

ANNALS OF SURGERY

Vol. 181

March 1975

No. 3



First Rib Fracture: A Hallmark of Severe Trauma

J. DAVID RICHARDSON, M.D., RICHARD B. McELVEIN, M.D.,
J. KENT TRINKLE, M.D.

*From the Division of Cardiothoracic Surgery,
Department of Surgery, The University of Texas Health
Science Center at San Antonio, San Antonio, Texas and
the University of Kentucky Medical Center, Department
of Surgery, Lexington, Kentucky*

First rib fractures occurred in 55 patients. This injury is a harbinger of major trauma with 35 patients suffering a major chest injury, and abdominal and cardiac injuries occurring in 18 and eight patients respectively. The mortality associated with this injury was high (36.3%). Neurologic lesions accounted for the majority of deaths, however, unrecognized abdominal injuries and pulmonary complications were significant causes of mortality. Brachial plexus injury (5) and Horner's syndrome (3) occurred in survivors. Three patients had an associated injury of the subclavian artery, and the importance of this association is stressed. One late-developing post-traumatic thoracic outlet syndrome occurred. A fracture of the first rib is a hallmark of severe trauma; its presence should alert the clinician to: 1) generalized massive trauma with abdominal, chest, and cardiac injuries; 2) local injury to the subclavian artery and brachial plexus and; 3) necessity of long-term followup for late-developing sequelae.

THE TRAUMA VICTIM with multi-system injuries is one of the most perplexing and difficult patients to manage. Evaluation is especially difficult if there is an associated neurologic injury. The subsequent delay in diagnosis and treatment is a major cause of mortality due to blunt abdominal or chest trauma.^{2,3,9,16}

The importance of the radiologic evaluation of accident victims has been stressed by several authors and a number of radiographic signs helpful in assessing the extent of injury have been recognized. On a plain abdominal film, free air, displacement of gas-containing structures, obliteration of the psoas shadow, and the like,

Submitted for publication July 20, 1974.

Reprint requests: J. David Richardson, M.D., Department of Surgery, University of Texas Health Science Center at San Antonio, 7703 Floyd Curl Dr., San Antonio, Texas 78284.

suggest visceral injury, while the fracture of certain bony structures indicate the possibility of internal injuries. For example, a fracture of the left eleventh rib should strongly suggest the possibility of a ruptured spleen while myocardial contusion commonly accompanies a sternal fracture.

In evaluating patients with multiple-system injuries we have noted a valuable sign indicative of severe trauma; *i.e.* fracture of the first rib. The anatomy of the first rib is such that it is protected from the minor insults that often break other ribs. Therefore, when a fracture of this bone occurs it should alert the physician to be highly suspicious of other associated injuries regardless of the initial appearance of the patient.

Patient Population

Fifty-five patients with a fracture of the first rib have been treated at the University of Kentucky Medical Center and its affiliated hospitals and the Bexar County Hospital in San Antonio, Texas, in the past ten years. There were 41 males and 14 females with an average age of 33 years. The youngest patient was eight and the oldest 71.

The overwhelming majority (50/55) of these injuries occurred in vehicle accidents. Two patients were pedestrians struck by automobiles, one was injured in a

TABLE 1. *Associated Injuries With First Rib Fracture (55 Patients)*

Injury	No.	Per cent
Chest	35	64
Abdominal	18	33
Cardiac	8	14
Cranial	29	53
Other fracture	41	75
Other rib fracture	43	78

mining accident, one in a fall, and the other in a lumbering accident. Most of those injured while in an automobile apparently hit the steering wheel or dashboard. The charts of all patients were reviewed for the occurrence of associated injuries, treatment, and eventual outcome.

Table 1 shows the occurrence of associated injuries in patients with a first rib fracture.

Chest Injuries

Thirty-five of the 55 patients had a major chest injury defined as a pneumothorax, hemothorax, pulmonary contusion, or flail chest (Table 2). Twenty patients had a unilateral pneumothorax while seven had bilateral pneumothoraces. Hemothorax was present in 14 patients and was bilateral in four cases. Twenty-two patients had radiographic evidence of pulmonary contusion. Seven patients had a flail chest.

