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Comparison of thoracic epidural and thoracic erector spinae plane block for pain relief of posterolateral rib fractures—a retrospective cohort study

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Abstract

Background: Pain from rib fractures (posterior/lateral/anterior) is associated with significant pulmonary morbidity. Earlier epidural and paravertebral blocks were implemented in the algorithm for multimodal pain management of rib fracture pain. Administration of these blocks are fraught with challenges encountered in intensive care unit (ICU). The erector spinae plane block (ESPB) is a viable alternative in ICU set up.

This retrospective study compared continuous thoracic ESPB and continuous thoracic epidural analgesia (TEA) [$n=28$ versus $n=24$] for polytrauma patients who sustained unilateral multiple rib fractures (MRFs), i.e., more than 3 admitted in ICU. Demography data were noted and compared. Outcome measures were block efficacy in terms of pain scores, opioid consumption (intravenous fentanyl), technical difficulties, and complications.

Results: Age, gender, and sides of ribs fractures were comparable in all groups. Pain scores and fentanyl consumption were significantly better in patients who received TEA.

Conclusions: Though statistically significant analgesic efficacy was observed with continuous TEA for managing pain due to unilateral posterolateral MRFs, the small sample size was a major limitation. Further prospective comparative study including effects on incentive spirometry and effectiveness of chest physiotherapy is warranted. However, continuous ESPB is simple and safe to perform with few theoretical contraindications.

Keywords: Rib fractures, Epidural block, Erector spinae, Ultrasound, Acute pain

Background

Multiple rib fractures (MRFs), due to high velocity blunt thoracic trauma, require intensive care unit (ICU) admission and are associated with significant morbidity and mortality as high as 33% (Pressley et al., 2012). Inadequately managed thoracic cage pain and inability to cough predisposes to significant atelectasis, retention of pulmonary secretions, and pneumonia (Kent et al., 2008).

Non-opioids have limitations and opioids lead to undesirable hypoventilation. Benefits of regional anaesthesia techniques are numerous compared to opioid-based analgesia. Along with multimodal analgesia (MMA), a continuous thoracic epidural anaesthesia (TEA) is the recommended technique for post-thoracotomy pain and MRFs. A comparison between TEA and thoracic paravertebral block (TPVB) for MRFs revealed no significant intergroup difference in mean pain scores either at rest or on coughing at different time intervals (Kim et al., 2011; Mohta et al., 2009). Coagulopathy, hemodynamic instability, patients on anticoagulants, and positioning are limitations and contraindications for neuraxial

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and para-neuraxial blocks. Moreover, nerve injuries and epidural hematoma may be unrecognized in critically ill intubated patients. Furthermore, these blocks cannot be administered in the presence of neurologic or spine injuries (Bulger et al., 2008)

Ultrasound (US)-guided erector spinae plane block (ESPB) is an inter-fascial plane block that allows placement of the catheter and local anesthetic infusion in the plane deep to erector spinae muscle and superficial to the transverse processes. A continuous thoracic ESPB has been used successfully in mitigating pain due to MRFs (Thiruvengadarajan et al., 2018; Kumar et al., 2019) and has been incorporated in algorithmic pain management for MRFs in our institution.

To our knowledge, there are no studies comparing the efficacy of ESPB versus TEA in the pain management of MRFs. To design a prospective trial in future, we in a small cohort retrospectively attempted to compare these two techniques for analgesic benefits in patients who sustained posterior and lateral MRFs. The primary aim of the study was to compare 48-h fentanyl consumption in the TEA and thoracic ESPB groups. The secondary aims were to compare visual analog scale (VAS) scores for 48 h, identify the technical difficulties, and record complications in all groups.

