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Traumatic flail chest injuries and the benefits of epidural analgesia

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Abstract

Introduction: Many poly-trauma patients sustain chest wall injuries. Flail chest is considered one of the uncommon injuries that may happen in traumatized patients and may increase morbidity and mortality in polytrauma patients. Pulmonary contusion, mechanical ventilation, pneumonia, sepsis and poor pain control are expected to be common complications in patients sustaining chest wall injuries. We hypothesize that the use of epidural analgesia can lead to improved clinical outcomes in this group of patients.

Methodology: A retrospective study conducted for the years 2008 – 2013 for patients admitted to a level 1 trauma center (Figure 1). Patients were diagnosed with flail chest by clinical exam and imaging. Trauma registry was queried to study modalities of pain control; especially the use of epidural. We divided the patients to two groups; those who had received epidural analgesia and those who did not have epidural analgesia. A logistic regression model was developed to identify independent predictors of 30 days in hospital mortality.

Results: 180 patients had flail chest; with a mean age was 57.4 years. There were 74.4% males. There were 43.3% who had a chest tube, 23.8% who developed pneumonia and 6.7% who had tracheostomy. 79 patients (44.4%) had epidural analgesia. ISS was 26.19 for patients with epidural analgesia and 30 for patients without epidural (p-value 0.02). The mean Hospital length of stay (LOS) was 18.46 days and the 30 days mortality was 3% for the epidural group V.S 10% for the non-epidural group (p-value 0.058). Logistic regression analysis for 30-day mortality revealed a significant association in the group with epidural analgesia for Age, ISS score, Hospital LOS and pneumonia.

Conclusion: Epidural analgesia as pain control for patients with flail chest is understudied. This study demonstrates a significant statistical reduction in mortality with the use of epidural in patients diagnosed with flail chest sustained in a trauma setting. There was a significant statistical difference in ISS scores between both groups. This difference can be attributed to head injuries and other complications that may restrict the use of epidural analgesia. Further randomized studies are needed to evaluate the superior efficiency of epidural analgesia over standard pain control modalities in flail chest in trauma patients.

Introduction

Severe blunt chest trauma continues to be one of the leading causes of morbidity and mortality in both young and old trauma victims [1]. Among the different types of blunt chest injury, flail chest is one of the worst, and is likely the most common serious injury to the thorax seen by clinicians [2,3].

Flail chest is traditionally described as the paradoxical movement of a segment of chest wall caused by fractures of three or more consecutive ribs anteriorly and posteriorly within each rib [4]. It occurs when a segment of the thoracic cage is separated from the rest of the chest wall, leading to paradoxical movement of that segment. A segment of the chest wall that is flail is unable to contribute negative pressure to generate lung expansion [5]. Variations include posterior flail segments, anterior flail segments, and flail including the sternum with ribs on both sides of the thoracic cage fractured.

The exact incidence of flail chest is not precisely known. In 1990, Champion, *et al.* documented 75 patients with flail chest injuries in The Major Trauma Outcomes Study of more than 80,000 patients [6]. In 1995, Ahmed and Mohyuddin documented 64 cases over a 10-year period [7]. Borman evaluated data from the Israel National Trauma Registry, and noted 262 flail chest diagnoses in 11,966 chest injuries (118,211 total patients) examined between 1998 and 2003 [8].

Unfortunately, flail chest is associated with a higher morbidity compared with multiple rib fractures [9]. In a recent review of outcomes and treatment practices from the national trauma databank, Deghan, *et al.* concluded that patients who have sustained a flail chest have significant morbidity (ICU admission, 82%; mechanical ventilation, 59%; need for chest tube, 44%; tracheostomy, 21%; ARDS, 14%; sepsis, 7%) and a high rate of mortality (16%) [10]. In addition, pulmonary contusions, prolonged mechanical ventilation, pneumonia, sepsis and poor pain control are common among patients sustaining flail chest injuries [7,10-12].

