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Surgical Sternal Fixation versus Conservative Management in Patients with Traumatic Fracture Sternum

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ABSTRACT

Background: Traumatic sternal fractures, though uncommon, can lead to significant morbidity and mortality. Management strategies vary between conservative approaches and open surgical sternal fixation, with no established guidelines to recommend one over the other.

Objective: This study aimed to compare the outcomes of surgical sternal fixation versus conservative management modalities.

Methods: A retrospective analysis was conducted on 87 patients admitted with traumatic sternal fractures from January 2016 to October 2024. Propensity matching resulted in two comparable groups of patients, 36 patients in each group, those managed conservatively and those undergoing surgical sternal fixation. The primary result measured was mortality, while secondary results included hospital stay, intensive care unit stay, ventilation duration & in-hospital complications.

Results: Surgical fixation was associated with significantly lower mortality (2.8% vs. 13.9%, $p = 0.11$). However, the surgical group had longer hospital and ICU stays ($p < 0.001$). Ventilation duration and complication rates, including acute respiratory distress syndrome (ARDS), pneumonia, and myocardial infarction (MI), were comparable between groups. Patients in the non-surgical group reported more severe pain levels on numeric pain scale (25.0% vs. 11.1%, $p = 0.126$), though this difference was not statistically significant.

Conclusion: Surgical sternal fixation demonstrated a clear advantage in reducing mortality and potentially improving pain outcomes in cases of traumatic sternal fractures involving instability or displacement. Conservative management remains effective for less severe injuries.

Keywords: Conservative management, Polytrauma, Sternal fracture, Surgical sternal fixation.

INTRODUCTION

About three to eight percent of blunt traumas result in post-traumatic sternal fractures, an unusual type of injury [1]. Although direct blunt trauma from seat belts or steering wheels is linked to these fractures in traffic accidents, these injuries also commonly arise from a combination of direct trauma & indirect flexion-compression or flexion-rotation injuries to the chest, as in high-speed collisions or falls from a height [2]. Traumatic sternal fractures may cause myocardial and pulmonary contusions, as well as vascular damage [3].

Sternal fractures can result in both immediate & long-term consequences. The most frequent short-term side effect; chest pain lasts eight to twelve weeks on average for all age groups when treated with analgesics alone. Pain-induced anxiety can make it difficult to breathe, which puts the patient at risk for a chest infection. Non-union & mal-union are long-term issues that manifest as excruciating pseudoarthrosis & frequently lead to postponed surgical repair [4].

Despite their prevalence in trauma settings, the optimal management of sternal fractures remains a topic of debate, with treatment strategies varying widely depending on the severity, stability of the fracture, and associated injuries [5, 6].

Conservative treatment is used for the majority of sternal fractures. This consists of analgesia, corset fixation, rest, & passive reduction of displacement if necessary [7]. However, surgical treatment may be required for stable fractures, thoracic wall instability, fracture displacement or persistent dislocation, sternal deformity, respiratory insufficiency, severe discomfort, and fracture non-union [8]. Open surgical sternal fixation involves the stabilization of the fractured sternum using plates and screws, or stainless steel wire thereby restoring chest wall stability and reducing pain [9].

Recent studies suggest that surgical fixation may lead to better sternal comfort, which further contributes to the case's early mobilization & shorter recovery time [10]. Moreover, surgical intervention reduces the ventilation time and consequently less incidence of tracheostomy, less intensive care unit stay following a traumatic flail chest injury & could decrease the risk of acquiring pneumonia after such an event [11].

There aren't any published recommendations for surgery fixation for sternal fractures at the moment. This is most likely connected to patient heterogeneity and the dearth of high-quality data in published research [12].

Based on that, this study aimed to compare between two groups (open surgical sternal fixation group and conservative management group) in terms of mortality, hospital stay, ICU stay, ventilation time, and in-hospital complications.

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SUBJECTS AND METHOD

This is a retrospective analysis of 87 studied cases older than eighteen years old, who were admitted to Tanta University Hospital, Emergency Department with traumatic sternal fracture through the period from January 2016 to October 2024.

Exclusion criteria: Patients with associated severe head injuries.

