

Utility of Ultrasound-Guided Erector Spinae Plane Block in Patients Presenting to the Emergency Department with Rib Fractures

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Abstract

Context: Alleviating significant pain and enhancing lung function in patients with multiple rib fractures presents a formidable challenge to all emergency physicians (EPs). Conventional pharmacological measures and traditional thoracic regional analgesia techniques are not always feasible or safe in the emergency department (ED). Therefore, an effective, feasible, and safe method for providing analgesia in such patients will be extremely advantageous to all patients and EPs alike. Here, we describe the utility of a regional block technique that can be applied in patients suffering from multiple rib fractures in the ED. **Aims:** The aims of this study were as follows: (1) to determine the effectiveness of an ultrasound-guided erector spinae plane block (ESPB) in ameliorating pain and improving lung function in patients presenting to the ED with multiple rib fractures and (2) to assess the safety and the feasibility of the ESPB in the ED. **Setting and Design:** This was a retrospective observational clinical study conducted in the ED of a tertiary care hospital over a period of 12 months. **Subjects and Methods:** Data regarding all patients with rib fractures who had undergone an ESPB in the ED were extracted from the ED procedure register, and the inpatient case sheets were obtained from the medical records department for review and analysis. The data included, but were not limited to, the Numerical Rating Scale (NRS) for pain and respiratory parameters, i.e., respiratory rate and peak expiratory flow rate (PEFR) at 30 min post procedure and subsequently after every top-up dose up to a period of 48 h. **Statistical Analysis:** Descriptive statistics such as mean, standard deviation, frequency, and percentage were used. Inferential statistics such as repeated-measures ANOVA were done using SPSS software version 22 (IBM). **Results:** The mean NRS was significantly reduced by >50% at 30 min and by 72% over a 48-h period ($P < 0.001$). Meaningful improvements in the respiratory parameters were also observed during the same period with significant increments in the PEFR values (49% increase [$P < 0.001$]) as well as a decrease of 36% in the respiratory rate ($P < 0.001$). The mean time for performing the procedure was 16.27 min, and no adverse events were observed as a consequence of the block. **Conclusion:** The study demonstrates the efficacy of USG-guided ESPB in ameliorating pain as well as improving lung function for multiple rib fracture patients. This procedure can be performed in a short time making it suitable for application in the ED. No adverse events as a consequence of the ESPB were noted.

Keywords: Emergency department, erector spinae plane block, Numerical Rating Scale, respiratory parameters, rib fractures, ultrasound

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INTRODUCTION

Ten percent of all mortalities worldwide are attributed to trauma, which amount to over 5.8 million people annually.^[1] Out of these, road traffic injuries predominate globally, and are now considered the leading cause of mortality among people aged 5–29 years.^[2] During 2017, the total number of road accidents is reported to be 4,64,910 claiming 1,47,913 lives in India alone.^[2] This translates to approximately 53 accidents every hour, and 16 individuals succumb to those

accidents.^[2] Thoracic trauma accounts for 10%–15% of all trauma admissions and is responsible for 25% of traumatic

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deaths.^[3] Rib fractures are the most common injury sustained following blunt trauma, frequently encountered in up to 80% of blunt trauma patients.^[4,5]

Several studies have proven a correlation between rib fractures and higher mortality and morbidity.^[4,6] In addition, several associated thoracic complications such as pleural effusion, pneumonia, Acute Respiratory Distress Syndrome (ARDS), aspiration, and lobar collapse are commonly seen in such patients.^[4] The pain and altered breathing mechanics associated with rib fractures often lead to hypoventilation and necessitate intensive care unit (ICU) admission. Providing adequate pain relief remains the key for preventing the aforementioned complications.^[7]

ED options for pain management are limited and, more often than not, the patients are treated with large doses of opioids until they are subsequently transferred to an inpatient setting where thoracic regional analgesia techniques may be performed.^[6] Opioids, in turn, have potentially dangerous dose-dependent complications, and they themselves can promote hypoventilation which elevates fears regarding their usage in the ED.^[8]

