

Evaluation of Sternum Fractures: A Single-institution Study

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Abstract

Aim: Sternal fractures are relatively uncommon. Although most sternal fractures are managed conservatively, the presence of associated injuries to adjacent organs is associated with a significant increase in morbidity and mortality. This study aimed to evaluate the clinical characteristics, associated thoracic and extrathoracic injuries, management strategies, and outcomes of patients with traumatic sternal fractures.

Materials and Methods: Patients diagnosed with sternal fractures following thoracic trauma between January 2013 and May 2021 were retrospectively analyzed. Demographic data, mechanism of injury, fracture localization and type, concomitant injuries, seatbelt use, Injury Severity score (ISS), length of hospital stay, and mortality were assessed.

Results: Sternal fractures were identified in 230 of 2131 patients with thoracic trauma (10.7%). Traffic accidents were the most common mechanism of injury (n=189, 82.2%). Most fractures involved the sternal body (n=129, 56.1%) and were non-displaced (n=128, 55.7%). Retrosternal hematoma was detected in 10% of patients and was significantly associated with hemothorax and pulmonary contusion (p=0.021, p=0.033). Patients not using seatbelts had significantly higher ISS values and longer hospital stays (p=0.005, p=0.001). Thirteen patients (5.7%) died, predominantly due to severe associated injuries.

Conclusion: Although most sternal fractures can be managed conservatively, the presence of a retrosternal hematoma may indicate underlying pulmonary injury rather than cardiac involvement. Careful radiological evaluation and close in-hospital monitoring are essential to optimize outcomes and reduce mortality in these patients.

Keywords: Retrosternal hematoma, seatbelt, sternum fracture, thoracic trauma

Introduction

Trauma is a prevalent etiological risk of mortality throughout the first 40 years of life (1). Approximately 25% of these injuries are thoracic injuries (2). Thoracic trauma can be classified into two primary categories: blunt and penetrating. Blunt trauma constitutes the majority, accounting for approximately 75%, of thoracic injuries (3,4). Blunt thoracic trauma generally arises from motor vehicle collisions, falls from height, and direct impacts, whereas sternal fractures are relatively uncommon within this spectrum. Nonetheless, motor vehicle collisions represent the most frequent mechanism associated with sternal fractures (5-9).

The prevalence of sternum fractures varies according to age, gender, and the nature of the accident. Advanced age, female sex,

and front-seat occupancy are established risk factors for sternal fractures (10). The primary determinant affecting morbidity in sternum fractures is associated injury to adjacent organs. Clinically, substantial morbidity and elevated mortality rates are evident, especially in cases of displaced fractures, mediastinal bleeding, cardiac contusion, and vascular injuries, which can increase mortality by 25-40% (6,10-12).

Conservative management can effectively address the majority of sternal fractures. However, in cases of displacement at the fracture site, significant discomfort, persistent non-union, and sternal instability, surgical fixation may be necessary (13,14). Timely diagnosis and intervention in these patients can enhance therapeutic results. Moreover, whereas approximately 95% of sternal fractures are successfully managed conservatively, the



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existence of underlying cardiac abnormalities necessitates prompt surgery, underscoring the critical importance of early detection (10,15).

The primary aim of this study is to provide a comprehensive analysis of patients with traumatic sternal fractures evaluated at a single center. The primary outcome is to assess the impact of concomitant thoracic and extrathoracic injuries on clinical outcomes. Secondary outcomes include an evaluation of demographic characteristics, trauma mechanisms, fracture localization and type, and the relationship between applied treatment strategies and the clinical course.

Materials and Methods

The study encompassed patients who presented to the emergency department with thoracic trauma between January 2013 to May 2021. The study was conducted as a retrospective cohort study including patients diagnosed with traumatic sternal fractures at a single center. Ethical approval was obtained from Ethics Committee Approval for Non-Interventional Research from Kirikkale University on (decision number: 2021.07.02, date: 08.07.2021). The study was conducted in accordance with the Declaration of Helsinki established by the World Medical Association. The study excluded patients with non-traumatic sternal fractures, those with missing data, and patients whose thoracic computed tomography (CT) scans were inadequate for evaluating sternal fractures due to artifacts. The methodological framework of the study was structured according to the PICO (population): patients with traumatic sternal fractures; exposure: presence of retrosternal hematoma; comparator: patients without retrosternal hematoma; outcomes: mortality, pulmonary complications, and clinically relevant outcomes during hospitalization approach to clearly define the study design and analytical focus.