The treatment of these chest injuries varied somewhat depending on the clinical setting. One patient with a small unilateral pneumothorax was treated with aspiration, but the remainder underwent a tube thoracostomy to allow re-expansion of the collapsed lung. Many had a sizable collection of blood which was drained as well.

One patient with a flail segment was treated with a traction device and the other six by volume ventilation. Thirteen patients (23.6% of the total group) required ventilatory assistance at some point in their management.

The treatment of pulmonary contusion was initially fluid restriction and ventilatory assistance as needed for hypoxia. Recently we have undertaken a more aggressive approach^{17,19} using intravenous furosemide, strict fluid limitation, colloid for volume replacement, and vigorous pulmonary care in an attempt to diminish the development of pulmonary contusion and obviate the need for mechanical ventilation.

The severity of the thoracic injury in patients with a first rib fracture is reflected by the hypoxia detected by arterial blood gases. Forty-one patients had an initial determination of arterial blood gases shortly after injury and only 13 had a pO₂ of greater than 80 mm Hg. Eighteen were between 60 and 70 mm Hg at some point in their post-injury phase, while ten persons had an arterial oxygen tension of less than 60 mm Hg.

TABLE 2. *Chest Injuries With First Rib Fracture* (35 Patients)*

Injury	No.
Unilateral pneumothorax	20
Bilateral pneumothorax	7
Hemothorax	14
Pulmonary contusion	22
Flail chest	7

*Many patients had multiple injuries.

Abdominal injuries

Eighteen patients (33%) required an exploratory laparotomy because of associated intra-abdominal trauma (Table 3). Multiple intra-abdominal injuries were common. Eleven patients underwent splenectomy, three had liver lacerations, two had renal injuries, three an intestinal injury and two a ruptured bladder. There was one negative exploratory laparotomy.

Ten of the 16 patients who required abdominal operations had associated neurologic injuries with an altered level of consciousness which made evaluation of their abdomen difficult on clinical grounds. Diagnosis of abdominal injury was often strengthened by positive peritoneal lavage or falling hematocrit; however, exploratory laparotomy was occasionally undertaken only on strong clinical suspicion.² The presence of a first rib fracture in these patients was another indication that they had indeed received massive trauma and merited careful evaluation.

Cardiac Injuries

Eight patients were felt to have cardiac injuries secondary to blunt chest trauma. Two patients with hemopericardium were treated with pericardiocentesis. Neither of these patients required further intervention for their cardiac problems. An additional six persons were felt to have myocardial contusion as demonstrated by serial changes in their electrocardiogram. Inversion of the T-wave with ST segment depression was seen at some stage in each of the patients. One ECG had returned to normal within four days while changes in the others persisted two to three weeks. The true incidence of cardiac contusion may be higher than was actually diagnosed since several patients did not have an ECG. No cardiac injuries were encountered that required operative intervention.

TABLE 3. *Associated Abdominal Injuries* (18 Patients)*

Injury	No.
Ruptured spleen	11
Liver injury	3
Intestinal injury	3
Pancreatic injury	3
Ruptured bladder	2
Renal injury	2
Negative exploration	1

*Many patients had multiple injuries.

Other Associated Injuries

Major injuries associated with first rib fracture were not limited to the thoracoabdominal area. Twenty-nine patients suffered neurologic damage with the majority having a loss of consciousness. The addition of this insult further clouds an already difficult evaluation.

Three-fourths of patients with first rib fracture had an associated fracture of another bone (other than another rib). Long bone fractures of the upper and lower extremities, often multiple, were the most common with ten patients having a pelvic fracture. Forty-three persons had fractures of other ribs. These multiple rib fractures undoubtedly contributed directly to the high number of patients with intra-thoracic injuries.

Mortality

There were 20 deaths in 55 patients with first rib fractures for a mortality of 36.3% (Table 4). Although most patients had combined, multi-system trauma, the leading cause of death was head injury. The combination of a major chest injury with hypoxia and a neurologic lesion was a lethal combination.

Fourteen of the 20 patients who died had a neurologic injury. Eight of these had associated chest trauma and despite ventilatory assistance, this combination of injuries was often difficult to overcome. Three patients also had an unrecognized abdominal injury and in each it contributed to the patient's death. A delayed rupture of the spleen in a man recovering from a head injury produced one death, while another died of sepsis as a result of a mesenteric vascular injury that went undiagnosed with resultant infarction of the colon.