Recently, there has been interest in regional analgesia techniques for managing the pain associated with rib fractures as a way to avoid the various opioid-related complications.^[6,7,9,10] Several studies have concluded that catheter-based analgesia, including thoracic epidural, may be beneficial in patients with multiple rib fractures.^[4,8,11-13] However, with the advent of ultrasound technology in the emergency department (ED), the potential to safely and effectively administer such peripheral nerve blocks has increased several folds.^[14]

The erector spinae plane block (ESPB) is one such novel and promising technique which offers a safe means of providing analgesia to a large part of the thorax with a single injection.^[8,11] This myofascial plane block is gaining popularity worldwide for a variety of ailments ranging from postherpetic neuralgia

to postoperative pain, but nevertheless, the data regarding its application in the ED are limited despite its immense potential.^[15-18]

The current study was conducted with the objective of identifying the utility of an USG-guided ESPB for alleviating pain and improving lung function in patients with rib fractures from our population, as well as assessing the safety and feasibility of its application in the ED.

SUBJECTS AND METHODS

Study design

This was a retrospective observational clinical study covering a period of 12 months from April 2019 to March 2020. The study was conducted on patients presenting to the ED of a tertiary care hospital in Karnataka, India. All adult patients presenting to the ED with multiple rib fractures satisfying the inclusion and exclusion criteria were included in the study.

Subject eligibility

Inclusion criteria

All patients presenting to the emergency medicine department with:

- Age >18 years
- Patients with unilateral, multiple (2 or more) rib fractures and moderate-to-severe pain (Numerical Rating Scale [NRS]: 4–10) measured on a self-reported NRS
- Normal lower extremity neurovascular examinations
- Having undergone an USG-guided ESPB.

Exclusion criteria

- Inpatients shifted from other hospitals for elective procedure and continued care
- Patients who received opioid analgesia within 30 min prior to presenting to ED
- Patients with altered pain perception – unconscious patients, severe head injury
- Known international normalized ratio >3.0 and prior history of bleeding diathesis
- Known hypersensitivity to local anesthetics or bupivacaine
- Pregnant patients (positive urine or serum Beta Human Chorionic Gonadotropin (B-HCG)).

Method of collection of data

Data regarding all patients with unilateral rib fractures who had undergone an ESPB in the ED were extracted from the ED procedure register, and the inpatient case sheets were obtained from the medical records department for review and analysis.

Data included:

- Demographic details
- Details of mechanism of injuries
- Time of injury and time of arrival to the hospital
- Vital signs
- Pain assessment using the NRS
- Respiratory parameters including respiratory rate and the peak expiratory flow rate (PEFR) using an automatic peak flow meter

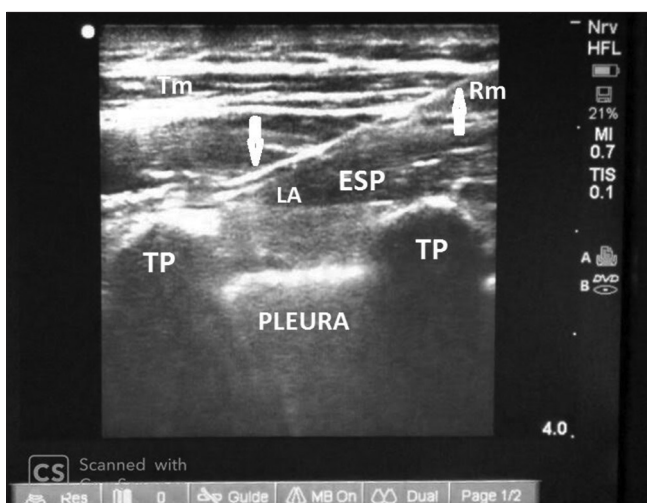


Figure 1: Ultrasound image of an erector spinae plane block with local anesthetic infiltration. Tm: Trapezius muscle, Rm: Rhomboid muscle, ESP: Erector spinae muscle, LA: Local anesthetic rise, TP: Transverse process, PLEURA: Lung pleura, The white arrows depict the infiltration of the needle into the erector spinae plane under USG guidance

- Patient position and site of the block
- Time taken for the procedure
- Any adverse events
- Other specific details.

