

## Sternal and thoracic spinal fractures: case reports of two in one accident

### 胸骨及胸椎骨骨折：一宗意外中的兩個個案報告

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Two restrained back-seat taxi passengers suffered from sternal fracture as a result of head-on collision with another car. They were wearing shoulder-lap seat belts at the time of the collision. Both of them also complained of upper back pain one day after admission. Computed tomography of the thorax showed fracture of the thoracic spine in both of them. We performed literature search, analysing the mechanism of sternal fracture and its association with spinal fracture. A management guideline in the emergency department is proposed to handle this injury. (*Hong Kong j.emerg.med.* 2006;13:94-99)

兩名束有肩與大腿安全帶的後座乘客因其乘坐的計程車與另一車迎頭相撞而引致胸骨骨折，兩者住院一天後都申訴上背部疼痛，胸部電腦掃描顯示兩者均有胸椎骨骨折。我們搜查文獻，分析胸骨骨折的創傷機制與脊椎骨折的關聯，並提議一個在急症室處理這類創傷的指引。

**Keywords:** Seat belt syndrome, spinal fractures, spinal injuries, thoracic vertebrae

**關鍵詞：**安全帶綜合症、脊椎骨折、脊椎創傷、胸椎骨

### Case 1

A 36-year-old female Filipino back-seat taxi passenger wearing shoulder-lap seat belt presented with chest wall pain after head-on collision with another car in September 2003. On arrival, her blood pressure was 122/76 mm Hg and her pulse rate was 102 beats per minute. Physical examination did not reveal any external lesions except mild sternal tenderness. X-rays of the chest (CXR) and sternum showed sternal fracture (Figure 1) and a crack fracture of the left 6th rib. There was no pneumothorax. She was admitted to the surgical ward for management. However she complained of

back pain and tenderness over the thoracic spine one day after admission. X-rays showed a compression fracture of the thoracic vertebrae at

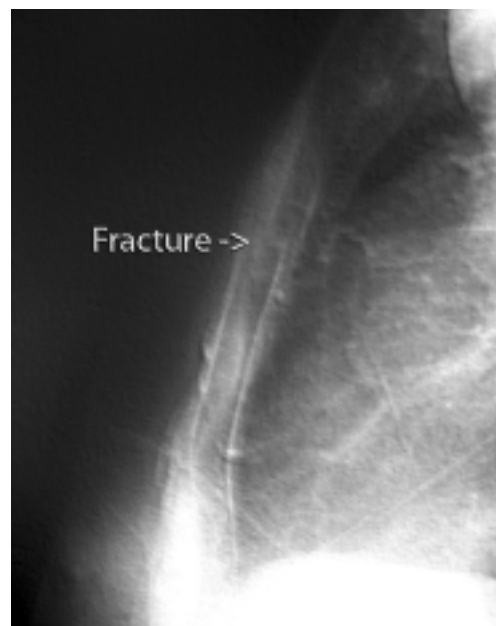


Figure 1. Sternal fracture (white arrow).

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T4 & T5 (Figure 2). Computed tomogram (CT) of the thoracic spine revealed a burst fracture of the T5 vertebra with retropulsed fragments indenting the spinal cord (Figure 3). The retropulsion was about 20%



**Figure 2.** Compression fracture of T4 and T5 vertebrae (white arrows).



**Figure 3.** CT showing fractured T5 with retropulsed fragment.

without neurological involvement. She was then transferred to the orthopaedic unit of Pamela Youde Nethersole Eastern Hospital (PYNEH) for management. The patient was treated conservatively with bed rest and brace for three weeks and then transferred to Tung Wah Eastern Hospital for rehabilitation. No neurological deficit was found during the hospitalisation.

## Case 2

Sitting next to Case 1 was another shoulder-lap belt restrained back-seated female Filipino 26 years old with the same complaint. Physical examination did not reveal any external lesion. X-rays of the chest and sternum showed a sternal crack fracture. There was no pneumothorax. She was admitted to the surgical unit for management. Similarly, she also complained of upper back pain. X-rays of the thoracic spine showed a 30% anterior wedge compression fracture at the T5 level. CT of the thorax showed compression of T5 without retropulsed fragments. She was transferred to PYNEH for pain control, spinal brace and rehabilitation. She also did not suffer from any neurological damage.