Methods

An institutional ethics committee approval was obtained for this retrospective study. All patients included in the study were admitted in trauma ICU of our hospital. The study population included were patients more than 18 years of age admitted with multiple injuries following polytrauma between 1 January 2015 and 31 December 2019 with a diagnosis of MRFs. All patients had some or the other form of associated injuries (head, intra-thoracic, intra-abdominal, upper, and lower extremity). As a part of routine protocol, a whole-body computed tomography (CT) scan was performed in polytrauma patients and findings are noted in the charts. The data obtained from CT chest findings were analyzed for the side and numbers of posterolateral MRFs. Associated findings like extensive subcutaneous emphysema, pneumothorax, pneumomediastinum, and pneumopericardium were noted. Data scanned for laboratory investigations were available for immediate reference. The patients who were taken for emergency surgery (laparotomy, craniotomy, lower limb/pelvic fractures) were not offered either TEA or ESPB for associated MRFs and were thus excluded.

Dataset was acquired manually and a total of 63 polytrauma patients with MRFs were matched from our existing institutional registry who had received a continuous TEA or a continuous thoracic ESPB for unilateral

rib fracture pain between January 2015 and December 2019.

At our institute, we follow a protocol for pain management in patients with fracture ribs. If patient has 2 displaced fracture ribs and/or less than 2 undisplaced fracture ribs and is hemodynamically stable, they are admitted in wards. Pain management is initiated with parenteral non-opioid analgesics and gets a transdermal fentanyl patch. If pain persisted with VAS more than 4, then patient was shifted to ICU for intravenous (IV) fentanyl infusion. If patients are admitted in ICU (polytrauma/hemodynamically unstable), IV fentanyl is infused along with IV paracetamol 1 gm 6th hourly. If VAS persists more than 4, despite above measures, pain physicians are alerted for interventional pain therapy within 12 h of admission. In case of break through pain after an intervention and with a VAS of more than 4, rescue analgesics in the form of IV fentanyl bolus along with the infusion is the policy.

Demographics including the age and number of rib fractures were retrieved. Of the 63 patients, 52 qualified for the study as per inclusion criteria. The remaining 11 patients who were excluded suffered from abdominal, pelvic, head injuries, and bilateral fracture ribs and were hemodynamically unstable.

Block efficacy in both groups were evaluated by total opioid consumption in the form of IV fentanyl administered in the first 48 h after the procedure and VAS score as reported by patients at various time points [1,2,4,6,18,24,30,36,42,48] and were retrieved and compared. All blocks were administered depending on the fracture level of the ribs obtained from CT scan chest.

Techniques performed

All blocks were administered with the catheter tip at the center of rib fractures (fractures of 2–6 ribs, then catheter tip at 4th thoracic vertebral level). TEA was administered in a sitting position with a midline approach and between T3 and 6 intervertebral space with loss of resistance technique in group T, and an initial bolus of 8ml of 0.2% ropivacaine was injected. A catheter was inserted to a distance of 3–4 cm in the epidural space and was followed by an infusion of 0.1% ropivacaine at 5ml/h. An ultrasound-guided ESPB was implemented in sitting position, between T3 and T7 vertebral levels, with needle insertions from caudal to cephalad and these cohorts were referred to as group E. After an initial bolus of 0.2% ropivacaine 25ml was injected deep to the erector muscle and superficial to the transverse process, 20 G catheter was inserted to a distance of 5–6cm in the erector spinae plane. A 0.1% ropivacaine at 8ml/h for 72 h was initiated thereafter.

IV paracetamol 1g was infused every 6 hours in all patients irrespective of the group. Vital parameters were monitored for all patients in ICU. Technical difficulties and complications were noted in the block sheet.

Statistical analysis

Statistical Package for the Social Sciences (SPSS) version 21 was used for statistical analysis. The Kolmogorov-Smirnov test of normality was used to analyze if data were normally distributed. Continuous variables were expressed as mean ± standard deviation. Age and VAS

scores at different time intervals were analyzed using unpaired *t* test. Categorical variables were analyzed using the chi-square test (gender and side of MRFs). *p* value of less than 0.05 was considered as statistically significant. The statistical tests were performed using online tool: www.graphpad.com