Current emergency treatment of the flail chest should initially follow the principles of advanced trauma life support (ATLS), including adequate analgesia, which is a crucial part of management. However, there is currently some ongoing discussion as to which analgesia modality would be most beneficial to the flail chest patient. In 1975, Trinkle, *et al.* provided compelling evidence that many

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patients fared better with adequate pain control and pulmonary toilet (including medical management of their pulmonary injury) than those placed on mechanical ventilation [13], which remains the standard today. Patient-controlled analgesia (PCA) machines, oral pain medications, and indwelling epidural catheters form the mainstay of current pain management. While the effects of PCA and oral pain medications are well studied [14], conclusions on the benefits derived from epidural analgesia are inconsistent [15]. Studies in the past have demonstrated that epidural analgesia provides superior pain relief and improves pulmonary function tests when compared to intravenous opioids for patients with rib fractures [14,16,17]. In 2004, Bulger, *et al.* concluded that epidural analgesia is associated with a decrease in the rate of nosocomial pneumonia and a shorter duration of mechanical ventilation after rib fractures [18], and in 2014, Gage, *et al.* concluded that epidural catheter placement was associated with a significantly decreased risk of mortality in patients with blunt thoracic injury with three or more rib fractures [15]. While these studies, along with others, have provided insight into the benefits of epidural analgesia in multiple rib fracture management, no studies were found discussing the benefits of epidural analgesia specifically in flail chest injuries, which led us to hypothesize that better pain control by the use of epidural analgesia leads to improved clinical outcomes in this group of patients (Figure 2 and 3).

Methodology

A retrospective database review was carried for the years 2008-2013. The study was conducted at The Montreal General Hospital (MGH), Montreal, Canada, a level 1 trauma center affiliated with the McGill University Health Center (MUHC).

In order to study the effects of epidural analgesia, we divided our patients into two groups; those who received epidural analgesia and those who did not.

Patients' charts, electronic medical records and ICU sheets were consulted to identify their characteristics. The primary outcome of interest was to evaluate the potential benefits of administering epidural analgesia to the flail chest patient, with our hypothesis being that this analgesic modality would show a superior benefit in regards to pain control and reducing complications, namely, hospital length of stay (LOS), ICU LOS, pneumonia, mortality, and sepsis.

Data was summarized using methods of means with standard deviations (SD) and medians with inter quartile ranges (IQR) for continuous data and ratios for categorical data. Student T or Mann-Whitney tests were used to describe continuous data; Chi-square or Fischer exact tests were used to describe categorical data, as appropriate. A logistic regression model was developed to identify independent predictors of 30-day in-hospital mortality. Statistical analysis was carried out using the SPSS software (version 2.0) (SPSS Inc., Chicago, IL), with consideration of a p value of <0.05 as a statistically significant.

