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Ultrasound Guided Erector Spinae Plane Block Versus Ultrasound Guided Thoracic Paravertebral Block for Pain Relief in Patients with Multiple Fractured Ribs

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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Original Research Article

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ABSTRACT

Background: Patients with rib fractures or chest contusions are unable to cough or breathe deeply, which may lead to atelectasis and pneumonia. And the cornerstone of management of rib fractures is aggressive treatment of this pain. Ultrasound guided (US) regional techniques was linked with fewer adverse effects and higher efficacy if compared with systemic therapy with multiple rib fractures. We designed this work for comparing the efficacy and safety of thoracic paravertebral block (TPVB) versus erector spinae plane block (ESPB) in cases with multiple fractured ribs.
Methods: This is a double-blinded prospective randomized controlled trial which was conducted on 60 patients aged ≥ 18 years of both sexes. The participants had unilateral multiple fractured ribs (≥ 3 ribs), and they were randomly enrolled into two equal groups. Group I had US guided TPVB. Bupivacaine 0.25% in a volume of 20 mL was injected in a bolus dose, then a continuous infusion of bupivacaine 0.25% at a rate of 0.1 mL/kg/hr. Group II received (US) guided ESPB. Bupivacaine 0.25% in a volume of 20 mL was injected in a bolus dose and then suspected to a continuous infusion of bupivacaine 0.25% at a rate of 0.1 mL/kg/hr.

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Results: Visual analogue score (VAS) decreased significantly after institution of blocks (p-value <0.05) without considerable difference between two groups (P >0.05). And total morphine consumption was insignificant between two groups (P =0.836). Also, heart rate (HR) and mean arterial blood pressure (MAP) decreased significantly compared to pre-block values in both groups with an insignificant difference between the two groups (P >0.05). Moreover, respiratory, and arterial blood gases (ABG) parameters improved significantly in both groups in the form of reduced in respiratory rate (RR), elevated oxygen saturation, and increase in P/F ratio with an insignificant difference between the two groups (P >0.05). Occurrence of complications as hypotension, bradycardia and pneumothorax was less in ESPB group than TPVB group.
Conclusions: ESPB is nearly effective as TPVB to relief pain in cases with rib fractures as demonstrated by significant decrease in VAS scores in both groups.

Keywords: Ultrasound guided; erector spinae plane block; thoracic paravertebral block; pain relief; multiple fractured ribs.

1. INTRODUCTION

Blunt trauma of chest wall is the most frequent reason of rib fracture. Three or more rib fractures (Multiple Fractured Ribs, MFRs) increased the risk of morbidity and death [1]. The risk of death is determined by the patient's degree of pain. Pain is typically more acute and commonly alters pulmonary mechanics in situations of numerous rib fractures. Breathing-related pain occurs during shallow breaths and inefficient coughing, resulting in less clearing of secretions of airway and sputum retention, which frequently precipitates subsequent problems [2,3].

When several ribs are fractured, systemic narcotic pain relief may lead to excessive drowsiness, inability to expectorate, and deterioration of the pulmonary condition. Consequently, the regional mode of analgesia is a favored approach to control the pain [1].

Injection of local anesthetic into thoracic paravertebral space has showed to be more effect to relief pain in cases with rib fractures by injection of a local anesthetic agent near to spinal nerves. Also, the intervertebral foramina, thoracic paravertebral block (TPVB) may apply high-quality somatic, segmental, ipsilateral, and sympathetic nerve blockade [4,5]. Despite, there is a low risk for vascular puncture, pleural puncture, pneumothorax, and a probability of toxic effect because of the fast absorption of local anesthetic [4]. The erector spinae plane block (ESPB) is an interfacial block. It has effectively treated severe neuropathic pain associated with the ribs. The rationale for using ESPB is that it is more likely to work in the dorsal and ventral rami of the thoracic spinal neurons [6]. The ESPB is considered a simple technique when compared with epidural or paravertebral block (PVB) and furthermore, an inherently lower risk of neurovascular injury and toxicity of local anesthetic [7].

The goal of this research was to examine the effectiveness and safety of TPVB and ESPB in cases with multiple rib fractures.

