

Brief Report

COMPARISON OF ULTRASOUND-GUIDED ERECTOR SPINAE PLANE BLOCK WITH INTERCOSTAL NERVE BLOCK FOR TRAUMA-ASSOCIATED CHEST WALL PAIN

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Abstract—Background: Pain associated with chest wall trauma is a major issue in the emergency department (ED). However, it may be challenging to select among the various analgesic procedures. **Objective:** Our aim was to compare single-shot erector spinae plane block (ESPB) with intercostal nerve block (ICNB) under ultrasound guidance for pain management in thoracic trauma. **Methods:** This study was a randomized nonblinded clinical trial performed in a level I urban trauma center. A convenience sample of patients with isolated chest wall trauma and initial Numeric Rating Scale pain scores (NRS 0) > 5 were included. Exclusion criteria were large pain area, surgical interventions, discharged from the ED, and presence of contraindications to lidocaine. Pain scores at 20 min and 60 min (NRS 20 and 60) and at disposition (disp) were recorded. **Results:** Twenty-seven patients in the ESPB and 23 in the ICNB groups were enrolled. Mean values of NRS 0, 20, 60, and disp for the ESPB vs. ICNB groups were 8.0 vs. 7.4, 5.2 vs. 6.1, 4.1 vs. 5.4, and 4.3 vs. 5.8, respectively ($p = 0.07$, $p = 0.04$, $p = 0.001$, and $p < 0.001$, respectively). Four patients in the ESPB and 8 patients in the ICNB groups required administration of adjunctive doses of fentanyl for satisfactory pain control ($p = 0.09$). **Conclusions:** Ultrasound-guided ESPB was

superior to ICNB regarding pain control during the ED stay period of patients with painful chest wall trauma. We recommend ESPB in the ED for pain control in blunt or penetrating thoracic trauma. © 2022 Elsevier Inc. All rights reserved.

Keywords—erector spinae plane block; intercostal nerve block; trauma; chest wall; pain

INTRODUCTION

Owing to the vital organs held within the continuously moving thoracic cavity, proper trauma management is an integral part of improving patient outcomes in both blunt and penetrating thoracic injuries (1). A pivotal part of chest trauma management, besides life-saving interventions, is pain management. However, pain control can be challenging or may be disesteemed in certain circumstances, such as socioeconomic disparities, underinsurance, or busy time periods in the emergency department (ED) (2). Regardless of the presence or absence of rib fractures, chest wall trauma-associated pain can be severe and lead to repeated ED visits and days of pain or adverse consequences. Traditionally, epidural analgesia (EA) and paravertebral block (PVB) have been used for postoperative and chest trauma-related pain control. However, these techniques may not be applicable in cer-

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tain populations and also in certain circumstances, such as EDs with high patient turnover rates (3). Intravenous narcotic administration is rapid and easy to perform, but it may require repeated doses in the presence of intense monitoring and lead to more systemic adverse effects. As a result, some clinical guidelines recommend modalities such as EA or multimodal strategies rather than using opioids alone for pain management of chest trauma (4). The literature evidence, however, still seems to be unsatisfactory to firmly recommend one modality, such as EA, over the others, including intercostal nerve block (ICNB) or the recently considered erector spinae fascial plane block (ESPB) (5). In several studies, EA has been found to result in higher rates of improvement in postoperative pain scores in relation to intravenous analgesia (IA) (6). Comparably, ICNB was superior to IA in rib fracture–associated pain control in other articles (7,8). Similar results have also been reported for PVB vs. IA (9). Because EA and PVB, as well as many other types of nerve blocks, could not be performed conveniently in the EDs, many emergency physicians (EPs) tend to perform ICNB (with or without adjunctive narcotic administration) as a fast and simple technique to manage localized trauma-related thoracic pain. Although some studies showed conflicting results when comparing ultrasound-guided ICNB with EA, ICNB has been found to be safe and effective for pain management in chest trauma (7, 10–12). Similarly, ultrasound-guided ESPB has gained the attention of EPs and researchers because it can be performed simply in the ED and has been found to be safe and effective (13,14). As a result, in the present study, we aimed to compare single-shot, ultrasound-guided ESPB with ultrasound-guided ICNB (simply referred to as ESPB and ICNB here) with regard to pain scores and requirements for adjunctive narcotic administration during the ED stay period in patients with isolated chest wall trauma.