The procedure had been performed using Fujifilm Sonosite M-Turbo (FUJIFILM, Bothell, WA, USA) with the 10-5 MHz linear transducer and frequency settings adjusted as necessary. All emergency physicians (EPs) who performed the procedure had undergone the necessary training for administering ultrasound-guided block.

A total of 15 patients who met the criteria were included in the study. Approval was obtained from the institutional ethical committee (IEC number – JSS/MC/PG/4623/2018-19). Informed written consent from patients or close family members was obtained and filed after thorough explanation of the study. The ultrasound-guided ESPB had been administered parallel to the usual care of the patient.

Description of technique

All ESPB had been performed in a dedicated procedure room in the ED. The target vertebral level was chosen to correspond to the approximate mid-point of the extent of fractured ribs. The portable ultrasound machine, SonoSite M-TURBO (FUJIFILM, Bothell, Washington, U.S.A.), was used during the study. The linear transducer 13-6 MHz was used to visualize the target Transverse Process. The patient was made to either sit or lie in a left/right lateral position. The mean time taken for the procedure from patient preparation to administration of the drug was noted.

With the transducer held fixed over the targeted transverse process, a needle insertion site aligned the long axis of the ultrasound beam using a linear probe was identified, approximately 1–2 cm away from the probe. The insertion site can be cephalad or caudal to the probe, as the transverse process can be approached from either direction. After sterile prep, a local anesthetic skin wheal was raised at the insertion site using a 25–27-g needle. A block needle (Tuohy 20G) was inserted through the skin wheal and advanced at a 30°–45° angle toward the ultrasound beam. After initial insertion of 1–2 cm, slight transducer and needle adjustments, keeping the transverse process in view, are made until the needle tip is visible. The needle was further advanced with in-plane ultrasound guidance to the posterior surface of the targeted transverse process. “Fascial clicks” corresponding with the fascia of the trapezius, rhomboid, and erector spinae muscles are felt, with a final firm end point upon contacting bone.

Once the needle tip was in the erector spinae plane below the erector spinae muscle, and after aspiration to confirm lack of inadvertent vascular puncture, injection of small aliquots of local anesthetic or normal saline was done. Anechoic fluid was seen separating the erector spinae muscle from the transverse process, confirming spread within the erector spinae plane [Figure 1]. Once needle position is confirmed, 0.5% bupivacaine was gradually injected until a total of 20 mL was deposited within the plane. An epidural catheter was inserted

along the needle and the needle was withdrawn. The catheter was secured and fixed by the process of tunneling and the catheter remained *in situ* for administering further top-up doses of 10 mL of 0.5% bupivacaine every 8th h.

Patients were reassessed for pain, as per the NRS, and for the respiratory parameters such as the PEFR, using an automatic peak flow meter (Microlife Corporation, Taipei, Taiwan), as well as the respiratory rate, at 30 min post procedure and subsequently after every top-up dose up to a period of 48 h. Secondary characteristics of pain such as general condition, heart rate, blood pressure, and respiratory rate were evaluated prior and post procedure at regular intervals.

Statistical analysis

The data were entered into MS Excel followed by the analysis using SPSS (v. 22) Armonk, New York, USA: IBM Corp.

The following descriptive statistics were employed in the present study: mean, standard deviation, frequency, and percentage.

Inferential statistics employed included repeated-measures ANOVA.

RESULTS

A total of 15 patients satisfying the inclusion criteria were included in the study. The mean age of the patient population was 49.93 ± 14.59 . All patients were male, and the mechanism of injury was predominantly road traffic accident (60%) followed by fall (33.33%). All patients had unilateral rib fractures, and the mean number of fractures was 5.6 ± 2.06 . Intercostal Drainage tube (ICD tube) was placed in 66.66% of the patients, and 26.66% had received an analgesic prior to the procedure. 46.7% of the study population were smokers. All patients had an NRS score of ≥ 7 at presentation [Table 1].

