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Case Report

Surgical Treatment of Sternal Fracture: Case Report and Literature Review

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ABSTRACT

Sternal fractures are uncommon thoracic trauma that can ensue in isolation or conjunction with other organ injuries, implying more significant morbidity and mortality. These fractures result from diverse aetiological mechanisms, some of which may provoke minor chest wall issues, while others can have deadly outcomes. The sternal fracture's primary aetiological culprits are direct impact and the upper thoracic region's compression. Studies reveal that traumatic sternum fractures occur in 8-18% of blunt thoracic and polytrauma victims, whereas they are unusual in open trauma. This report aims to outline the case of a 54-year-old Caucasian male with hypertension and an alcohol consumption history who sustained a direct impact on the anterior thorax after a traffic accident. He experienced severe pain that worsened with movement and coughing, and breathing difficulty. We noticed a painful haematoma and depression with bony crepitus at the sternal body level. Abdominal-pelvic echography indicated no intra-abdominal lesions and showed pleural effusion in the left lung base, while thoracic X-rays (lateral and anteroposterior view) and chest computerized tomography (CT) scan exhibited mid-sternum segment displaced fracture and haemothorax. We diagnosed a mid-sternum completely displaced overlapping fracture and a traumatic left haemothorax. Therefore, urgent surgical intervention was required. We performed a minimal-lower pleurotomy and internal fixation to address the fracture. His post-operative recovery was satisfactory. Although various authors advocate X-rays as an effective diagnostic means for sternal fractures, CT uncovers overlooked radiography abnormalities; therefore, CT must be considered in patients' initial assessment. While most sternal fractures can be treated conservatively, surgery is feasible in displaced fractures.

Keywords
Case report; Osteosynthesis; Sternal fracture; Sternum; Thoracic trauma.

INTRODUCTION

Trauma remains a global health concern with meaningful repercussions on peoples' lives and healthcare systems.[1,2] The development and mechanisation of industries and vehicles' widespread use has been determining factors in increased traumas.[3] The Swedish Trauma Registry informs that it is one of the leading cause of death and disability in individuals under 45 worldwide, surpassing cancer deaths among young adults.[4]

Road traffic crashes are a foremost cause of injury, posing a critical matter in numerous nations.[2] The World Health Organisation (WHO) conveyed that traffic accidents provoke approximately 1.3 million yearly casualties.[5] As per National Trauma Data Bank's 2016 annual report,[6] 223,866 motor vehicle accidents ensued in the United States, resulting in 10,343 casualties. A recent Cuban report[7] points out that between 2019 and 2020, there were 1,368 fatalities from road traffic accidents, of which 80.8% were male.

Blunt trauma is a common occurrence in motor vehicle collisions and is associated, in most cases, with severe organ damage.[1,6,8] In Sweden, blunt injuries account for approximately 90% of all injuries. Blunt thorax traumas (BTT) are the third leading cause of trauma-related death, preceded only by traffic-related head and abdominal injuries.[8]

The thorax is one of the most affected regions in motor vehicle accidents. The 2016 National Trauma Data Bank statistics[6] logged 1,29,338 thoracic traumas (TT) with AIS>3 with a fatality rate of 9.53. Multiple authors have noted that TT mortality is ap-

proximately 25% of all traumatic deaths globally and contributes 25% to mortality from other types of traumas. South Korean research Byun et al[1] shows that 33.6%-non-surviving caseload died due to significant chest harm. In contrast, a Cuban study[3] states that TT accounts for 4-6% of trauma admissions in Cuba and has a fatality rate of 15%.

The sternum is a peculiar, odd bone located in the anteromedial thorax region, it measures 15-20 cm in length, and as it extends distally, its thickness gradually decreases.[9] Fractures of this bone are uncommon and can ensue in isolation or alongside other organ damage, implying more significant morbidity and mortality.[10,11] Studies Brookes et al,[12] Hochhegger et al,[13] Knobloch et al,[14] and Bentley et al[15] reveal traumatic sternal fractures (SFs) occur in 8-18% of BTT and polytrauma victims. In contrast, they are unusual in open trauma and refer that using seat belts is associated with a higher frequency of these fractures.

