Comparison of Ultrasound Guided Erector Spinae Plane Block versus Paravertebral Block in Patients with Unilateral Fracture Ribs at Suez Canal University Hospitals

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Abstract

Background: There is still no consensus regarding the optimal regional technique for pain management. The aim of the present study was to compare the analgesic efficacy of continuous infusion ESP block compared versus continuous infusion thoracic paravertebral block during treatment of rib fracture patients. **Patients and methods:** This prospective interventional single blinded study was carried out on 70 patients with unilateral multiple rib fracture at intensive care unit in Suez Canal university hospitals.Patients divided into group (I) received ultrasound-guided erector spinae plane block (ESPB) with 20 ml of bupivacaine 0.25% as a loading dose and group (II) received ultrasound- guided paravertebral plane block (PVB) with 20 ml of bupivacaine 0.25% as a loading dose. **Results:** There was no statistically significant difference between the 2 groups regarding their heart rate, mean blood pressure,RR at different time intervals, PaO2, P/F ratio and PaCO2 at different recorded periods. There was a statistically significant decrease in the cortisol, CRP, NLR and PLR at 24 h and 48 h compared to the respective baseline in both groups. In ESPB group, they had significantly higher VAS values at rest at 24h compared to that of baseline, and statistically significant lower VAS values at rest at 6h, 12h, 36h, and 48 h compared to the baseline value. Regarding VAS at coughing, they had statistically significant lower values at 6 h, 12h, 24h, 36h and 48h compared to the baseline value. In PVB group, they had statistically significant higher VAS values at rest at 24h compared to the baseline value, and statistically significant lower VAS values at rest at 6h, 12h, 36h, and 48 h compared to the baseline value. Regarding VAS at coughing, they had statistically significant lower values at 6 h, 12h, 24h, 36h and 48h compared to the baseline value. There was a significantly less time to complete the block, less difficulty in performing of the procedure of the ESPB. In addition, a significantly less back pain and vomiting in the ESPB were reported. However, there was no statistically significant difference between both groups regarding other complications, length of hospital stay or need for MV. **Conclusion:** Continuous ESPB has advantages in terms of greater technical simplicity, shorter time to complete the block and fewer side effects. It may be thus considered as a viable effective compared to continuous thoracic PVB for establishing acute pain relief for unilateral multiple fracture ribs.

Keywords: Unilateral Fracture Ribs; Erector Spinae Plane Block; Paravertebral Block

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INTRODUCTION

Patients with multiple fractured ribs (MFRs) have increased risk of morbidity and mortality **[1]**. This risk is influenced by the severity of pain that a patient would experience **[2].** When multiple ribs are fractured, regional mode of analgesia is a preferred choice in the

pain management **[3]**. There are several regional analgesia techniques which can be used however; each technique has advantages and limitation for its usage **[4]**.

Thoracic epidural analgesia is the gold standard technique for blunt chest trauma and fracture ribs, thoracic paravertebral block (TPVB) has become a potential alternative approach **[3]**. Since the advent of ultrasound (US) in anesthetic practice, several inter fascial plane blocks have been described with an increase in their clinical applications **[5]**.

The erector spinae plane (ESP) block **[6]**. ESP which lies in the chest wall between the anterior surface of the cephalocaudal-oriented erector spinae muscles and the posterior surface of the spinal transverse processes **[7]**.

Continuous TPVB and erector spinae plane blockade (ESP) are accepted techniques at some medical centers for the management of thoracic pain following surgery and trauma **[4,8,9]**. Nevertheless, the relative efficacy of ESP and continuous paravertebral analgesia for patients with rib fractures remains to be established. Therefore, this study aimed to compare the analgesic efficacy of continuous infusion ESP block compared versus continuous infusion thoracic paravertebral block during treatment of rib fracture patients.

PATIENTS AND METHODS

This prospective interventional single blinded study was carried out on 70 patients with unilateral multiple rib fracture at intensive care unit in Suez Canal university hospitals. Each participant was subjected to clinical evaluation including: Medical history, physical examination, and laboratory investigations.

Patients were enrolled into one of the study groups on the day of consultation in an alternating fashion. Patients were divided into 2 groups:

(I) Group I (E) received ultrasound- guided erector spinae plane block.
(II) Group II (P) received ultrasound- guided paravertebral plane block.

Ethical approval:

An approval of the study was obtained from Suez Canal University Academic and Ethical Committee. Written informed consent of all the participants was obtained. This work has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.

Inclusion criteria:

Patients aged from 18 to 60 years old of both sexes. They were ASA I-II, with blunt chest trauma, sustained at least three unilateral rib fractures, and their pain score reached threshold despite using the current institutional standard of care for pain control.

Exclusion criteria:

Patients with coagulopathy, infection at the site of the block, neurological diseases or any systemic diseases causing neurological abnormalities, pregnancy, lactating mothers, a known sensitivity to study drugs, patients whose weight less than 60 kg, uncooperative and mentally retarded patients, patients who are intubated and mechanically ventilated with bilateral rib fracture, and patients whose body habitus prevents the practitioner's ability to adequately perform the procedure.

Procedures

1. **Group I (group E) received ultrasound- guided erector spinae plane block (ESPB):**

The patient was placed in a sitting position and a high-frequency linear ultrasound

transducer was placed in a longitudinal orientation 3 cm lateral to the thoracic spinous process. Three muscles were identified superficial to the hyperechoic transverse process shadow as follows: trapezius, rhomboid major, and erector spinae. The area was prepared and draped in a sterile fashion, and lidocaine infiltrated subcutaneously at the point of anticipated needle entry. A sterile Tuohy needle was introduced and advanced towards the corresponding transverse process. Hydro dissection ensured that the proper plane was located. Once the erector spinae musculature was separated from the rib a total of 20 mL of 0.25% bupivacaine was injected here. A catheter was placed to a depth 5 cm beyond the tip of the needle. The catheter was secured with Steri-strips and a transparent occlusive dressing **[10]**. Close monitoring of the vital signs was done every five minutes till end of the procedure.

