



Cohort Study

A retrospective study on the cardiac assessment of isolated sternal fracture patients based on radiographic and clinical outcomes

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ABSTRACT

Objective: Sternal fracture may be associated with major and serious injuries. In this study, the complications associated with isolated sternal fracture in trauma patients are evaluated based on radiographic and cardiac findings.

Methods: This retrospective study was performed on patients with isolated sternal fractures admitted to the emergency department of (XXX) Madani Educational-Medical. Data regarding demographic information, mechanism of trauma, length of hospitalization, electrocardiography (ECG), cardiac enzyme, and chest radiography were recorded in the questionnaire for each patient.

Results: The mean age of patients 41.2 ± 11.04 years and 63.9% were male. The most common cause of the trauma was car accidents in 41% (25 cases). The mean duration of hospitalization was 1.54 ± 0.90 days. The mechanism of trauma was not associated with x-ray and computed tomography findings, $p = 0.53$ and $p = 0.86$, respectively. ECG findings were significantly related to x-ray and computed tomography outcomes, $p < 0.001$, respectively.

Conclusion: Patients with isolated sternal fracture with displacement >0.5 cm and hematoma are likely to require cardiac consultation.

1. Introduction

Approximately, 10% of all trauma cases are blunt trauma [1]. Trauma accounts for more than 31 million visits in the emergency department and more than 100,000 deaths, yearly, in the United State. Thoracic traumas are associated with a significant number of mortality and morbidities since it includes vital organs like the lungs and the heart [2,3].

Isolated sternal fractures are caused by blunt trauma and are benign, however, depending on the nature and the severity of the fracture [4], patients are required to be assessed for supporting injuries [5,6]. Among trauma patients, 0.33% patients are reported with sternal fractures [7]. The mortality rate associated with isolated sternal injuries ranges from 0.7% to 3.5% [8]. Additionally, 0.8% of these patients are presented with cardiac complications [9]. Prognosis of isolated sternal fractures is relatively better than polytrauma sternal fracture and is likely to be

associated with fewer complications [10].

Patients with sternal fracture due to blunt trauma are commonly subjected to cardiographic analysis [11]. Evidence and guidelines regarding this practice are not clear [12]. Cardiac investigation in patients with isolated sternal injuries are performed due to the suspicion of occult myocardial contusions [13]. Some of these patients can be asymptomatic, however, asymptomatic patients without any history of cardiac disease usually have benign concomitant cardiac injuries that can be left untreated [14,15]. In rare cases, cardiac tamponade is also reported that occurs due to extrapericardial blood accumulation in the absence of hematoma or injury [16]. Sternal fracture has also been reported to cause aortic rupture [17,18].

The aim of this study is to examine the data of patients presented with isolated sternal fractures based on radiographic and cardiac findings.

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2. Methods

This retrospective study was performed on 61 patients with isolated sternal fractures admitted to the emergency department of (XXX) Educational-Medical Center during 2018–2019. The cases of patients with isolated sternal fractures who met the inclusion criteria of definitive diagnosis of sternal fracture and isolated fracture were included in the study. Exclusion criteria of the study included concurrent acute myocardial infarction, pneumothorax, pulmonary embolism, incomplete hospital records, and congenital malformations of sternum bone.

Initially, demographic information of patients including gender, age, mechanism of trauma, length of hospital stay were collected. In addition, subsequent results obtained during the patient’s stay included serial ECGs, chest radiographs, and cardiac enzyme levels (creatinine phosphokinase: CPK) were also evaluated.

2.1. Statistical analysis

The collected data were recorded in a checklist and computerized. Analysis was performed using SPSS version 25. The data were expressed in the form of frequency percentages. Fisher’s test was performed to compare the findings. $P < 0.05$ was considered to be statistically significant.

This study was approved by the Research Ethics Board of (XXX).

The work has been reported in line with the STROCCS criteria [19]. Unique identifying number is: researchregistry6601.

3. Results

The mean age of patients with sternal fracture was 41.2 ± 11.04 years with the range of 22–67 years. Overall, 63.9% (39 cases) were male and 36.1% (22 cases) were female. Male patients were almost twice as female patients.

The mechanism of blunt trauma in 19.7% (12 cases) was direct impact, 11.5% (7 cases) had motor accident, 27.9% (17 cases) had fall and 41% (25 cases) patients had car accidents. The average length of hospital stay was 1.54 ± 0.90 days in the range of 1–4 days.

In patients with sternal fractures, radiographic findings showed that 86.9% (53 cases) had sternal trunk fractures, 1.6% (1 case) fractures were with displacement less than 0.5 cm and 11.5% (7 cases) had more than 0.5 cm displacement.

