CLINICAL ARTICLE

Traumatic Vertebral Fractures with Concomitant Fractures of the First Rib

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Objective: To investigate the characteristics of patients with traumatic vertebral fractures and concomitant fractures of the first rib and their management.

Methods: From January 2001 to December 2010, 17/3142 patients (0.5%) with traumatic vertebral fractures who presented to our hospitals had concomitant fractures of the first rib.

Results: The study included 14 men (82.4%) and 3 women (17.6%) patients of age 32–57 years (mean, 46.6 years). The mechanisms of trauma were falls from heights in seven, motor vehicle accidents in five and direct collisions with blunt objects in five. Thirteen patients (76.5%) presented initially with pulmonary complications after sustaining trauma. Three patients sustained one rib fracture, two three rib fractures, three four rib fractures and 10 > five rib fractures. The injuries were right-sided in three cases, left-sided in three and bilateral in eleven. Four patients (23.5%) presented with craniocerebral injuries. According to the American Spinal Injury Association (ASIA) classification, 10 patients (58.8% of the total study group) had motor and sensory deficits (ASIA A–D). There were no vascular injuries or deaths.

Conclusion: Traumatic vertebral fractures with concomitant fractures of the first rib are associated with multisystem injuries, but not always with morbidity and mortality. A multidisciplinary approach, early diagnosis, appropriate treatment and observation in the intensive care unit may prevent morbidity and/or mortality.

Key words: First rib; Fracture; Pulmonary complications; Spine; Trauma

Introduction

Traumatic vertebral fractures are often associated with multisystem injuries, morbidity and mortality. An important but frequently overlooked combination is that of spinal and rib fractures. Rib fractures are a common, painful and disabling injury among trauma patients. Due to their protected location in the upper thoracic cavity, first rib fractures are relatively rare compared to other rib fractures¹. Because they are frequently associated with high energy trauma, multisystem injuries and injuries to the subclavian artery and aorta², early diagnosis and appropriate management is very important. Most such injuries are caused by motor vehicle accidents³. Recently, reports of fractures of the first rib associated with stress injury, bony

fatigue, Horner's syndrome and thoracic outlet syndrome have been published^{4–6}. To better guide the diagnostic workup, we sought to define the true incidence and clinical characteristics of traumatic first rib fractures in patients who had sustained traumatic vertebral fractures.

Patients and Methods

Study Site

In 2009, Chongqing Municipality, which is in southwest China, had 31,442,300 inhabitants; the rural population having accounted for 61.7% of all inhabitants. The data for this study were collected from two affiliated hospitals of the Third

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Fig. 1 Left first rib fracture (white arrows) showing on CT (a) and chest X-ray (b).

Military Medical University in Chongqing, China, the two biggest of the four public tertiary hospitals located in the Shapingba district, which is a core district located in the northwest of Chongqing city.

Patient Survey

The Research Ethics Board of the University Health Network approved the protocol for this study, which was a retrospective cross-sectional study of data from the Military Hospital Information Registry Database gathered from January 2001 to December 2010. Seventeen (0.5%) of all patients presenting with traumatic vertebral fractures had accompanying first rib fractures (Figs 1,2). The clinical records and radiographs of these 17 patients were reviewed. The level of vertebral fracture, presence of underlying neurological symptoms and associated injuries, particularly life-threatening intra-thoracic injuries, and the type of management undergone by each patient were studied.

Results

The study group included 17 patients who had presented with traumatic vertebral fractures and concomitant fracture of the first rib. They comprised 14 men (82.4%) and 3 women (17.6%) of mean age 46.6 years (range 32–57 years). Detailed characteristics of these 17 patients are shown in Table 1. All injuries were caused by blunt trauma, including falls from heights (height ≥ 2 m) in seven cases (41.2%), motor vehicle accidents in five (29.4%, passengers injuries in two, pedestrian injuries in three) and direct collisions with blunt objects in five (29.4%). Eleven (64.7%) cases gave a history of blows to their head, neck and/or shoulder. Five (29.4%) of the first rib fractures were detected on chest X-ray films and 12 (70.6%) by CT. Three patients sustained one rib fracture (isolated first rib fractures), two had three rib fractures, two four rib fractures and 10 > five rib fractures. In seven cases the rib fractures were right-sided, in five left-sided and in five they were bilateral. Of the patients with first rib fractures,

Fig. 2 Right first rib fracture (white arrows) showing on CT (a) and chest X-ray (b).