METHODS

Study Design and Setting

This was a randomized clinical trial, which was performed over a 3-month period (November 11, 2021 through February 10, 2022) in a level I urban trauma center—the main referral trauma center in the southeast region of the country—with an annual ED census of approximately 90,000. After triage in the ED using the five-level Emergency Severity Index system, patients are transported to the allocated divisions, including the resuscitation area, acute parts, or the fast track section. First-line visits are frequently performed by a resident and an attending emergency medicine (EM) physician, followed by expert consultations, as required at the discretion of the EM service.

Study Population

Convenience sampling was performed on adult (older than 16 years of age) patients presenting to the ED during the study period with acute blunt or penetrating isolated chest wall trauma and an initial pain score > 5 (out of 10) according to the Numeric Rating Scale (NRS) scoring system. Patients who refused to participate; had a contraindication to lidocaine injection; were affected with large painful areas not resolvable by means of ICNB; had received analgesics before the procedures; underwent some kind of invasive surgical procedure, such as tube thoracostomy; and those with mild injuries who were subsequently discharged home from the ED were excluded. In our center, intrapleural infiltration of lidocaine in the chest tube is usually performed to achieve analgesia for those undergoing tube thoracostomy.

Study Protocol, Variables, and Outcomes

Simple randomization by means of software-created sequences was performed. Random sequences were concealed in envelopes. Although blinding could not be performed classically, the evaluator of pain scores was blinded to the procedures. Main variables included initial pain score (NRS 0), gender, comorbidities, addiction history, mechanisms of injury, initial vital signs, body mass index (BMI), and time intervals (between ED arrival and analgesia and the total ED stay time). Outcomes were pain scores at 20 and 60 min after the procedures (NRS 20 and NRS 60, respectively) and at disposition (disp) from the ED, reduction in NRS between NRS 0 and the previously defined times post analgesia (NRS 0–20, 0–60, and 0–disp, respectively), adverse effects of the procedures, and the need for fentanyl administration as an adjunctive analgesic modality. Reduction of NRS from the baseline by at least 2 points while keeping the score < 7 during the ED stay time period was set as the goal of analgesic therapy during frequent assessments in roughly 30-min intervals. If the goal was not achieved, patients were asked whether they needed an adjunctive dose of systemic analgesic (fentanyl) after each assessment.

For both groups, the procedures were performed under cardiac monitoring and pulse oximetry in the resuscitation room using real-time ultrasound guidance using the high-frequency probe (7.5–10 MHz) of DC-7 Mindray ultrasound machine. While patients were being prepared in the sitting or lying positions, skin was prepared using chlorhexidine 2% and isopropyl alcohol 70% (BodyPrep), and skin analgesia was done by making a wheal of anesthetic injection at the time of skin penetration. For all of the procedures, 20-mL aliquots of lidocaine 1% without epinephrine were applied. In the ESPB group, the transverse process of T5 was identified initially, fol-

lowed by the erector spinae muscle and its fascial plane a few centimeters lateral to the transverse process. Twenty milliliters of lidocaine 1% was injected beneath the erector spinae fascial plane to visualize the expansion of the liquid in the desired plane via ultrasound. Two performers were separately involved in the procedure: an attending EM physician who had passed a training course on ultrasound-guided nerve blocks in Tehran, Iran, with more than 1 year of experience in ESPB (performer 1), and a senior resident of EM (postgraduate year 3) trained with a 1-day local course and 3 months of supervised clinical practice for ESPB and ICNB (performer 2). For ICNB, after localizing the site with the most severe pain, the ultrasound probe was placed transversely approximately 10 cm from the posterior midline to achieve a view of the involved rib angle and the intercostal muscles. Injections were performed in 4-mL aliquots of lidocaine from the inferior aspect of the rib at the depth between the internal and innermost intercostal muscles and repeated for two upper and two lower ribs.

Sample Size

Sample size was calculated by means of a pilot study of 10 patients in each group 2 months before the initiation of the main study. Based on the mean (SD) values for NRS 60 in the pilot study, and considering the study power of 0.9, a sample size of 17 was calculated for each group. Nonetheless, we performed the main study on a total sample of 50 patients. Regarding the difference between pain scores in the two pilot groups, we expected an effect size (r) of at least 0.45 in the study.

Statistical Analysis

For description of quantitative variables with normal and non-normal distributions, mean (SD) and median (interquartile range) were used, respectively. For qualitative (categorical) variables, percent of frequency was used. Comparisons between the two groups were performed using Student t -test or Mann-Whitney U test, depending on the normality of distribution of quantitative data. For qualitative variables, χ^2 test was used.

