

Sternal fracture with or without associated injuries.

Assessment of the difference in the diagnosis,
management and complications.
Eighteen years of experience



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AIM OF THE STUDY: *To determine the incidence of sternal fracture as an isolated injury as well as those which presented with concomitant injuries, and compare them in order to manage them more effectively. The Greek and International Literature related to the subject was also reviewed.*

MATERIAL AND METHODS: *From 1984 to 2002 the Authors treated 134 patients with sternal fracture in the Department of Thoracic Surgery of their hospital, 59 males and 45 females, age from 17 to 84 years.*

Ninety patients had isolated sternal fracture and 44 sustained in addition fractured ribs, flail chest, pneumo-haemothorax, pneumo-haemomediastinum, some of them experienced respiratory failure, vertebral fractures, myocardial infarction, heart contusion, pericarditis, head injuries, fractures of upper lower limbs and intraperitoneal bleeding.

twelve patients were admitted in ITU and 4 with multiple trauma were fatally injured. Aortic tears or ruptures didn't occur in any of our patients.

Sternal fracture as an isolated injury has a better prognosis compared to those with associated injuries.

CONCLUSIONS: *The management of sternal fracture is usually conservative with a good outcome, provided early diagnosis and treatment of concomitant injuries is offered from a well-trained and experienced medical team.*

KEY WORDS: Associate injury, Sternal fracture, Sternum.

Introduction

Ninety per cent of thoracic trauma in Europe and the United States¹ is obtuse. According to certain studies²⁻⁴, car accidents are the main cause for 59 to 89% of obtuse thoracic injuries, 3.7 to 8% of which are sternal fractures^{5,6}.

The amount of pressure needed to cause a sternal fracture and its position as superior to major interthoracic and mediastine structures greatly affects the evaluation and management of patients with associated injuries.

This study is a retrospective research of patients with

sternal fracture in order to determine the importance of this kind of injury and ways of treatment.

Material and Methods

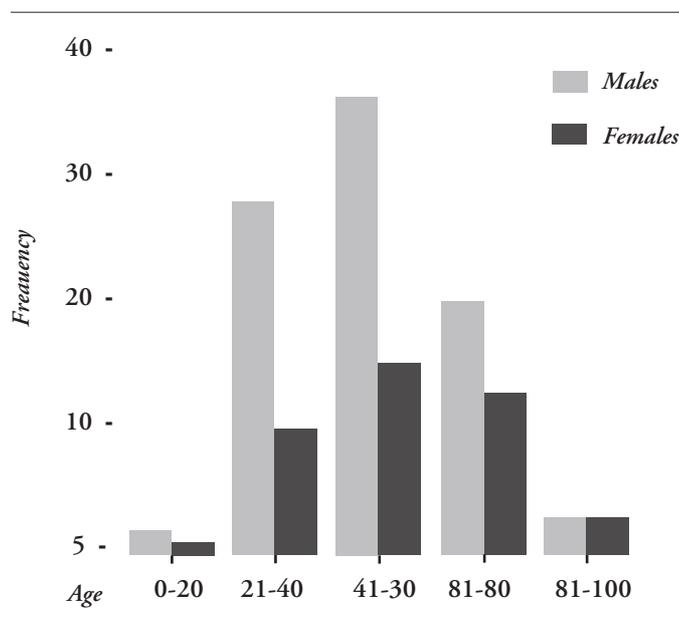
From 1984 to 2002 the Authors treated 134 patients with sternal fracture in the department of Thoracic Surgery of their hospital, 59 male and 45 female, between the ages of 17 and 84, mean aged 54.93 ± 15.12 years old (Mean \pm SD) (Table I). 44 (33%) of those patients suffered from multiple injuries, while the remaining 90 (67%) suffered solely from sternal fracture.

Among the latter, 61 were male and 29 female, between the ages of 27 and 84. Hospitalisation time was 2 to 8 days, with an average of 3.14 ± 1.28 (mean \pm SD).

Among the former, 33 were male and 11 female, between the ages of 17 and 80. Hospitalisation time was 10 to

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TABLE I – Sternal fractures between 1984 to 2002



39 days, with a higher average of 9.44 ± 6.89 (mean \pm SD), which is of statistic importance of $p=0.02$, compared to that of patients suffering solely from sternal fracture.

Diagnosis occurred based on clinical symptoms, such as pain in the frontal thoracic wall, anhelation (45% of patients), combined with the history of the injury, and validated with a lateral radiography of the thorax. All patients suffering from a radiographically diagnosed sternal fracture were admitted for ECG monitoring for at least 24 hours. Tests for cardiac enzymes, such as LDH (lactic dehydrogenase), CK (creatine-kinase), CK-MB (creatine-kinase MB), were conducted on all patients and repeated accordingly depending on the results.

