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Ultrasound -guided erector spinae plane block (ESPB) versus intravenous opioids based analgesia in patients with rib fractures

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ABSTRACT

Background: There has been a great interest in the erector spinae plane block (ESPB) to control pain in patients who are presented with rib fractures. ESPB has been shown to achieve adequate analgesia with little adverse effects, although its effectiveness in comparison to other analgesic alternatives has not been sufficiently studied.

Aim of the study: Our target was to compare the effectiveness of ESPB and opioid based analgesia in relieving pain in rib fractures patients.

Methodology: Fifty-two patients between 21 and 60 years old, divided into 2 equal groups, received either Ultrasound-guided (US) ESPB with 20 ml of bupivacaine 0.25% or intravenous (IV) morphine 0.1 mg/kg then IV Patient-controlled analgesia (PCA) containing morphine. Assessment of visual analogue scale (VAS) score before and after spirometer exercise at baseline, then at 30 minutes, 6 hours, and 12 hours after the intervention was done. Also Peak Inspiratory Flow Rate (PIFR) was measured by an incentive spirometer, first 12-hour morphine consumption as rescue analgesia was calculated, the incidence of complications was noted, and patients satisfaction was assessed.

Results: The VAS score was higher in morphine group compared to ESPB group before and after spirometry. PIFR was higher in ESPB group. Less opioid consumption and side effects, along with better patient satisfaction, were recorded in the ESPB group.

Conclusion: Erector spinae plane block provided superior analgesia and improved respiratory function for IV PCA morphine. Furthermore, ESPB was linked to fewer side effects, less opioid use, and better patient satisfaction.

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KEYWORDS
Erector spinae plane block; morphine; rib fractures

1. Introduction

There is a considerable risk of morbidity and mortality with rib fractures. This is mainly attributed to the intense pain associated with rib fractures, which has a negative impact on the patients' breathing capacity and may result in atelectasis, pneumonia, and eventually respiratory failure [1]. The management plan is to achieve efficient pain relief, chest physiotherapy, and respiratory care [2].

Opioids were previously the most commonly used analgesics in patients with rib fractures, but they have several undesirable complications, such as hypoventilation, a diminished cough reflex, and confusion. Now, the use of multimodal analgesia is more evident, including thoracic epidural analgesia and peripheral nerve blocks [3].

The erector spinae plane block is a novel fascial plane block. Its use has been documented in numerous instances with positive outcomes in controlling acute as well as chronic pain. The most popular technique was the single shot. The procedure is simple to use with a low incidence of complications [4].

This study compared the effectiveness of ESPB and systemic opioids based analgesia in patients with rib fractures.

2. Objectives of study

The primary outcomes included evaluation of pain control using the VAS score before and after respiratory effort and assessment of changes in PIFR using an incentive spirometer. The secondary outcomes included the recording of opioid (morphine) use as rescue analgesia in 12 hours, the rate of complications (such as vomiting, pneumothorax, seizures, bradycardia, and hypotension) and if the patients were satisfied with the analgesia or not.

3. Patients and methods

This study was a prospective randomized comparative study performed from July 2021 to June 2022 at Ain

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Shams University Hospitals, after being approved by the research ethics committee at the faculty of medicine, Ain Shams University (FMASU MD 100/2021) and registered with the Pan African Clinical Trial Registry, identifier PACTR202301909806348. All patients had signed informed written consent and were divided randomly into 2 equal groups, each containing 26 patients, using a computer generated random numbers table.

Group A: Patients were given US-guided ESPB with 20 ml of bupivacaine 0.25%.

Group B: Patients were given intravenous morphine 0.1 mg/kg, then provided with an IV PCA device of 100 ml volume containing 40 mg of morphine and normal saline at a rate of 2 ml/h.

3.1. Inclusion criteria

- Patients between 21 and 60 years old.
- Both sexes.
- ASA 1 or 2 patients.
- Patients presented with multiple unilateral consecutive rib fractures (three or more) and were admitted to ICU.

3.2. Exclusion criteria

- Patients who refused the intervention or participation in this study.
- Patients who could not achieve effective communication.
- Patients with a fractured sternum.
- Bleeding disorders.
- Relevant drug allergy.
- Significant lung or pleural injuries.
- Significant traumatic injuries, e.g., pelvic or spine fractures, injuries of the abdominal viscera, or severe injuries affecting the spinal cord or the brain.
- Intubated patients.
- Local infection at the site of intervention.

