Journal of Pediatric Surgery 55 (2020) 1224–1227

Contents lists available at ScienceDirect

Journal of Pediatric Surgery

journal homepage: www.elsevier.com/locate/jpedsurg

Pediatric sternal fractures: A single center retrospective review☆

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ARTICLE INFO

Article history:
Received 25 March 2019
Received in revised form 29 July 2019
Accepted 10 October 2019

Key words:
Sternal fracture
Trauma
Pediatric

ABSTRACT

Purpose: We sought to investigate the diagnosis, management, and outcomes of pediatric sternal fractures.
Methods: We used ICD codes to search our trauma registry and Hound Dog software to search the hospital data warehouse for all cases of radiologically confirmed sternal fracture in patients <21 years from January 1, 1997 to July 1, 2017. We extracted demographics, mechanism of injury, diagnostic modality, associated injuries, and clinical outcomes.
Results: We identified 65 children with sternal fractures. 46/65 (71%) were male, with median age 11 years. 34/65 (52%) presented to our emergency department (ED) and the remainder to outpatient clinics. 41/65 (63%) were diagnosed by chest X-ray, 11/65 (17%) by chest CT, 7/65 (11%) by sternal X-ray, and 5/65 (8%) by MRI. Mechanism of injury varied by age. The majority, 50/65 (77%), were isolated injuries and there were no cardiac injuries, aortic injuries or deaths. 18/33 (45%) of those who presented initially to the ED were admitted, and of these 7/18 (39%) had isolated sternal fractures.
Conclusions: In this series, most sternal fractures were isolated with low morbidity. Sternal fracture alone should not prompt aggressive workup for intrathoracic injuries and stable patients with isolated sternal fractures can be safely followed without admission.
Level of evidence: IV.

Fractures of the sternum are rare in children. Literature on sternal fractures in this population is scant, with the largest single-center series to date including 19 children over a 15 year period [1]. Less than 2% of sternal fractures occur in patients less than the age of 16, and they become more common in the later teenage years [2]. This pattern is attributed to the high elasticity of the younger, cartilaginous sternum compared to the stiffer teenaged or adult sternum. Forced flexion of the sternum, as in bending over a seatbelt or a direct blow, such as impact with a rail during a trampoline accident, is also a common mechanism [3]. While sternal fractures are associated with high-energy mechanisms and severe associated injuries in adults, this is less clear in children [1–14]. In adults, electrocardiogram (EKG) and cardiac enzymes are recommended to rule out significant traumatic damage to the myocardium, but it is unclear what role these tests should play in the pediatric population [7]. Some authors suggest that sternal fractures are associated with nonaccidental trauma in children, while more recent evidence calls this assertion into question [8,9]. Consensus is building that adult patients with isolated sternal fractures have low rates of underlying cardiac injury, and can be adequately managed without extensive workup or admission [10,11].

Our aim in this study is to add to the body of evidence on the epidemiology, diagnosis, treatment, and prognosis for sternal fractures in pediatric patients. Here we present what is, to our knowledge, the largest reported single-center experience with pediatric sternal fractures.

1. Methods

After institutional review board (IRB) approval, we searched our trauma registry for patients <21 years of age with the ICD9 or ICD10 code for closed fracture of sternum (807.2 and S22.20XA, respectively) from January 1, 1990 to July 1, 2017. We then proceeded to use HoundDog (GFI Software, Austin, TX), to text search all clinical notes in our institution's data warehouse for the search terms “sternal fracture” or “sternum fracture” where the patient age was <21 years of age at date of service from January 1, 1997 to July 1, 2017. Charts were then reviewed, and patients without radiologically confirmed sternal fracture or inadequate documentation were excluded. We defined adequate documentation as the presence of a radiograph report confirming the diagnosis and a clinical note describing the mechanism, workup, and treatment plan. We extracted demographics, mechanism of injury, comorbidities, diagnostic modality, associated injuries, and clinical outcomes from the medical record. Diagnosis of cardiac injury required both abnormal EKG and cardiac enzymes or echocardiography. We defined chronic chest pain as documentation of a unique clinic visit with a

☆ Authors' contributions: Dr. Chalpin acquired study data, performed the data analysis and wrote the publication. Dr. Mooney identified the clinical concern, assisted with data analysis and edited the publication.