TABLE 1 Details of 17 patients with traumatic vertebral fractures and concomitant fractures of the first rib

Case no.	Age (years)	Sex	Cause	Vertebral fractures	Rib fractures	Neurological deficit	Initial pulmonary complications	Other bone fractures
1	46	F	MVA	T ₁₀ , T ₁₁	L 10, R 1, 3-5, 8-11	ASIA A	Lung contusion	None
2	56	M	MVA	C ₇ , T ₄ , T ₅ , L ₁	L 1-5, R 1-4	ASIA B	None	R humeral fracture, R scapular fracture
3	44	F	MVA	C ₂ , T ₁₁ , T ₁₂ , L ₄	L 1-8	ASIA E	Lung contusion	None
4	51	M	MVA	L ₄	L 3-9, R 1-9	ASIA D	Pneumohemothorax	Scapular fractures, sternal fracture
5	53	M	MVA	C ₂ , T ₃	L 1-3, R 1, 2	ASIA E	Lung contusion	Sternal fracture
6	35	M	Fail	T ₁₂	L 10, 11, R 1	ASIA B	Pneumohemothorax	None
7	53	M	Fail	C ₅	L 1	ASIA E	None	None
8	52	M	Fail	T ₄ , T ₅ , T ₆ , T ₇	L 1, 4-8, R 1, 2, 4-6	ASIA E	Lung contusion	None
9	32	M	Fail	C ₁	R 1-4	ASIA E	Hemothorax	R tibial fracture, R fibular fracture
10	57	M	Fail	T ₆	L 5, 6, R 1, 3-6	ASIA A	None	None
11	50	M	Fail	L ₁	R 1, 3, 6, 8	ASIA D	Lung contusion	None
12	43	M	Fail	T ₇	L 1-6, 9, R 1	ASIA A	Lung contusion	R tibial/fibular fracture, L scapular fracture
13	35	M	Direct collision	L ₁ , L ₂	R 1	ASIA E	Lung contusion	R scapular fracture
14	37	M	Direct collision	T ₁₀	L 1, R 1, 5-7, 10	ASIA A	None	R scapular fracture
15	45	M	Direct collision	T ₁₂	L 1, R 7-12	ASIA A	Lung contusion	R tibial fracture, L femoral fracture
16	48	M	Direct collision	C ₇ , T ₃ , T ₄	L 1	ASIA A	Lung contusion	None
17	55	F	Direct collision	T ₈ , T ₉ , T ₁₂	L 1, R 2, 10	ASIA E	Lung contusion	None

ASIA, American Spinal Injury Association; F, female; M, male; MVA, motor vehicle accident.

eight (47.1%) had only thoracic vertebral fractures, three (17.6%) only lumbar vertebral fractures, two (11.8%) only cervical vertebral fractures, two (11.8%) cervical plus thoracic vertebral fractures and two (11.8%) cervical plus thoracic plus lumbar vertebral fractures. 13/17 patients (76.5%) presented initially with pulmonary complications after sustaining trauma (hemothorax in one, pneumohemothorax in two and pulmonary contusion in ten). Other associated bone fractures were recorded in eight patients (40.1%), the 14 fractures sites including extremities (seven), scapula (five) and sternum (two). Eight patients (47.1%) became comatose after sustaining trauma. No patients presented with thoracic outlet syndrome or Horner syndrome.

According to the American Spinal Injury Association (ASIA) classification⁷, six patients (35.3%) had complete motor and sensory deficits (ASIA A), four (23.5%) incomplete motor and sensory deficits (ASIA B, C, D) and seven (41.2%) no motor or sensory deficits (ASIA E). No patients in our study had vascular complications or died. All patients were primarily followed up in the intensive care unit (ICU). Four developed pulmonary infections, one pressure sores and one cystitis. In 14/17 patients (82.4%), the spinal fractures were treated surgically (with posterior open surgery in nine and anterior open surgery in five). The mean operating time was 225.7 mins; mean blood loss 871.4 mL, mean time in ICU 19.2 days; mean length of hospitalization 60.2 days and mean hospital charges 112,749.9 CNY. Chest strapping was performed in two patients, thoracocentesis and/or closed-chest drainage in four and assisted breathing with a ventilator in two. Three patients (17.6%) with incomplete lesions improved 1 grade in their ASIA classification during hospitalization.