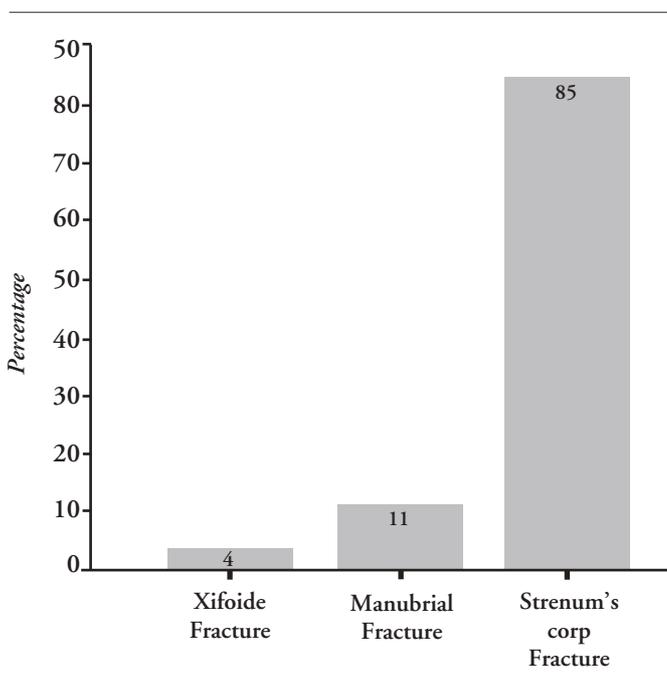
The echocardiogram and CT aided the diagnosis when there were suspicious indications, such as arrhythmia, haemodynamic instability, dilatation of the mediastine shadow, in a total of 16 (12%) patients.

Results

Eighty three per cent of sternal fractures studied were due to car accidents, 14% to falls, and 3% to pressure, one of which was caused by the collision with a bull's head, while two of the falls were suicide attempts.

The majority of fractures was focused around the sternum (85%) (Table II), in accordance with recent studies concurring to an increase in torso fractures due to the increased use of a 3-point safety belt, in which case the constriction of the upper sternum combined with the forward shift of the centre of gravity of the torso leads to the fracture of the upper area of the bone⁵. None of our 90 patients suffering solely from sternal

TABLE II – Anatomic location of sternal fractures



fracture were diagnosed with infarction or arrhythmia, while no aortic tears or other major vessel ruptures were noticed. No surgery or ITU hospitalisation was necessary. No deaths occurred.

Twelve patients, 9 males and 3 females, among our 44 suffering from sternal fracture with associated injuries needed artificial respiration support due to respiratory failure. We operated on a total of 9 patients, 8 males and 1 female. During the first 24 hours, the general surgeons performed urgent surgery on 8 patients, 3 of which due to intra-abdominal haemorrhage, 1 due to massive haemothorax (due to the rupture of inner mammary vessels), 1 to suture the sternum and stabilise the frontal thoracic wall with Steinman needles, 2 due to open pneumothorax and destruction of the sternum, and 1 to osteosynthesis of comminuted fracture of the right radius. During the following 24 hours, a 60-year old woman was operated on due to fractured ribs, sternum and thoracic wall, using Steinman needles.

The associated injuries

- Implications of the studied population can be seen in Table III.
- A myocardial infarction lead to the death of an 84-year old patient suffering from multiple injuries, including fractured ribs, sternum and hip, as well as flail chest, on the tenth day of hospitalisation in the ITU. The infarction was diagnosed using an ECG test, enzymic determination and a forensic check.
- Two cases of pericarditis were successfully treated, after being diagnosed with clinical examination and ultrasound.
- Fractured ribs were diagnosed in 31 patients (23%),

TABLE III – The associated injuries – implications of the studied population

Associated injuries – implications	Number %		
FRACTURES	79 51.6		
Fracture of thoracic vertebrae 4			
Flail chest	20		
Fracture of lumbar vertebrae 1			
Scapular fracture	2		
Limbs fracture	15		
Ribs fracture	Right 10	Left 8	Bilateral 13
Hip's fracture	6		
PULMONARY INJURIES	41 26.8		
Respiratory insufficiency	4		
Pneumothorax	Right 1, Left 2	Bilateral 1	Open 2
Haemothorax	Right 4	Left 5	Bilateral 1
Haemopneumothorax	Right 3	Left 2	Bilateral 3
Haemomediastinum	5		
Pneumomediastinum	2		
Subcutaneous emphysema 6			
HEART INJURIES	6 4		
Heart contusion	1		
Traumatic pericarditis	2		
Myocardial infarction	1		
Haemopericardium	2		
NECK CONTUSION	4 2.6		
HEAD INJURIES	19 12.4		
INTRAABDOMINAL HEMORRHAGE	3 1.9		
RETROPERITONEAL HAEMATOMA	1 0.6		
TOTAL	153 100		