These fractures arise from diverse aetiological mechanisms, some of which may provoke minor chest wall injuries, while others can have deadly outcomes. The sternal fracture's main aetiological culprits are direct impact, the upper thoracic region's compression, and deceleration.[16,17] In car crashes, the SFs are generally associate with seat belt use or the blow against the steering wheels.[17]

This report aims to outline the case of a patient who suffered a traumatic SF after a traffic crash, the injury's characteristics, and its clinical and surgical management.

CASE PRESENTATION

Clinical Assessment

A 54-year-old Caucasian male with hypertension and an alcohol consumption history was transferred by the Integrated Medical Emergency Service (SIUM for its Spanish acronym) to the Accident and Emergency Department (A&E) following a traffic incident. He sustained a direct impact on the anterior thorax, causing severe pain that worsened with movement and coughing, making it difficult for him to breathe.

In the medical interview, the patient shared accident details describing how he collided with a parked lorry while riding his motorbike. He confirmed the impact was only in his chest and denied experiencing discomfort in his abdomen, neck or other regions.

We adhered to the advanced trauma life support (ATLS) guidelines, and a complete physical examination was conducted. Two peripheral veins were cannulated, and a Fowley catheter was placed.

The noteworthy findings on the physical assessment included a weight of 65 kg, a height of 172 cm, and a body mass index (BMI) of 22.4 kg/m^2; the skin and mucous membranes appeared slightly pale and dry, predominantly affecting the conjunctival and oral mucosa. We noticed a haematoma and depression at the sternal body level. It was painful on palpation and had bony crepitus. No abnormalities were detected upon abdominal examination through palpation, percussion, and auscultation. Additionally, the abdominal puncture was negative.

Upon respiratory system asses, it was found that there was reduced thoracic expansion, a respiratory rate of 28 breaths per minute, decreased vocal resonance, and vesicular breath sounds towards the left lung base without crackles or pleural friction rub. As for the cardiovascular system, was found audible heart sounds, good tone with tachycardic, and a heart rate (HR) of 114 beats per min (b.p.m). Peripheral pulses were present, accelerated and synchronous, and blood pressure was measured at 140/110 mmHg.

Neurological sphere assessment showed that consciousness and orientation were preserved, and a Glasgow Scale score of 15 points was logged.

During the patient's initial evaluation at A&E, we diagnosed mild dehydration. We were administered crystalloid fluids (isotonic sodium chloride) at a 1,500 ml/m^{2}sc/24 h rate, passing 750 ml of fluid in the first hour. We conducted paraclinical examinations after ensuring the patient's clinical and haemodynamic stability.

Laboratory Tests

The detailed values of all the laboratory tests are given in the below box.

Box. *Laboratory Tests Values*

Partial blood red cell measurements: Hb (135 g/L (13.5 g/dL), Ht. (40.5 L/L)

Erythrocyte sedimentation rate (ESR) (5 mm/h)

Leukogram:

- leukocytes (7x109 /L)
  - neutrophils: 0.65
  - eosinophils: 0.01
  - lymphocytes: 0.31
  - monocytes: 0.03
  - basophils: 0.00

Partial screening test of haemostasis:

- Clotting time 7 min
- Bleeding time 2 min
- Platelet count (270x109 /L)
- Retractile clot. Glycaemia (5.8 mmol/L)

Arterial blood gasses analysis:

- pH (7.40)
- $PaCO_2$ (38 mmHg)
- PaO_2 (97 mmHg)
- HCO_3 (26 mEq)
- K^+ (4.0 mmol/L)
- Na^+ (143 mmol/L)
- Cl^- (98 mmol/L)

Electrocardiogram

Electrocardiogram showed sinus tachycardia without changes in the Q wave, R wave and S wave (QRS complex) or ST-segment and HR of 112 b.p.m.

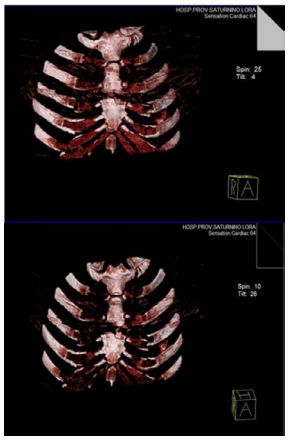
Imaging Studies

Abdominal-pelvic echography showed no organ damage, no fluid in the abdominal cavity, no urinary tract injury, and an empty bladder due to the Fowley catheter inside. Nevertheless, there was evidence of pleural effusion in the left lung base.