In three patients the deaths were primarily attributable to pulmonary complications. The oldest patient (age 71) suffered a bilateral pulmonary contusion and died of this injury as did one younger patient. A 60-year-old man underwent splenectomy and repair of his fractured femur and then required postoperative treatment on a volume ventilation for his flail chest. Despite a good initial response to therapy, he developed a bilateral pneumonia requiring a prolonged course of ventilatory assistance and eventually died of a suspected pulmonary embolus on his 28th hospital day.

Three other deaths occurred in young men. One died on the operating table from a bursting injury to the liver

TABLE 4. *Cause of Death*

Neurologic Injury	14	
With chest injury (8)		
With unrecognized abdominal injury (3)		
Primary Pulmonary	3	
Bilateral pulmonary contusion (2)		
Flail chest, ruptured spleen, fractured femur (1)		
Sepsis-Abdominal Injury	1	
Bursting Liver Injury	1	
Fat Embolism Syndrome	1	
Total	20/55	(36.3%)

TABLE 5. *Associated Local Injuries (12)*

Brachial plexus injury	5
Horner's syndrome	3
Arterial injury	3
Thoracic outlet syndrome	1

and another on the third post-injury day from a complication which was diagnosed as fat embolism syndrome. Intra-abdominal sepsis accounted for a third death.

Local Injuries With First Rib Fracture

Local injuries secondary to fracture of the first rib are shown in Table 5. Brachial plexus injuries occurred most commonly, with three transient and two permanent injuries occurring. Three patients had Horner's syndrome; in two it cleared completely while one patient had a residual ptosis. Arterial injuries to the subclavian artery occurred in three patients. Two patients had large hematomas which signaled the arterial injury while another had radial pulse diminution. Three other patients had first rib fracture with a fractured clavicle and developed sizeable hematomas. Arteriograms were negative in each and they were observed without obvious sequelae. One patient presented three years following a first rib fracture with a thoracic outlet syndrome which appeared secondary to callus formation in the healed fracture. He improved with resection of the first rib.

Discussion

Isolated fracture of the first rib without antecedent injury has been reported.^{1,5,13} Alderson¹ noted 73 cases of first rib fracture as an incidental finding in 77,607 chest films, and attributed their occurrence to "stress fracture." Generally, however, it is conceded that a blow of major proportions is needed to produce a first rib fracture. Hinton and Steiner¹⁰ noted first rib fractures occurred in 2.7% of their 807 cases of rib fractures reported in 1940. Conn and associates⁶ noted 9.2% of their 532 patients with non-penetrating chest trauma had a fracture of the first rib. The incidence appears to be increasing in recent years due to a greater frequency of high-speed automobile accidents with resultant massive trauma.

The high percentage of associated injuries indicates that persons who suffer a first rib fracture have sustained a major injury. Breslin,⁴ in 1937, listed abscess around the clavicle, rupture of the apex of the lung, empyema, pleurisy, hemorrhage and delayed nerve symptoms due to compression from callus as complications of first rib fracture. He also cited a case of subclavian artery injury due to a right first rib fracture. Holmes and Netterville¹¹ noted that five of their 16 patients with first rib fracture had major chest injuries, three had neurologic damage, and 13 of 16 had other major fractures. In addition, one patient developed a traumatic tracheo-esophageal fistula and another had an aortic arch aneurysm. However, only one patient had an

intra-abdominal injury, which is significantly lower than that seen in our patients.

