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Research Article

Acute pain services in flail chest-a prospective randomized trial of epidural versus parenteral analgesia in mechanically ventilated ICU patients

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KEYWORDS

Flail chest;
Acute pain service;
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Abstract *Introduction:* Flail chest following blunt trauma chest generally leads to severe pulmonary complications. Thoracic epidural analgesia by means of reducing the pain and consequent splinting may prove beneficial in improving the patient outcome in mechanically ventilated ICU patients.

Methods: Twenty patients, 18–55 years of age having ⩾3 rib fractures with flail segment, and required mechanical ventilation in the year 2012–14 were included. Patients were randomly divided into groups of 10 patients each to receive either thoracic epidural analgesia with 4 mL of 0.125% bupivacaine bolus followed by infusion @ 4 mL/h with 2 μg/mL fentanyl as adjuvant (Group E) or parenteral analgesia in the form of i.v fentanyl in a dose of 2 μg/kg (group P). Duration of mechanical ventilation, change in tidal volume during initial 24 h, pneumonia, ARDS, length of ICU stay, mortality along with complication were recorded.

Results: Duration of mechanical ventilation was significantly less in Group E than in group P (6 ± 2 days v/s 9 ± 3 days, $p = 0.02$). There was significant increase of tidal volume in 1st 24 h in group E (ΔTV: 156 ± 24 mL v/s 78 ± 13 mL in group E & P; $p < 0.001$). Incidence of pneumonia was 20% and 40% ($p = 0.63$) while ARDS was 20% and 35% ($p = 0.35$), in Group E and P respectively. Mortality was not different; however, length of ICU stay was significantly less in group E (9.5 ± 1.6 d v/s 12.8 ± 2.8 d, $p = 0.004$). No serious adverse effects were observed in any of the groups.

Conclusion: Epidural analgesia significantly decreased the length of ICU stay and duration of mechanical ventilation in our study population.

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1. Introduction

Out of all the patients hospitalized for blunt trauma chest, 10–20% suffer from flail chest with a mortality rate as high as 35% [1]. It is also observed that the fracture of 3 or more ribs leads to increased mortality and length of intensive care unit (ICU) and hospital stay especially in elderly patients [2]. Greater understanding of the pathophysiology of flail chest in recent era suggests that the associated morbidity is primarily due to contusion, pneumothorax and damage to thoracic structures [3]. Therefore, curtailment of further injury to the underlying lung, provision of adequate analgesia, and maintenance of oxygenation remain the principles of flail chest management [4]. In the past, surgical fixation was the main treatment in flail chest but with the improvement in intensive care facilities, non-operative methods in the form of positive pressure ventilation have gained popularity [3]. It has been shown that optimal use analgesic modalities, physiotherapy and noninvasive ventilation (NIV) could obviate the need for invasive mechanical ventilation in most of these patients.

The pain associated with rib fracture impairs ventilation with resultant increase in pulmonary morbidity [2]. Splinting as a reaction to pain leads to reduction in tidal volume and functional residual capacity [4] (FRC) predisposing to atelectasis and hypoxemia [3]. Moreover, Ventilation perfusion mismatch secondary to contusion, hematoma and increased oxygen consumption further aggravates the hypoxia in these patients [5]. Administration of analgesia is not only ethical but it also allows improved chest wall excursion and alveolar ventilation, decreasing the incidence of pulmonary complications and frequently encountered hypoxia. Management of these patients is therefore centered on achieving aggressive pain control and pulmonary toilet to decrease the incidence of pneumonia [2].

Intravenous narcotics have traditionally been the most ubiquitous mode of pain management in most patients. Ease of administration and obviation for specialized personnel without the risks of an invasive procedure are obvious advantages of parenteral analgesia. The efficacy of this modality is however controversial in context to blunt trauma chest. Parenteral opioids have generally improved pain scores and vital capacity; nevertheless, some authors consider them unsatisfactory in this setting [6,7].

The most obvious advantage of epidural analgesia is excellent analgesia with absence of parenteral narcotic adverse effects. Epidural analgesia is shown to provide superior pain relief and improvement in pulmonary function tests in various studies [3,8–10]. Its use has been associated with an increase in Tidal volume, functional residual capacity (FRC), lung compliance, vital capacity and pO2 with reduction in airway resistance and chest wall paradox of flail segments [11].

However, only few of the previous studies have mentioned about the association between use of epidural analgesia and outcome of mechanically ventilated patients in ICU. Therefore, this prospective randomized trial was done with an intent to determine the association between the use of two forms of analgesia with duration of mechanical ventilation and outcome of these patients.