Results

Age, gender, and sides of ribs fractures were comparable in both groups (Table 1). Continuous catheter techniques were implemented in both groups. Blocks were performed successfully in all patients and were placed on infusion pumps for 48 h. A 48-h fentanyl consumption was less in groups T compared to E group ($p \leq 0.00001$) (Table 1). Mean fentanyl consumption over 48 h was $174.10 \pm 20.95 \mu\text{g}$ in group E and in group T was $122.91 \pm 22.01 \mu\text{g}$ in 48 h. VAS scores were significantly better in TEA group at 1, 12, 18, 24, 30, 36, 42, and 48 h when compared to patients in E group (*p* values of 0, 0.004, 0, < 0.00001, 0.00008, < 0.00001, < 0.00001, 0.002, respectively) (Table 1, Figs. 1 and 2). **VAS at 2, 4, and 6 h were comparable in both groups.** The VAS demonstrated a stable course in the T group as against the E group which showed a steady increase from the 18th hour requiring rescue fentanyl boluses. **There were no complications in any patient after both the interventions.**

Table 1 showing demographic differences, comparison of pain scores, and 24-h opioid consumption between group T and group E

	Group E (n=28)	Group T (n=24)	<i>p</i> value
Age (years)	44.14 ± 14.26	46.87 ± 13.07	0.238#
Gender (male/female)	13/15	11/13	0.965®
Side (right/left)	15/13	11/13	0.577®
VAS-1	1.67 ± 0.548	1.13 ± 0.344	0
VAS-2	1.53 ± 0.63	1.33 ± 0.48	0.104
VAS-4	2.03 ± 0.63	1.83 ± 0.63	0.129
VAS-6	2.10 ± 0.56	2.12 ± 0.67	0.445
VAS-12	2.46 ± 0.63	2 ± 0.58	0.004
VAS-18	2.84 ± 0.47	2.12 ± 0.67	0
VAS-24	3.14 ± 0.44	2.25 ± 0.60	<0.00001
VAS-30	3.03 ± 0.63	2.50 ± 0.51	0.00008
VAS-36	3.21 ± 0.41	2.45 ± 0.50	<0.00001
VAS-42	2.92 ± 0.26	2.33 ± 0.48	<0.00001
VAS-48	3.21 ± 0.56	2.79 ± 0.41	0.002
48 h fentanyl	174.10 ± 20.95	122.91 ± 22.01	<0.00001

Unpaired *t* test, ®chi-square test, for VAS scores and 24-h fentanyl consumption—unpaired *t* test
p value < 0.05—statistically significant

Discussion

In this retrospective study, the 48-h fentanyl consumption was significantly less in the T group as compared to the E group. Fentanyl requirements were on higher side after the 18th hour in group E. Though TEA is not always shown to be the most effective modality in MRFs (Adhikary et al., 2019a) and the outcomes of the TEA administration have been inconsistent in the MRFs scenario