Clinical data were retrieved from the hospital information system, encompassing patients' age, sex, radiological imaging, laboratory results, mechanism of trauma, seatbelt usage in traffic accidents (based on patient self-report), length of hospitalization, Injury Severity score (ISS), concomitant thoracic and extra-thoracic injuries, fracture localization, and fracture type. Trauma severity was assessed using the ISS. A score below 16 was classified as low ISS, while a score of 16 or above was classified as high ISS. All thoracic CT scans were evaluated by a single experienced thoracic surgeon. Thoracic CT scans (64-slice multidetector CT, performed with intravenous (IV) contrast in arterial and/or venous phases, using 0.5-1-mm thin-section acquisition with multiplanar reconstructions) were evaluated as part of the routine trauma protocol. Thoracic CT was performed immediately after admission to the emergency department,

following the initial assessment and resuscitation. Contrast-enhanced CT was preferred in cases of high-energy trauma and when physical examination findings suggestive of intrathoracic bleeding such as asymmetric respiration, hypoxia, subcutaneous emphysema, or crepitation were present. Additionally, contrast-enhanced thoracic CT was obtained in patients who demonstrated deterioration in vital signs during clinical follow-up and in those with suspected intrathoracic bleeding on radiologic surveillance.

Fracture localization was categorized according to the anatomical segments of the sternum: manubrium, corpus, xiphoid, and mixed regions. Fracture patterns were classified as displaced (a fracture characterized by disruption of cortical alignment between fracture fragments, with axial or translational displacement, angulation, or overlap between the fragments) or non-displaced (a fracture in which a fracture line is visible in the rib cortex, while anatomic alignment is preserved without significant displacement, angulation, or shortening between the fracture fragments) (16,17). A retrosternal hematoma was defined as a blood collection located in the anterior mediastinal space posterior to the sternum, secondary to trauma, appearing on non-contrast CT as a soft-tissue-density lesion [40-70 Hounsfield unit (HU)] or a heterogeneous hyperdense area (18). A pulmonary contusion was defined as parenchymal lung injury representing alveolar hemorrhage and edema, characterized on CT by patchy ground-glass opacities or consolidations, typically adjacent to the pleura and not confined to segmental boundaries (19). A hemothorax was defined as the presence of pleural fluid with increased attenuation values (>35 HU) on CT, consistent with blood within the pleural space (20). Pneumomediastinum was defined as the presence of free air within the mediastinal space, visualized on CT as linear or focal air densities surrounding the trachea, esophagus, and major vessels (21).

All patients had chest CT for diagnostic purposes. Electrocardiograms were conducted on all patients with sternal fractures, and troponin I levels were assessed in individuals exhibiting abnormal electrocardiographic findings or those suspected of cardiac damage based on radiological imaging. Transthoracic echocardiography was performed in patients with increased troponin I levels (0-0.014 negative, 0.014-0.025 equivocal, 0.025-<10 positive). Additional diagnostic evaluations were initiated at the discretion of the thoracic surgeon, while a cardiologist performed echocardiography. The presence of myocardial contusion or pericardial effusion was considered diagnostic for blunt heart damage.

Surgical indications for sternal fractures included flail chest, displaced sternal fractures, open fractures, sternal fracture ends impinging on mediastinal organs, and the development of organ damage as surgical indications for sternal fractures.

The conservative treatment regimen comprised IV analgesics, suitable IV fluid resuscitation, nasal oxygen supplementation, and structured respiratory physiotherapy.

Statistical Analysis

Data were analyzed using IBM SPSS Statistics Standard Concurrent User, Version 26 (IBM Corp., Armonk, New York, USA). As the data demonstrated a normal distribution, descriptive statistics were expressed as mean \pm standard deviation. The normality of numerical variables was assessed using the Shapiro-Wilk test, and homogeneity of variances was evaluated with the Levene's test. Since the numerical variables were normally distributed, comparisons with binary categorical variables were performed using the independent two-sample t-test. Comparisons between categorical variables were conducted using the chi-square test based on the Exact method. When the chi-square test yielded statistically significant results, subgroup analyses were performed using the two-proportion z-test with Bonferroni correction. A p-value < 0.05 was considered statistically significant in all analyses.