## Discussion

We performed a literature search using the keywords sternal fracture, thoracic fracture and spinal fracture. The articles were limited to English and humans. Further references were extracted by cross-referencing. Not surprisingly, most of the publications were case reports with only a few papers involving the analysis of more than 200 victims. We present the search results in chronological order.

The first paper was published by Sevitt who documented three out of 13 sternal fractures were associated with spinal fractures by analysing 250 post-mortem reports in 1968.<sup>1</sup> Since Sevitt's paper was published this relationship has aroused more attention.<sup>2-5</sup> In 1985, Budd found that the incidence of sternal fracture was increased threefold after the execution of compulsory wearing of seat belts in 1983, and a new

concept of "seat belt syndrome" was introduced.<sup>4</sup> In 1998, Porter et al reviewed 1,124 patients involved in traffic accidents, out of which 376 patients were belted, 544 were unbelted and 204 were unknown.<sup>3</sup> Not surprisingly, belted patients were more likely to have sternal fractures than those unbelted after statistical analysis (4% versus 0.7%, positive likelihood ratio 1.97 with 95% confidence interval 1.09 to 3.29). However, there was no intention to suggest that passengers should not wear seat belts since head injury was less likely in belted passengers (30.6% vs 46.0%, positive likelihood ratio 0.67, 95% confidence interval 0.53 to 0.83).<sup>3</sup>

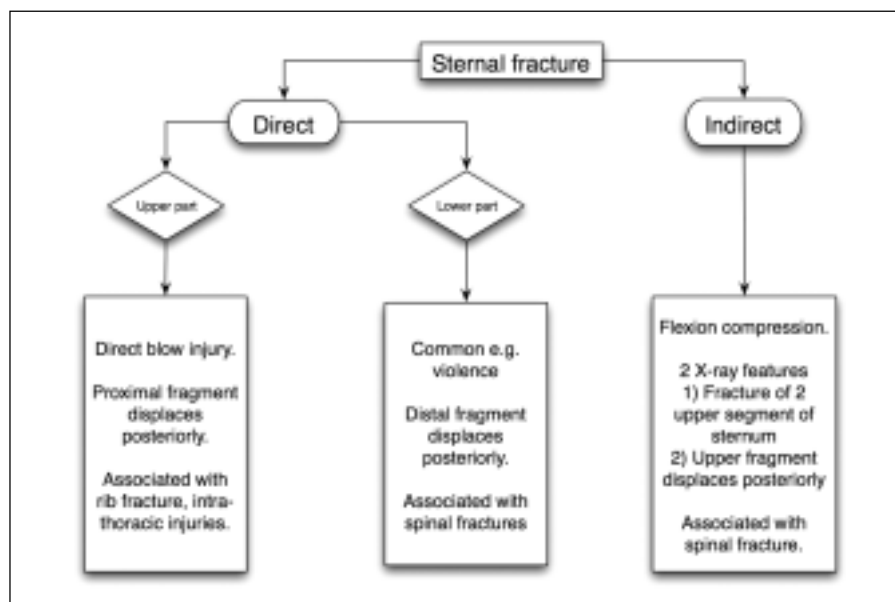
### ***Anatomical classification and mechanism of injury***

Fowler was the first to explore the mechanism of sternal fracture.<sup>6</sup> The force from a seat belt could jeopardize the sternum in two ways: direct and indirect. The direct impact traumatizes either the upper part of the sternum or the lower part depending on the direction of the force and the chest position of the victims. For upper sternal fracture, the proximal fragment moves posteriorly. The displacement of the fracture jeopardizes the ribs and the intra-thoracic organs lying behind the sternum such as the heart and the aorta. Fowler pointed out that the more common form was

fracture of the lower sternum. The distal fragment displaces posteriorly and is associated with spinal injuries.<sup>6-9</sup> When the seat belt limits the forward movement of the restrained victim, the thoracic spine is then subjected to flexion. This is the indirect cause of injury. The flexion could be either a flexion-compression or flexion-rotation of the thoracic spine. The sudden acceleration-deceleration force could also fracture vertebrae of the spine.