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https://doi.org/10.1016/j.jpedsurg.2019.10.002
0022-3468/

chief complaint of chest pain following an initial ED or clinic visit for sternal fracture that was not a follow-up appointment planned at the initial visit. This definition was not derived from any other source.

2. Results

2.1. Inclusion, demographics, presentation, and injury severity

13 patients were identified from the Boston Children's Hospital trauma registry using ICD codes, and no patients were excluded from this group. Hound Dog search returned 107 unique patients. Of these, 55 were excluded owing to the absence of radiographically confirmed sternal fracture or inadequate documentation. Overall, we identified 65 patients with sternal fractures. The majority, 46/65 (71%) were male, with a median age 11 years and an interquartile range of 6–16 years. Roughly half, 34/65 (52%) presented to the ED, with the remainder presenting to outpatient clinics. Outpatient clinics included general surgery, orthopedics, and sports medicine. Overall median ISS score in the cohort was 4 (interquartile range 4–4). The median ISS score was 4 (IQR 4–5) among patients who presented to our ED and 4 (IQR 4–4) among patients who presented to our clinics (Table 1). Patients who presented to the ED did so more quickly than those who presented via specialty clinics (Figure 1).

2.2. Mechanism

The most common mechanisms of injury were motor vehicle collision (MVC) (12/65, 18%) and sports (12/65, 18%), with hockey the most commonly cited sport (4/12, 33%). Other common mechanisms included trampolines (8/65 12%), snow sports (5/65, 8%), which we defined as skiing, snow-boarding, or sledding, and playground falls (4/65, 6%). No known mechanism was identified in 7/65 (11%) cases. Two of 65 (3%) cases were directly attributed to non-accidental trauma (NAT). Fifteen of 65 (23%) cases were from events such as falls from horseback, roughhousing, and projectiles. The mechanism of injury varied by age, with unknown and NAT predominating from age 0 to 4 years, playground falls from age 3 to 6 years, trampolines from age 7 to 12 years, sports from age 10 to 20 years, and MVC from age 13 to 19 years (Figure 2). Patients who presented via the ED were more likely to have high-energy mechanisms, such as MVCs, or NAT compared to those who presented to specialty clinics, who were more likely to have sports related injuries (Figure 3).

2.3. Diagnosis

The most common diagnostic modality was chest radiograph (41/65, 63%), followed by chest computerized tomography (CT) (11/65, 17%), dedicated sternal radiograph (7/65, 11%), and magnetic resonance imaging (MRI) (5/65, 8%). All MRI studies were obtained in the outpatient setting. There were no cases of diagnosis by ultrasound. Chest CT was utilized at equivalent rates regardless of whether patients presented to the ED (13/33, 39%) or specialty clinics (12/32, 38%). Chest

Table 1
Descriptive statistics by site of presentation.

	Presented to ED ($n = 33$)	Presented to Clinic ($n = 32$)	p-value
Age (mean years)	9.5	11.8	0.113
Male *n* (%)	27 (81%)	18 (56%)	0.033
Isolated Injury *n* (%)	22 (67%)	26 (81%)	0.26
ISS (median, IQR)	(4, 4–5)	(4, 4–4)	0.363
Received Chest CT *n* (%)	13 (39%)	12 (38%)	1
Received MRI *n* (%)	2 (6%)	8 (25%)	0.044

Presentation refers to how patients first presented to our institution, not first presentation to any medical care. Clinic includes general surgery, orthopedics, and sports medicine. ED, emergency department; ISS, injury severity score; IQR, interquartile range.