Results

General Information About the Patients

The analysis demonstrated that sternum fractures occurred in 230 of 2131 patients (10.7%) who presented to the emergency department with thoracic injuries. Among these patients, 85 (37%) were female, while 145 (63%) were male. The mean age was 48.4 ± 17.1 years. The predominant cause of injuries was traffic accidents (n=189, 82.2%). The mean length of hospitalization was 5.5 ± 12.1 days. Thirteen individuals (5.7%) died (Table 1, Figure 1).

The predominant site of sternum fracture in our study was corpus (n=129, 56.1%). The majority of sternum fractures were non-displaced (n=128, 55.7%). Forty-nine patients (21.3%) sustained an isolated sternal fracture. The most common associated thoracic injury was rib fractures (n=140, 54.3%) while the most frequent accompanying-extra-thoracic injury was vertebral fractures (n=71, 36.2%). No patient underwent surgical sternal fixation due to the sternum fracture. Retrosternal hematoma was detected in 23 patients (10%) with sternal fractures. All patients underwent chest CT for diagnostic evaluation. A total of 80 patients (34.8%) were suspected of having cardiac injury and therefore underwent troponin I measurement and echocardiographic evaluation. Echocardiography revealed no evidence of cardiac injury in any patient. A significant positive correlation was observed between troponin I levels and ISS (p < 0.010).

No statistically significant association was observed between fracture localization and mortality (p=0.778). Among the patients

who died, the predominant fracture location was the corpus (n=7). Concomitant rib fractures and intracranial hemorrhage were present in ten mortality cases (76.9%). No mortality was observed among patients with isolated sternal fractures who were using seatbelts. All patients were managed conservatively, except for one patient with a retrosternal hematoma who developed hemothorax and subsequently underwent video-assisted thoracoscopic surgery (VATS) for hematoma evacuation.

Presence of Retrosternal Hematoma

Retrosternal hematoma occurred more frequently in patients with corpus fractures and displaced fractures, with statistically significant difference (p < 0.001, p = 0.001). Furthermore, a significant association was identified between retrosternal hematoma and the presence of hemothorax and pulmonary contusion (p = 0.021, p = 0.033). No statistically significant association was observed between the presence of retrosternal hematoma and ISS groups, ISS, length of hospitalization, or mortality (p = 0.210, p = 0.206, p = 0.243, p = 0.128) (Table 2).

Sternum Fracture and ISS Groups

The incidence of traffic accidents was higher in the low ISS group, and this difference was statistically significant (p = 0.007). No statistically significant association was observed between fracture localization or fracture displacement and ISS groups (p = 0.713, p = 0.381). All isolated sternum fractures occurred in the low ISS group, which was statistically significant (p = 0.002).

The low ISS group demonstrated a significantly higher incidence of rib fractures, hemothorax, pulmonary contusions, pneumothorax, facial injuries, scapular fractures, upper extremity fractures, and intra-abdominal organ injuries (p = 0.005, p < 0.001, p = 0.046, p < 0.001, p = 0.001, p = 0.008, p = 0.023, p = 0.032, p = 0.016). In contrast, the high ISS group showed a significantly higher incidence of intracranial hemorrhage and lower extremity fractures (p < 0.001, p = 0.001). Both the length of hospitalization and mortality rate were significantly higher in the high ISS group (p = 0.048, p < 0.001) (Table 3).

Consequences of Seatbelt Use

Among patients using seatbelts, the predominant fracture localization was the corpus, and this difference was statistically significant (p = 0.008). However, no statistically significant association was observed between fracture displacement and seatbelt usage (p = 0.434). Vertebral fractures were more frequently observed in patients not using seatbelts, which was statistically significant (p = 0.030). Patients without seatbelt use had significantly higher ISS values and longer hospitalization durations (p = 0.005, p = 0.001) (Table 4).