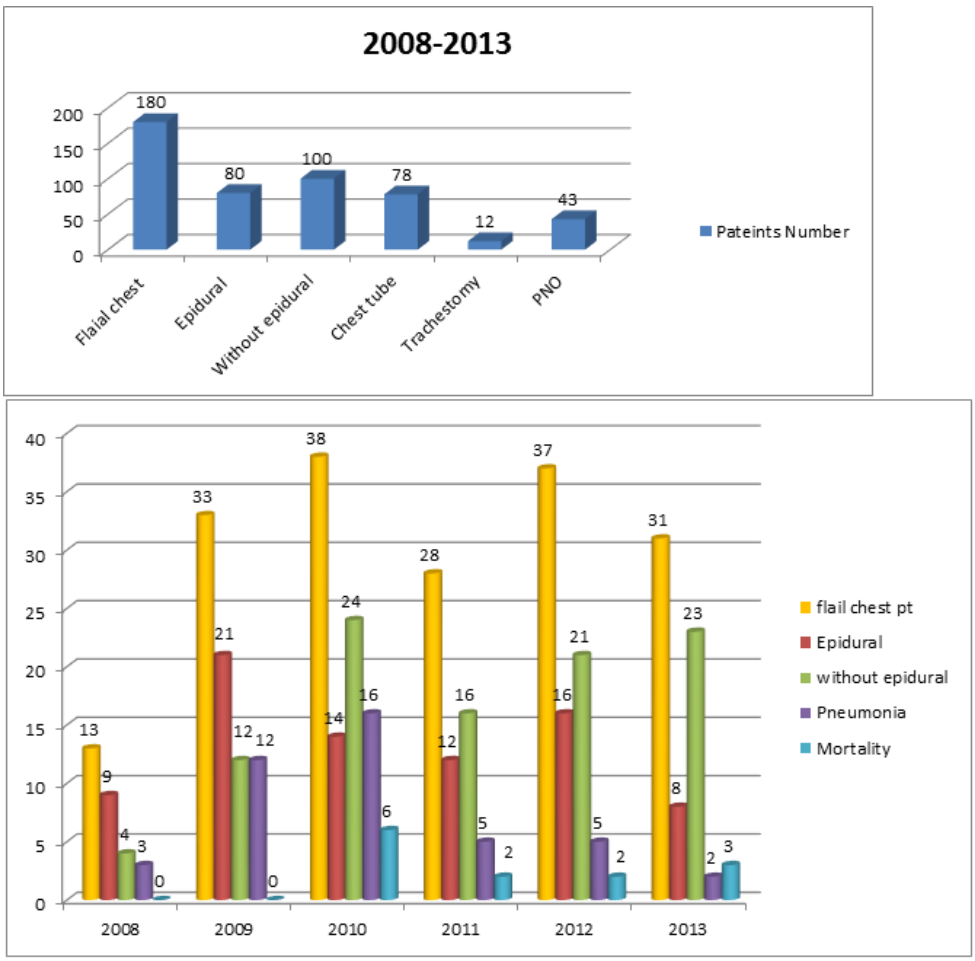

Figure 1. Patients admitted to a level 1 trauma centre.

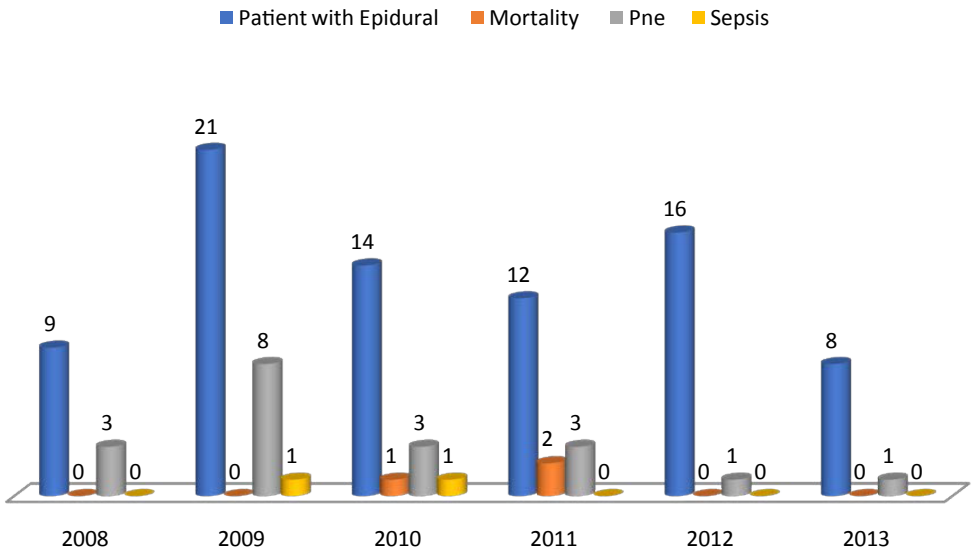

Figure 2. Pneumonia/Spesis/Mortality in Flail chest patients with Epidural.