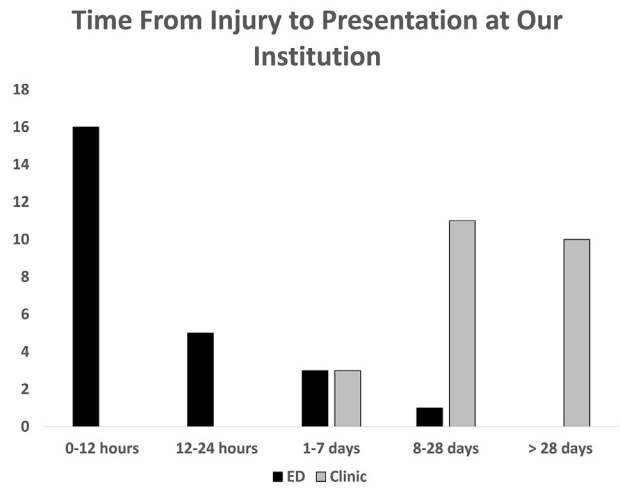

Fig. 1. Time from injury to presentation at our institution. Presentation refers to how patients first presented to our institution, not first presentation to any medical care. Clinic includes general surgery, orthopedics, and sports medicine. ED, emergency department.

MRI was used more often in patients who presented to specialty clinics (8/32, 25%) than the ED (2/33, 6%). Chest radiographs were performed more frequently on patients who presented to the ED (33/33, 100%) compared to patients who presented to specialty clinics (25/32, 78%). One patient underwent a bedside transthoracic echocardiogram, which identified no cardiac injury.

An EKG was documented in 19/33 (61%) of patients who initially presented to the ED. There was only one case of an abnormal EKG, where the patient was found to be bradycardic with inverted T waves in V1 and V2. There was no previous EKG with which to compare these findings. This patient was admitted, and no other injuries were diagnosed.

Creatinine kinase (CK) and/or troponin assays were documented in 6/33 (27%) patients who initially presented to the ED. There were no abnormal troponin levels. CK was elevated in 2 patients, both of whom were admitted. One patient was found to have rib fractures, pulmonary contusions, and a small left pneumothorax, while no other injuries were identified in the other patient. Each of the cases with abnormal EKG or CK described above represents unique, nonoverlapping patients. All 3 patients were hemodynamically stable, suffered no known cardiac sequelae, and did not undergo echocardiography or other further workup. Accordingly, given the lack of specificity of EKG and CK for cardiac injury and the absence of other data, we did not count any of these patients as having a confirmed blunt cardiac injury.

2.4. Associated injuries

Associated injuries included long bone fracture ($n = 5$), rib fracture ($n = 4$), pulmonary contusion ($n = 4$), retrosternal hematoma ($n = 3$), pneumothorax ($n = 2$), vertebral fracture ($n = 2$), and brain injury ($n = 3$). The brain injuries in this series included 2 concussions and a single small subarachnoid hemorrhage. Both vertebral fractures were stable, and did not require operative intervention or carry neurologic sequelae. Underlying sternal abscess was present in 2 patients, requiring operative debridement. In both cases the mechanism of injury was unknown. There were no cardiac injuries, aortic injuries, paralysis, or deaths in the cohort (Figure 4). Isolated injuries were more common among patients who presented to specialty clinics compared to the ED, although this difference did not meet statistical significance (Table 1).

2.5. Admission and outcomes

Of those patients who initially presented to the ED, 18/33 (55%) were admitted. Of these, 7/18 (39%) had no other associated injuries.