Table 1. General information of the patients	
	n (%)
Gender	
Male	145 (63)
Female	85 (37)
Age, (year) $\bar{x} \pm SD$	48.4±17.1
Troponin I, (ng/L) $\bar{x} \pm SD$	0.02±0.06
Trauma	
Vehicular traffic accident	189 (82.2)
Non-vehicle traffic accident	24 (10.4)
Fall from height	12 (5.2)
Animal kick	4 (1.7)
Assault	1 (0.4)
Fracture localization	
Manubrium	84 (36.5)
Sternal body	129 (56.1)
Xiphoid process	6 (2.6)
Mixed	11 (4.8)
Degree of fracture separation	
Non-displaced	128 (55.7)
Displaced	102 (44.3)
Retrosternal hematoma	
Yes	23 (10)
No	207 (90)
Isolated sternal fracture	
Yes	49 (21.3)
No	181 (78.7)
Seat belt use	
Yes	64 (33.9)
No	125 (66.1)
Comorbid thoracic injuries	
Rib fracture	140 (54.3)
Pulmonary contusion	50 (19.4)
Pneumothorax	42 (16.3)
Hemothorax	24 (9.3)
Pneumomediastinum	2 (0.7)
Comorbid extra-thoracic injuries	
Vertebral fracture	71 (36.9)
Intracranial injury	22 (11.5)
Pelvic fracture	17 (8.9)
Intra-abdominal organ injury	17 (8.9)
Clavicle fracture	15 (7.8)
Scapular fracture	15 (7.8)
Maxillofacial trauma	15 (7.8)
Upper extremity fracture	10 (5.2)
Lower extremity fracture	10 (5.2)
ISS group	
<16 (low)	199 (86.5)
≥16 (high)	31 (13.5)
ISS $\bar{x} \pm SD$	10.5±14.5
Length of hospitalization, (days) $\bar{x} \pm SD$	5.5±12.1
Mortality	13 (5.7)
n: Number of patients, %: Percentage of patients, \bar{x} : Mean, SD: Standard deviation, ISS: Injury Severity score	