2. METHODOLOGY

This double-blinded prospective randomized controlled trial was conducted between March 2019 and March 2020 at Tanta University Hospital's intensive care unit on 60 patients aged ≥ 18 years of both sexes. They suffered unilateral multiple fractured ribs (≥ 3 ribs). Each patient signed an informed consent. Cases were randomized by opaque sealed envelopes into 2 groups; to receive either TPVB or ESPB. Full data were confidential with secret codes and private file for each case, all obtained data were utilized for only the recent medical research. Any unexpected risks appeared during the research were clarified to the participants and the ethical committee approved the study on time. This trial was randomized controlled, double blinded trial in which the patient and the data collector were blinded to the technique.

Patients with unilateral multiple fractured ribs were included while excluded cases had contraindication for regional block such as: bleeding disorders, infection at the injection site, unstable cardiac conditions, clear hypersensitivity to the study drugs, unconscious, outside significant trauma from chest wall e.g., acute spine or severe traumatic brain, pelvic fracture or spinal cord injury, or abdominal visceral injuries, chronic opioid users, uncooperative patients, and patients with psychiatric illness were excluded.

Primary outcome: Visual Analog Scale (VAS) pain scores and Total rescue analgesics consumption. Secondary outcome: Adverse effects and complications as Hypotension, Complications related to catheter insertion, Pneumothorax, Local anesthetic toxicity, Respiratory depression, Bilateral block (epidural spread) and Intensive care and hospital length of stay.

Preparation: In all patients, monitoring was applied in the form of pulse oximetry, non-invasive blood pressure cuff and electrocardiogram. A peripheral cannula (20 G) was inserted and secured. Cases were familiarized with the VAS, identifying 0 as no pain and 10 as the worsening of pain. The following was recorded at admission: VAS, Mean Arterial Blood pressure (MAP), Heart rate (HR), Respiratory rate (RR), Oxygen saturation and PaO_2/ FiO_2 ratio (P/F) through drawing an arterial sample. All the patients had oxygen via a venturi mask to deliver fixed percentage of oxygen. In all patients we started by using the red venturi mask to deliver 40% oxygen on a flow rate 10-12 L/min and then weaning of patients was done on different types of venturi masks delivering lower percentage of oxygen according to patient's oxygen saturation and P/F ratio. Different venturi masks that were used: Blue = 2-4L/min = 24% O_2. White = 4-6L/min = 28% O_2. Yellow = 8-10L/min = 35% O_2. Red = 10-12L/min = 40% O_2.

After finishing the regional block in each group, all patients were positioned in semi-sitting position with full monitoring in the form of pulse oximetry, non-invasive blood pressure cuff and electrocardiogram. Intravenous paracetamol (1 gm) was commenced and was given on a regular basis every 8 hrs. And the following were recorded: All demographic data, injury data (mechanism and associated injuries, number of fractured ribs, the appearance or disappearance of flail chest, hemothorax, pneumothorax, subcutaneous emphysema, pulmonary contusion, or chest tube drainage). VAS scores at rest and on coughing at admission, 30 minutes, 1, 2, 3, 4, 5, 6, 12, 24 hours post-block and then daily for subsequent four days. Analgesic rescue as incremental IV Morphine (0.05mg /kg) was given if VAS ≥4. Total consumption was recorded. Hemodynamic data (MAP, HR, oxygen saturation) at admission, 30 minutes, 1, 2, 3, 4, 5, 6- and 12-hours post-block. RR at admission, 30 minutes, 1, 2, 3, 4, 5, 6, 12, 24 hours post-block and then daily for subsequent four days. Ratio of partial pressure of oxygen in arterial blood to inspired oxygen concentration (PaO_2 / FiO_2) at admission, 30 minutes post block, daily for subsequent four days. Any adverse effects were recorded. Hypotension was defined as MAP< 65 mmHg and was treated with ephedrine up to 6 mg increments intravenously (IV). Total number of patients who developed hypotension was recorded. Bradycardia was defined as HR < 50 beat/min and was managed with atropine (0.01-0.02 mg/kg) IV. Number of total cases who had bradycardia was recorded. Complications related to catheter insertion: infection at site of insertion, hematoma, abscess, and catheter retention. Pneumothorax if was suspicious, chest x-ray had to be performed and if confirmed the diagnosis, chest tube would be inserted and connected to an underwater seal. Manifestations of local anesthetic toxicity if occurred: bradycardia managed by intravenous atropine, convulsions managed by intravenous diazepam, respiratory depression or hypoxia managed by respiratory support and mechanical ventilation if needed, cardiac arrest managed by immediate CPR and intravenous intralipid infusion, respiratory depression, bilateral block (epidural spread) as well as intensive care and hospital length of stay.