Discussion

Fractures of the first rib are the rarest of all rib fractures⁸. First rib fractures are considered an important indicator of severe chest trauma and are associated with a wide range of local concurrent injuries. In our study, the incidence of first rib fracture was 0.5% among 3142 patients with traumatic vertebral fractures. 76.5% of these patients presented initially with pulmonary complications after sustaining trauma and 23.5% with craniocerebral injuries. According the ASIA classification, 58.8% of patients had motor and sensory deficits. Thus, first rib fracture is indeed an important indicator of severe chest trauma.

Because the first rib is situated quite deep, most cases of traumatic first rib fractures are associated with clavicular and/or scapular fractures⁹. Most traumatic first rib fractures are associated with motor vehicle accidents and falls from a height³. These accidents may result in severe blunt blows to the sternum and anterior chest wall. The mechanisms of traumatic first rib fracture can be divided into the following four categories. The first is direct trauma to the posterior upper thorax or shoulder girdle. The second is an indirect blow to the sternum and anterior chest wall, which is transmitted through the shoulder girdle to the first rib. The third involves the clavicle: injuries to the lateral clavicle causing acromioclavicular

separation may displace the costal cartilage and the anterior first rib via the subclavian muscle, thereby fracturing it from its posterior position. The fourth mechanism is a strong sudden contraction of the anterior scalene muscle combined with traction on the arm³. In the present study, 11 (64.7%) cases had a history of a blow to their head, neck and/or shoulder. In our study seven fractures involved the first of the above mechanisms, five involved the second, three the third and two the fourth. Thus, posterior direct trauma to the upper thorax or shoulder girdle was the main mechanism for traumatic first rib fracture in the current study.

The documented incidence of vascular injuries associated with first rib fractures ranges from 3% to 45% with a mean of 12%³. Aortic lesions occur in 3% of isolated first rib fractures; however, the rate of this vascular complication is 24% when there is concomitant thoracic, abdominal or cerebral trauma or a fracture of the long bones^{10,11}. On the other hand, Lee *et al.* reportedly found no clinically relevant correlation between thoracic skeletal injuries and acute traumatic aortic tears¹². Formerly, arteriography was routinely performed in all patients with first rib fractures because of the risk of subclavian artery and aortic injuries. Nowadays, CT is preferred because it has less morbidity and is indispensable when chest X-ray films show widened mediastinum^{2,10}. Previous investigators have suggested that the finding of first and second posterior rib fractures on plain radiographs in the setting of trauma should prompt strong consideration of vascular imaging to exclude associated aortic or subclavian artery injuries^{3,13}. Khosla *et al.* claimed that first and second rib fractures are not associated with a greater incidence of aortic injury¹. In our study, no vascular injuries or deaths occurred, neither were there any neurological injuries caused by first rib fractures. However, neurologic injuries caused by spinal fractures were frequent, with an overall incidence of 58.8%. Thus, the previous axiom that first and second rib fractures should result in a high index of suspicion for aortic injury may not hold true.

In the current study, five cases (29.4%) of first rib fractures were detected on chest X-ray films and 12 (70.6%) by CT. Ishibashi *et al.* pointed out that, even in the presence of massive subcutaneous emphysema, three-dimensional computed tomography (3D-CT) can detect fractures of the sternum, additional rib cartilage or rib fractures causing delayed pneumothorax or hemothorax¹⁴. Moreover, 3D-CT is useful for determining the details of injuries and is strongly recommended for patients with blunt chest trauma. In a prospective study, Livingston *et al.* found that CT evaluation of rib fracture number and patterns better predicts respiratory failure and mortality after chest injury than do data derived from the initial plain chest radiographs¹⁵. Therefore, CT or 3D-CT are indicated to detect rib fractures, especially when first rib fracture is suspected in order to make an early diagnosis and provide appropriate treatment and observation.

Fracture of the first rib, the rarest of all rib fractures, is associated with serious injuries such as intrathoracic injuries and other bone fractures, but not always with vascular injuries and death. The trauma team must be aware of the potential

severity of first rib fractures in patients with traumatic vertebral fractures. A multidisciplinary approach, early diagnosis

and appropriate observation in the ICU may prevent morbidity and/or mortality.

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