A p value < 0.05 was considered statistically significant in all tests. Effect size was reported for all outcomes according to the tests performed for each outcome. SPSS, version 16.0 (IBM SPSS) was used for analysis.

RESULTS

Basic Characteristics

A total of 50 patients were enrolled in the study: 27 in the ESPB and 23 in the ICNB groups (Figure 1). Ten pa-

Table 1. Basic Characteristics of Quantitative Variables

Characteristic	ESPB	ICNB
Age (y), mean (SD)	34.2 (13.3)	39.4 (16.2)
Gender, n (%)		
Female	7 (14)	3 (6)
Male	20 (40)	20 (40)
Injury type, n (%)		
Blunt	22 (44)	19 (38)
Penetrating	5 (10)	4 (8)
SBP (mm Hg), mean (SD)	121.0 (7.7)	129.1 (18.8)
PR, mean (SD)	85.0 (9.9)	81.3 (13.0)
BMI, mean (SD)	22.5 (3.0)	24.4 (3.7)
ED arrival-analgesia interval (min), mean (SD)	23.2 (8.6)	29.7 (5.9)

BMI = estimated body mass index; ED = emergency department; ESPB = erector spinae plane block; ICNB = intercostal nerve block; PR = pulse rate at admission; SBP = systolic blood pressure at admission.

tients (20%) were female. Mean (SD) age was 36.6 (33.0) years. Rib fractures were diagnosed in 9 patients (18%). The mechanisms of injury were fall in 10 patients (20%), motor vehicle collisions in 27 patients (54%), and direct chest wall impacts in 13 patients (26%). Based on history, 11 patients (22%) reported regular use of opium or methadone. Mean (SD) score for pain on admission (NRS 0) was 7.7 (0.9) in total, but considering ESPB and ICNB groups separately, the mean (SD) score were 8 (0.7) and 7.4 (1.0), respectively. At the end of the study, 16 blocks (32%) were performed by performer 1 and the remainder by performer 2. Table 1 provides detailed statistics for each group.

Comparison of Baseline Variables Between the Groups

There was no statistically significant difference in gender composition between the two groups ($p = 0.22$). Opioids or methadone addiction history was present in 7 and 4 patients in the ESPB and ICNB groups, respectively ($p = 0.21$). Lung contusions were diagnosed in 3 patients in each group. Similarly, no statistically significant difference was seen between the groups regarding the other qualitative variables, namely performance by performer 1 or 2 ($p = 0.30$), frequency of rib fractures ($p = 0.48$), and incidence of penetrating chest trauma ($p = 0.32$). Moreover, except for ED arrival to analgesia time period ($p = 0.01$), comparisons between the groups resulted in no statistically significant difference among baseline quantitative variables, including age ($p = 0.29$), pulse rate ($p = 0.34$), systolic blood pressure ($p = 0.11$),