- this being the commonest associated injury. They were all treated conservatively.
- 24 patients suffered from pleuritic collection of air or blood (8 cases of haemopneumothorax, 10 cases of haemothorax, 6 cases of pneumothorax). We used a Büllau closed thoracic drainage pipe and monitored them. 2 were successfully operated on due to open pneumothorax, and one due to massive haemothorax.
 - 5 patients suffering from vertebral fractures (4 thoracic, 1 lumbar) were successfully treated conservatively using a thoracolumbar splint without experiencing any neurological deficiency. Thoracic vertebral fractures^{7,8} are considered dangerous because they may be partly or wholly detached, thus causing the dissection of the spinal cord, paralysis, in some cases rupture of vessels such as thoracic aorta and pulmonary artery, while in other pulmonary, pericardial or even heart trauma can be found.
 - 5 patients were diagnosed with pneumo-haemomediastinum using a CT^{5,9-11}. One of them was treated surgically with success due to a left haemothorax, following the rupture of the inner mammary vessels.

TABLE IV – Deaths caused by sternal fractures

Associated injuries	Sex	Age	Time
RESPIRATORY INSUFFICIENCY	Male	48	48 hours
Rib's fracture on the right side and flail chest on the left side, sternal fracture, haemothorax on the right side, fracture of the right tibia, stabilization of the thoracic wall, stabilization of the fracture of the tibia			
MYOCARDIAL INFARCTION	Male	84	240 hours
Rib's fracture on the left side and flail chest on the left side, sternal fracture, hip fracture			
HEART CONTUSION	Male	61	24 hours
Rib's fracture on the left and on the right side, sternal fracture, cranial fracture, subarachnoid hemorrhage, haemomediastinum, haemopericardium without tamponade			
MASSIVE HAEMOPTYSIS	Male	54	48 hours
Rib's fracture on the left and on the right side with flail chest, sternal fracture, subcutaneous emphysema, fracture of t ₁₂			

Four out of 134 patients ended up in the ITU due to multiple injuries. A 48-year old man died from respiratory failure during the second 24-hour hospitalisation period, a 84-year old man died from myocardial infarction on the tenth day of hospitalisation, a 54-year old man died from massive haemoptysis during the second 24-hour hospitalisation period, while a 61-year old man died from heart contusion during the first 24 hours, diagnosed with an ECG and echogram (Table IV).

Discussion

The amount of pressure needed to cause a sternal fracture and its position as superior to major intrathoracic and splachnic structures has important consequences, and to many it still poses a dilemma concerning the evaluation and management of patients suffering solely from sternal fracture or from associated injuries as well. Since 1983, when wearing a safety belt became obligatory, despite the reduction of serious injuries¹² due to car accidents, sternal fractures are just as frequent, or even more^{4,13}. The explanation lies in the change of the mechanism and pathophysiology of sternal fracture due to the use of safety belts, which seem to be different than the one before the time it was made obliga-

tory, when the fracture was caused by a serious and immediate injury of the front thoracic wall due to an impact with the steering wheel and dashboard. To be more specific, it has been noted that sternal fracture due to the use of a safety belt induces less implications, such as heart contusion, in comparison with those before the obligatory use of a safety belt, which is probably due to the fact that the fracture mechanism is a flexion of the sternum with the diagonal part of the belt acting as a fulcrum, so that less pressure is put on the heart. Without the belt, the heart is crushed between the sternum and thoracic part of the spine, and this is probably accompanied by rib fractures increasing the possibilities of implications^{14,15}.

Twenty three per cent of our patients suffered from rib fractures, the most common associated injury according to other studies¹⁶ as well.

Four per cent of our patients suffered from obtuse myocardial trauma, < 1% of whom suffered from heart contusion. The frequency of heart contusion in various studies ranges from 1.3 to 64%^{2,4,16,17}.

