusions

Prehospital administration of ESPB for Blunt Chest Trauma improved the pain scores, decreased the opioid administration without negative consequences on the patient's hemodynamic status or occurrence of complications. The use of the landmark-based ESB in this patient population may provide a safe alternative for acute pain management in the case of limited medical recourse.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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