The mean time taken for the procedure was 16.27 min [Table 2]. The mean distance from the skin to the block site was 2.71 cm. Majority of the patients had the catheter inserted at T4 level (46.7%) followed by T5 (40%).

Rescue analgesia was required in one patient. No adverse events or complications were noted related to the erector spinae plane blockade in any of the patients.

Following the ESPB, a significant reduction in the mean NRS compared to that at presentation was noted. There was a 51% reduction over the first 30 min following the procedure ($P < 0.0001$). During the course of the next 48 h, the mean NRS fell by $>72\%$ [Graph 1]. The maximum drop in NRS observed was 80%, while a minimum of at least 60% pain relief was observed in all patients.

The respiratory parameters also showed a trend toward improvement, with the mean respiratory rate falling from 29.4 to 24.0667 at 30 min and to 18.8 over the course of 48 h ($P < 0.0001$) [Graph 2].

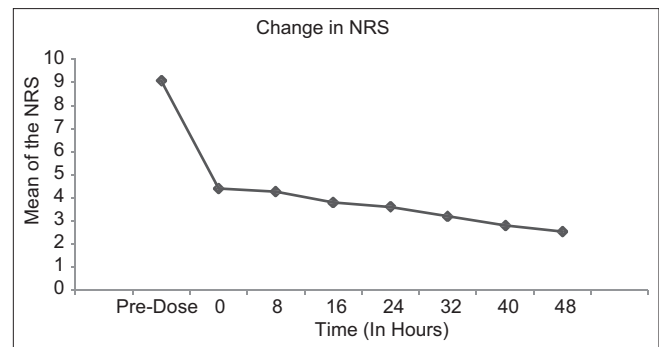
The mean PEFR was 96.8 ± 24.11 which improved subsequently to 144.47 ± 44.37 at the end of 48 h ($P < 0.0001$) [Graph 3].

Table 1: Baseline characteristics of 15 patients who underwent an ultrasound-guided erector spinae plane block in the emergency department

Variables	Count	Percentage (%)
Age category		
21-40	5	33.30
41-60	5	33.30
61-80	5	33.30
Gender		
Male	15	100.00
Mechanism of injury		
Animal attack	1	6.70
Road traffic accident	9	60
Fall	5	33.30
Side		
Unilateral	15	100.00
Number of rib fractures		
3	3	20.00
4	1	6.70
5	5	33.30
6	1	6.70
7	2	13.30
8	2	13.30
10	1	6.70
Pleural injury		
No	4	26.70
Yes	11	73.30
ICD		
No	5	33.30
Yes	10	66.70
Head injury		
No	15	100.00
Spinal injury		
No	14	93.30
Yes	1	6.70
Distal neurovascular deficits		
No	15	100.00
Previous spinal surgery		
No	15	100.00
Prior analgesia		
No	4	26.70
Yes	11	73.30
Analgesia received 30 min prior		
No	4	26.70
Yes	11	73.30
Comorbidities		
No	8	53.30
Yes	7	46.70
Smoking		
No	8	53.30
Yes	7	46.70

ICD: Intercostal Drainage tube

The mean oxygen saturation at room air was $86.2\% \pm 6.91\%$ at presentation, and at the end of 48 h, the values rose to a mean of $95.47\% \pm 2.88\%$ ($P < 0.001$).

**Graph 1:** Pre- and post-erector spinae plane block outcome data in Numerical Rating Scale for study population (circles depict mean Numerical Rating Scale)

DISCUSSION

Optimal pain relief is of cardinal importance in the management of rib fractures. Pain predisposes to respiratory failure, atelectasis, and infection as it inhibits coughing and adequate ventilatory efforts. Even though systemic analgesics remain a mainstay in the treatment of pain, they are not always completely effective and are associated with significant adverse effects. Opioids, in particular, may cause somnolence, respiratory depression, and hemodynamic instability, negating any analgesic benefit. Regional analgesia procedures are, therefore, a useful adjuvant for these patients.