2.1 Statistical Analysis

The IBM SPSS software version 20.0 was used to analyze our data. (Armonk, New York: IBM Corporation) Numbers and percentages were used to describe qualitative data. The Kolmogorov-Smirnov test was performed to determine the distribution's normality. The range (minimum and maximum values), mean, standard deviation, and median were used to characterize quantitative data. The tests that were utilized were as follows: The chi-square test is used to compare category variables. Fisher's Exact: chi-square adjustment when more than 20% of cells have an anticipated count < 5. Student t-test is used to compare two sets of normally distributed quantitative data. Repeated measured ANOVA is used to compare quantitative variables that are normally distributed throughout more than two periods or stages. For pairwise comparisons, a post hoc test (Bonferroni adjusted) is used. The Mann Whitney test is performed to compare between two groups with improperly distributed quantitative characteristics. Additionally, Friedman test is performed to compare quantitative variables with an anomalous distribution across more than two periods or stages. Pvalue ≤ 0.05 was considered significant.

3. RESULTS

In this trial, 74 cases were determined for eligibility, 9 cases did not match the criteria and 5 cases refused to contribute to the trial. The remaining 60 cases were randomly allocated into two groups (30 patients in each). All cases (60) were followed-up and analyzed statistically [Fig. 1].

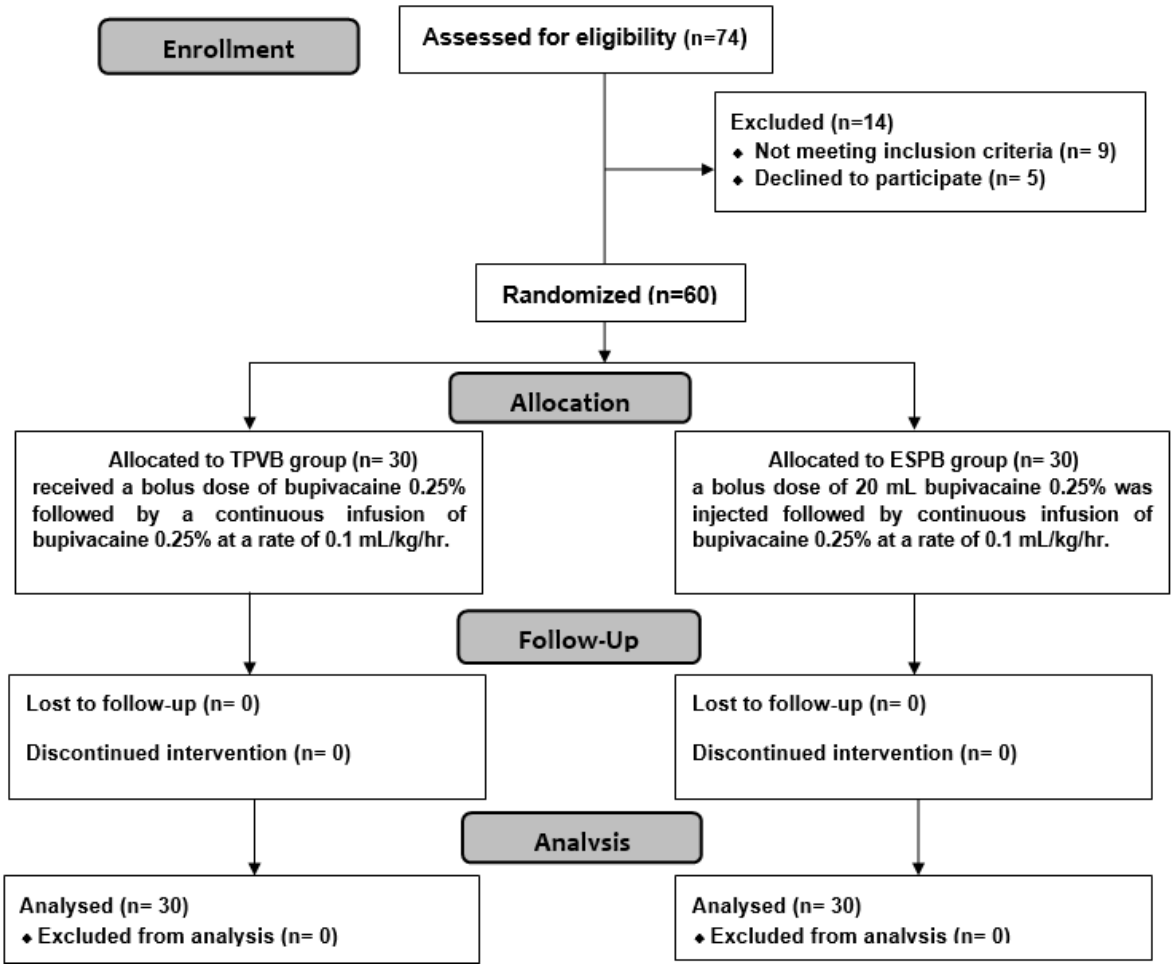


Fig. 1. Consort flowchart of the studied patients