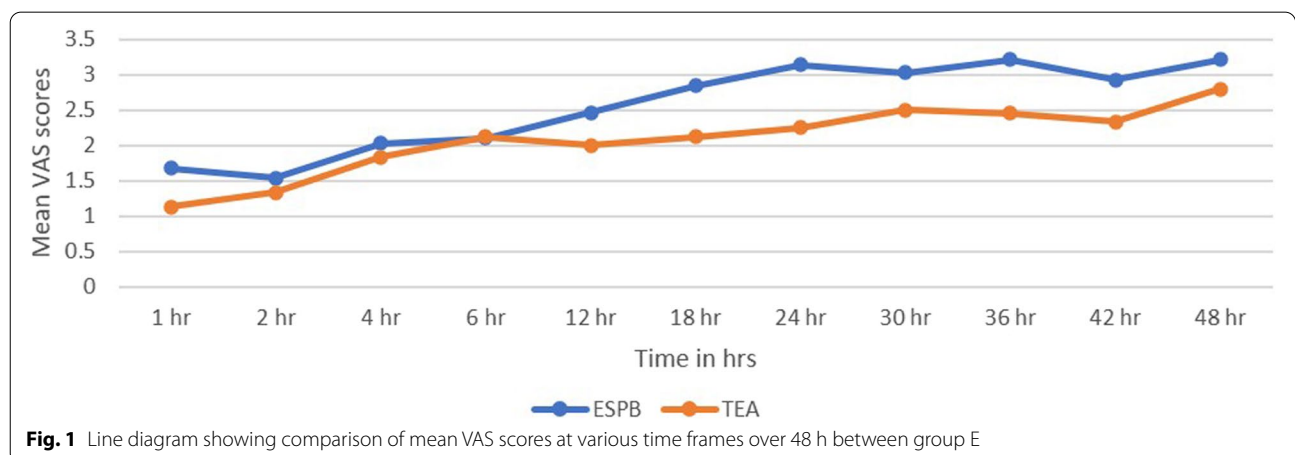
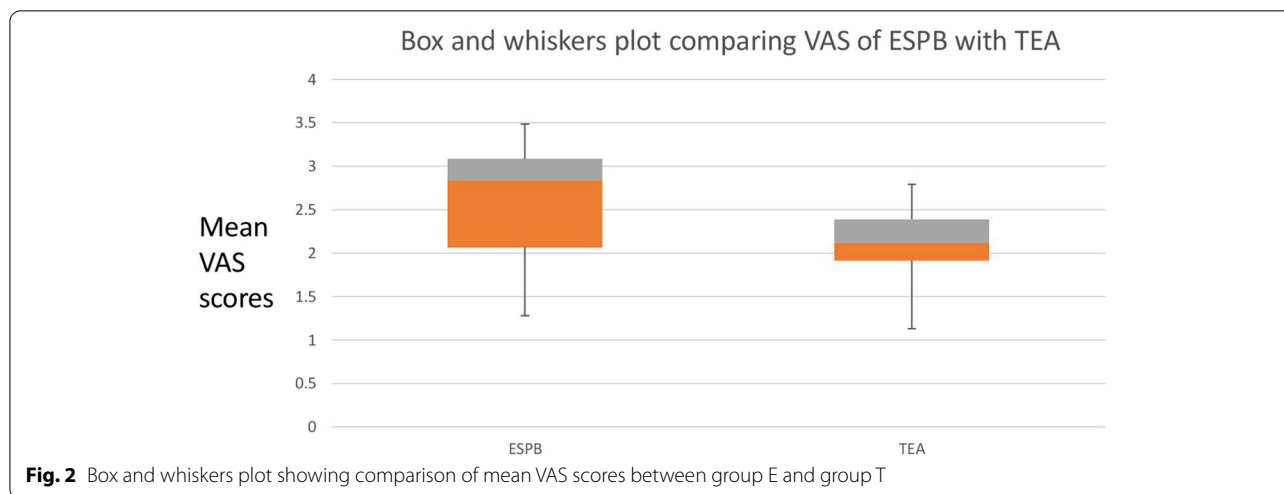


Fig. 1 Line diagram showing comparison of mean VAS scores at various time frames over 48 h between group E



(Peek et al., 2019; McKendy et al., 2017), our study confirms otherwise.

Major limitations of TEA are it is technically more demanding and the incidence of hypotension, lower limb weakness, and retention of urine dictates intensive care admission and improved nursing care (Zaw et al., 2015; Tran et al., 2016). Though considered as a gold standard, TEA is contraindicated in neuraxial or head injuries and anticoagulant therapy. Recent study incriminates TEA worsening in-hospital complications and increase length of hospital stay (Carrier et al., 2009). The TPVB is another alternative for unilateral MRF-related pain (McKendy et al., 2017; Womack et al., 2019; Ho et al., 2011). But it has a steep learning curve and a risk of procedure-associated complications such as a pulmonary hemorrhage (Thomas et al., 1999; Kus et al., 2013) with landmark technique and a pleural puncture with ultrasound guidance have been reported. Further, we perceive in posterior rib fracture the TPVB would be a difficult proposition due to distorted anatomy. A contrast study demonstrated an US-guided TPVB acts through a unilateral epidural spread with volumes of 20ml (Diwan & Nair, 2020a).