The selection of the ideal regional analgesia technique is also debatable. Thoracic epidural analgesia, once the gold standard, has certain contraindications such as in patients with spinal or head injuries and those on anticoagulant therapy.^[19] A recent study suggested that thoracic epidural analgesia may actually worsen complications and increase length of hospital stay.^[20] Evidence regarding improvement in respiratory function is also limited, and hence, a prudent approach needs to be taken regarding the application of thoracic epidural analgesia in the general patient population of an ED.^[19]

Thoracic paravertebral blockade is another viable option that has been well studied, but the technical expertise required involves a steeper learning curve and there remains a risk of procedure-associated complications such as pneumothorax, pleural injury, and local anesthetic systemic toxicity.^[7,21,22]

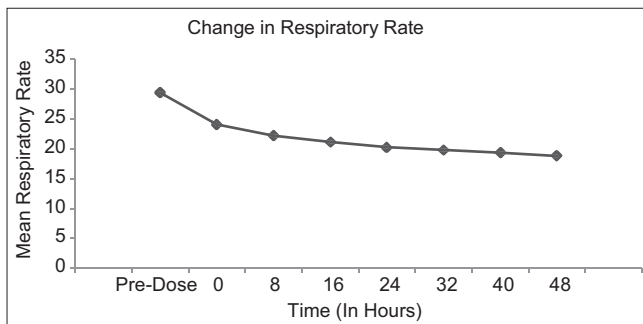
In the present study, data were collected on 15 patients presenting with multiple rib fractures, who underwent an USG-guided ESPB. The degree of pain relief and improvement in lung function was observed over the course of 48 h. Variables regarding the feasibility and safety of the procedure such as the time taken to perform the block and the adverse events as a consequence of the block were also noted.

The demographic profile of the study population was comparable to the study conducted by Adhikary *et al.*^[8] [Table 1] and Riley *et al.*^[23] [Table 3].

Table 2: Descriptive analysis of the time taken for the procedure

Variable	Mean	Median	Minimum	Maximum	Q1	Q3	SD
Time taken for the procedure (min)	16.27	16.00	13.00	20.00	15.00	18.00	2.19

SD: Standard deviation

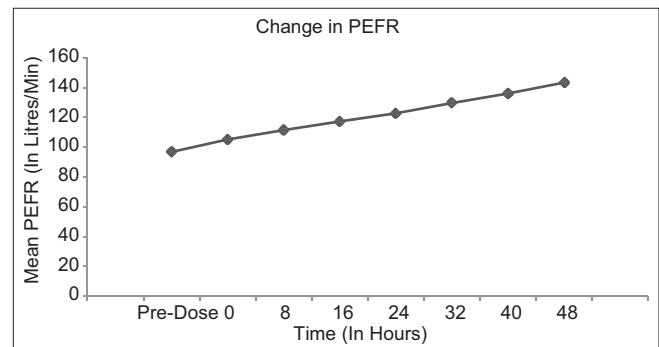
**Graph 2:** Pre- and posterector spinae plane block outcome data in respiratory rate for study population (circles depict mean respiratory rate)

Hamilton and Manickam, in a case report,^[24] observed a 60% reduction in NRS within 2 min of ESPB in a patient of multiple rib fractures. Gursoy *et al.* in their case report performed the ESPB in the ICU setting for a patient with five unilateral rib fractures and reported a 50% reduction in the NRS.^[25] Adhikary *et al.* in a retrospective cohort study observed a 39% decrease in pain relief over the first 3 h following erector spinae block.^[8] Kumar *et al.*^[26] in another case report demonstrated an 87.5% decrease in the Visual Analog Score for a patient with 7 unilateral rib fractures and pneumothorax 30 min post ESPB. All these findings are comparable with the present study where we found a 51% reduction in the mean NRS over the first 30 min after the procedure ($P < 0.0001$) followed by a 72% decrease in the same over the course of 48 h.