Patients' characteristics; age, weight and sex show insignificant difference between both groups. The mechanism of injury and associated injury was insignificantly different between both groups [Table 1].

Table 1. Patients' characteristics, comparison between the two studied groups according to mechanism of injury and associated injury

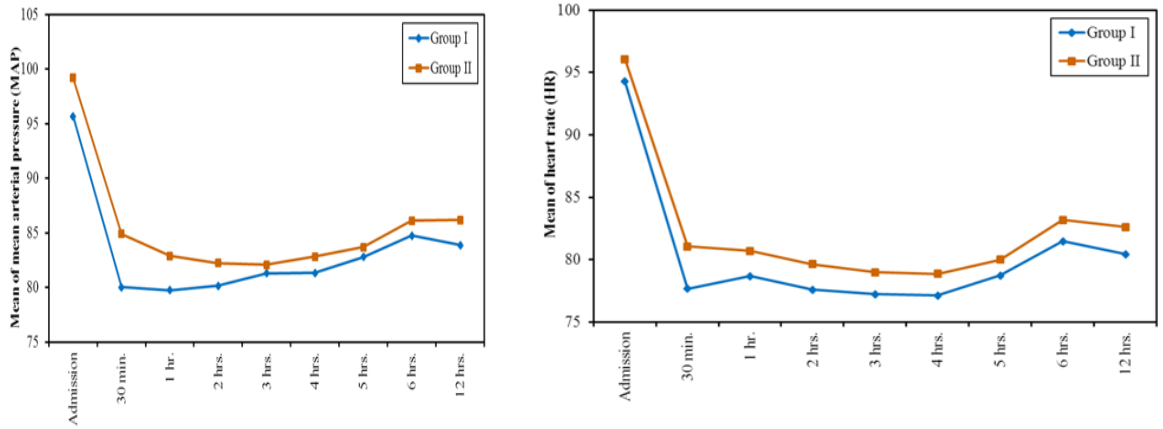
	Age (years)		Sex		Weight (kg)	
	Group I	Group II	Group I	Group II	Group I	Group II
Min.	18.0	19.0	Male=	Male=	55.0	54.0
Max.	65.0	67.0	18 (60.0%)	17 (56.7%)	95.0	95.0
Mean	40.63	40.17	Female=	Female=	76.57	75.43
±SD.	14.29	14.37	12 (40.0%)	13 (43.3%)	12.08	10.14
Test of sig. (p)	t= 0.126 (0.900)		χ2= 0.069 (0.793)		t= 0.394 (0.695)	
Mechanism of injury	Group I (n = 30)		Group II (n = 30)		χ2	P
Road traffic accident	14(46.7%)		17 (56.7%)		0.601	0.438

	Age (years)		Sex		Weight (kg)	
	Group I	Group II	Group I	Group II	Group I	Group II
Crush injury	8 (26.7%)		4 (13.3%)		1.667	0.197
Fall from height	5 (16.7%)		7 (23.3%)		0.417	0.519
Other Associated injury	3 (10.0%)		2 (6.7%)		0.218	FEp=1.000
Flail segment	4 (13.3%)		6 (20.0%)		0.480	0.488
Contusion	3 (10.0%)		3 10.0%)		0.000	FEp=1.000
Hemothorax	4 (13.3%)		5 (16.7%)		0.131	FEp=1.000
Pneumothorax	5 (16.7%)		4 (13.3%)		0.131	FEp=1.000
Chest tube	6 (20.0%)		9 (30.0%)		0.800	0.371
Emphysema	3 (10.0%)		2 (6.7%)		0.218	FEp=1.000
Flail segment	4 (13.3%)		6 (20.0%)		0.480	0.488

χ^2: Chi square test, t: Student t-test, p: p value for comparing between the studied groups, FE: Fisher Exact

There was an insignificant difference in MAP and HR between the studied groups at all time intervals [Fig. 2].