2. Group II (group P) received ultrasound- guided paravertebral plane block (PVB):

An appropriate thoracic spinous process was located by positioning the probe in the transverse plane. Then the probe was moved laterally to locate the transverse process. The probe was manipulated slightly caudad or cephalad to locate the intercostal space. The transverse process was visualized medially with the pleura dipping under the inferolateral aspect. The internal intercostal membrane, which was contiguous with the superior costotransverse ligament, generally was seen as a thin, radiopaque line extending from the transverse process, creating a wedge-shaped pocket, which represents the thoracic paravertebral space. The area was prepped and draped in a sterile fashion, and lidocaine infiltrated subcutaneously at each point of anticipated needle entry.

For each of the catheter placement, a sterile gauge Tuohy needle was introduced with ultrasound guidance towards the paravertebral space in plane, from the lateral aspect of the ultrasound probe. When the needle pierced the internal intercostal membrane, after aspiration demonstrating the absence of air or blood, 20 mL 0.25% bupivacaine was deposited in 5-mL increments. The insertion of the nerve block catheter to a depth 5 cm beyond the tip of the needle. The catheters were secured with Steri-strips and a transparent occlusive dressing.

Close monitoring of the vital signs was done every five minutes till end of the procedure. Thirty minutes after the loading dose for both blocks, a continuous infusion of 0.125% bupivacaine started at 0.1 ml/kg/h by a syringe pump. The infusion was increased gradually up to a maximum rate of 0.2 ml/kg/h if the VAS pain scale became more than 3 at rest or if the patient requested additional analgesia **[10,11]**. The rate adjustment was preceded by injection of a bolus of 3–4 ml 0.125% bupivacaine. Chest radiography was done 24 h after the technique or at any time if there were symptoms and signs of respiratory distress to exclude pneumothorax or hemothorax.

Control of breakthrough pain:

In both groups, if the VAS was more than 3 at rest at any time, an intravenous bolus dose of morphine (20 μg/kg/dose) was given for rapid control of pain simultaneously with increasing the infusion rate according to VAS, where for severe pain (VAS: 6-8), the infusion rate was increased by 50-100% and increased by 25–50% for moderate pain (VAS: 3-5) irrespective of starting dose.

Weaning off analgesia:

It was done after two days of analgesic regimen, where the drug dose was initially reduced by 20% once and then by 10% (of original dose) at 6-8 h. The drug was discontinued if the rib fracture pain is tolerable. If the pain is intolerable, morphine was given with gradual tapering of the bupivacaine in both groups. When there was no indication for ICU and the

patient was free of pain or easily managed by the systemic analgesic, the patient was shifted to the ward and followed until hospital discharge.

Outcome Measures:

I. Primary outcome: total morphine consumption at 48 hours post regional block.
II. Secondary outcomes:

1. Pain at rest and on coughing was estimated with the VAS pain score (0, no pain; 10, worst imaginable pain).
2. Blood gas analysis was performed to measure arterial partial pressure of oxygen (PaO2), arterial partial pressure of carbon dioxide (PaCO2), PaO2/Fraction of inspiration oxygen (FiO2). These parameters were recorded (A) pre-block (T0), recorded just before the block and (B) after the block at (12 hr., 24 hr., 36 hr. and 48 hr).
3. Inflammatory stress response markers were withdrawn such as C- reactive protein, total leukocyte count, differential leukocyte count (neutrophils and lymphocytes and neutrophil-to-lymphocyte ratio (NLR)), platelet-lymphocyte ratio of peripheral blood and serum cortisol level at different three times (before block, 24 hours after block and 48 hours after block).
4. Hemodynamic changes (HR, MAP) and respiratory rate (Before block and 60 minutes, 6 hours, 24 hours and 48 hours after either block).
5. Compare between ESP block versus paravertebral block regarding the duration of accomplishing the procedures (measured in minutes from the time of application of the probe to the completion of the technique), difficulty of the procedure (difficulties encountered during application were rated on a verbal scale (easy, rather difficult, difficult) as well as the rate of failure.
6. Adverse effects signs related to the blocks such as pneumothorax, hemothorax, epidural block, and catheter related infection, bleeding, and unintentional catheter removal was also recorded. Pulmonary complications including pneumonia, atelectasis, pleural effusion, acute respiratory distress syndrome, and respiratory failure were observed and recorded.
7. The need for mechanical ventilation and duration of hospital stay in both groups.

Statistical analysis:

All data manipulation and analyses were performed using SPSS® Statistics version 25 (IBM Corporation, Armonk, NY, USA). All graphs were created using Microsoft® Excel. Continuous variables were summarized as the mean, standard deviation, and range. Categorical variables were described as frequencies and percentages (%). Differences between frequencies in the groups were compared by Chi-square test or Fisher's exact test (if >20% of expected values were less than 5). Normality of continuous variables was assessed with Kolmogorov Smirnov test. Mann-Whitney test and Kruskal Wallis test were used as the continuous variables were not normally distributed. A p-value of less than 0.05 was considered statistically significant.