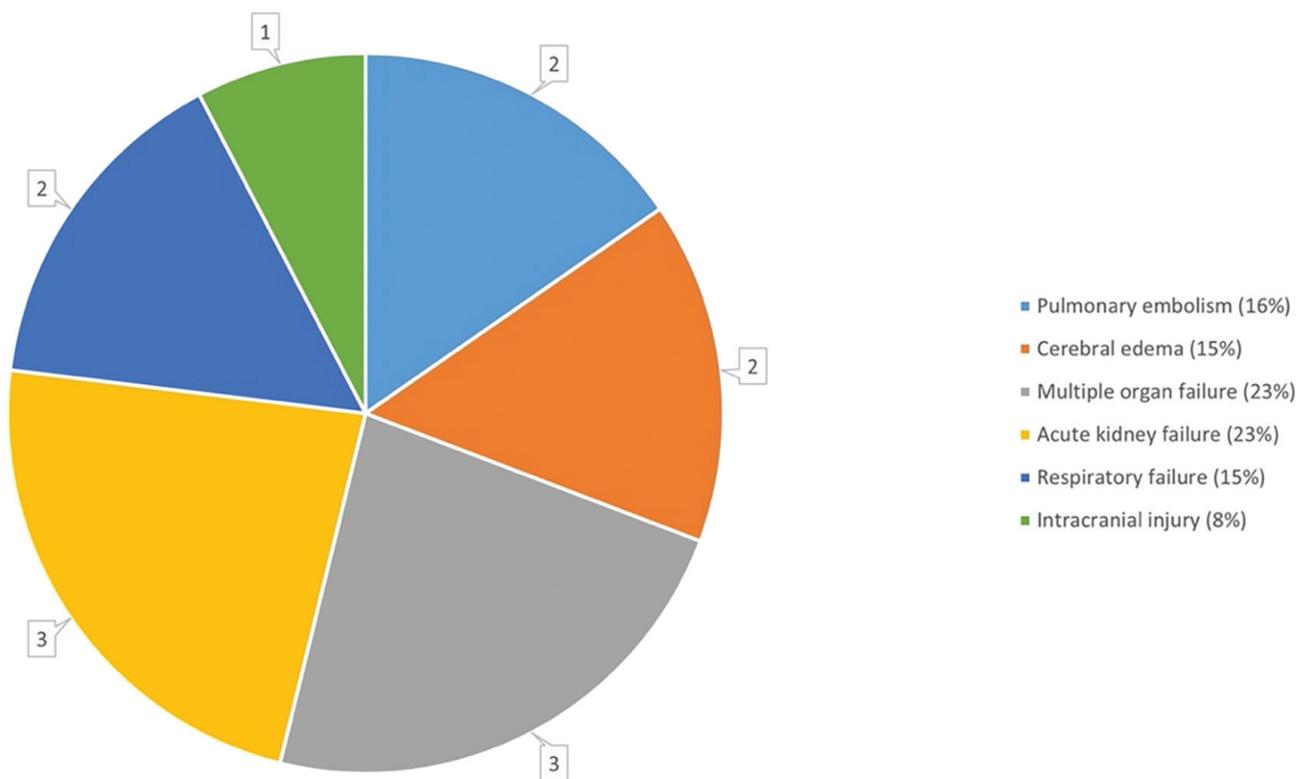


Figure 1. Causes of death

	Retrosternal hematoma present n=23	Retrosternal hematoma not present n=207	p
Gender			
Male	8 (34.8)	77 (37.2)	0.820
Female	15 (65.2)	130 (62.8)	
Age, (year) $\bar{x} \pm SD$	54.4±15.8	47.7±17.1	0.075
Troponin, (ng/L) $\bar{x} \pm SD$	0.02±0.04	0.02±0.06	0.851
Trauma			
Vehicular traffic accident	19 (82.6)	170 (82.1)	0.937
Non-vehicle traffic accident	3 (13)	21 (10.1)	
Assault	0 (0)	1 (0.5)	
Animal kick	0 (0)	4 (1.9)	
Fracture localization			
Manubrium	7 (30.4)	77 (37.2)	<0.001
Sternal body	9 (39.1)	120 (58)	
Xiphoid process	0 (0)	6 (2.9)	
Mixed	7 (30.4)	4 (1.9)	
Degree of fracture separation			
Non-displaced	5 (21.7)	123 (59.4)	0.001
Displaced	18 (78.3)	84 (40.6)	
Isolated sternal fracture			
Yes	5 (21.7)	44 (21.3)	>0.999
No	18 (78.3)	163 (78.7)	
Seat belt use			
Yes	7 (36.8)	57 (33.5)	0.772
No	12 (63.2)	113 (66.5)	

Table 2. Continued			
	Retrosternal hematoma present	Retrosternal hematoma not present	p
	n=23	n=207	
Rib fracture			
Yes	11 (47.8)	129 (62.3)	0.177
No	12 (52.2)	78 (37.7)	
Hemothorax			
Yes	6 (26.1)	18 (8.7)	0.021
No	17 (73.9)	189 (91.3)	
Pulmonary contusion			
Yes	1 (4.3)	49 (23.7)	0.033
No	22 (95.7)	158 (76.3)	
Pneumothorax			
Yes	4 (17.4)	38 (18.4)	>0.999
No	19 (82.6)	169 (81.6)	
Pneumomediastinum			
Yes	1 (4.3)	1 (0.5)	0.190
No	22 (95.7)	206 (99.5)	
Intracranial injury			
Yes	4 (17.4)	18 (8.7)	0.250
No	19 (82.6)	189 (91.3)	
Maxillofacial trauma			
Yes	1 (4.3)	14 (6.8)	>0.999
No	22 (95.7)	193 (93.2)	
Clavicle fracture			
Yes	0 (0)	15 (7.2)	0.374
No	23 (100)	192 (92.8)	
Scapular fracture			
Yes	1 (4.3)	14 (6.8)	>0.999
No	22 (95.7)	193 (93.2)	
Vertebral fracture			
Yes	11 (47.8)	60 (29)	0.093
No	12 (52.2)	147 (71)	
Upper extremity fracture			
Yes	1 (4.3)	9 (4.3)	>0.999
No	22 (95.7)	198 (95.7)	
Pelvic fracture			
Yes	3 (13)	14 (6.8)	0.389
No	20 (87)	193 (93.2)	
Intra-abdominal organ injury			
Yes	2 (8.7)	15 (7.2)	0.681
No	21 (91.3)	192 (92.8)	
Lower extremity fracture			
Yes	3 (13)	7 (3.4)	0.066
No	20 (87)	200 (96.6)	
ISS group			
<16	18 (78.3)	181 (87.4)	0.210
≥16	5 (21.7)	26 (12.6)	
ISS			
$\bar{x} \pm SD$	15.5±20.0	10.0±13.7	0.206
Length of hospitalization, (days)			
$\bar{x} \pm SD$	8.3±10.6	5.2±12.2	0.243
Mortality			
Yes	3 (13)	10 (4.8)	0.128
No	20 (87)	197 (95.2)	

n: Number of patients, \bar{x} : Mean, SD: Standard deviation, ISS: Injury Severity score, categorical data were expressed as number of patients (percentage). Significant p-values as a result of statistical analysis were bolded