There was an insignificant difference in oxygen saturation and RR between the studied groups at all time intervals [Table 2].



(A) **(B)**

Fig. 2. Comparison between the two studied groups according (A) MAP and (B) HR

Table 2. Comparison between the two studied groups according to oxygen saturation and respiratory rate

Oxygen saturation	Group I (n = 30)	Group II (n = 30)	t	p
Admission	93.97 ± 2.01	93.97 ± 2.03	0.000	1.000
30 min.	96.37 ± 1.27	96.47 ± 1.74	0.254	0.800
1st day	97.20 ± 1.10	97.17 ± 1.58	0.095	0.925
2nd day	97.33 ± 1.58	96.80 ± 1.35	1.404	0.166
3rd day	97.57 ± 1.55	96.90 ± 1.56	1.662	0.102
4th day	98.0 ± 1.46	97.70 ± 1.62	0.752	0.455
Respiratory rate				
Admission	23.63 ± 2.98	24.90 ± 3.38	1.541	0.129
30 min.	16.30 ± 2.89	17.20 ± 2.59	1.270	0.209
1 hr.	14.43 ± 2.13	15.43 ± 2.53	1.657	0.103
2 hrs.	13.53 ± 1.70	14.20 ± 1.61	1.563	0.123
3 hrs.	13.73 ± 2.12	13.33 ± 1.42	0.859	0.394

Oxygen saturation	Group I (n = 30)	Group II (n = 30)	t	p
4 hrs.	13.40 ± 1.59	13.80 ± 1.40	1.035	0.305
5 hrs.	14.20 ± 1.75	14.50 ± 2.15	0.593	0.555
6 hrs.	16.10 ± 2.35	16.40 ± 2.92	0.438	0.663
12 hrs.	15.80 ± 2.34	16.87 ± 2.87	1.577	0.120
24 hrs.	15.40 ± 2.76	15.87 ± 2.67	0.665	0.509
1st day	15.60 ± 2.33	16.07 ± 2.15	0.807	0.423
2nd day	13.87 ± 1.89	13.70 ± 1.29	0.399	0.691
3rd day	13.10 ± 1.03	13.03 ± 1.16	0.236	0.815
4th day	12.60 ± 0.86	12.90 ± 1.09	1.184	0.241

Data was expressed by using mean ± SD, t: Student t-test, p: p value for comparing between the two groups

There was an insignificant difference in P/F ratio between the studied groups at all time intervals [Fig. 3].

There was an insignificant difference in VAS at rest between the studied groups at all time intervals [Fig. 4].