RESULTS

The current study included patients with unilateral multiple rib fracture with the following criteria **(Figure 1)**. It was found that there was no statistically significant difference between the 2 groups regarding their pre-block heart rate ($p = 0.512$), 60 min HR ($p = 0.436$), 6 h HR ($p = 0.535$), 24 h HR ($p = 0.456$), and 48h HR ($p = 0.071$) values. However, in both of

group E and group P, there was a statistically significant decrease in the heart rate at 60 min, 6 h, 24 h, and 48h compared to the respective pre-block value ($p < 0.05$) **(Table 1)**.

There was no statistically significant difference between the 2 groups regarding their pre-block MBP ($p = 0.987$), 60 min MBP ($p = 0.942$), 6 h MBP ($p = 0.112$), 24 h MBP ($p = 0.262$), and 48h MBP ($p = 0.542$) values. However, in both of group E and group P, there was a statistically significant decrease in the MBP at 24 h and 48h compared to the respective pre-block value ($p < 0.05$) **(Table 2)**.

There was no statistically significant difference between the 2 groups regarding their pre-block RR ($p = 0.687$), 60 min RR ($p = 0.847$), 6 h RR ($p = 0.718$), 24 h RR ($p = 0.759$), and 48h RR ($p = 0.720$) values. However, in both of group E and group P, there was a statistically significant decrease in the RR at 6 h, 24h and 48h compared to the respective pre-block value ($p < 0.05$) **(Table 3)**.

There was no statistically significant difference between the 2 groups regarding their pre-block PaO2 ($p = 0.945$), 12h PaO2 ($p = 0.566$), 24 h PaO2 ($p = 0.144$), 36 h PaO2 ($p = 0.155$), and 48h PaO2 ($p = 0.258$) values. However, in both of group E and group P, there was a statistically significant increase in the PaO2 at 24 h, 36h and 48h compared to the respective pre-block value ($p < 0.05$) **(Table 4)**.

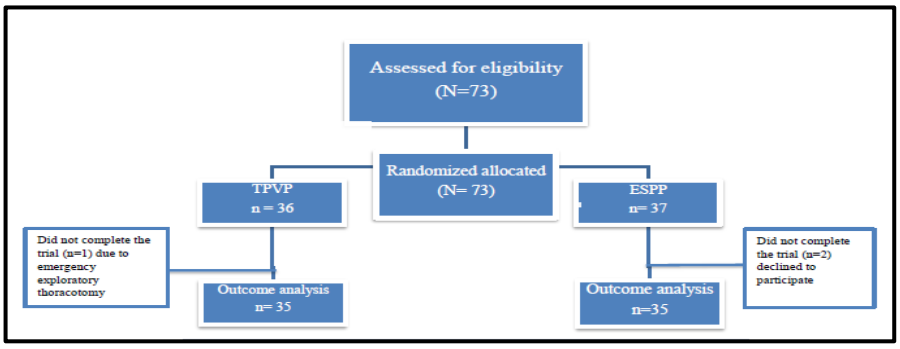

Figure (1): Flowchart of the patients who met the inclusion and exclusion criteria

Table (1) Baseline and follow-up values of heart rate in the studied groups:

Time	heart rate (beats/min)		95% CI	P
	Group E	Group P		
Pre-block	**106.77 ± 16.636**	**109.34 ± 15.996**	**-10.4, 5.2**	**0.512**
60 min	**98.89 ± 13.603***	**101.14 ± 10.276***	**-8.0, 3.5**	**0.436**
6 hours	**93.11 ± 11.393***	**94.60 ± 8.304***	**-6.2, 3.3**	**0.535**
24 hours	**88.74 ± 10.966***	**86.94 ± 9.026***	**-3.0, 6.6**	**0.456**
48 hours	**85.31 ± 11.943***	**80.40 ± 10.432***	**-0.4, 10.3**	**0.071**

*Data are expressed as mean and standard deviation. 95% CI: 95% confidence interval of the mean difference between both groups. P is significant when < 0.05. * Indicates a significant statistical difference between the corresponding reading and the respective pre-block value.*

Table (2) Baseline and follow-up values of MBP (mmHg) in the studied groups:

Time	MBP (mmHg)		95% CI	P
	Group E	Group P		
Pre-block	**91.43 ± 9.690**	**91.46 ± 3.853**	**-3.5, 3.5**	**0.987**
60 min	**91.80 ± 4.057**	**91.74 ± 2.267**	**-1.5, 1.6**	**0.942**
6 hours	**89.17 ± 3.846**	**90.43 ± 2.559**	**-2.8, 0.3**	**0.112**
24 hours	**87.51 ± 3.390***	**86.69 ± 2.698***	**-0.6, 2.3**	**0.262**
48 hours	**82.57 ± 3.883***	**81.91 ± 5.014***	**-1.5, 2.8**	**0.542**

*Data are expressed as mean and standard deviation. 95% CI: 95% confidence interval of the mean difference between both groups. P is significant when < 0.05. * Indicates a significant statistical difference between the corresponding reading and the respective pre-block value*

Table (3) pre-block and follow-up values of respiratory rate in the studied groups:

Time	respiratory rate (breath/minute)		95% CI	P
	Group E	Group P		
Pre-block	**19.63 ± 3.465**	**19.91 ± 2.331**	**-1.7, 1.1**	**0.687**
60 min	**19.31 ± 1.891**	**19.23 ± 1.800***	**-0.8, 1**	**0.847**
6 hours	**17.97 ± 2.242***	**18.14 ± 1.665***	**-1.1, 0.8**	**0.718**
24 hours	**16.31 ± 1.530***	**16.20 ± 1.568***	**-0.6, 0.9**	**0.759**
48 hours	**15.00 ± 1.000***	**15.11 ± 1.586***	**-0.7, 0.5**	**0.720**

*Data are expressed as mean and standard deviation. 95% CI: 95% confidence interval of the mean difference between both groups. P is significant when < 0.05. * Indicates a significant statistical difference between the corresponding reading and the respective pre-block value.*

There was no statistically significant difference between the 2 groups regarding their pre-block PaCO2 (p = 0.202), 12h PaCO2 (p = 0.977), 24 h PaCO2 (p = 0.553), 36 h PaCO2 (p = 0.370), and 48h PaCO2 (p = 0.131) values. In group P, there was a statistically significant decrease in the PaCO2 at 36 h compared to the respective pre-block value ($p < 0.05$). In both of group E and group P, there was a statistically significant decrease in the PaCO2 at 48 h compared to the respective pre-block value ($p < 0.05$) **(Table 5)**.