Table 3. Low ISS and high ISS comparison			
	Low ISS	High ISS	p
	n=199	n=31	
Gender			
Male	126 (63.3)	19 (61.3)	0.828
Female	73 (36.7)	12 (38.7)	
Age, (year) $\bar{x} \pm SD$	47±16.5	52.1±20.4	0.277
Troponin, (ng/L) $\bar{x} \pm SD$	0.01±0.05	0.08±0.11	0.179
Trauma			
Vehicular traffic accident	170 (85.4)	19 (61.3)	0.007
Non-vehicle traffic accident	17 (8.5)	7 (22.6)	
Assault	1 (0.5)	0 (0)	
Animal kick	2 (1)	2 (6.5)	
Fracture localization			
Manubrium	71 (35.7)	13 (41.9)	0.713
Sternal body	113 (56.8)	16 (51.6)	
Xiphoid process	6 (3)	0 (0)	
Mixed	9 (4.5)	2 (6.5)	
Degree of fracture separation			
Non-displaced	113 (56.8)	15 (48.4)	0.381
Displaced	86 (43.2)	16 (51.6)	
Retrosternal hematoma			
Yes	18 (9)	5 (16.1)	0.210
No	181 (91)	26 (83.9)	
Isolated sternal fracture			
Yes	49 (24.6)	0 (0)	0.002
No	150 (75.4)	31 (100)	
Seat belt use			
Yes	61 (35.9)	3 (15.8)	0.079
No	109 (64.1)	16 (84.2)	
Rib fracture			
Yes	114 (57.3)	26 (83.9)	0.005
No	85 (42.7)	5 (16.1)	
Hemothorax			
Yes	14 (7)	10 (32.3)	<0.001
No	185 (93)	21 (67.7)	
Pulmonary contusion			
Yes	39 (19.6)	11 (35.5)	0.046
No	160 (80.4)	20 (64.5)	
Pneumothorax			
Yes	29 (14.6)	13 (41.9)	<0.001
No	170 (85.4)	18 (58.1)	
Pneumomediastinum			
Yes	2 (1)	0 (0)	>0.999
No	197 (99)	31 (100)	
Intracranial injury			
Yes	9 (4.5)	13 (41.9)	<0.001
No	190 (95.5)	18 (58.1)	
Maxillofacial trauma			
Yes	9 (4)	7 (22.6)	0.001
No	191 (96)	24 (77.4)	
Clavicle fracture			
Yes	11 (5.5)	4 (12.9)	0.126
No	188 (94.5)	27 (87.1)	

Table 3. Continued			
	Low ISS	High ISS	p
	n=199	n=31	
Scapular fracture			
Yes	9 (4.5)	6 (19.4)	0.008
No	190 (95.5)	25 (80.6)	
Vertebral fracture			
Yes	56 (28.1)	15 (48.4)	0.023
No	143 (71.9)	16 (51.6)	
Upper extremity fracture			
Yes	6 (3)	4 (12.9)	0.032
No	193 (97)	27 (87.1)	
Pelvic fracture			
Yes	13 (6.5)	4 (12.9)	0.258
No	186 (93.5)	27 (87.1)	
Intra-abdominal organ injury			
Yes	11 (5.5)	6 (19.4)	0.016
No	188 (94.5)	25 (80.6)	
Lower extremity fracture			
Yes	4 (2)	6 (19.4)	0.001
No	195 (98)	25 (80.6)	
Length of hospitalization, (days)			
$\bar{x} \pm SD$	4.68±11.0	11.0±16.6	0.048
Mortality			
Yes	0 (0)	13 (41.9)	<0.001
No	199 (100)	18 (58.1)	

n: Number of patients, \bar{x} : Mean, SD: Standard deviation, ISS: Injury Severity score, categorical data were expressed as number of patients (percentage). Significant p-values as a result of statistical analysis were bolded

Table 4. Consequences of seat belt use			
	Seat belt Available	Seat belt Not available	p
	n=64	n=125	
Gender			
Male	27 (42.2)	52 (41.6)	0.938
Female	37 (57.8)	73 (58.4)	
Age, (year)			
$\bar{x} \pm SD$	50.4±14.3	46.9±17.7	0.142
Fracture localization			
Manubrium	15 (23.4)	54 (43.2)	0.008
Sternal body	44 (68.8)	62 (49.6)	
Xiphoid process	3 (4.7)	1 (0.8)	
Mixed	2 (3.1)	8 (6.4)	
Degree of fracture separation			
Non-displaced	32 (50)	70 (54)	0.434
Displaced	32 (50)	55 (44)	
Retrosternal hematoma			
Yes	7 (10.9)	12 (9.6)	0.772
No	57 (89.1)	113 (90.4)	
Troponin, (ng/L)			
$\bar{x} \pm SD$	0.01±0.01	0.02±0.05	0.405
Isolated sternal fracture			
Yes	19 (29.7)	26 (20.8)	0.175
No	45 (70.3)	99 (79.2)	
Rib fracture			
Yes	39 (60.9)	74 (59.2)	0.818
No	25 (39.1)	51 (40.8)	