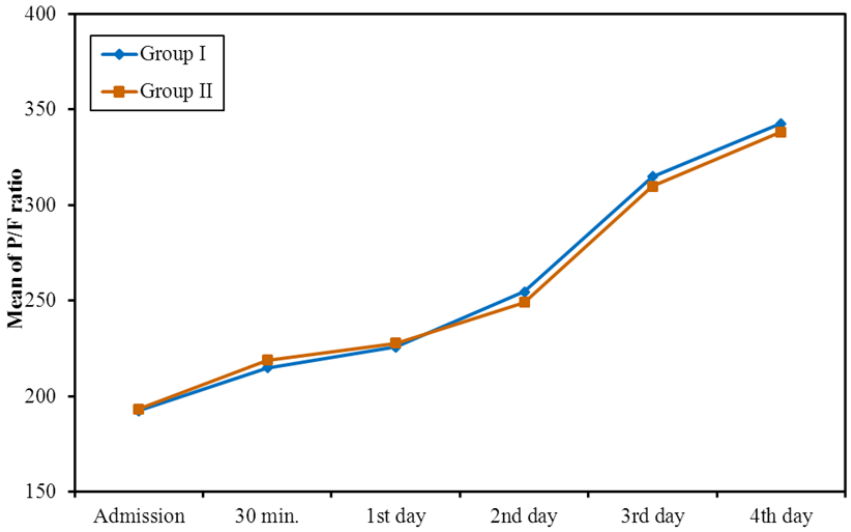
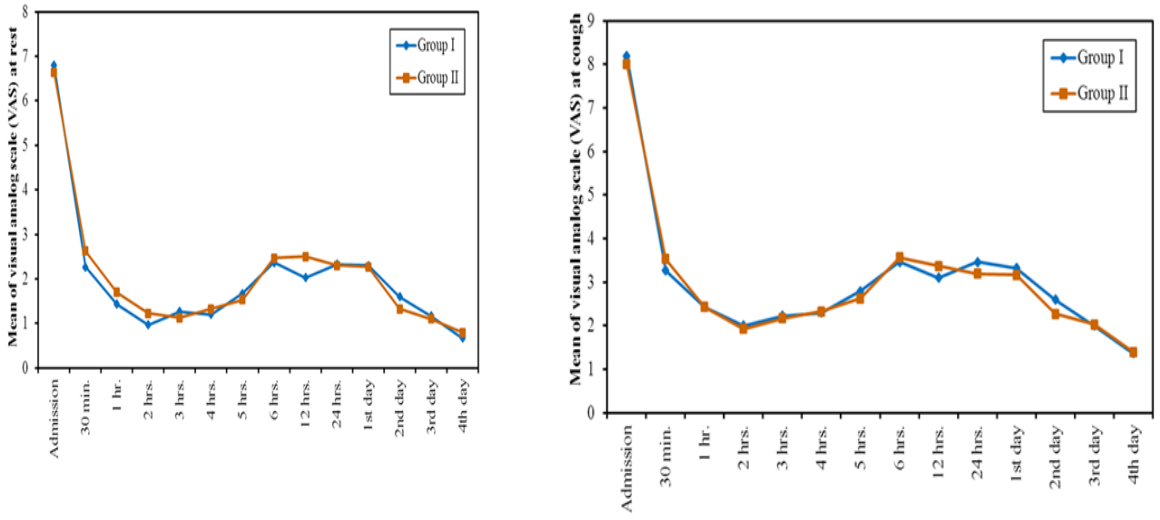


Fig. 3. Comparison between the two studied groups according to P/F ratio



(A) **(B)**

Fig. 4. Comparison between the two studied groups according to visual analog scale (VAS) at rest (A) and at cough (B)

Morphine consumption(mg) was insignificantly different between two groups [Fig. 5].

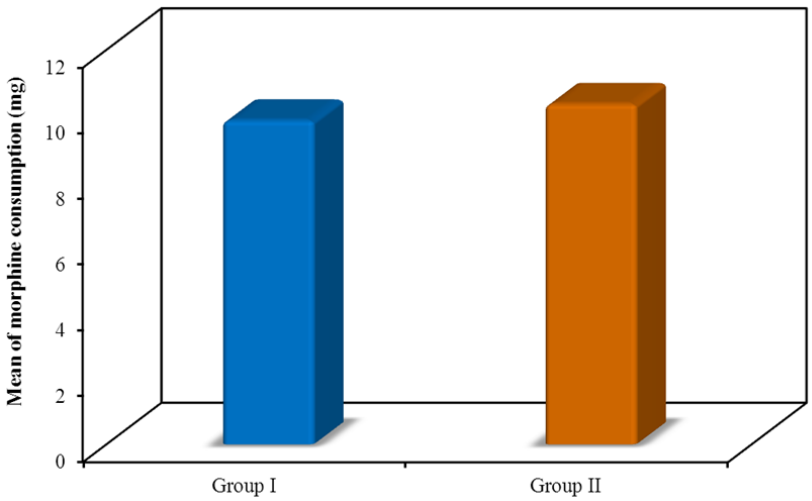


Fig. 5. Comparison between the two studied groups according to morphine consumption

Table 3. Comparison between the two studied groups according to complication

Complications	Group I (n = 30)	Group II (n = 30)	χ^2	p
	N (%)	N (%)		
Hypotension	8 (26.7%)	2 (6.7%)	4.320	**0.038***
Bradycardia	4 (13.3%)	1 (3.3%)	1.964	FEp=0.353
Catheter related	0 (0.0%)	0 (0.0%)	–	–
Pneumothorax	2 (6.7%)	0 (0.0%)	2.069	FEp=0.492
LAST	0 (0.0%)	0 (0.0%)	–	–
Resp. depression	0 (0.0%)	0 (0.0%)	–	–
Bilat. Block	0 (0.0%)	0 (0.0%)	-	-

*χ^2: Chi square test, FE: Fisher Exact, p: p value for comparing between the studied groups, *: Statistically significant at p ≤ 0.05*

The number of patients who developed hypotension was significantly different between two groups while the number of patients who developed bradycardia or pneumothorax was insignificant different between two groups. None of the patients in both groups developed bilateral block, catheter related complications, local anesthetic systemic toxicity, or respiratory depression [Table 3].