Two comparable groups were examined; patients underwent conservative management for traumatic sternal fractures (non-operative group, N=36) and others who underwent surgical sternal fixation (Operative group, N=36).

Surgical fixation was performed using a stainless-steel wire suture in the form of a figure of eight with or without simple stitches.

The primary outcome was mortality. Secondary results comprised hospital stay, ICU stay, ventilation time, and in-hospital complication (ARDS, myocardial infarction, pneumonia, ventilation acquired pneumonia, deep site infection, unplanned intubation, and pain). The signed consents were skipped due to the retrospective nature of the research, however all studied cases subjected to surgical fixation signed for accepting the surgery and the possible complications of the operation.

DATA MANAGEMENT

SPSS version 27 (IBM, Armonk, New York, United States) had been used for all statistical work. Using the Kolmogorov–Smirnov test, the normality of quantitative data was evaluated. The median & interquartile range (IQR) were used to summarize quantitative data based on normalcy. Numbers and percentages had been used to summarize categorical data. The Mann-Whitney U test had been used to compare quantitative data among any 2 unpaired groups. Fisher exact & Chi-square had been used to compare categorical data. There were 2 sides to every statistical test. Significant P values were defined as those that were less than or equal to 0.05.

Ethical Concerns: The Ethics Committee of faculty of Medicine, Tanta University approved the study with a number of 36264BR1123/3/25. All patients provided their consents, and the hospital's Ethics Review Committee approved the study. The study adhered to the Helsinki Declaration throughout its execution.

RESULTS

Table (1) explained that the median age of non-operative group was 45.5 years (IQR=35.0-61.3 years), while it was 40.0 years (IQR=32.5-54.5 years) for operative group. There was male predominance in both groups with no statistically significant difference among them 63.9% for non-operative group, 58.3% for operative group; p=0.629). There was no statistically significant difference among both groups regarding smoking history, diabetes mellitus or hypertension.

Table (1): Baseline characteristics of patients

Parameters		Non-operative group	Operative group	P-value
Age (Years)	Median (IQR)	45.5 (35.0-61.3)	40.0 (32.5-54.5)	0.532ǂ
Gender				
Male	No (%)	23 (63.9)	21 (58.3)	0.629ǂǂ
Female	No (%)	13 (36.1)	15 (41.7)	
Smoking	No (%)	12 (33.3)	11 (30.6)	0.800ǂǂ
DM	No (%)	10 (27.8)	6 (16.7)	0.257ǂǂ
HTN	No (%)	15 (41.7)	11 (30.6)	0.326ǂ

No=Number, IQR=Inter-quartile range, DM= Diabetes Mellitus, HTN=Hypertension, *Indicates significant p-value, ǂMann-Whitney U test, ǂǂChi-square test.

Table (2) clarified that there was no significant difference among both groups regarding the mode of trauma (p=0.237). Motor vehicle accidents were the most common mechanism of injury in both groups, occurring in 72.2% of the non-operative group & 88.9% of the operative group. Falling from height accounted for 19.4% of injuries in the non-operative group & 8.3% in the operative group.

Other mechanisms were less frequent, with 8.3% in the non-operative group & 2.8% in the operative group. Fractures were most commonly located in the sternal body (61.1% in the non-operative group & 55.6% in the operative group, p=0.814). Fractures of the manubrium and combined fractures were less common, with no significant differences between groups (p=0.759 and p=0.710 respectively). Spine fractures were present in 11.1% of the non-operative group & 13.9% of the operative group. Rib fractures, mediastinal hematomas, pulmonary contusions, pneumothorax, hemothorax, and other thoracic injuries showed no statistically significant differences among groups.

The median Glasgow Coma Scale (GCS) score was 14.0 (IQR: 13.0–15.0) in the non-operative group & 14.0 (IQR: 12.0–15.0) in the operative group. Median systolic blood pressure was slightly higher in the operative group (110.0 mmHg vs. 105.0 mmHg), but the difference was not significant (p=0.176). The respiratory rate on admission was marginally higher in the operative group (median 19.0 vs. 18.0), with a p-value of 0.467, indicating no significant difference.