Table 4. Continued			
	Seat belt available	Seat belt not available	p
	n=64	n=125	
Hemothorax			
Yes	4 (6.3)	13 (10.4)	0.345
No	60 (93.8)	112 (89.5)	
Pulmonary contusion			
Yes	10 (15.6)	33 (26.4)	0.094
No	54 (84.4)	92 (73.6)	
Pneumothorax			
Yes	6 (9.4)	25 (20)	0.062
No	58 (90.6)	100 (80)	
Pneumomediastinum			
Yes	0 (0)	2 (1.6)	0.550
No	64 (100)	123 (98.4)	
Intracranial injury			
Yes	1 (1.6)	12 (9.6)	0.064
No	63 (98.4)	113 (90.4)	
Maxillofacial trauma			
Yes	4 (6.3)	9 (7.2)	>0.999
No	60 (93.8)	116 (92.8)	
Clavicle fracture			
Yes	3 (4.7)	4 (3.2)	0.690
No	61 (95.3)	121 (96.8)	
Scapular fracture			
Yes	1 (1.6)	8 (6.4)	0.277
No	63 (98.4)	117 (93.6)	
Upper extremity fracture			
Yes	2 (3.1)	8 (6.4)	0.499
No	62 (96.9)	117 (93.6)	
Vertebral fracture			
Yes	11 (17.2)	40 (32)	0.030
No	53 (82.8)	85 (68)	
Pelvic fracture			
Yes	2 (3.1)	8 (6.4)	0.499
No	62 (96.9)	117 (93.6)	
Intra-abdominal organ injury			
Yes	2 (3.1)	12 (9.6)	0.145
No	62 (96.9)	113 (90.4)	
Lower extremity fracture			
Yes	3 (4.7)	5 (4)	>0.999
No	61 (95.3)	120 (96)	
ISS			
$\bar{x} \pm SD$	5.3±5.1	10.6±14.4	0.005
ISS group			
<16	61 (95.3)	109 (87.2)	0.079
≥16	3 (4.7)	16 (12.8)	
Length of hospitalization, (days)			
$\bar{x} \pm SD$	2.8±2.7	4.9±6.0	0.001
Mortality			
Yes	0 (0)	119 (95.2)	0.098
No	64 (100)	6 (4.8)	

n: Number of patients, \bar{x} : Mean, SD: Standard deviation, ISS: Injury Severity score, categorical data were expressed as number of patients (percentage). Significant p-values as a result of statistical analysis were bolded

Discussion

This study demonstrated the incidence of sternal fractures in individuals with thoracic trauma at 10.7%. Literature indicates that the frequency of sternal fractures in patients with thoracic trauma varies between 3% and 8% (6,10,22). Recent developments in imaging technologies may account for the elevated rate observed in our study. The hospital's proximity to a busy road that links major centers may increase the incidence of accidents, thereby resulting in a higher observed rate.

The predominant cause of sternal fractures was traffic accidents (82.2%). The enhanced capability of cars to attain greater velocities is a critical contributor to the escalating incidence of traffic accidents (15). Although seatbelt utilization decreases mortality in vehicular collisions, it has been linked to a heightened occurrence of sternal fractures. Literature indicates that sternal fractures occur 0.7% to 4% more frequently in belted passengers (15). Sternal fractures are frequently termed "seatbelt trauma" (5-7,10,15). In our study, 33.9% of patients with sternal fractures resulting from traffic accidents were utilizing seatbelts. The absence of mortality in these patients, their shorter hospitalization, and a lower average ISS further support findings reported in the literature.

Our analysis predominantly identified non-displaced corpus fractures. The site and classification of sternal fractures are crucial for diagnosing thoracic organ damage (14,15,23). Research indicates that the prevalence of cardiac injury in individuals with sternal fractures varies between 1% and 21% (10,24). The resultant mortality is predominantly linked to corpus fractures (22-25). Our results were largely consistent with the existing literature, albeit minor statistical differences, which we attribute to the limited sample size.