Recently Thomas and his co-workers set up another classification for sternal fracture. They categorised the severity of the fracture into four types: (1) non-displaced; (2) slightly displaced – one fourth to one half the thickness of the sternum; (3) moderately displaced – one half to the whole thickness of the sternum; (4) complete displacement – more than the thickness of the sternum.<sup>10</sup> All classifications are useful for studying the relationship between the severity of the sternal fracture and its concomitant injuries.<sup>7,10</sup> We summarised the mechanism into a flowchart as shown in Figure 4.

Jones et al retrospectively analysed patients' medical records and radiographs from January 1981 to August 1987 in the Orlando Regional Medical Center. A total of 28 patients (21 males, 7 females) sustained sternal



**Figure 4.** Mechanism of sternal fracture and its associated injuries.

fracture. Eight of them suffered spinal fracture. Among these, 3 sustained thoracic spine injury, 4 had lumbar spine injury and 1 received a combination of cervical and thoracic spinal injuries. None of them had rib fracture. Furthermore, Jones et al showed the indirect mechanism elicited by the seat belt was the major reason for both sternal and spinal injuries. They concluded that a lateral view of the sternum should be taken routinely in seat belt injury patients and spinal radiographs should be considered if indicated.<sup>7</sup>

Brookes and his colleagues retrospectively reviewed the medical records of all patients with sternal fracture treated in the emergency department of Box Hill Hospital between January 1985 and June 1991. A total of 272 patients were evaluated. Sternal fracture was found in 34 patients, being more common in females and the elderly but there was no statistical difference between men and women, drivers and non-drivers. The data showed that 6 had cervical spine injury, 13 had thoracic, 9 had lumbo-sacral and 6 had pelvic fracture. No cord injury was noted. Rib fracture was found in 27.2% (74 out of 272 patients). There was no statistical significance in the degree of sternal fracture displacement and associated injuries.<sup>2</sup>

The association was not clear until Hill's review.<sup>11</sup> All trauma patients admitted to Westmead Hospital in Australia were prospectively analysed between January 1985 and August 1991. A total of 12,618 patients were recruited and 172 patients (1.36%) had sternal fracture, of which 152 (89%, 69 males, 83 females) were involved in motor vehicle crashes. The mean age was 30.5 years old. Statistics using the Wilcoxon Rank Sum Test showed there was a significant difference in females with sternal fracture when compared to males ( $z$  value = 2.281,  $p=0.023$ ). Ten patients had spinal fracture and five of them had thoracic spine injury. There was no association between sternal fracture and spinal injury as a whole (Chi-square = 1.043,  $p=0.307$ ). But association with thoracic spine fracture (Chi-square = 5.871,  $p=0.015$ ) was noted. No rib fracture association was calculated.<sup>11</sup>

Thomas and co-workers studied this aspect further, analysing the correlation between the fracture

morphology and concomitant injuries from January 1986 to December 1995.<sup>10</sup> During that 10-year period they collected 200 sternal fracture victims. There were 102 men and 98 women with an average age of 44.1. Sixty-five percent of fractures were within the age range of 20 to 60 years. Eighty-three percent (166 out of 200) was attributed to traffic accidents. Eighty-nine percent (148 out of 166) of those injured were seat belted. Sternal fracture was documented in 13% (26 out of 200) victims. Vertical chest compression tenderness and positive cough-induced pain test were pathognomonic for sternal fracture. Eight had cervical fracture, 23 had fracture in the thoracic region and 14 had lumbar spinal involvement. On the other hand, 10% of patients (21 out of 200) had rib fracture. A significant correlation ( $p=0.021$ ) was found in completely displaced sternal fracture and spinal fracture.<sup>10</sup>

Potaris and his colleagues reviewed 239 patients with sternal fracture admitted to their thoracic trauma centre between October 1989 and May 2000 in Greece.<sup>12</sup> There were 140 males and 99 females with a mean age of 50.3 years (15 to 93 years). Sternal fracture accounted for 8% of admissions for thoracic trauma and 0.002% of all admissions for trauma. They found that 10 of them had thoracic spine fracture (4%) whereas 4 of them suffered from pelvic fracture (2%). No cervical or lumbar injury was documented. Multiple rib fractures were more common and found in 60 patients (25%) in contrast to Thomas's result. However Potaris could not find any significant association between the sternal fractures and spinal fractures.<sup>12</sup> We simplified our data into a table (Table 1).