CT scan findings showed that 82% (50 cases) were sternal trunk fractures, 1.6% (1 case) was of displacement fractures, 1.6% (1 case) of fracture was with lung contusion and hematoma was seen in 14.8% (9 cases). The findings reported in chest x-ray showed 63.9% (39 cases) sternal trunk fracture and 36.1% (22 cases) mediastinal dilatation. ECG of these patients showed 85% (52 cases) normal cases and 14.8% (9 cases) had ST segment elevation. Cardiac enzyme report showed 9.8% (6 cases) with an increase in CPK and in 90.2% (55 cases) CPK was normal.

Among 53 patients diagnosed with sternal fracture on radiograph, 20.8% ($n = 11$) were due to direct impact, 9.4% ($n = 5$) were motor accidents, 26.4% ($n = 14$) falls, 43.4% (23 cases) were car accidents. In 1 case where the fracture was with a displacement of less than 0.5 cm that was due to fall, and in 7 cases with a displacement of more than 0.5 cm where 14.3% (1 case) was due to direct impact, 28.6% (2 cases) were motor vehicle accidents, 28.6% (2 cases) were of falls and 28.6% (2 cases) were caused by car accidents. No significant difference was found between the trauma mechanism and radiographic findings, $p = 0.53$ (Table 1).

CT scan diagnosed sternal trunk fractures in 22% ($n = 11$) due to direct impact, 10% ($n = 5$) motor crashes, 28% ($n = 14$) due to falls and 40% (20 cases) due to car accidents. In 1 case (100%) of fracture with displacement, the trauma was due to car accident and in 1 patient with fracture associated with lung contusion, it was due to car accident. Among 9 patients with hematoma, 11.1% (1 case) had direct impact, 22.2% (2 cases) had motor accidents, 33.3% (3 cases) falls and 33.3% (3

Table 1

Distribution of relative and absolute frequency of radiographic findings based on trauma mechanism.

	sternal trunk fractures	displacement less than 0.5 cm	displacement more than 0.5 cm displacement.
direct impact	11 (20.8%)	0	1 (14.3%)
motor accidents	5 (9.4%)	0	2 (28.6%)
fall	14 (26.4%)	1 (100)	2 (28.6%)
car accidents	23 (43.4%)		2 (28.6%)
Total	53 (100%)	1 (100%)	7 (100%)

$P = 0.53$

cases) were caused by car accidents. The findings of CT scan were not significantly associated with the mechanism of trauma, $p = 0.86$ (Table 2).

According to radiographic findings, in 52 patients with normal ECG, 98.1% (51 patients) had sternal trunk fractures and 1.9% (1 patients) had displacement of more than 0.5 cm. Among 9 patients with ST elevation, 22.2% ($n = 2$) had sternal trunk fractures, 11.1% ($n = 1$) had fracture displacement less than 0.5 cm and in 66.7% ($n = 6$) fracture was with displacement more than 0.5 cm. There was a significant relationship between ECG findings and radiographic findings, $p < 0.001$ (Table 3).

Based on CT findings, in 52 patients with normal ECG, 94.2% ($n = 49$) had a sternal trunk fracture and 1.9% ($n = 1$) had a displacement at the fracture site, 1.9% (1 case) had a lung contusion and 1.9% (1 case) had hematoma. Among, 9 patients who had ST segment elevation, 11.1% (1 case) had sternal trunk fracture and 88.9% (8 patients) were diagnosed with hematoma. There was a significant relationship between ECG findings and CT scan findings, $p < 0.001$ (Table 4).

4. Discussion

Our study evaluated the CT and x-ray findings among trauma patients presented with sternal fracture at our medical center. The findings of our study showed that x-ray and CT findings are not associated with trauma mechanism whereas, in patients with elevated ST-segment, most patients had a radiographic diagnosis of fracture displacement greater than 0.5 cm from x-ray and most of these patients were diagnosed with hematoma on CT scan.

In the study by Celik et al., which examined sternal fractures in 80 patients, the age of patients ranged from 18 to 83 years with an average of 48.7 ± 15.4 years and 84% of patients were male. 44% of patients had isolated sternal fractures and 56% of patients had injuries associated with sternal fractures. The most common cause of motor vehicle crashes was 77% and the most common fracture was in the sternum trunk (76%) [20]. The average age of the patients in our study is close to that of this study and the most common radiographic finding was sternal trunk fracture.

Bar et al., conducted a study on 55 patients with sternal fractures and

Table 2

Distribution of relative and absolute frequency of CT scan findings based on trauma mechanism.

	sternal trunk fractures	displacement	lung contusion	hematoma
direct impact	11 (22%)	0	0	1 (11.1%)
motor accidents	5 (10%)	0	0	2 (22.6%)
fall	14 (28%)	0	0	3 (33.3%)
car accidents	20 (40%)	1 (100%)	1 (100%)	3 (33.3%)
Total	50 (100%)	1 (100%)	1 (100%)	9 (100%)

$P = 0.86$

Table 3

Distribution of relative and absolute frequency of ECG findings based on radiographic findings.