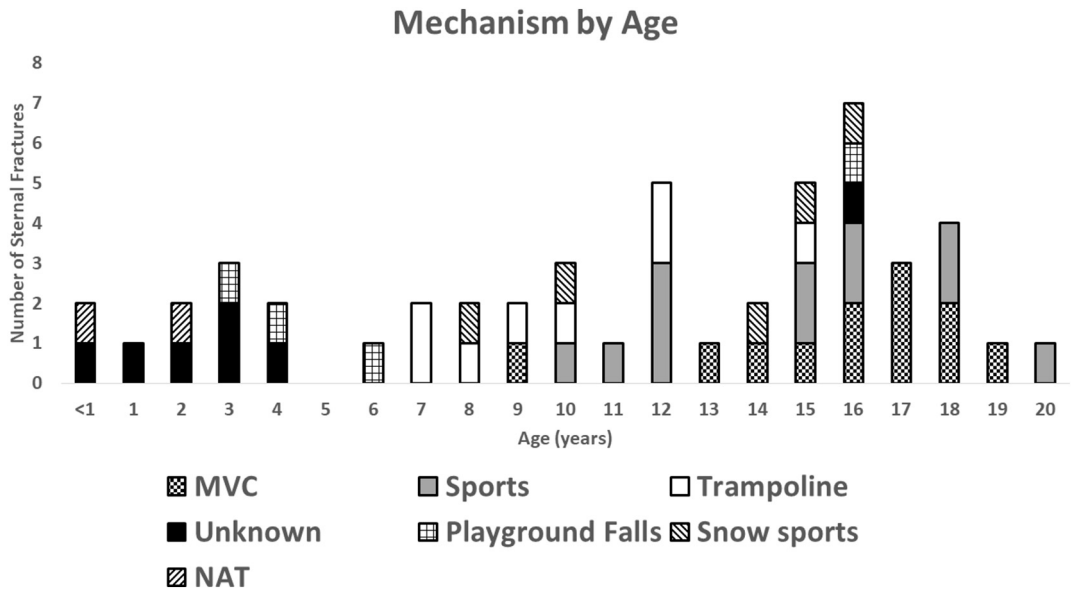

Fig. 2. Select mechanisms of sternal fracture by age. MVC, motor vehicle collision; NAT, nonaccidental trauma.

The only long-term complication directly attributable to sternal fracture reported in this cohort was chronic chest pain (4/65, 6%). In 3 of these cases, bone stimulators were utilized as recommended by outpatient sports medicine specialists.

3. Discussion

We report a single center retrospective review of pediatric patients with sternal fractures. To our knowledge, this series represents the largest single-center experience with sternal fractures in this population with 65 unique cases. Unlike other recent reports that focused solely on sternal fractures diagnosed in the setting of the ED, our approach allowed us to review sternal fractures in both the inpatient and outpatient setting and provides a fuller picture of the injury. Inclusion of outpatient records is likely the reason why our reported rate of isolated sternal fractures is higher than others reported in the literature [1].

Our data diverge widely from the recent review of pediatric sternal fractures from the National Trauma Data Bank (NTDB) by Vogel et al., which did document major thoracic and cardiac injuries in this population [12]. Our study differs from that of Vogel et al. in several important dimensions: first, the average age of patients in our data set is 11 years, versus 17 years in NTDB dataset; second, our study included both inpatients and outpatients, while the NTDB includes only inpatients; finally, our study includes patients seen in follow-up, not just in the context of acute injury. We believe that the methods we used to identify patients present a more complete impression of sternal fractures in children than that obtained solely from a review of inpatient trauma center care, although the real picture is probably somewhere in between.

Our findings are consistent with those of Ferguson et al., in that sternal fractures are often caused by relatively mild traumatic mechanisms, such as playground falls and trampoline injuries, especially in school toddlers and school age children [13]. In contrast, higher energy mechanisms such as sports, snow sports, and MVCs predominate in older high school-aged children, which are more consistent with the findings of Ramgopal et al. and Vogel et al. [1,12]. This observation suggests that perhaps the diagnostic and therapeutic approach to sternal fractures should vary based on age, although our cohort is too small to adequately address this question.

The relationship between sternal fractures and NAT remains unclear [8,9]. We found that most sternal fractures in infants and toddlers do not have a known mechanism. We also found that in both confirmed cases of NAT, patients presented with additional metachronous fractures. It may be that several of the cases in infants and toddlers with unknown mechanism could in reality represent NAT, although we are unable to fully assess this risk. As both cases of NAT occurred in the setting of

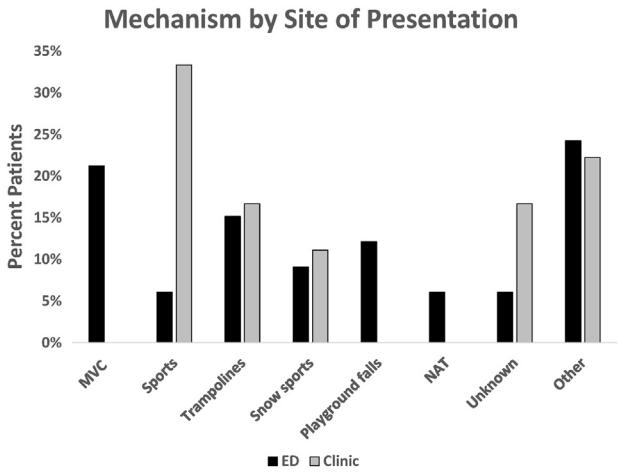

Fig. 3. Select mechanisms of sternal fracture by site of presentation. Presentation refers to how patients first presented to our institution, not first presentation to any medical care. Clinic includes general surgery, orthopedics, and sports medicine. ED, emergency department; MVC, motor vehicle collision; NAT, nonaccidental trauma.