2. Methods

Following approval by the Ethical committee of Faculty and written informed consent from patient's next kin, this prospective randomized study was conducted on 20 patients who were 18–55 years of age, had 3 or more rib fractures with flail segment, and required mechanical ventilation in the year 2012–2014 (Fig. 1). Patients who had acute spine fracture or preexisting spine deformity, severe traumatic brain or spinal cord injury, unstable pelvic fracture or open abdomen that would preclude positioning for epidural placement, ongoing cardiac instability or coagulopathy, and active chest wall infection

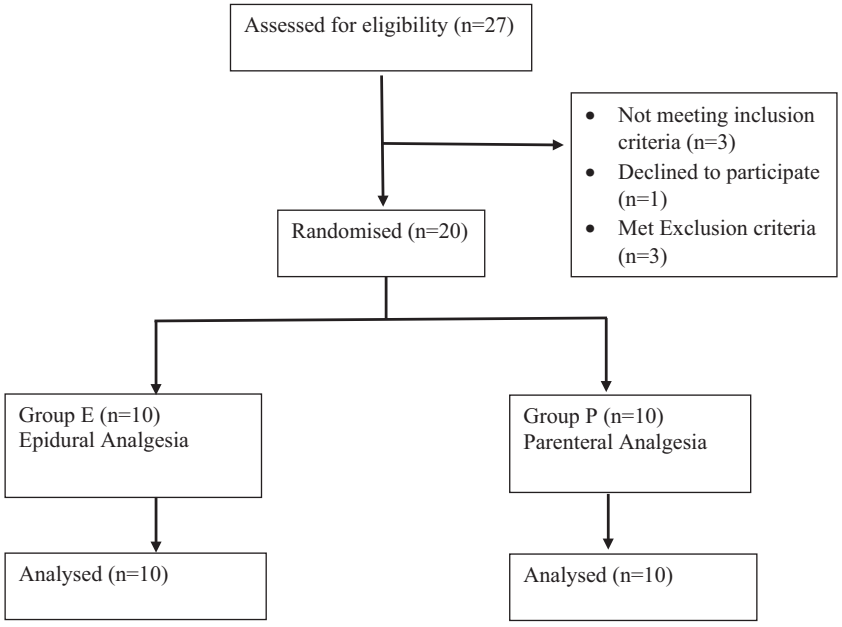

Figure 1 CONSORT flow diagram.

were excluded from the study. Patients were randomly divided into two groups of 10 patients each to receive either thoracic epidural analgesia (Group E) or parenteral analgesia in the form of iv opioids (group P).

Patients of Group E were placed in lateral decubitus position, then under strict aseptic precautions, an 18 G epidural catheter (Perifix® Filter Set, B. Braun, Melsungen, Germany) was inserted in thoracic epidural space depending on the location of rib fractures. Catheter was fixed and secured with 5 cm length in epidural space. Catheter location was confirmed by giving "Test dose" before institution of drug. Patients were administered 4 mL of 0.125% bupivacaine bolus followed by infusion @ 4 mL/h with 2 μg/mL fentanyl as adjuvant. Blood pressure was continuously monitored and infusion rate was decreased to 2 mL/h when BP was ⩽90 mmHg. Patients of Group P received i.v fentanyl (Trofentyl®, troika, India) in a dose of 2 μg/kg. All the drugs were titrated by a Pain physician to minimize the variability.

Baseline data included demographics (age/sex), APACHE II score, injury severity based on the injury severity score (ISS) and chest abbreviated injury score (AIS), number of rib fractures, presence of a pulmonary contusion based on the review of chest radiographs over the first 48 h and hemodynamic status on admission.

The primary outcome variable was duration of mechanical ventilation, while secondary outcome variables included change in tidal volume during initial 24 h (ΔTV), pneumonia, ARDS, length of stay in intensive care unit and mortality. Pneumonia is defined as per CDC definition [12], while ARDS as per berlins definition [13]. Pulmonary contusion was defined as a dominant infiltrate on chest X-ray within the first 48 h consistent with the pattern of injury. Data were also collected detailing any complications associated with the analgesics and its technique.

Statistical analysis was performed using Excel 2013 (Microsoft, Redmond, VA) and Graph Pad Prism 5.00 (Graph Pad Software, San Diego, CA). Data are presented as mean (±SD), median (range), or frequencies (%) as appropriate. Demographic data were compared using Students *t*-test or chi square (χ^2) test, whichever applicable. Data analysis was done on intention to treat basis. A probability value $p < 0.05$ was regarded as significant.

3. Results

No significant differences were found in demographic parameters such as age, sex, APACHE II score, ISS, chest AIS, number of rib fractures, pulmonary contusion, or shock on admission Table 1. Duration of mechanical ventilation was significantly less in Group E than in group P (6 ± 2 days v/s 9 ± 3 days, $p = 0.02$). There was significant increase of tidal volume in 1st 24 h in group E (ΔTV in group E 156 ± 24 mL v/s 78 ± 13 mL in group P; $p < 0.001$). Incidence of pneumonia was 20% and 40% in Groups E and P respectively which was not significant ($p = 0.63$). In group E, 20% of patients suffered ARDS in comparison with Group P, where 35% patients were diagnosed to have ARDS ($p = 0.35$). There was no significant difference in mortality between the groups ($p = 1.00$). However, length of stay in ICU was significantly less in group E (9.5 ± 1.6 d v/s 12.8 ± 2.8 d, $p = 0.004$). Hypotension was observed in 20% while bradycardia in 10% patients of group E. No case of spinal hematoma or epidural abscess was observed in either of the group. None of the patient suffered from any kind of neurological injury (see Tables 2 and 3).