In a thoracic ESPB, the injection point is more posterior close to the posterior rib fracture site and the target is the erector spinae plane (ESP), where the dorsal rami are positioned. At a target 3-cm lateral to the spinous process, injections made deep to the erector spinae muscle (ESM) demonstrated a cephalad to caudal, paravertebral, and an epidural spread (Wardhan & Kantamneni, 2020; Forero et al., 2016; Adhikary et al., 2018). A cadaveric study and a clinical case report demonstrate the dye spread from the erector spina plane at the level of T5 into the paravertebral and epidural spaces, though this may not be reproduced at all levels (Diwan et al., 2019; Diwan

& Nair, 2020b). Moreover, we hypothesize that in posterolateral MRF's with fractured costotransverse junctions, ribs, and the ligaments a dorsal local anesthetic (LA) deposition in the erector spinae plane would percolate on ventral aspect into the thoracic paravertebral space (PVS) and the epidural spaces. One of the major advantages of thoracic ESPB is its implementation in anticoagulated patient, which of course is a contraindication for thoracic PVB and TEA (Adhikary et al., 2019b). The serratus anterior plane block (SAPB) is suggested ahead of TEA, and thoracic PVB in an algorithm proposed for the management of MRFs (May et al., 2016) has shown a limited posterior spread of LA with SAPB (Kunigo et al., 2018). Similarly, though a thoracic ESPB is currently included in the algorithm for pain management (Williams et al., 2020) of multiple rib fractures, to our knowledge, a comparison between two or more techniques is lacking.

A small sample exploratory analysis of a retrospective data has its inherent limitations. To demonstrate superiority of block efficacy amongst comparable techniques requires a larger population and a prospective study. In consequence, it is impossible to recommend TEA as the choice for unilateral MRF's. If parameters like incentive spirometry and pain on cough were not evaluated could be another limitation. Though both groups included infusions through the catheter, the initial volumes and infusion volumes vary in the T and E groups, as the latter is closed low-volume compartment and the former is open and high-volume compartment. Catheters and infusion may be unavailable and are costly. Moreover, many anesthesiologists in clinical practice tend perform single bolus or intermittent injections through the catheter for varying reasons. Besides, in polytrauma patients, it is difficult to distinguish the correct pain scores as these patients receive opioid infusions.

Though ESPB is effective in improving pulmonary function with a modest reduction in pain scores when implemented in rib fracture (Adhikary et al., 2019a; Luftig et al., 2018), in our study, both groups had patients with polytrauma and the analgesic outcomes of TEA and thoracic ESPB may have been obscured. Probably a sub-group analysis of patients with fractured ribs of 3, 3–5, and more than 5 and the effects of the interventional technique should have been performed. However, in our study, a small sample size is a limitation for a sub-group analysis. All these flaws could be addressed by performing prospective, well-designed, randomized controlled trial between interventional groups addressing pain management for MRF'S.

For its ease of insertion, maintenance of catheter, and infusion without any adverse effects, thoracic ESPB remains the first choice for all posterolateral MRF'S in our institution. Our study emphasizes the role of thoracic ESPB as an alternative technique for posterior and lateral rib fractures and add to the existing literature (Adhikary et al., 2019a; Luftig et al., 2018).

Conclusions

Although TEA is the gold standard analgesic intervention for MRFS and has been demonstrated in our study also, thoracic ESPB is a relatively simple and reasonably effective intervention in patients with MRFs as a component of MMA.

Abbreviations

TEA: Thoracic epidural analgesia; ESPB: Erector spinae plane block; MRFs: Multiple rib fractures; VAS: Visual analog scale; ICU: Intensive care unit; MMA: Multimodal analgesia; TPVB: Thoracic paravertebral block; US: Ultrasound; CT: Computed tomography; IV: Intravenous; ANOVA: Analysis of variation.

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Authors' contributions

SMD: literature review, manuscript preparation, concepts, and design. BA: manuscript review and data analysis. AN: literature review, manuscript editing, final draft, and data analysis. PS: manuscript review and data analysis. The authors read and approved the final version of the manuscript.

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Declarations

Ethics approval and consent to participate

An Institutional Ethics committee approval was obtained for this retrospective study from Sancheti Hospital for Orthopedics & Rehabilitation, Pune-411005, India. As mentioned in the title, it was a retrospective study. Therefore, only ethical approval was sought to conduct this retrospective study.

Consent for publication

Not applicable

Competing interests

The author declare that they have no competing interests.

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