There was no statistically significant difference between the 2 groups regarding their pre-block P/F ratio (p = 0.565), 12h P/F ratio (p = 0.851), 24 h P/F ratio (p = 0.348), 36 h P/F ratio (p = 0.050), and 48h P/F ratio (p = 0.121) values. However, in both of group E and group P, there was a statistically significant increase in the P/F ratio at 24 h, 36h and 48h compared to the respective pre-block value ($p < 0.05$) **(Table 6)**.

Regarding cortisol levels, it was found that there was no statistically significant difference between the 2 groups regarding their pre-block cortisol (p = 0.972), 24h cortisol (p = 0.078), 48h cortisol (p = 0.168) values. However in both of group E and group P, the cortisol level was significantly lower at 24h and 48h compared to the respective pre-block value ($p < 0.05$). Regarding CRP levels, it was found that there was no statistically significant difference between the 2 groups regarding their pre-block CRP (p = 0.274), 24h CRP (p = 0.720), and 48h CRP (p = 0.910) values. However in both of group E and group P, the CRP level was significantly lower at 24h and 48h compared to the respective baseline value ($p < 0.05$). Regarding NLR, it was found that there was no statistically significant difference between the 2 groups regarding their pre-block NLR (p = 0.761), 24h NLR (p = 0.140) and 48h NLR (p = 0.094) values. However in both of group E and group P, NLR was significantly lower at 24h and 48h compared to the respective pre-block value ($p < 0.05$). Regarding PLR, it was found that there was no statistically significant difference between the 2 groups regarding their pre-block PLR (p = 0.380), 24h PLR (p = 0.586) and their 48h PLR (p = 0.264) values. However in both of group E and group P, PLR was significantly lower at 24h and 48h compared to the respective pre-block value ($p < 0.05$) **(Table 7)**.

The VAS values at rest was significantly higher at 24h compared to the pre-block value, and it was significantly lower VAS at rest at 6h, 12h, 36h, and 48 h compared to the pre-block value. Regarding VAS at coughing, it was significantly lower values at 6 h, 12h, 24h, 36h and 48h compared to the pre-block value. In the P group, regarding VAS at rest, it was significantly higher at 24h compared to the pre-block value, and it was significantly lower VAS at rest at 6h, 12h, 36h, and 48 h compared to the pre-block value. Regarding VAS

at coughing, it was significantly lower values at 6 h, 12h, 24h, 36h and 48h compared to the pre-block value **(Table 8)**.

Table (4) Pre-block and follow-up values of PaO2 (mmHg) in the studied groups:

Time	PaO2 (mmHg)		95% CI	P
	Group E	Group P		
Pre-block	74.94 ± 6.338	74.86 ± 3.574	-2.4, 2.5	0.945
60 min	74.46 ± 4.648	75.03 ± 3.560	-2.5, 1.4	0.566
6 hours	78.91 ± 4.388*	79.31 ± 3.488*	-3.3, 0.5	0.144
24 hours	82.74 ± 3.433*	81.60 ± 3.210*	-0.4, 2.7	0.155
48 hours	88.71 ± 3.793*	87.63 ± 4.166*	-0.8, 3.0	0.258

*Data are expressed as mean and standard deviation. 95% CI: 95% confidence interval of the mean difference between both groups. P < 0.05. * a significant statistical difference between the corresponding reading and the respective pre-block value*

Table (5) Pre-block and follow-up values of PaCO2 (mmHg) in the studied groups:

Time	PaO2 (mmHg)		95% CI	P
	Group E	Group P		
Pre-block	39.66 ± 5.047	38.37 ± 3.059	-0.7, 3.3	0.202
60 min	39.00 ± 4.678	38.97 ± 3.382	-1.9, 2.0	0.977
6 hours	37.86 ± 3.557	37.40 ± 2.820	-1.1, 2.0	0.553
24 hours	37.43 ± 2.227*	37.91 ± 2.280	-1.6, 0.6	0.370
48 hours	36.29 ± 2.824*	35.14 ± 3.405*	-0.3, 2.6	0.131

*Data are expressed as mean and standard deviation. 95% CI: 95% confidence interval of the mean difference between both groups. P < 0.05. * a significant statistical difference between the corresponding reading and the respective pre-block value.*

Table (6) Pre-block and follow-up values of P/F ratio in the studied groups:

Time	P/F ratio		95% CI	P
	Group E	Group P		
Pre-block	356.03 ± 29.974	352.66 ± 17.031	-8.3, 15.0	0.565
60 min	352.51 ± 22.122	353.40 ± 16.933	-10.3, 8.5	0.851
6 hours	374.40 ± 21.349*	378.71 ± 16.566*	-13.4, 4.8	0.348
24 hours	392.46 ± 16.921*	384.80 ± 15.204*	0.0, 15.3	0.050
48 hours	421.83 ± 18.454*	414.54 ± 20.277*	-2.0, 16.5	0.121