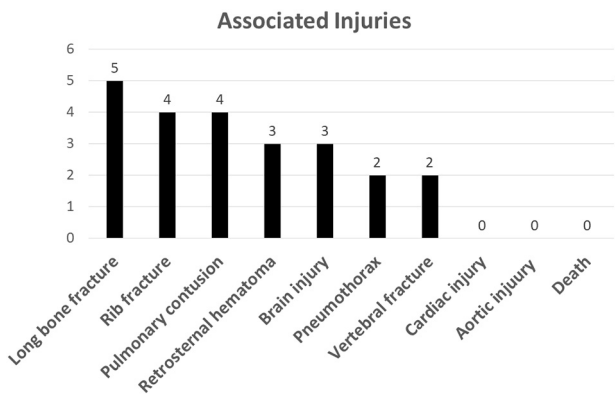

Fig. 4. Injuries associated with sternal fracture.

other fractures, it seems reasonable to consider this mechanism in the setting of sternal fractures in children <2 years of age.

Given the lack of cardiac injury, aortic injury, paralysis, or death in our cohort, we conclude that the presence of sternal fracture alone should not prompt aggressive workup. Specifically, studies that carry significant radiation, such as CT, anesthesia, such as transesophageal echocardiogram, or cost, such as MRI or serial cardiac enzymes, are likely not necessary solely owing to the presence of a sternal fracture. No patients in our series were diagnosed via ultrasound, but several case reports suggest that this modality may represent an option for patients that avoids ionizing radiation [14]. While EKG and cardiac enzymes are recommended to rule out blunt cardiac injury in the adult literature, we did not identify any instances of cardiac injury in this cohort [7]. Furthermore, it does not appear that these studies were helpful in guiding the management of any patients in this series. As a result, we are unable to make any strong recommendations for the use of EKG or cardiac enzymes in screening for blunt cardiac injury in pediatric patients with sternal fractures.

Given that most sternal fractures in children are isolated injuries with low risk of complications, we agree with other authors that patients with isolated sternal fractures without other concerning features can be safely discharged home [1,13]. Patients who go on to develop chronic chest pain may benefit from bone stimulators, but this approach is uncommonly reported and this study was not designed to assess this intervention.

These data must be interpreted in the context of their limitations. While this report represents, to our knowledge, the largest single center retrospective review of pediatric sternal fractures, the trends we describe may not be generalizable to other populations. Our institution is an urban, stand-alone children's hospital, and many trauma patients are referred from great distances. It is possible that severely injured children with sternal fractures may have died at referring facilities and were not captured by our methodology. Many patients initially presented to a primary care physician or outside hospital ED before receiving care at our institution. While clinical data from outside providers are often included in our electronic medical record, it is possible that some labs or imaging studies were not included. Additionally, it must be noted that this delay from time of injury to time of assessment at our ED or clinics may have implications for the rates of cardiac injury reported in our study.

4. Conclusions

Sternal fracture is presumed a harbinger of major intrathoracic trauma. In this series, most sternal fractures were isolated with low morbidity and no cardiac injuries, aortic injuries, or deaths. These data suggest that sternal fracture alone should not prompt aggressive workup for intrathoracic injuries and that stable patients with isolated sternal fractures can often be safely followed without admission.

Acknowledgments

This work was supported by the Chairman's Fellowship Research Fund at Boston Children's Hospital.[1]

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[1] Authors' Contributions: Dr. Chalpin acquired study data, performed the data analysis and wrote the publication. Dr. Mooney identified the area of clinical concern, assisted with data analysis and edited the publication.