4. Study interventions

Fifty-two patients in the ICU with unilateral multiple rib fractures (3 or more) were enrolled in this study after taking a complete medical history, revising their laboratory and radiological investigations, and ensuring that they fulfilled the inclusion criteria. A Chest examination was done, hemodynamic monitors were attached (pulse oximetry, temperature, non-invasive arterial blood pressure, and a 5-lead electrocardiogram). Pain was assessed using the VAS pain score, donated by 0 meaning absent pain, 10 meaning extreme pain. Tidal volume was measured by an incentive spirometer as an index of PIFR. We randomly divided the patients into 2 groups, with 26 patients in each.

4.1. For group A

Patients in this group received ESPB, which was administered in a lateral decubitus position. Patients received IV midazolam (0.05 mg/kg) to safely perform the procedure. The desired vertebral level corresponded to the middle of the extent of the broken ribs. The linear high frequency US probe (Sonosite, Bothell, Washington, USA) was used to localize the tip of the transverse process of the desired vertebra. It was placed in a cephalo-caudal direction, 3 cm from the spinous process. After sterilization, 2-3 ml of 2% lignocaine were injected into the skin and subcutaneous layer. After fixing the transducer on the desired transverse process, we introduced a 22-gauge, 90-mm needle (Spinocan, B. Braun, Germany) in-plane to the US beam in a cephalo-caudal orientation to reach the transverse process. Then we aspirated to rule out accidental vascular puncture and injected 1-2 ml of normal saline to verify proper needle tip positioning. A fluid line was seen spreading below the erector spinae muscle, splitting it from the transverse process. A 20-ml bolus of plain bupivacaine 0.25% was administered.

4.2. For group B

Patients in this group received IV morphine 0.1 mg/kg then were provided with an IV PCA device of 100 ml volume containing 40 mg of morphine and normal saline at a rate of 2 ml/h.

4.3. Outcome assessments

The primary outcomes of interest were as follows: pain evaluation, which was done with a 10 cm VAS score at rest and after spirometer exercise (10 cm worst pain, 0 cm absent pain). Pain evaluation was performed before intervention, then 30 minutes, 6 hours and 12 hours after intervention. Incentive spirometer volume was measured before the intervention, then 30 min, 6 h and 12 h after the intervention to record the amount of balls elevated in the spirometer, which was considered an indicator of PIFR (1 ball = 600 ml, 2 balls = 900 ml, 3 balls = 1200 ml) [5].

Secondary outcomes included rescue morphine requirements in 12 hours, recorded in both groups. when the VAS score was equal to or more than 4 at any assessment (30 min, 6 h, and 12 h after the intervention), morphine 0.05 mg/kg IV was given. Any complications during or after the intervention were recorded. The patients satisfaction was assessed by asking the patients if they were satisfied by the analgesia or not and the number of satisfied patients were recorded.

5. Statistical analysis

Sample size was established with G Power software, with power at 80% and α-error at 0.05. As there was no previous literature comparing these two methods, a large effect size difference was assumed between the two groups regarding continuous outcome measures (e.g., pain score, respiratory function). A sample size of 26 patients for each group (total 52) was needed.

Statistical Package for Social Science (SPSS) version 22.0 was used for data analysis. Quantitative data were represented as mean± standard deviation (SD) or median (IQR) when indicated. Percentage and frequency were used to demonstrate qualitative data.

5.1. The tests used were as follows

- When comparing 2 means, the independent-samples t-test of significance was applied.
- The proportions between 2 qualitative parameters were compared using the Chi-square (X^2) test of significance.
- For two-group comparisons in non-parametric data, Mann–Whitney U test was used
- The accepted margin of error was set at 5%, and the confidence interval was set at 95%. The p-value was therefore deemed significant as follows:
- Probability (P-value)
- A P-value below 0.05 was regarded as significant.
- A P-value below 0.001 was regarded as highly significant.
- A P-value equal to or above 0.05 was regarded as non-significant.

6. Results

6.1. Demographics and ASA

The 2 groups were compared for age, ASA, sex, and body weight without a statistically significant difference between them (Table 1).

6.2. Peak inspiratory flow rate(pifr)

PIFR was significantly lower in the morphine group compared to ESPB group (Table 2).

6.3. Pain control

ESPB achieved better pain relief with a statistically significant difference at 30 min, 6 h, and 12 h, at rest and after spirometry (Table 3).

6.4. Complications

A statistically significant difference was shown between groups with regard to vomiting. It was only detected in the morphine group, and no other complications such as pneumothorax, respiratory depression, or local anesthetic toxicity could be detected (Table 5).

Table 1. Comparison between 2 groups regarding Age, Sex, ASA, and Body weight.