Adhikary *et al.* employed spirometry volumes to assess the improvement in lung function and observed a mean increase of 545 mL in the inspiratory volumes during the first 24 h following ESPB, which translated to a >50% increase from the inspiratory volumes at presentation.^[8] In the present study, the respiratory parameters taken into account for assessing lung function included respiratory rate and PEFR. The improvements in inspiratory volumes were comparable to Adhikary *et al.*, with an observed 49% increase in the PEFR in our study. Simultaneously, an 18% decrease in the respiratory rate was observed at 30 min which further dropped by 36% at 48 h. This again paralleled the findings observed by Gursoy *et al.* who, in a case report, incorporated respiratory rate, tidal volume, and PaO₂/FiO₂ ratio as a measure of lung function and found a decrease of 38% in the respiratory rate at 6 h and a 46% and 61% increase in the tidal volume and PaO₂/FiO₂ ratio, respectively.^[25]

None of the patients had any adverse effects as a consequence of the ESPB, and these findings were similar to those observed by Adhikary *et al.*^[8]

The present study also evaluated the mean time for the block to be performed in the ED, and it was found to be <17 min (16.27 ± 2.17)

**Graph 3:** Pre- and posterector spinae plane block outcome data in peak expiratory flow rate for study population (circles depict mean peak expiratory flow rate)

which is an important factor to be considered when assessing the utility of the ESPB in the ED [Table 2].

CONCLUSION

The results of this study indicate that erector spinae plane blockade is effective in reducing the degree of pain, especially in the ED, where immediate pain relief might bring about a more favorable course in the hospital. Significant improvements in the inspiratory volumes were also observed which are likely to reduce the chances of pulmonary complications. The short time taken to administer the block enhances its utility in the ED. The limited risk of adverse events following this block further increases its appeal to the EP.

Limitations

Our study had a few limitations which need to be addressed. The study population was restricted to a small number of 15 patients. A larger number of patients need to be included to more fully ascertain the incidence of adverse events associated with the block. Similarly, all the patients in the study population were males and this apparent gender disparity may affect the outcomes of the study in the general population. Furthermore, certain other parameters such as the length of hospital/ICU stay were not considered in the present study. Finally, there needs to be a comparative analysis with other treatment modalities including other regional analgesic techniques and/or systemic analgesics to precisely establish the utility and effectiveness of the ESPB in the emergency setting.

In this present study, we have come to a conclusion that the block is effective in improving the pain scores and the inspiratory volumes without compromising on time or the patient's safety.

Table 3: Comparison of demographic profile and clinical characteristics of patients

Variables	Adhikary <i>et al.</i>	Riley <i>et al.</i>	Present study
Age	61±16	61.6±16.4	50 ± 15
Mechanism of injury (%)			
Motor vehicle accident	47	-	60
Fall	39	-	33
Others	14	-	7
Type of rib fracture (%)			
Unilateral	79	96.66	100
Bilateral	21	3.33	
Mean number of rib fractures	-	5±2.1	5.6±2.1
Number of fractured ribs (%)			
<5	30	-	27
5-7	53	-	53
>7	17	-	20
Pleural injury (%)	33	69.7	73.3
ICD <i>in situ</i> (%)		18.2	33.3
Additional injuries (%)			
Head	22	-	Exclusion criterion
Intra-abdominal	14	-	6.6
Spine	33	-	13.3
Upper limb	28	-	53.3
Lower limb/pelvis	28	-	20
Comorbidities (%)	-	42.4	53.3
COPD	-	12.1	20
Hypertension	-	12.1	40
Diabetes mellitus	-	-	26.6
CKD	-	9.1	0
Liver disease	-	9.1	0
Smoking (%)	-	30.3	53.3

ICD: Intercostal Drainage tube, COPD: Chronic Obstructive Pulmonary Disease, CKD: Chronic Kidney Disease

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Conflicts of interest

There are no conflicts of interest.

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