Chest X-ray in a standing position (posteroanterior view) showed sternum body displaced fracture and a radiopacity that obscured the left costophrenic angle. (Figures 1 and 2).

Figure 1. *Sagittal CT Scan Image: Mid-sternum Completely Displaced Overlapping Fracture*

Figure 2. *Coronal CT Scan Images:The Mid-sternum Completely Displaced Overlapping Fracture*

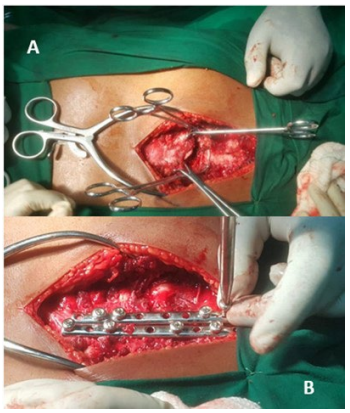


Surgical Management and Post-surgery

Based on clinical and imaging studies, it was determined that the patient had suffered a mid-sternum complete displaced overlapping fracture and a traumatic left haemothorax. As a result, emergency surgical treatment was required.

The haemothorax was evacuated through a minimal lower pleurotomy under local anaesthesia; it removed approximately 480 ml of haematic contents. The sternum was fixed under general endotracheal anaesthesia using an internal fixation system of galvanised stainless-steel plates and screws (Figure 3).

Figure 3. *A.The Incision Made Over the Sternum and the Sternal Fracture is shown B. Placement of the Fixation System for Osteosynthesis*

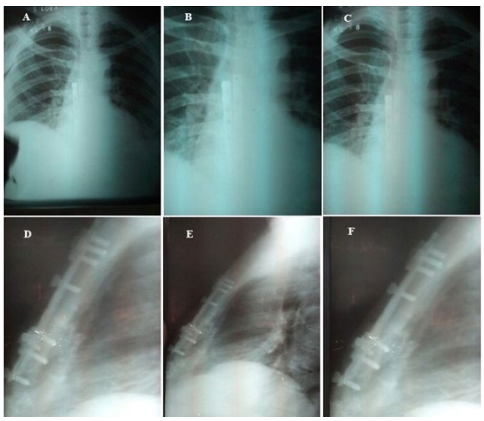


The fracture was accessed through a longitudinal incision approximately 12-15 cm above the sternum. Fortunately, there were no intraoperative complications.

Following a 1 hour and 20-minute surgery, he was transferred to the intermediate care unit (ICU), where he stayed for 12-days. During his stay, he experienced cardiac arrhythmia, which subsided after removing his chest tube. After 18-days, he was discharged with regular outpatient follow-up and pain management.

The patient complained of mild pain three months later, but the sternum was stable. There were no reported complications at six months, and the radiological images showed favourable healing with intact bony fixation (Figure 4).

Figure 4. *Post-operative Evolutionary Chest X-rays: A. Trans-operative; B and C. Evolutionary in ICU; D, E and F. Evolutionary in Consultation*



DISCUSSION

Most of the reviewed-available literature indicates sternum fractures are infrequent TT. However, authors such as Bentley et al[15] argue that it is not as uncommon as believed. Some researchers[18,19] claim that SFs diagnoses have increased recently because of the increasingly routine use of computerized tomography (CT) scans in multiple trauma patients' initial assessment. Şimşek et al[20] con-

tend that SFs account for a small thoracic trauma proportion and occur in 4% of road traffic accidents and 3-8% of blunt abdominal traumas. Meanwhile, Doyle et al[19] and Hochhegger et al[13] based on previous research, inform 68% of SFs incidence in motor vehicle collisions, 7.9% in falls and motorbike accidents, respectively, 3.4% in pedestrian-struck, and 1.4% in bicycle accidents.

Ayes-Valladares et al[21] apprise that SFs secondary to blunt chest trauma are rare in Honduras, where only a 1.4% incidence rate is notified. Similarly, reports Fonseca Sosa,[10] Ferrer Lozano et al,[16] Nazario Dolz et al[22] and Herrera et al[23] indicate that Cuba's frequency rate is low; i.e., Moya Rosa et al[24] reported a rate of 0.78% in their series. Isolated cases of SFs have been reported in our country. One such case involved a subject gored by an ox, as Nazario et al[22] documented from our hospital.