4. DISCUSSION

Patients with rib fractures or chest contusions are unable to cough or breathe deeply, which may lead to atelectasis and pneumonia. Additionally, patients have sustained pulmonary contusion because of the damage. This may result in acute respiratory distress syndrome and/or respiratory failure, with some patients requiring mechanical ventilation [8].

Our results revealed that both blocks provided significant reduction in VAS scores at rest and on coughing at all-time points after institution of both blocks. There was no significant difference between both groups as regard VAS scores at rest and on coughing. Also, an insignificant difference between both groups in morphine requirements. This significant decrease in VAS scores can be explained by the fact that both TPVB and ESPB provide sensory and somatic block of thoracic nerves [9,10]. In line with our results, Fang et al. [11] who investigated 94 cases comparing ultrasound-guided preoperative single-dose ESPB versus TPVB following thoracotomy and found that VAS was insignificantly different at rest and during coughing between the TPVB group and ESPB group. No difference in total press times of PCA between the groups. Also, El Ghamry et al. [12] compared the role of ESPB versus PVB in pain

control after modified radical mastectomy. They reported that post-operative 24 h morphine consumption and VAS were comparable between both groups over the 24 h of study.

Regarding the analgesic effect of ESPB in fracture ribs, our findings were in line with Adhikary et al. [9] who discussed the influence of ESPB on respiratory and analgesic outcomes in multiple rib fractures on 79 patients. They showed that maximum NRS pain scores were significantly reduced from baseline from mean (SD) 7.7 (2.5) to 4.7 (3.2). There was a 39 percent drop in the first three hours, followed by a modest increase over time.

In disagreement with our results, Chen et al. [13] investigated the efficacy of ultrasound-guided intercostal nerve block, single-injection ESPB, and multiple-injection PVB on postoperative analgesia after thoracoscopic surgery. At rest and during coughing, the PVB group exhibited considerably lower VAS values than the ESPB group. During the 48 postoperative hours, the ESPB group required additional rescue analgesia. These results may be secondary to multiple injection in TPVB group.

As regard to hemodynamics our results revealed that MAP and HR significantly decreased in both groups at all time intervals compared with pre block value.

As regards incidence of hypotension episodes and bradycardia and in consistence with our results, Fang et al. [11] in their study found that hypotension episodes was significantly higher in the TPVB group than in the ESPB group (21.7% vs. 6.7% respectively), as did bradycardia (4 patients in the TPVB group versus 0 patients in the ESPB group).

As regard respiratory and arterial blood gases ABG parameters, our results revealed significant decrease in respiratory rate, significant improvement in oxygen saturation and P/F ratio at all time intervals compared to pre block value in both groups. There was no significant difference between the two groups. In line with our results, Karmakar et al. [4] in their study for continuous TPV infusion in patients with MRFs found a significant decrease in RR, significant increase in Sao2 and P/F ratio. These enhancements also were remained for the 4 days that the thoracic paravertebral infusion was in usage.

Regarding ESPB effect on respiratory functions in fracture ribs , Adhikary et al. [9] revealed a significant increase in incentive spirometry volume and this was sustained for 72 hrs. Moreover, Klesius et al. [14] in a case report study using bilateral ESPB proved improvement in respiratory status in the form of successful weaning from high flow nasal cannula (HFNC).

Our study has some limitations. First, we did not compare the exact level of the block by sensory testing. Second, respiratory functions were better assessed via lung volumes like forced expiratory volume. Additional researches are recommended to assess the effectiveness and safety of ESPB compared to other regional techniques.

5. CONCLUSIONS

The present study showed that ESPB is nearly as effective as TPVB for pain relief in cases with rib fractures as demonstrated by significant decrease in VAS scores in both groups. The occurrence of complications is lower in ESPB group than TPVB group. Also, being easier to perform ESPB may be recommended as an alternative to TPVB.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

ETHICAL APPROVAL

As per international standard or university standard written ethical approval has been collected and preserved by the author(s).

CONSENT

As per international standard or university standard, patients' written consent has been collected and preserved by the author(s).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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