		ESPB group (*n*=26)	Morphine group (*n*=26)	T/x2	p-value
Age (years)		35.88±10.0	36.19±9.8	0.11 ^{t}	0.91
ASA	I	16 (61.5%)	20 (76.9%)	1.4 ^{x2}	0.23
	II	10 (38.5%)	6 (23.1%)		
Sex	Male	23 (88.46%)	20 (76.9%)	1.2^{x2}	0.27
	Female	3 (11.54%)	6 (23.1%)		
Body weight (kg)		75.04±8.3	77.12±7.6	0.9 ^{t}	0.35

Note: Data were expressed as mean ± SD, proportion., x2= Chi square test, t=student t-test, ESPB=erector spinae plane block.

Table 2. Comparison between groups regarding PIFR.

Peak inspiratory flow (PIFR) (ml/sec)	ESPB group (*n*=26)	Morphine group (*n*=26)	T	p-value
Peak inspiratory flow rate (spirometer) before intervention	315.38±112.0	269.23±83.8	1.6	0.10
Peak inspiratory flow rate (spirometer) 30 min	688.46±147.9	526.92±100.2	4.6	**<0.001**
Peak inspiratory flow rate (spirometer) 6h	869.23±97.0	619.23±109.6	8.7	**<0.001**
Peak inspiratory flow rate (spirometer)12h	875.00±84.0	650.00±110.5	8.3	**<0.001**

Note: Data expressed as mean ± SD, *t* = student t test, ESPB=erectors pine plane block. P-value < 0.05 is significant.

Table 3. Comparison between 2 groups regarding VAS score.

	ESPB group (*n*=26)			Morphine group (*n*=26)			
Variable	Range	Median	IQR	Range	Median	IQR	P-value
VAS at rest before intervention	6–9	8	7–8	6–9	8	7–8	0.433
VAS at rest 30min after intervention	2–4	3	2–3	3–5	4	3–4	**<0.001**
VAS at rest 6h	1–3	2	1–2	1–5	3.5	3–4	**<0.001**
VAS at rest 12h	1–3	2	1–2	1–4	3	3–4	**<0.001**
VAS after spirometry before intervention	7–9	8	8–8	7–9	8	8–9	0.400
VAS after spirometer 30 min	3–5	3	3–4	3–6	4.5	4–5	**<0.001**
VAS after spirometer 6h	1–3	2	2–3	3–5	4	4–5	**<0.001**
VAS after spirometer 12h	1–4	2.5	2–3	2–5	4	3–4	**<0.001**

Note: Data expressed as median and IQR, *P* = Mann–Whitney test, ESPB=erector spine plane block. P-value< 0.05 is significant.
The two groups were compared with regard to the amount of morphine consumed as rescue analgesia. In the ESPB group, it was significantly less **Table 4**).

Table 4. Comparison between groups regarding rescue morphine consumption.

	ESPB group (*n*=26)	Morphine group (*n*=26)	t/x2	p-value
Patient needs rescue analgesia	8 (30.8%)	19 (73.1%)	9.1^{X2}	**0.003**
Dose of rescue analgesia (mg)	6.88±0.6 (*n*=8)	7.89±1.7 (*n*=19)	2.3^{t}	**0.03**

Note: Data expressed as mean ± SD, proportion, x2= Chi square test, *t* = student t test, ESPB=erector spinae plane block. P-value< 0.05 is significant.

Table 5. Comparison between two groups regarding complications.

	ESPB group (*n*=26)	Morphine group (*n*=26)	X2	p-value
Vomiting	0(0%)	4 (15.4%)	4.2^{X2}	**0.04**

Note: Data were expressed as, proportion, x2= Chi square test, ESPB=erector spine plane block, p-value< 0.05 is significant.

Table 6. Comparison between groups as regard patients' satisfaction.

	ESPB group (*n* = 26)	Morphine group (*n* = 26)	X2	p-value
Patients satisfaction	21(80.8%)	10 (38.5%)	9.5^{X2}	**0.002**

Data were expressed as, proportion, x2= Chi square test, ESPB=erector spinae plane block, p-value<0.05 is significant.

6.5. Patients satisfaction

In comparison to the morphine group, the number of patients satisfied with the analgesia in the ESPB group was significantly higher (Table 6).

7. Discussion

Our study focused on patients who had at least three rib fractures, as these injuries have higher mortality rates and require prolonged hospital and ICU stays. Multiple rib fracture pain can result in muscle spasms and voluntary splinting that result in atelectasis, hypoventilation, pneumonia, and respiratory failure. Effective analgesia that is started as soon as possible reduces hypoventilation, allowing appropriate coughing and cooperation with chest physical therapy, which lessens subsequent pulmonary complications.

The cornerstone of pain management has been multimodal systemic analgesics using IV patient-controlled opioids, which are satisfactory for patients who have one or two rib fractures. However, research and clinical experience have confirmed that regional analgesic techniques as serratus anterior plane, thoracic epidural, intercostal, and thoracic paravertebral blocks achieve better analgesia for fractures involving more than three ribs [6]. Elderly patients and patients having extreme pain or diminished pulmonary function benefit most from regional methods [7].