Table 1 Demographics.

Variable	Group E ($n = 10$)	Group P ($n = 10$)	*P* value
Age (yrs)	39.80 ± 8.82	36.70 ± 10.56	0.49
Male:Female	7:3	8:2	1.0
APACHE II score	11.40 ± 3.53	10.80 ± 3.46	0.70
ISS	25 ± 7	28 ± 7	0.36
Chest AIS	3.7 ± 1.2	4.0 ± 1.1	0.57
No. of rib fracture	3.90 ± 0.88	4.10 ± 1.101	0.66
Pulmonary contusion	6(60%)	4(40%)	0.66
Shock on admission	3(30%)	2(20%)	1.0

Table 2 Outcome variables.

Variable	Group E ($n = 10$)	Group P ($n = 10$)	*P* value
Ventilation (days)	6 ± 2	9 ± 3	0.02
Change in tidal volume in 1st 24 h (mL)	156 ± 24	78 ± 13	<0.001
Pneumonia (%)	20%	40%	0.63
ARDS (%)	20%	50%	0.35
Mortality (No.)	0	1	1.00
LICU (days)	9.5 ± 1.6	12.8 ± 2.8	0.004

Table 3 Adverse effects.

Variable	Group E ($n = 10$)	Group P ($n = 10$)	*P* value
Hypotension	2 (20%)	0	0.43
Bradycardia	1 (10%)	0	1.00
Neurological injury	0	0	–

4. Discussion

In our study, there was significant reduction in the duration of mechanical ventilation and length of ICU stay in patients given epidural analgesia. Patient characteristics were not significantly different in our study.

With the increasing trend in road traffic accidents (RTA), rib fractures have been considered as a marker of injury severity [14]. Further, there seems a close association between rib fractures and increased morbidity and mortality of trauma patients. This has generated interest among clinicians for exploring the efficacy and characteristics of various modes of analgesia and early institution of acute pain services in thoracic trauma.

Pain in flail chest is a crucial factor limiting the voluntary respiration and delaying the extubation in these patients. Many studies in the past have shown improvement in pain scores with epidural analgesia [15]. Moon et al. [9] in a prospective, randomized trial showed superior analgesia and pulmonary function in epidural group in comparison with controlled analgesia. Similarly, Wu et al. [10] also showed superiority of epidural than patient controlled analgesia. As our study is based only on mechanically ventilated patients, we used change in tidal volume as a measure of analgesic efficacy. There was significant increase in tidal volume in the initial 24 h of mechanical ventilation in patients receiving epidural analgesia consistent with previous studies [9,10,15].

Although many studies have been done in the past which showed decreased duration of mechanical ventilation with epidural analgesia, its reflection in terms of patient outcome had not been evident so far [8,9]. In a study, Bulger et al. [2] showed that there is no significant difference in mean ventilatory duration between the two groups (incident rate ratio-IRR = 1.19; 95% CI, 0.97–1.45; $P = 0.09$). But, When stratified based on the presence of a pulmonary contusion, number of ventilator days in the systemic opioid group increased significantly (IRR, 2.0; 95% CI, 1.6–2.6; $P < 0.001$). We in our study found significantly decreased duration of mechanical ventilation and length of ICU stay (LICU). Our results show significant improvement in outcome of flail chest patients with epidural analgesia. This seems reasonable as our study population was similar in most of the confounding variables such as APACHE II score, chest AIS, number of rib fracture and pulmonary contusion.

There was increasing trend in incidence of pneumonia, ARDS and mortality in our study; nevertheless, it did not reach to the level of significance. In a meta-analysis by Jarvis et al. [14], he observed no significant difference between the two groups in terms of mortality and incidence of ARDS (all, $p > 0.070$); however, incidence of pneumonia was significantly less in the epidural group (Odds ratio 2.405; $Z = 1.964$; $p = 0.049$). Contrary to this Wu et al. [10] found no significant difference in pulmonary complications between the two groups. Similarly, Bulger et al. [2] found no significant difference between the two groups while comparing incidence of nosocomial pneumonia but when adjusted for various confounding factors it became significant (OR = 6.0; 95% CI, 1.0–35; $p = 0.05$). So, considering the sample size of our study and the multifactorial association of ventilator associated pneumonia (VAP), further large randomized controlled trials are warranted to confirm our findings.

Hypotension (20%) was the most common adverse effect observed in epidural group, followed by bradycardia (10%). However, it was not significantly different from parenteral analgesia (group P). None of the patients suffered any kind of neurological injury.

5. Conclusion

Epidural analgesia is a safe and effective technique for flail chest patients. It significantly decreased the length of ICU stay and duration of mechanical ventilation in our study population.

Conflict of interest

None declared.

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None.

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