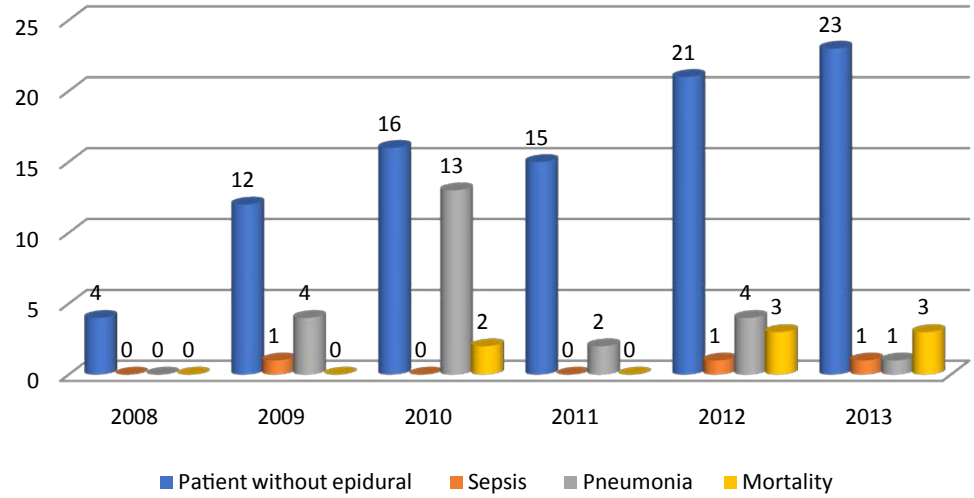

Figure 3. Sepsis/Pneumonia/Mortality in Flail chest patients without Epidural.

Results

180 patients had flail chest; with mean age was 57.4 years. There were 74.4% males. There were 43.3% who had a chest tube, 23.8% who developed pneumonia and 6.7% who had tracheostomy. 79 patients (44.4%) had epidural analgesia. ISS was 26.19 for patients with epidural analgesia and 30 for patients without epidural (p-value 0.02). The mean Hospital length of stay (LOS) was 18.57 days in the epidural group vs. 20.4 (25.5) in the group without epidural and the 30 days mortality was 3.8% for the epidural group vs 11.5% for the non-epidural group (p-value 0.058) (table-1). Logistic regression analysis for 30 days mortality revealed significant p-value 0.002, 0.006, 0.003 and 0.028 in the group with epidural analgesia for Age, ISS score, Hospital LOS and pneumonia respectively (Table 2,3 and 4).

Discussion

Rib fractures are a common injury in the blunt trauma population with a reported incidence of 10% among patients admitted to a regional trauma center [19].

Table 1. Baseline demographic data for 180 patients with flail chest enrolled in the study from April 2008 – Dec.2013.

Flail chest patients	**N =180**
Age Mean (SD) Median (IQR)	 57.4 (17.7) 59 (44-70.75)
Sex Male Female	 74.4 % 25.6 %
ISS Mean (SD) Median (IQR)	 28.2 (11.8) 26 (20-35.75)
Ventilation Hours (SD)	232.86 (306.6)
ICU LOS Mean (SD) Median (IQR)	 9.55 (11.6) 5 (2-13)
Hospital LOS Mean(SD) Median(IQR)	 18.9 (20.5) 11 (6-25)
Epidural	44.4%
Tracheostomy	6.7%
Chest tube	43.3%
Pneumonia	23.8%

Table 2. Univariate analysis of variances revealed significant (P value < 0.05) difference in ISS and hospitals length of stay.

Variables	Flail chest with epidural (N=80)	Flail chest without epidural (N=100)	P Value
Sex Male Female	 59/80 21/80	 75/100 25/100	0.491
Age (SD)	57.9 (17.1)	57 (18.2)	0.929
ISS Mean (SD) Median (IQR)	 26.19 (11.5) 24 (17-34)	 29.91 (11.9) 29 (21-38)	0.022*
Ventilation Hours	241.69	225.6	0.243
ICU LOS Mean (SD) Median (IQR)	 9.27(9.7) 5 (2-12.5)	 9.75(14) 7 (2.5-15)	0.360
Hospital LOS Mean (SD) Median (IQR)	 18.46 (14.9) 14 (4.25-28)	 19.27 (24.3) 10 (9-25)	0.042*
30 days Mortality	3.8% (3/80)	11% (11/100)	0.061
Rib surgery	5% (4/80)	1% (1/100)	0.122
Pneumonia	23.8% (19/80)	24% (24/100)	0.556
Sepsis	2.5% (2/80)	3% (3/100)	0.604

Table 3. Logistic regression analysis for variables predicating 30 days mortality in flail chest patients.