Table (2): Injury characteristics of studied participants

Parameters		Non-operative group (36 patient)	Operative group (36 patients)	P-value
Mechanism of injury				
Motor accident	No (%)	26 (72.2)	32 (88.9)	
Fall	No (%)	7 (19.4)	3 (8.3)	0.237ǂǂ
Others	No (%)	3 (8.3)	1 (2.8)	
Sternal fracture location				
Manubrium	No (%)	11 (30.6)	12 (33.3)	0.759ǂ
Sternal body	No (%)	22 (61.1)	20 (55.6)	0.814ǂ
Combined manubrium and body fracture	No (%)	3 (8.3)	4 (11.1)	0.710ǂǂ
Associated injury				
Spine fracture	No (%)	4 (11.1)	5 (13.9)	1.0ǂǂ
Rib fracture	No (%)	19 (52.8)	17 (47.2)	0.496ǂ
Mediastinal hematoma	No (%)	8 (22.2)	10 (27.8)	0.173ǂ
Pulmonary contusion	No (%)	7 (19.4)	6 (16.7)	0.894ǂǂ
Pneumothorax	No (%)	8 (22.2)	9 (25)	0.710ǂǂ
Hemothorax	No (%)	3 (16.7)	4 (19.4)	0.915ǂǂ
Other thoracic injuries	No (%)	7 (19.4)	5 (13.9)	0.527ǂ
Glasgow Coma Scale on admission	Median (IQR)	14.0 (13.0-15.0)	14.0 (12.0-15.0)	0.872ǂǂǂ
Systolic blood pressure on admission	Median (IQR)	105.0 (90.0-117.5)	110.0 (100.0-120.0)	0.176ǂǂǂ
Respiratory rate on admission	Median (IQR)	18.0 (16.0-19.0)	19.0 (17.0-20.0)	0.467ǂǂǂ

No=Number, IQR=Inter-quartile range, *Indicates significant p-value, , ǂChi-square test, ǂǂFisher Exact test, ǂǂǂMann-Whitney U test.

Table (3) presented the primary and secondary outcomes for both groups. For primary outcome, the mortality rate was significantly higher in the non-operative group (13.9%) compared to the operative group (2.8%), with a p-value of 0.011 indicating statistical significance. For secondary outcome, the median hospital stay was significantly longer in the operative group (11.0 days, IQR: 7–14.8) compared to the non-operative group (6.5 days, IQR: 4.0–8.5; p-value <0.001). Similarly, the median ICU stay was significantly longer in the operative group (8.0 days, IQR: 4–12.5) compared to the non-operative group (4.5 days, IQR: 3.5–6; p-value <0.001). The median ventilation time was comparable between groups (3.0 days in the non-operative group vs. 2.5 days in the operative group with no statistically significant difference among both groups (p=0.628). Acute Respiratory Distress Syndrome (ARDS) occurred in 11.1% of participants in both groups. Moreover, pneumonia and ventilation-acquired pneumonia were observed in 5.6% and 8.3% of participants in the non-operative group respectively, and in 5.6% for each of them in the operative group, with no significant differences among groups (p=1.0). Deep site infections were more frequent in the operative group (8.3% vs. 2.8%), but the difference was not statistically significant (p=0.174). Unplanned intubation occurred in 13.9% of the non-operative group & 8.3% of the operative group (p=0.710). Severe pain levels on numeric pain scale were reported by 25.0% of the non-operative group & 11.1% of the operative group, with no significant difference (p=0.126).

Table (3): Primary and secondary outcome of studied patients

Parameters		Non-operative group	Operative group	P-value
Mortality	No (%)	5 (13.9)	1 (2.8)	0.011*ǂ
Hospital stay	Median (IQR)	6.5 (4.0-8.5)	11 (7-14.8)	<0.001*ǂǂ
ICU stay	Median (IQR)	4.5 (3.5-6)	8.0 (4.0-12.5)	<0.001*ǂǂ
Ventilation time	Median (IQR)	3 (2.5-4.0)	2.5 (1.8-3.5)	0.628ǂǂ
ARDS	No (%)	4 (11.1)	4 (11.1)	1.0ǂǂǂ
Myocardial infarction	No (%)	0 (0.0)	2 (5.6)	0.493ǂǂǂ
Pneumonia	No (%)	2 (5.6)	2 (5.6)	1.0ǂǂǂ
Ventilation acquired pneumonia	No (%)	3 (8.3)	2 (5.6)	1.0ǂǂǂ
Deep site infection	No (%)	1 (2.8)	3 (8.3)	0.174ǂ
Unplanned intubation	No (%)	5 (13.9)	3 (8.3)	0.710ǂǂǂ
Severe Pain	No (%)	9 (25.0)	4 (11.1)	0.126ǂ

ǂChi-square test, ǂǂMann-Whitney test, ǂǂǂFisher exact test.