*Data are expressed as mean and standard deviation. 95% CI: 95% confidence interval of the mean difference between both groups. P < 0.05. * a significant statistical difference between the corresponding reading and the respective pre-block value.*

Table (7) pre-block and follow-up values of serum Cortisol level, CRP, NLR, and PLR in the studied groups:

	Time interval	Group E (n= 35)	Group P (n= 35)	95% CI	P
Cortisol (mg/dl)	Pre-block	19.05 ± 2.507	19.07 ± 2.238	-1.2, 1.1	0.972
	24 hours	16.03 ± 2.075*	16.95 ± 2.252*	-2.0, 0.1	0.078
	48 hours	11.63 ± 2.966*	12.56 ± 2.615*	-2.3, 0.4	0.168
CRP (mg/dl)	Pre-block	25.60 ± 11.991	23.09 ± 6.199	-2.0, 7.1	0.274
	24 hours	15.94 ± 5.891*	16.40 ± 4.673*	-3.0, 2.1	0.720
	48 hours	7.80 ± 3.123*	7.71 ± 3.223*	-1.4, 1.6	0.910
NLR	Baseline	4.49 ± 1.670	4.60 ± 1.470	-0.9, 0.6	0.761
	24 hours	3.65 ± 1.119*	3.23 ± 1.248*	-0.1, 1.0	0.140
	48 hours	2.42 ± 0.852*	2.70 ± 0.485*	-0.6, 0.0	0.094
PLR	Baseline	153.55 ± 59.683	164.69 ± 44.545	-36.3, 14.0	0.380
	24 hours	140.54 ± 56.776*	146.71 ± 34.922*	-28.7, 16.3	0.586

	48 hours	**115.36 ± 50.239***	**105.43 ± 13.348***	**-7.6, 27.4**	**0.264**

*Data are expressed as mean and standard deviation. 95% CI: 95% confidence interval of the mean difference between both groups. P < 0.05. * a significant statistical difference between the corresponding reading and the respective pre-block value*

Table (8) Post-procedure analgesic profile in the studied groups compared to the pre-block value:

	Time interval	**Group E (n= 35)**		**Group P (n= 35)**	
VAS at rest	**Pre-block**	**4.69 ± 0.758**	**-**	**4.66 ± 0.725**	**-**
	6 hours	**3.31 ± 0.471**	**< 0.001**	**3.14 ± 0.355**	**< 0.001**
	12 hours	**3.43 ± 0.502**	**< 0.001**	**3.46 ± 0.505**	**< 0.001**
	24 hours	**4.71 ± 0.458**	**< 0.001**	**4.80 ± 0.473**	**< 0.001**
	36 hours	**3.11 ± 0.323**	**< 0.001**	**3.26 ± 0.505**	**< 0.001**
	48 hours	**2.29 ± 0.458**	**< 0.001**	**2.29 ± 0.458**	**< 0.001**
VAS on coughing	**Pre-block**	**5.83 ± 0.822**	**-**	**5.71 ± 0.710**	**-**
	6 hours	**4.20 ± 0.406**	**< 0.001**	**4.00 ± 0.767**	**< 0.001**
	12 hours	**4.23 ± 0.426**	**< 0.001**	**4.14 ± 0.355**	**< 0.001**
	24 hours	**5.31 ± 0.796**	**< 0.001**	**5.14 ± 0.430**	**< 0.001**
	36 hours	**3.86 ± 0.550**	**< 0.001**	**3.86 ± 0.430**	**< 0.001**
	48 hours	**2.83 ± 0.382**	**< 0.001**	**2.69 ± 0.530**	**< 0.001**

Data are expressed as mean and standard deviation. 95% CI: 95% confidence interval of the mean difference between both groups. P is significant when < 0.05.

The time to complete the block was significantly lower in the E group compared to the P group ($p < 0.001$). In addition, the procedure of the block was easier with less difficulty in the E group compared to P group ($p = 0.008$) **(Table 9)**.

There was a significantly lower incidence of back pain ($p= 0.029$) and vomiting ($p=0.041$) in the E group compared to the P group. However, there were no statistical significant differences in the other possible complications **(Table 10)**.

There was no statistically significant difference between the 2 groups regarding length of hospital stay ($p= 0.754$) or need for MV ($p=1$) **(Table 11)**.

Table (9) Time to achieve the block in minutes, and its difficulty in the studied groups:

		Group E (n= 35)	**Group P (n= 35)**	**95% CI**	**P**
Time to complete block(minutes)		8.37 ± 1.060	9.83 ± 1.098	-2.0, -0.9	**< 0.001**
Difficulty of the procedure	**Easy**	71.4% (25)	40.0% (14)	-	**0.008**
	Rather difficult	22.9% (8)	28.6% (10)		
	Difficult	5.7% (2)	31.4% (11)		

Data are expressed as mean and standard deviation or as percentage and frequency. 95% CI: 95% confidence interval of the mean difference between both groups. P is significant when < 0.05

Table (10) Post-procedure complications in the studied groups:

	Group E (n= 35)	**Group P (n= 35)**	**P**
Back pain	**14.3% (5)**	**37.1% (13)**	**0.029**
Vomiting	**11.4% (4)**	**31.4% (11)**	**0.041**
Pneumothorax	**0.0% (0)**	**2.9% (1)**	**0.314**
Hemothorax	**0.0% (0)**	**0.0% (0)**	**1**
Epidural block	**0.0% (0)**	**2.9% (1)**	**0.314**
Catheter related infection	**0.0% (0)**	**0.0% (0)**	**1**
Hematoma at puncture site	**5.7% (2)**	**5.7% (2)**	**1**
Unintentional catheter removal	**0.0% (0)**	**0.0% (0)**	**1**
Pneumonia	**0.0% (0)**	**0.0% (0)**	**1**
Atelectasis	**2.9% (1)**	**2.9% (1)**	**1**

Pleural effusion	**0.0% (0)**	**0.0% (0)**	**1**
ARDS	**0.0% (0)**	**0.0% (0)**	**1**
Respiratory failure	**0.0% (0)**	**0.0% (0)**	**1**
Failure rate	**0.0% (0)**	**0.0% (0)**	**1**

Data are expressed as mean and standard deviation or as percentage and frequency. P is significant when < 0.05.