Variables	Odds Ratio	95% C.I		P Value
		Lower	Upper	
Epidural	0.352	0.055	2.241	0.269
ISS	1.105	1.038	1.176	0.002*
Hospital LOS	0.817	0.708	0.944	0.006*
Age	1.085	1.028	1.145	0.003*
Pneumonia	8.780	1.268	60.788	0.028*

Table 4. Logistic regression analysis for variables predicating epidural in flail chest patients.

Variables	Odds Ratio	95% C.I		P Value
		Lower	Upper	
Age	0.582	0.987	1.023	0.582
ISS	0.977	0.949	1.005	0.103
Sex	1.031	0.518	2.053	0.930
Hospital stay	1.000	0.985	1.016	0.959
30 days Mortality	0.347	0.085	1.415	0.140

A flail chest, defined as three or more consecutive rib fractures in two or more locations creating a flail segment, can lead to numerous complications, such as chest wall instability, asynchronous movement of the flail segment, and paradoxical chest motion. It may also cause physical deformity of the chest wall and loss of thoracic volume [11]. These in turn lead to decreased lung volume, atelectasis, chest tightness, dyspnea, and chronic pain [12,20].

One of the cornerstones of management of multiple rib fractures and flail chest is appropriate analgesia [11,12,21]. We chose to study the benefits of epidural analgesia in patients with flail chest because we believe that this is an understudied topic and we adopt a more aggressive approach at our center with epidural use.

The main advantage of epidural analgesia over narcotics is that it is non-sedating, and patients can generally remain awake to cooperate with respiratory therapies [22]. However, there are also numerous contraindications to epidural catheter placement in trauma patients, including thoracic vertebral fractures, spinal cord injury, coagulopathy, unstable pelvis, and severe head injury [23,24].

Our study demonstrated that there is a trend towards reduction in mortality with the use of epidural analgesia in flail chest patients, along with a reduction in the overall ICU and hospital LOS, in comparison to patients who did not receive epidural analgesia. Additionally, we found lower incidences of flail chest complications, namely sepsis and pneumonia. This supports the conclusion of other studies, which reported improved outcomes and lower complications in flail chest patients who were managed with epidural analgesia compared with other methods of pain control [18,21,25,26]. These studies found that compared with intravenous narcotic use, epidural catheters allow for improved subjective pain perception, pulmonary functions tests, lower rates of pneumonia, as well as decreased length of time on a mechanical ventilator or ICU stay [21,25,26]. They also reported lower rates of complications such as respiratory depression, somnolence, and gastrointestinal symptoms [21].

An interesting observation in our study was the difference in ISS score [27] in the two groups of patients. The patients who were managed with epidural analgesia had lower ISS scores than those who were not (26.4 vs 30.3). This can be attributed to the nature of the injuries in the high ISS score patients who were more likely to have contraindications to receiving epidural anesthesia, such as increased intracranial pressure, coagulopathy, and spine trauma, [28,29] which ultimately precluded them from receiving epidural anesthesia, and necessitated their management with other modalities of pain control.

Limitations

One of the limitation that not all patients were included in the epidural group due to numerous contraindications to epidural catheter placement in trauma patients, including thoracic vertebral fractures, spinal cord injury, coagulopathy, unstable pelvis, and severe head injury.[23,24] Other limitations to this study is that it is a retrospective study with all it's inherent limitations. It was conducted in only one Trauma center and could not be generalized to a larger population. The sample size for this study is considered small and a larger sample could yield more significant data.

Conclusion

Although the use of epidural analgesia as method of pain control for patients with flail chest remains to be relatively understudied, multiple studies and outcome reviews seem to consistently support its use. Similarly, our study also demonstrated positive outcomes in flail

chest patients managed with epidural analgesia. Given the high rates of morbidity and mortality in patients with a flail chest injury, it may be of benefit to standardize the modality of analgesia administered to these patients. However, large randomized controlled trials are needed before standardization can take place.

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