Although thoracic epidural is effective in pain management, it is not suitable for many trauma patients, as they may suffer from head or spinal injuries or be on anticoagulant therapy. Other limitations to thoracic epidural include a significant rate of technical failure, the possibility of hypotension or urinary retention, the requirement of nursing care and monitoring, and longer hospital stay. Another regional technique is the paravertebral block, which is efficient in pain management but may be associated with complications as pneumothorax. ESPB has been surrounded by great enthusiasm as it is safer and simpler than Paravertebral block [8].

Erector spinae plane block is delivered mainly by an in-plane US-guided approach. Local anesthetic is administered between the erector spinae muscle and the thoracic transverse process [9]. Consequently, dorsal and ventral rami of the abdominal and thoracic spinal nerves are blocked, resulting in a multi-dermatomal sensory block of posterior, lateral, and anterior abdominal and thoracic walls [9,10]. This block may be attributed to local anesthetic spreading cranially and caudally with the help of the thoracolumbar fascia extending along the posterior thoracic wall and abdomen [10].

Chin et al investigated the local anesthetic spread in cadavers and found that, radiologically, it extended three or four levels in cranial and caudal directions from the site of injection [11]. A newer study used the MRI to detect local anesthetics' transforaminal and epidural diffusion in ESPB. This study mentioned the advantage of ESPB over other thoracic interfacial plane blocks as it produces abdominal visceral analgesia [12].

In our study, 52 patients fulfilled the inclusion criteria, and ESPB with bupivacaine or IV opioid analgesia was given. Pain scores recorded at rest and after spirometry were much lower in the ESPB group than IVPCA group at all time intervals. Therefore, ESPB may achieve better analgesia than IV PCA. Our findings match those of Adikary et al, in their retrospective study, which included 79 patients with multiple fractured ribs who received ESPB. They concluded that ESPB should be taken in consideration as a potential substitute to other analgesic techniques as it was associated with better analgesic outcomes and increased inspiratory capacity after rib fractures, and was not accompanied by haemodynamic instability [8].

As demonstrated by randomized controlled trials, bilateral ESPBs offer better analgesia than systemic analgesics for post-sternotomy pain relief after cardiac surgery. Krishna et al compared, in their single-blind, single-center, randomized controlled study, preoperative ESPBs and conventional medical management. They discovered reduced first 12-hour total fentanyl use, a longer time before first rescue analgesia was administered, better pain scores through 10 hours after extubation, and decreased sedation scores [13]. Additionally, as reported by Nagaraja PS et al in their study which compared bilateral ESPB to continuous epidural analgesia for perioperative pain management in cardiac surgery, both techniques have equal analgesic effect [5].

In our study, we considered the incentive spirometer volume as an indicator of PIFR [5,14]. A statistically significant difference was noted between groups in the measurements 30 minutes, 6 hours and 12 hours after the intervention. The ESPB group showed higher PIFR than the Morphine group, indicating that ESPB was accompanied by better respiratory functions, which is consistent with Adikary et al's results [8].

Regarding the 1st 12-hours rescue morphine use as a secondary outcome of this study, it was much lower in the ESBP group. Furthermore, the patients required rescue analgesia were more in the IV morphine group, which consolidate the fact that ESPB provides better analgesia than IV morphine in patients with fractured ribs.

In this study, any side effects in both groups were documented. Vomiting was only detected in four patients in the morphine group. In the ESPB group, no side effects were detected.

Also in our study, we assessed the patients' satisfaction in each group, the number of satisfied patients was recorded and it was significantly higher in the ESPB group.

8. Conclusion

ESPB provided superior analgesia and improved respiratory function compared to IV PCA morphine. Furthermore, ESPB was associated with fewer side effects, less opioid use, and better patients' satisfaction.

9. Limitations to our study

Some limitations to our study were found. First, data were collected at few time intervals to prevent annoying the patients. Second, parameters as respiratory rate and end tidal CO2 were not incorporated in the study. So, future studies need to include more parameters.

10. Future scope

Incorporating ESPB as a principle method of analgesia in patients with rib fractures can improve pain management, facilitate respiratory rehabilitation, and decrease hospital stays.

Abbreviations

US	Ultra Sound.
ESPB	Erector Spinae Plane Block.
IV	Intravenous.
VAS	Visual Analogue Scale
PIFR	Peak Inspiratory Flow Rate.
PCA	Patient Controlled Analgesia.
ICU	Intensive Care Unit.

Disclosure statement

No potential conflict of interest was reported by the authors.

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