Table (11) Length of hospital stay and Need for MV in the studied groups:

	Group E (n= 35)	Group P (n= 35)	95% CI	P
Length of hospital stay (days)	**3.86 ± 1.216**	**3.77 ± 1.060**	**-0.5, - 0.6**	**0.754**
Need for MV	**0.0% (0)**	**0.0% (0)**	**-**	**1**

Data are expressed as mean and standard deviation or as percentage and frequency. 95% CI: 95% confidence interval of the mean difference between both groups. P is significant when < 0.05

DISCUSSION:

Several factors affect the decision of whether a patient will benefit from a regional block in patients with multiple rib fractures. Common indications include those unable to cough or perform deep inspiration, pain refractory to intravenous analgesia and patients at high risk of complications such as hypertensive patients and asthmatic patients **[5,12]**.

Once the decision has been made to perform a regional block, the anesthetist needs to decide which block is most appropriate for the individual patient. Deciding which block to place at times can seem complex. Factors to be considered include the location of fractures, number of fractures, absolute and relative contraindications, as well as, anesthetist comfort with various types of neuraxial and regional blocks. There is then the question of whether to perform a single shot or site a catheter. Instances where a single shot block may be of benefit include patients where the indication is less clear or when an appropriately skilled clinician isn't available for catheter placement **[12]**.

In the present study, it was advocated for the recruited patients to insert a catheter. Therefore, this prospective, comparative, randomized interventional single blinded study was carried out to determine the analgesic efficacy of continuous infusion ESP block compared versus continuous infusion thoracic paravertebral block in patients with traumatic rib fracture.

The obtainable finding was compared with several studies. **Giang et al. [13]** evaluated the efficacy of thoracic paravertebral block with bupivacaine-fentanyl mixture in 172 patients with unilateral MRF in case series. They demonstrated that the TPVB provided an effective pain relief in those patients. **Womack et al. [14]** evaluated the safety, complications and clinical outcome after ultrasound-guided paravertebral 290 catheters insertion for rib fracture analgesia in 290 patients in a retrospective observational study. They concluded that paravertebral catheters were a safe and effective technique for rib fracture analgesia.

Also, **Bataille et al. [15]** evaluated the diaphragmatic motility in a prospective observational study on ten patients with multiple rib fractures. They showed that the significant decrease in numerical pain rating scale following PVB improved significantly diaphragmatic motility in those patients. Additionally, a retrospective, non-randomized case series of 11 patients with unilateral MRF, **Shukla et al. [16]** found that continuous TPV block was a safe and effective technique for analgesia in patients with unilateral MRF. Lastly, **Ahmed and Hasan [17]** compared the efficacy of ultrasound-guided continuous thoracic paravertebral block using bupivacaine versus continuous intravenous morphine infusion in pain relief for patients with unilateral MRF. They found continuous PVB provided better pain control with less rescue analgesia.

Several studies showed that single shot or continuous ESPB; whether ultrasound guided or not; provided adequate analgesia with fair outcome in patients with multiple rib fractures **[18, 19, 108-112]**. **Hamilton and Manickam [10]** reported a successful and effective analgesia following erector spinae plane block using a continuous catheter technique for pain relief in a patient with unilateral MRF. **Nandhakumar et al. [18]** reported a case series of erector spinae plane block in patients with MRF. They reported an effective pain relief that helped in weaning from mechanical ventilation. **Adhikary et al. [19]** in a retrospective cohort study of 79 patients, 77% of whom received continuous ESPB for 3.7 ± 1.9 days. They showed that ESPB was associated with improved inspiratory capacity and analgesic outcomes following rib fracture. Also, **Syal et al. [20]** carried out a prospective observational study on 10 patients with MRF. They found that continuous ESPB provided adequate analgesia.

Interestingly, **Dultz et al. [21]** concluded that ESPB can be safely placed in patients on chemoprophylaxis. It should be considered over traditional blocks in patients with blunt chest wall trauma because of its technical ease and ability to be performed with chemoprophylaxis. Also, **White et al. [22]** concluded that the safety based on the results presented in the population of trauma patients, the erector spinae plane block catheter was a low-risk analgesic technique that may be performed in the presence of abnormal coagulation status or systemic infection. In a recent case report of flail chest, unilateral bilevel erector spinae plane catheters were effective in pain relief in a patient with flail chest secondary to a motor vehicle accident **[23]**.

Moreover, in a pilot sampling of emergency department patients with acute rib fractures who failed traditional analgesic therapy, it has been reported that the ESPB performed by emergency physicians provided a safe and effective pain control **[24]**.