Chance fracture is one of the diagnostic considerations in our literature search. But it differs from our cases in several ways. First, the definition of Chance fracture is the horizontal splitting fracture of the spine and neural arch extending from the spinous process, transverse process to the vertebral body anteriorly. Second, the mechanism is of the flexion-distraction type due to lap belt rather than shoulder-lap belt injury. Third, the axis of rotation is at about the level of umbilicus. Fourth, it is due to improperly worn lap seat belt. Fifth, it occurs almost exclusively in the

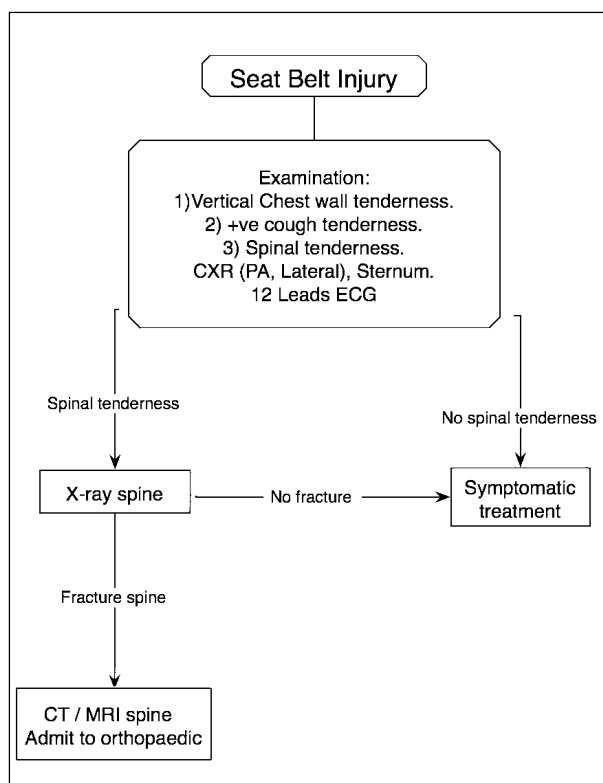
**Table 1.** Summary of studies on the relationship between sternal and spinal fractures

Author	Year of study	No of victims	Sternal + spinal fracture	Remark
Sevitt <sup>1</sup>	1968	13	3	Aroused attention
Gopalakrishnan <sup>8</sup>	1981-1986	250	8 upper thoracic (T2 - T7) 2 lower thoracic (T9, T10) 1 lumbar 1 cervical + thoracic	Sternal fracture may be associated with spinal fracture
Jones <sup>7</sup>	1981-1987	28	3 thoracic 4 lumbar 1 cervical + thoracic	Lateral view on spine was recommended
Brookes <sup>2</sup>	1985-1991	272	6 cervical 13 thoracic 9 lumbar 6 pelvis	Rib fracture was more common (74 patients) No statistical difference in degree of sternal fracture
Hills <sup>11</sup>	1985-1991	172	5 thoracic 5 others	Weak association between sternal and spinal fractures
von Garrel <sup>10</sup>	1985-1995	200	8 cervical 23 thoracic 14 lumbar	Significant correlation (p=0.021) in completely displaced sternal fracture and spinal fracture
Potaris <sup>12</sup>	1989-2000	239	10 thoracic 4 pelvis	Rib fracture more common Could not find any association

thoracolumbar region rather than anywhere in the spine. Finally it does not involve the sternum.<sup>13,14</sup>

### ***Lessons to learn***

Indirect force is often ignored but can be more hazardous than direct impact. There are similar analogies in our emergency setting such as calcaneal and lumbar fracture, the medial malleolus and head of fibula fracture, the radial styloid and scaphoid fracture, and clavicular fracture when one falls with out-stretched hands. For decades, we have been trained to be alert on direct injury as well as transmitted impact when managing trauma victims. We believe that this is another association we should be aware of after our literature search. The atypical delayed presentation illustrated is definitely a pitfall for emergency physicians especially junior trainees who may account for the back pain by muscle sprain. Moreover it could be easily overlooked when the case burden is high or even worst, if we underestimate the tremendous indirect energy involved. Hence we propose a guideline (Figure 5) for reference since the treatment and outcome could

**Figure 5.** Proposed management guideline for seat belt injury.

be dramatically different. We believe this article can attract attention in managing victims with "minor" trauma.

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