DISCUSSION

This research aimed to evaluate & compare the results of open surgical sternal fixation with conservative management in studied cases suffering from traumatic sternal fractures. The findings provided valuable insights into a debate that has persisted in trauma care.

Our study revealed a significantly lower mortality rate in the surgical group (2.8%) compared to the non-operative group (13.9%, p = 0.011). **Christian and his colleagues** [13] revealed that surgical group patients exhibited a lower mortality rate (2.7% vs. 11.2%, p = 0.008) and this supports our study findings. The reduced mortality in the operative group confirms the potential life-saving role of surgical fixation, especially in cases where sternal instability contributes to secondary complications.

Our study revealed that patients undergoing surgical fixation had significantly longer hospital and ICU stays (p < 0.001). Similarly, **Christian *et al.*** [13] claimed that patients undergoing surgical sternal fixation had an increased median hospital length of stay (16 vs. 7 days, p < 0.001) and ICU stay (9.5 vs. 5.5 days, p = 0.016). On contrary, **Madjarov *et al.*** [14] found that surgical sternal fixation following blunt trauma minimizes risk of sternal nonunion & reduces length of hospitalization. This could be explained by the need of surgical patients for prolonged monitoring and postoperative care. However, the longer stays could also reflect the severity of injuries necessitating surgery, as this group included patients with unstable fractures and thoracic wall instability. Despite the extended hospital stay, the improved mortality rate suggests that these patients might benefit from intensive management tailored to their complex needs.

Interestingly, there was no significant difference in ventilation time among the 2 groups, with median values of 3.0 days for the non-operative group & 2.5 days for the operative group (p = 0.628). In the same line of this study, **S Klei *et al.*** [5] stated that the median days of mechanical ventilation was 5 days for the conservative group and it was 4 days for the operative group with no statistically significant difference (p=0.776). This finding contrasts with some studies that associated surgical fixation with significant earlier weaning from mechanical ventilation [4, 15]. The absence of a significant difference in our study may reflect the small sample size or variations in ventilation protocols.

Furthermore, the rates of pneumonia, ventilator-associated pneumonia, and ARDS were comparable between the groups, suggesting that both treatment modalities can effectively manage these complications when tailored to patient needs.

Severe chest pain was reported by fewer patients in the surgical group (11.1%) compared to the non-operative group (25.0%), though the difference was not statistically significant (p = 0.126). The trend toward reduced pain in the surgical group is consistent with literature highlighting the role of sternal stabilization in mitigating pain and promoting early patient mobilization [16].

While the surgical group showed a slightly higher incidence of deep-site infections (8.3% vs. 2.8%, p = 0.174), this was not statistically significant. The risk of infection remained a recognized challenge in surgical management, emphasizing the need for meticulous perioperative care. Additionally, the lack of significant differences in other complications, such as myocardial infarction and unplanned intubations, indicates that

surgical fixation does not increase systemic risk when performed under appropriate clinical conditions.

LIMITATIONS

The retrospective design of this study introduced potential biases. Furthermore, the small sample size limited the generalizability of the results. Prospective studies with larger cohorts and standardized treatment protocols are needed to confirm these results and establish evidence-based guidelines.

CONCLUSION

In summary, this study supported the role of open surgical sternal fixation in reducing mortality and potentially improving pain outcomes in traumatic sternal fractures, particularly for cases involving instability or displacement. While conservative management remains effective for less severe injuries, surgical intervention should be considered in appropriate cases to optimize patient results. Future research must focus on refining studied case selection criteria and minimizing postoperative complications to further enhance the benefits of surgical fixation.

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