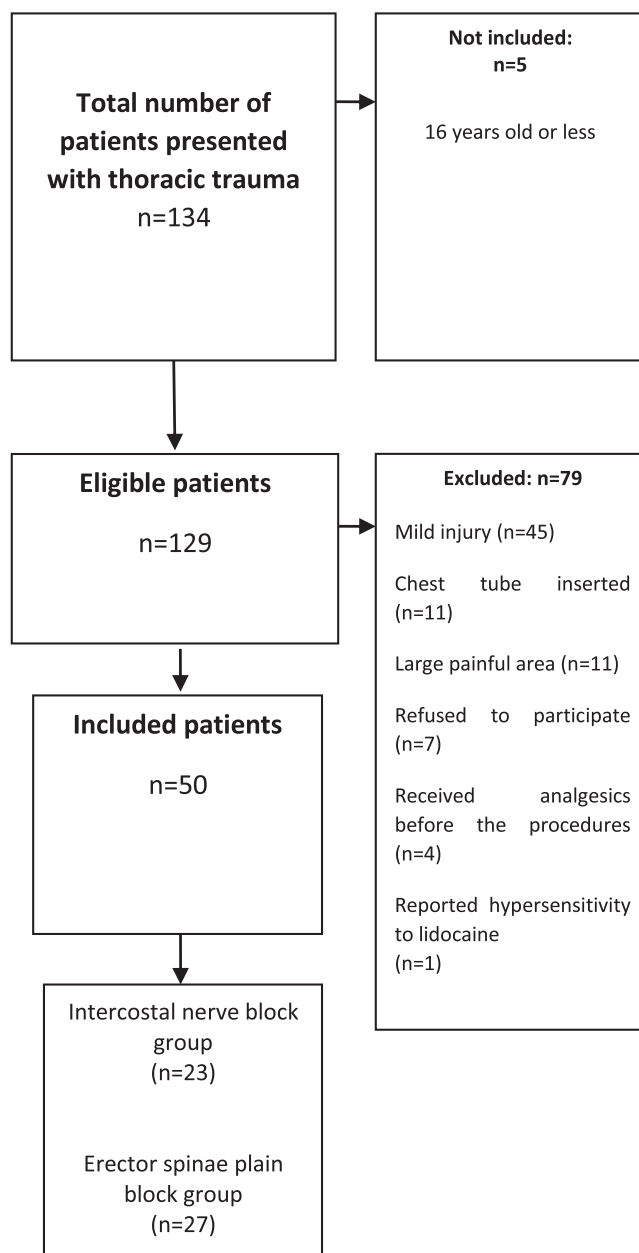


Figure 1. Flow diagram showing the enrollment process.

BMI ($p = 0.09$), and NRS 0 ($p = 0.07$). Mean (SD) total ED stay was 6 (3) h for both groups.

Comparison of the Outcomes Between the Groups

Table 2 compares the NRS scores between the two groups: the ESPB group reported significantly lower NRS 20, NRS 60, and NRS disp. Consequently, reductions in the scores between NRS 0 and NRS at 20, 60, and disp were significantly more prominent in the ESPB group. There were also fewer patients in need of intravenous fentanyl injections in the ESPB group;

8 and 4 patients received adjunctive fentanyl for pain management in the ICNB and ESPB groups, respectively. However, the difference was not statistically significant ($p = 0.09$). Similarly, regarding the total quantity of fentanyl used in the ED for those in need, the mean (SD) doses administered were 71.4 (26.7) μg and 75 (36.5) μg for ESPB and ICNB groups, respectively ($p = 0.92$).

Only 1 patient, who had been allocated to the ICNB group, reported adverse effects after lidocaine injection. He reported dizziness and nausea of mild to moderate severity, which resolved after 30 min and required on-

Table 2. Comparison of Pain Scores Between the Two Groups

Variable	NRS-20	NRS-60	NRS disp	NRS 0–20	NRS 0–60	NRS 0–disp
ICNB, mean (SD)	6.1 (1.3)	5.4 (1.2)	5.8 (1.0)	–1.2 (0.9)	–2.0 (0.7)	–1.5 (1.1)
ESPB, mean (SD)	5.2 (1.2)	4.1 (1.0)	4.3 (1.0)	–2.7 (1.5)	–3.9 (1.2)	–3.6(1.0)
Difference between mean	0.9	1.3	1.5	1.5	1.2	2.1
values (95% CI)	(0.18–1.61)	(0.67–1.92)	(0.92–2.07)	(0.78–2.21)	(0.62–1.77)	(1.50–2.69)
<i>p</i> Value	0.04	0.001	< 0.001	0.001	< 0.001	< 0.001
Effect size (Cohen's <i>d</i>)	0.71	1.17	1.50	1.20	1.93	1.99

ESPB = erector spinae plane block; ICNB = intercostal nerve block; NRS-20, 60, disp = Numeric Rating Scale score at 20 min, 60 min, and at disposition time, respectively; NRS 0–20, 0–60, and 0–disp: Numeric Rating Scale score reduction from 0–20 min, 0–60 min, and from 0 min to disposition time from the emergency department, respectively.

dansetron (4 mg) administration. No local adverse effects were seen at the injection sites.

DISCUSSION

Our findings about ESPB in this study confirmed our previous 1-year experience with this method of analgesia. Although the NRS scores showed satisfactory pain control results for ICNB, ESPB was superior to ICNB in pain reduction during the ED stay period.

Although the underlying analgesic mechanism is not well defined, ESPB has been studied as an effective technique for management of postoperative pain in different types of thoracic surgery (15). ESPB has been found to be effective in pain associated with breast surgery compared with pectoralis nerve block, with cardiac surgery compared with EA, with video-assisted thoracoscopic surgery compared with PVB, and with minimally invasive thoracic surgery compared with serratus anterior plane block (16–19). In all of those studies, ESPB was either noninferior or superior to the more specific and sophisticated aforementioned techniques, making this method an interesting choice for surgeons and intensivist physicians. In a study comparing PVB, ESPB, and ICNB after thoracoscopic surgery, the former was superior to the equally effective latter two methods. However, PVB was performed through multiple injections in contrast to the single-shot ESPB (20).