Sternal fractures are typically caused by direct impacts or deceleration, resulting in sternal body or manubrium harm, by and large. Fracture severity varies depending on the accompanying lesions.[15,16] Commonly, fractures occur at the sternal body level and in its distal portion due to the tapering of the bone in the caudal direction. According to the Brookes et al[12] caseload and von Garrel et al[25] study most lesions (93.4% and 76.5%, respectively) were found in the sternal body. Notwithstanding, Şimşek's et al[26] research of 108 subjects revealed that 59.3% had injuries in the sternal manubrium, while only 39.1% had them in the sternal body.

The SFs diagnosis is primarily based on the history recorded by interrogation, clinical findings on physical examination and imaging studies. Suspicion signs comprise a trauma history, retrosternal pain exacerbated by coughing or inspiration, respiratory distress, oedema, ecchymosis or haematomas at the sternum level. Other findings include bone crepitus and depression.[13,15,26]

Detecting STs through anteroposterior radiography alone has a sensitivity of only 50%; nevertheless, when combined with a lateral view chest X-ray, sensitivity increases because these fractures typically occur in the sagittal plane.[15,24,27]

Some authors, Ferrer Lozano et al[16] and Nazario Dolz et al[22] especially in our environment, state that the lateral and anteroposterior chest X-ray views provide an adequate STs initial diagnosis, whereas a CT scan should only be used if additional radiological abnormalities are detected. Nonetheless, while radiography can still be a valid diagnostic option, other experts Perez et al,[18] Doyle et al,[19] Ramgopal et al[27] and Kim et al[28] assert that CT scans are the gold standard for detecting sternal fractures and should be required. We align with this standpoint.

It is crucial excluding associated injuries in these patients. It is rare for isolated sternal fractures to be related to blunt cardiac traumas. Regardless, if they do occur, the mortality rate is 0.8%. In polytrauma cases, concurrent injuries can be severe and lead to a mortality rate as high as 7.9%.[29,30]

In Şimşek's et al[26] the most frequent intrathoracic lesions were pulmonary contusion and pneumothorax (53.7% each), while pneumothorax occurred in 51.9%. In contrast, in Perez's report,[18] the highest intrathoracic injury incidence was a pulmonary contusion (26.3%), followed by pneumothorax (23.6%), while haemothorax had an incidence of 11.9%.

Acute sternal trauma management should adhere to the guidelines set out in the ATLS.[15] Identifying associated life-threatening injuries should be a priority to rule out damages such as cardiac tamponade (uncommon in closed chest trauma), tension pneumothorax, large haemothorax or other significant damages to the skull, abdomen and pelvis.

SFs surgical treatment is infrequent, and its initial choice is controversial; conservative management is generally chosen.[11,18,31,32] Regardless, surgical treatment should be used in intractable pain cases, altered ventilatory mechanics, and poor bony alignment to optimise rehabilitation due to rachimedullary trauma.[18,33]

McKim made the first sternal fracture fixation description. Over time, various materials for fixation have appeared, but the most widely accepted technique is plate osteosynthesis using titanium plates and screws.[19] However, Harston et al,[34] in his meta-analysis, where he analysed 52 individuals who underwent fixation with plates and 24 with wire, showed healing in all cases regardless of the technique used.

CONCLUSION

Although various authors advocate X-rays as an effective diagnostic means for sternal fractures, CT uncovers overlooked radiography abnormalities; therefore, CT must be considered in patients' initial assessment. While most sternal fractures can be treated conservatively, surgery is feasible in displaced fractures.

PATIENT PERSPECTIVE

The patient confirms that he is pleased with the treatment and aftercare provided by the medical staff. He acknowledges that he was well-informed about his injury, its potential complications, and the surgical procedure he underwent. He feels content with his progress and has gradually resumed his daily routines.

ETHICAL RESPONSIBILITIES

Protection of People and Animals

The authors declare that no experimentation was performed on the patient, and therapeutic management was under our hospital standards.

Data Confidentiality

No data that could compromise the patient's privacy is disclosed in this report.

RESEARCH QUALITY

The authors adhered to the EQUATOR Guidelines recommen-

dations and specifically to CARE Guidelines for publishing Case Reports.

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CONSENT

The patient consented to use his medical history data in this report.

CONFLICTS OF INTEREST

No competing interests were disclosed.

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