	Normal	ST segment elevation
sternal trunk fractures	51 (98.1%)	2 (22.2%)
displacement less than 0.5 cm	0	1 (11.1%)
displacement more than 0.5 cm displacement	1 (1.9%)	6 (66.7%)
Total	52 (100%)	9 (100%)

P = 0.0001

Table 4

Relative and absolute frequency distribution of ECG findings based on CT scan findings.

	Normal	ST segment elevation
sternal trunk fractures	51 (98.1%)	2 (22.2%)
displacement less than 0.5 cm	0	2 (11.1%)
displacement more than 0.5 cm displacement	2 (1.9%)	6 (66.7%)
Total	52 (100%)	9 (100%)

P = 0.0001

reported that the most common mechanism of injury was motorcycle accidents. Cardiac enzymes were abnormally high in 5 patients and the average hospital stay varied from 6 h to 6 days. None of these patients had abnormal ECG [21]. In our study, the most common cause of sternal fracture was due to car accidents and the average length of hospital stay was 1–4 days. The findings of ECG and cardiac enzymes are not consistent with this study.

A study by Sadaba, Oswal [22] reported that widening of mediastinum in chest x-ray can predict abnormal ECG findings. The study suggested that patients with normal ECG and radiography can be discharged on analgesics and echocardiography and CK test are not indicated in such cases. Similar conclusions are drawn from the study by Dua, McMaster [23]. Furthermore, Al Mogrampi, Papoulidis [24] recommended that sternal fracture patients with abnormal ECG findings should be monitored for at least 48 h before discharge. von Garrel, Ince [25] reported that displacement associated with the fracture are associated with corpus, thoracic and cardiac injuries. The study concluded that displacement can indicate the severity and prognosis of the fracture and associated injuries. However, Heidelberg, Uhlich [26] reported that displacement cannot predict fracture displacement and its severity. A recent study conducted by Yakar, Baykan [27] on 128 sternal fracture patients showed that car traffic accidents are the most common cause of these accidents. Localization of fracture was not associated with abnormal ECG findings in the study. CK was higher than normal levels in approximately 72% of patients.

Our study is a retrospective study and is based on small sample size. This study lacks data regarding therapeutic measures and follow-up. Further studies are required to deduce absolute conclusion based on larger sample size, therapeutic measures and follow-up. These findings can help researchers and clinicians to draft guidelines and protocols regarding the management of isolated sternal fracture patients requiring cardiac evaluation. Future studies can help clinicians to make evidence-based judgment in such cases and prolonged hospitalization can be reduced.

5. Conclusion

The outcomes of our study suggest that patients with fracture displacement more than 0.5 cm and hematoma should undergo ECG analysis, in order to identify cardiac abnormalities. The type of mechanism of trauma may not predict radiographic findings.

Provenance and peer review

Not commissioned, externally peer-reviewed.

Human and animal rights

No animals were used in this research. All human research procedures followed were in accordance with the ethical standards of the committee responsible for human experimentation (institutional and national), and with the Helsinki Declaration of 1975, as revised in 2013. This study was approved by the Research Ethics Board of Alborz University of Medical Sciences.

Consent for publication

Informed consent was obtained from each participant.

Availability of data and materials

All relevant data and materials are provided with in manuscript.

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Ethical approval

All procedures performed in this study involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Registration of research studies

1. Name of the registry: researchregistry
2. Unique Identifying number or registration ID: researchregistry6601
4. Hyperlink to the registration (must be publicly accessible): <https://www.researchregistry.com/browse-the-registry#home/registrationdetails/603428ebd480f3001b9c40bb/>

Guarantor

Mojtaba Ahmadinejad.

Contributors' statement page

Dr. Mojtaba Ahmadinejad and Dr. Izadmehr Ahmadinejad: conceptualized and designed the study, drafted the initial manuscript, and reviewed and revised the manuscript.

Dr. Haleh Pak: and Dr. Mohsen Pouryaghoubi: Designed the data collection instruments, collected data, carried out the initial analyses, and reviewed and revised the manuscript.

Dr. Ali Soltanian and Dr. Sanaz Mohammadzadeh and Dr. Abtin Ahmadi: Coordinated and supervised data collection, and critically reviewed the manuscript for important intellectual content.

Declaration of competing interest

The authors deny any conflict of interest in any terms or by any means during the study.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.amsu.2021.102762>.

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