Nonetheless, the effects of both regional blocks on postoperative analgesia were compared in different surgeries including thoracic surgeries and mastectomy with diverse outcomes and conclusions. **Fang et al. [25]** showed that preoperative single-injection ESPB plus postoperative sufentanil PCA provided similar effects of pain relief for patients undergoing thoracotomy when comparing to TPVB. However, **Zhao et al. [26]** found that ultrasound-guided ESPB applied before video assisted thoracic surgery was non-inferior in analgesic effect compared with PVB in terms of pain score, and analgesic rescue consumption. On the contrary, **Chen et al [27]** found that ultrasound-guided multiple-injection PVB provided superior analgesia to single-injection ESPB after thoracoscopic surgery.

Recently, ESPB exhibited a simple analgesic technique superior to general anesthesia alone 24 hours after breast surgery while its efficacy was similar to paravertebral block and can thus serve as an alternative to PVB with similar analgesic effects **[28]**.

The reasons that account for these different results include; first, it was probably that good manipulation abilities and skills of surgeons caused less pain than expected. In more invasive surgery, larger difference in morphine consumption between ESPB and PVB would reveal so that significant analgesic superiority of PVB would be showed. Second, it is difficult for patients to effectively operate patient-controlled analgesia (PCA) device.

In the present study regarding hemodynamic parameters, in both of PVB group and ESP group, there was a statistically significant improvement in the HR values at 60 min, 6 h, 24 h, and 48h compared to the respective pre-block value and a significant improvement in the MBP at 24 h and 48h compared to the respective pre-block value. However, there was no statistically significant difference in the HR and MBP between the 2 groups at different time intervals. In agreement with these findings, **El Ghamry et al. [29]** showed that both TPVB

and ESPB can be effectively used in controlling post-mastectomy pain with a stable hemodynamic profile in both groups.

In addition, **Moustafa et al. [30]** in a randomized comparative study of erector spinae versus paravertebral plane blocks on 102 patients undergoing modified radical mastectomy demonstrated no significant differences in the heart rate and mean arterial pressure between both groups. ESPB provided equivalent profile of postoperative analgesia with less time to perform the block.

On the contrary, in **Fang et al. [25]** study, ninety-four patients scheduled for thoracotomy surgeries were randomly allocated to an ESPB or TPVB group. They found that there was significantly less hypotension (6.7% vs. 21.7%, P=0.04), and bradycardia (0 vs. 8.7%, P=0.04) in the ESPB group. It was explained that the higher incidence of hypotension and bradycardia may be a result of unilateral sympathetic blockage of TPVB.

Recovery from stress (pain), after analgesia and pain relief will lead to normalization of hemodynamics (pulse and mean blood pressure) and this means return to baseline readings. **Adhikary et al. [19]** in a retrospective study on ESPB in patients with MRF reported that mean arterial blood pressure remained unchanged from pre-block parameters. Also, in **Syal et al. [20]** study of ESPB in patients with multiple rib fractures in a prospective cohort study, they demonstrated that the hemodynamic variables did not show any significant change.

In the present study regarding respiratory parameters, it was found that there were no statistically significant differences between both groups as regard the RR, PaCO2, PaO2, and P/F ratio at different time intervals. However, there was an improvement in the previous respiratory parameters compared to the respective baseline values in both groups.

The reason for this is because rib fractures cause sharp and severe chest pain which is aggravated by deep breathing. Therefore, the patients try to get less pain by maintaining shallow respirations with near-motionless chest wall **[31].** So after establishing an adequate analgesia which could be capable of reversing the negative effects of chest pain of traumatic multiple rib fractures on pulmonary function parameters through improvement respiratory mechanics.

In accordance with these findings, **Adhikary et al. [19]** showed that the erector spinae plane block in multiple rib fractures was associated with an immediate and significant improvement in inspiratory volumes and oxygenation. **Syal et al. [20]** in a prospective cohort study demonstrated that continuous erector spinae plane block in patients with multiple rib fractures was accompanied with an improving in the RR, SpO2, inspiratory capacity and PaO2 after the block placement. However, PCO2 did not show any significant change.

Circulating cortisol antagonizes the anabolic actions of growth and thyroid hormones further exacerbating tissue catabolism **[32]**. **Hayden et al [33]** in a prospective, double-blind, placebo-controlled pilot study using intraperitoneal ropivacaine found a lower cortisol concentration after 6 hours in the intraperitoneal local anesthetic group followed by a rise above the levels in the placebo group at 24 hours. They concluded that IPLA could delay the normal stress induced rise in cortisol but does not abolish it. Moreover, higher cortisol levels were predictive of mortality in critically ill trauma patients. Two hundred forty-two patients were analyzed in a retrospective study. Cortisol level has 77 per cent accuracy in differentiating survivors from non-survivors **[34]**.

C-reactive protein (CRP) is considered to reflect the development of systemic inflammatory response syndrome. The plasma CRP level in a normal healthy state is 5 mg/L. CRP is considered to quantify surgical trauma and to assess the surgical trauma experienced by individual patients **[35]**. Regional anesthesia is considered to be effective in protection from surgical trauma and nociceptive stimuli **[36]**. Correlation between the level of CRP and

the severity of pain syndrome in the early postoperative period depends on the method of analgesia, and allows using it as a criterion for evaluating of the effectiveness of adequate analgesia **[37]**. Moreover, CRP is a useful parameter to detect and monitor postoperative infections in trauma surgeries. The rise in C-reactive protein on the third and seventh postoperative days can be used as a reliable predictor of postoperative infections **[38]**.

In the current study regarding the time to complete the block, its difficulty, and post-procedure complications, it was found that in the PVB group, there was a significantly higher time to complete the block, more difficulty of the procedure, more back pain, and vomiting than in the ESB group. However, there were no significant differences between both groups regarding the incidence of pneumothorax, hemothorax, epidural block, catheter related infection, hematoma at puncture site, unintentional catheter removal, pneumonia, atelectasis, pleural effusion, ARDS, respiratory failure and failure rate. In addition, there was no statistically significant difference between both groups regarding the length of hospital stay or need for MV.