In the ED, the use of ESPB is usually confined to acute pain management, either resulting from trauma to the chest wall or from nontraumatic conditions, such as renal colic (21). The easy-to-find landmarks and simplicity of administration in this method, besides its effectiveness, have made use of ESPB an area of increasing interest among ED practitioners and researchers to reduce the need for repeated narcotic injections (22). As EPs, we had 1 year of ED experience with ESPB for pain management of chest trauma-associated pain and found that,

regardless of the presence of rib fractures or lung complications, this method is safe and effective. Nevertheless, there were no studies to compare this technique with the other more extensively studied block method, which can be done in the ED, namely ICNB. A few studies or reports performed in the acute setting have focused mostly on ESPB pain-control efficacy or reduction in the narcotic administration requirements after its use (23–25). In this regard, our study seems to be unique because it compared two methods with relatively equal simplicity for EPs and included not only the cases with rib fractures, but also patients with penetrating and nonpenetrating, painful, soft-tissue injuries, which frequently comprise most of the chest wall trauma-associated pain symptoms among ED patients.

In our study, a single-shot ESPB was faster and more efficacious for pain control than ICNB and provided acceptable pain relief, at least up to the end of the ED disposition time. Moreover, although the difference between the groups was not statistically significant regarding the need for adjunctive fentanyl administration, fewer people in the ESPB group required fentanyl. Both performers agreed that ESPB and ICNB were almost equally demanding, and the average time to accomplish both of the procedures from preparation to the end was < 20 min. The difference between the groups was also confirmed by reporting the effect size, which was higher than expected. In addition, our study found that a single-shot ESPB with epinephrine-free lidocaine could be considered to achieve a sufficiently long-lasting analgesia in the ED if bupivacaine was not readily available or the use of epinephrine was contraindicated or the EPs considered it a risk. Another advantage of ESPB is its large area of coverage. Due to ethical issues in this study, we excluded cases with large areas of pain because their discomfort might not be relieved if randomized to the ICNB group. However, ESPB could be performed for more generalized painful injuries to the chest wall and even the abdominal area.

Limitations

Although we previously stated that our sampling method, including bony and soft-tissue penetrating and blunt injuries, might be a more realistic reflection of the ED population, it could also be considered a limitation because it resulted in assessment of a relatively small and heterogenic total sample size. Another limitation could be the use of only two performers in this study. However, both of the procedures are easy for EPs to learn, and we believe that our results could be duplicable in different ED settings. From the standpoint of achievement quality, the nonblinded nature of this study may affect the ability of the involved physicians to accomplish ESPB with higher precision than ICNB. In addition, although the simple randomization technique provided us with the advantage of having the least selection interference, it led to size inequality between the groups. Nevertheless, we did not encounter disparities between the groups regarding important variables and confounders, such as NRS 0, opium/methadone addiction, and rib fractures. In case of encountering such disparities, we had to increase the sample size to resolve this issue. Lastly, for the purpose of reliability of interpretations, we excluded both mildly and severely injured patients, including those with multiple trauma or distracting painful injuries, and also those with interventions, such as tube thoracostomy. This exclusion process limited our study population to approximately the middle of the injury severity range. Consequently, our results should be applied with caution to severely injured patients.

CONCLUSIONS

Chest trauma-associated pain resulting from different mechanisms of injury could be managed by ESPB or ICNB over the ED stay period. However, ESPB was superior from the aspect of pain control in our study. Physicians may consider replacing ICNB with ESPB to possibly achieve better results, as similar levels of time and effort should be dedicated to both procedures.

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ARTICLE SUMMARY

1. Why is this topic important?

Achieving proper analgesia is of paramount importance in the management of chest trauma due to the vital functions of organs in the continuously moving thoracic cage. Few comparative clinical trials in chest wall trauma have been performed to date, especially between erector spinae plane block (ESPB) and block methods that are practically performable in a busy emergency department (ED).

2. What does this study attempt to show?

This study aimed to compare ESPB and intercostal nerve block (ICNB) under ultrasound guidance in the ED and in a population of patients with moderate to severe pain, irrespective of blunt or penetrating trauma mechanisms and presence or absence of rib fractures.

3. What are the key findings?

ESPB was superior to ICNB with regard to pain score reduction and requirement for adjunctive opioid administration during the ED stay period.

4. How is patient care impacted?

ESPB is simple for emergency physicians (EPs) to learn and perform. EPs are encouraged to improve their expertise regarding application of this technique.