Lindstaedt¹⁸ reports myocardial infarction in 19.7% of patients suffering from obtuse thoracic trauma and needed to be treated in the ITU due to non cardiac injuries, and in 1.9% of patients suffering from less serious injuries. Myocardial infarction in the entire population of this study amounted to 11.9% greatly affecting patients in need of ITU treatment due to serious non cardiac trauma. Hence, alertness should be increased concerning the diagnosis of an obtuse cardiac trauma in surgical patients. In a study on the frequency of cardiac injury in patients suffering from obtuse thoracic trauma, Illig¹⁹ concluded that an EKG performed in the ER is the only reliable means of suggesting myocardial infarction, and suggested a protocol based solely on EKG and the haemodynamic condition of the patient, thus reducing the use of cardiac enzyme measurement and echocardiogram.

In our material, no tear of the thoracic aorta was diagnosed, thus concurring with Brooks²⁰, Hills⁴ and associates. No rupture of pulmonary vessels, the bronchotracheal arbour, as mentioned in other studies²¹⁻²³, or abscess in the mesothorax, like Cuschieri²⁴, or osteomyelitis and mediastinitis, like Rehling²⁵, were diagnosed as implications of the sternal fracture.

Comparing thoracic CT with simple radiography as far as the diagnosis of sternal fracture is concerned, Hugget²⁶ found that while radiography diagnosed 8 out of 9 cases, CT diagnosed only 6. However, CT can easily show vertebral fractures, pleural collection of blood-air in the hemithoraces and mediastinum.

Spiral CT²⁷ and Oesophageal echocardiogram²⁸⁻³⁰ have also been reported to aid the diagnosis of sternal fractures and associated injuries.

Surgical reparation of the sternum is infrequent, especially in case of a major ectopia or flail sternum, in order to reduce the need to ventilate the lungs by applying positive pressure.

Conclusion

Sternal fracture is an increasingly common injury in car drivers and passengers using a safety belt, as well as elderly people³¹. Although it is related to the use of a safety belt, it protects us of further injuries^{16,32}, as both the belt and the fracture are probably absorbing a great part of the energy produced by the collision.

It is important for the patient's history to record the mechanics of the injury, whether or not the patient was wearing a safety belt in case of a car accident.

The prognosis for a patient suffering solely from sternal fracture is good, and naturally better than when there are other injuries or implications as well. According to our research, the hospitalisation span of our patients and the results of the treatment were determined mostly by the associated injuries and their timely diagnosis and management by a properly trained and experienced medical team.

Riassunto

INTRODUZIONE: Dal 1984 fino al 2002 (18 anni) nel Dipartimento di Chirurgia Toracica dell'Ospedale Generale Statale di Nikaia - Pireo, abbiamo trattato 134 pazienti affetti di frattura sternale, di cui 89 di sesso maschile e 45 di sesso femminile. La loro età era compresa tra i 17 e gli 84 anni.

SCOPO DELLO STUDIO: Lo scopo di questo lavoro era di studiare la frattura sternale sia quale singola lesione, ma anche nel contesto di lesioni associate, confrontando i risultati tratti tra loro e con quelli della bibliografia scientifica relativa, sia Greca che Internazionale, al fine di dare, di caso in caso, le migliori proposte terapeutiche.

MATERIALE E METODO: In 90 dei pazienti del nostro campione di studio la frattura dello sterno era l'unica lesione riportata mentre nei rimanenti 44 parallelamente alla frattura sternale abbiamo osservato anche altre lesioni associate quali fratture delle costole, flail chest, pneumotorace, pneumoemomediastino, insufficienza respiratoria, fratture vertebrali, infarto miocardico, contusione cardiaca, pericardite, lesioni craniocerebrali, fratture degli arti superiori ed/od inferiori ed infine emorragia intraperitoneale.

Solo 12 pazienti dei 134 pazienti, che erano politraumatizzati, sono stati ricoverati in Unità di Terapia Intensiva e di essi solo 4 sono deceduti.

In nessuno di questi pazienti sono state osservate rotture traumatiche o/e traumi dell'aorta.

La frattura dello sterno, vista come singola lesione, ha ottima prognosi e sicuramente migliore della frattura dello sterno associata ad altre lesioni.

La frattura dello sterno va affrontata nella maggior parte dei casi in modo conservativo con ottimi risultati. Nel caso però in cui la frattura dello sterno si associ ad altre

lesioni, bisogna che si tenga conto dello stato clinico del paziente, delle lesioni associate e delle possibili complicazioni oltre alla frattura stessa.

Sia lo studio delle lesioni che i necessari e talvolta urgenti interventi terapeutici, pensiamo che sia meglio che vengano effettuati da un'équipe di esperti nel campo del trauma e correttamente preparati di proposito, al fine di ottenere ogni volta, i migliori possibili risultati.

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