The paravertebral block may replace epidural analgesia for thoracic surgery as it offers equivalent analgesic effect with fewer adverse effects like hypotension, urinary retention, and pulmonary complications. However, as the paravertebral space is often small, even with the guidance of ultrasound, the risk for pleural puncture is still presents **[39]**.

Pace et al. [40] in a retrospective study of the incidence of complications ultrasound-guided thoracic paravertebral blockade on eight hundred fifty-six patients underwent a total of 1427 injections reported only 6 complications including symptomatic bradycardia and hypotension (n=3), vasovagal episode (n=1), and evidence of possible local anesthetic toxicity (n=2). There was no incidence of suspected accidental pleural puncture or symptomatic pneumothorax in their study.

Naja et al [41] studied the failure rate and complications following thoracic and lumbar paravertebral blocks performed in 620 adults and 42 children. The technique failure rate in adults was 6.1%. No failures occurred in children. The complications recorded were inadvertent vascular puncture (6.8%); hypotension (4.0%); hematoma (2.4%); pain at site of skin puncture (1.3%); signs of epidural or intrathecal spread (1.0%); pleural puncture (0.8%); pneumothorax (0.5%).

ESPB is a relatively safer method in which the transverse process acts as an anatomical barrier and avoids needle insertion into pleura **[42]**. The relatively superficial nature of the ESPB, with the needle tip distant from the pleura and no structures at risk of needle injury in the immediate vicinity provides advantages of technical simplicity, direct ultrasound visualization, and less concern in the case of a hematoma.

ESPB is a novel nerve-blocking technique first proposed by **Forero et al. [43]**. It is generally implemented through deposition of drugs into the fascial plane beneath the erector spinae muscle at the tip of the transverse process of the vertebra, thereby reducing pneumothorax and significant neurovascular damage. Many studies have also reported that ESPB plays an effective role in postoperative analgesia for thoracic and breast surgery, and it is proven to be easily implemented with a high successful block rate **[44,45]**. A report of 242 patients also showed that ESPB had almost no operation failure or adverse complications **[46]**. In **Fang et al. [25]** study, 5 patients in the TPVB group experienced hematoma occurring at the puncture site, and ESPB showed advantages of shorter puncture time, a higher success rate of single puncture, and higher satisfaction with the puncture. There was no difference between the two groups in terms of postoperative nausea and vomiting, which may be explained by the similar cumulative sufentanil consumptions postoperatively.

Erector spinae plane block affects thoracic nerves' roots without entering of needle in the paravertebral space which makes the ESPB safer compared to the central blocks including the TPVB and preferable in patients under anticoagulation therapy **[47]**.

In the study by **Chen et al. [27]** in patients undergoing thoracoscopic surgery, although more rescue analgesia was needed in the ESPB group compared to the PVB group, hematoma was noted in four patients in the PVB group and none in ESPB group after performance of block. Besides, four and five patients respectively in the PVB and ESPB groups had nausea or vomiting. No patients developed pneumothorax, pruritus and urinary retention in both groups.

In the study of **Gürkan et al. [48]** showed the ESPB group had a significantly higher postoperative nausea than the PVB group. This difference could be explained by decreased morphine consumption in the PVB group, while there was no significant difference between the groups in terms of postoperative vomiting.

Xiong et al. [49] meta-analysis compared ESPB with PVB for thoracic and breast surgery, they found no significant difference in the incidence of postoperative nausea and vomiting between the two blocks. Regarding the block procedure time, the results clearly showed that the time required for ESPB was significantly shorter than that required for PVB. This is the advantage of the new technology ESPB, which reflects its simplicity to a certain extent.

Agarwal et al. [50] in a randomized controlled trial comparing the efficacy of ultrasound-guided PVB versus ESPB for postoperative analgesia in modified radical mastectomy found a similar analgesic profile in both groups, although the time to perform ESP block was significantly shorter than that of paravertebral block. Also, **Kot et al. [51]** concluded that the technique is easy to perform and has a low rate of complications.

There are some limitations in this study. First, VAS is not an objective indicator, so it may affect the efficacy evaluation. Secondly, the sample size of this study is small. Therefore, the results may need to be further validated by a larger sample size test. Thirdly, recruitment of relatively healthy patients (ASA I and II) resulted in flawed extrapolation of the study. Fourthly, we did not use cutaneous sensory test to document the block range. Also, the post procedure follow-up was up to 48 hours and chronic pain was not investigated. But this study was designed to compare efficacy of these blocks in acute pain control.

Lastly, in an ideally structured study, an additional arm that would be placebo group is needed. But, it would be unfair to leave patients without a reliable pain management in multiple fracture ribs.

CONCLUSION:

Continuous Erector spinae plane regional block has advantages in terms of greater technical simplicity, shorter time to complete the block and fewer side effects. It may be thus considered as a viable effective compared to continuous thoracic paravertebral block for establishing acute pain relief for unilateral multiple fracture ribs.

The present results could provide a basis for future trials regarding the relationship between the volumes or concentration of LA with the analgesic effect of ESPB should be further studied. Sensory testing could be done to find out the dermatome distribution of these two blocks. It would be better to show and compare the exact limits of the blocks for further investigations

Currently, there is no enough evidence to choose one block over another on efficacy and safety data alone. Until this evidence is available the decision should be guided by factors

such as the experience of procedure operator, fracture location, number of fractures and contraindications.

No Conflict of interest.

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