The most commonly detected thoracic trauma associated with sternal fractures was rib fractures (n=140, 54.3%), while the predominant extra-thoracic injury was vertebral fractures (n=71, 36.9%). Literature frequently indicates an association between sternal fractures and rib fractures (14). Nevertheless, no prior research has specifically examined the association between sternal fractures and extra-thoracic injuries. Our data were consistent with the literature, and we contend that the relationship with extra-thoracic injuries may fluctuate depending on the mechanism of trauma.

The literature underscores the significance of electrocardiography and cardiac enzyme evaluation in diagnosing cardiac injury. We advocate performing echocardiogram upon identification of abnormal findings. Several studies emphasize the

necessity of hospitalization for patients exhibiting abnormal electrocardiographic findings associated with sternal fractures, whereas others suggest that hospitalization may be unnecessary in patients with only mildly elevated cardiac enzyme levels (23,26). In our study, all patients underwent electrocardiographic evaluation; however, no abnormalities were detected. Consequently, additional investigations were not pursued based solely on electrocardiographic findings. Troponin levels were assessed in patients suspected of cardiac injury during thoracic CT evaluation, irrespective of electrocardiography results, and echocardiography was performed in those with elevated levels. Although echocardiography revealed no evidence of cardiac injury, a positive association was observed between troponin levels and ISS. Despite differing perspectives in the literature, we advocate hospitalization and close monitoring of patients with elevated troponin levels in the presence of sternal fractures.

The management of sternal fractures depends on the degree of fracture displacement and the presence of associated complications; nonetheless, conservative treatment remains the primary approach in most cases (27). In our investigation, a single patient developed hemothorax secondary to a retrosternal hematoma, and was managed with VATS and hematoma evacuation. This patient had no associated cardiac or vascular injuries. The origin of the retrosternal hematoma was attributed to be the mediastinal fascias and the sternal structures. Literature indicates that retrosternal hematoma occurs in approximately 25% of patients with sternal fractures, a prevalence consistent with previous reports (28). In our study, however, this rate was lower, and the presence of retrosternal hematoma was not associated with the length of hospitalization, mortality, or trauma severity scores. Consistent with the literature, retrosternal hematoma was not associated with cardiac injury (29,30). However, its significant association with pulmonary contusion and hemothorax in our study suggests that clinicians should remain vigilant for potential pulmonary complications in patients with sternal fractures.

Sternal fractures represent a substantial source of morbidity and mortality due to their frequent association with concomitant organ injuries. Literature reports suggest that mortality rates in these patients are approximately 10% (14,15). In our study, however, the mortality rates was lower than that reported previously. Multiple factors may influence mortality, with early initiation of appropriate treatment and the quality of healthcare delivery being critical determinants. We believe that these factors contributed to the favorable outcomes observed in our cohort. Nevertheless, further studies are needed to validate these findings.

Study Limitations

The limitations of our study include its retrospective nature, single-center design, and relatively small sample size. Reliance on patient self-report to obtain information regarding seatbelt use may be considered a limitation of this study. In addition, the absence of a radiologist in the evaluation of radiological imaging and image interpretation being conducted by a single experienced thoracic surgeon may also be regarded as study limitations.

Conclusion

Seatbelt use in traffic accidents is life-saving; however, it can lead to rare injuries such as sternal fractures. While conservative treatment often successfully manages sternal fractures, signs such as the presence of a retrosternal hematoma may suggest associated pulmonary injury rather than cardiac involvement. The use of appropriate diagnostic modalities and close in-hospital monitoring of these patients can help prevent mortality.

Ethics

Ethics Committee Approval: Ethical approval was obtained from Ethics Committee Approval for Non-Interventional Research from Kırıkkale University on (decision number: 2021.07.02, date: 08.07.2021). The study was conducted in accordance with the Declaration of Helsinki.

Informed Consent: The study is notable for its retrospective nature, single-center design, and relatively small sample size.

Footnotes

Authorship Contributions

Surgical and Medical Practices: S.K., E.Z., N.G., Concept: S.K., N.G., Design: S.K., N.G., Data Collection or Processing: S.K., K.B.Ç., E.Z., N.G., Analysis or Interpretation: S.K., K.B.Ç., E.Z., N.G., Literature Search: S.K., K.B.Ç., E.Z., N.G., Writing: S.K., K.B.Ç., E.Z., N.G.

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