The severity of the trauma inflicted on this group of patients is reflected in the 36.3% mortality rate. Several patients sustained a massive head injury and may have been initially unsalvageable from a neurologic point of view. However, other remediable injuries occurred with frequency and the clinician caring for accident victims must be alert for such problems. In three of our patients abdominal injuries were initially missed and directly contributed to deaths. Missed abdominal injury continues to be a significant cause of mortality following automobile accidents. Gertner et al.⁹ reviewed the experience at the Baltimore City Hospitals with deaths following motor injuries due to blunt abdominal trauma and found 32 of 33 fatalities arrived at the hospital alive. They concluded that 50% of these cases had a failure to make either the correct diagnosis or institute proper treatment. At our own institution¹⁶ the delay in recognition of abdominal injuries which often occurred in patients referred from outlying hospitals was an influential factor in mortality from blunt abdominal trauma. While techniques such as diagnostic peritoneal lavage have aided in establishing a diagnosis in massively injured patients, exploratory laparotomy often has been performed on the strong clinical suspicion that such a lesion exists. Those patients with a first rib fracture exemplify such trauma victims.

While a major pulmonary injury may be more easily diagnosed by physical examination with radiological assistance than is an abdominal injury, the presence of a first rib fracture demands careful evaluation for thoracic injuries. Cardiac injuries are frequently missed because they are not considered and appropriate ECG and enzyme studies not obtained.

Major vascular injuries in association with first rib fractures are being recognized with increasing frequency. Galbraith et al.⁸ reported a subclavian artery laceration with a first rib fracture and stressed the importance of vascular injuries with this fracture. Sturm and associates¹⁸ treated five patients with rupture of the subclavian artery due to blunt trauma. Three of the patients had a first rib fracture. They recommended arteriography in all patients with fracture of the first three ribs because of the frequent association of subclavian artery injuries. Previously, Fisher and Rienhoff⁷ reported a subclavian artery laceration secondary to a first rib fracture. Our experience added to these indicates this association is not rare, and a first rib fracture should alert the clinician to beware of major vascular injury.

In addition to its usefulness as an indication of severe trauma, a fracture of the first rib may produce injuries itself. The report of Holmes and Netterville¹¹ is the most thorough in outlining this problem. They reported

patients with a traumatic tracheoesophageal fistula, aortic arch aneurysm, brachial plexus injury, and Horner's syndrome following first rib fracture. One other patient was found at autopsy to have died from congestive heart failure secondary to bilateral subclavian vein obstruction produced by callus formation due to bilateral first rib fracture. This death occurred several months post-injury. In our series several patients with Horner's syndrome¹² and brachial plexus injury occurred following a first rib fracture. Additionally, one patient had a post-traumatic thoracic outlet syndrome which was detected three years after first rib fracture. Mulder¹⁴ previously reported seven cases of post-traumatic thoracic outlet syndrome with two of these following a first rib fracture. These sequelae and the more serious ones reported by others^{4,11} may not be initially apparent, therefore, a fracture of the first rib should necessitate a long-term followup to detect late-occurring sequelae.

References

1. Alderson, B. R.: Fractures of the First Rib. *Br. J. Radiol.*, 20:345, 1947.
2. Belin, R. P., Richardson, J. D. and Griffen, W. O.: Reducing the Lethality of Simultaneous Head Injury and Blunt Abdominal Trauma. *South Med. J.*, 65:976, 1972.
3. Blair, E., Cemalettin, T. and Davis, J. H.: Delayed or Missed Diagnosis in Blunt Chest Trauma. *J. Trauma*, 11:129, 1971.
4. Breslin, F. J.: Fractures of First Rib Unassociated with Fractures of Other Ribs. *Am. J. Surg.*, 38:384, 1937.
5. Cohen, A. G.: Isolated Fracture of the First Rib. *N.Y. State J. Med.*, 43:448, 1943.
6. Conn, H. J., Hardy, J. D., Fain, W. R. and Netterville, R. E.: Thoracic Trauma—Analysis of 1022 Cases. *J. Trauma*, 3:22, 1963.
7. Fisher, R. D. and Rienhoff, W. F., III.: Subclavian Artery Laceration Resulting from Fractured First Rib. *J. Trauma*, 6:579, 1966.
8. Galbraith, N. F., Urschel, H. C., Wood, R. E., et al.: Fracture of First Rib Associated with Laceration of Subclavian Artery. *J. Thorac. Cardiovasc. Surg.*, 65:649, 1973.
9. Gertner, H. R., Baker, S. P., Rutherford, R. B. and Spitz, W. U.: Evaluation of Management of Vehicular Fatalities Secondary to Abdominal Injury. *J. Trauma*, 12:425, 1972.
10. Hinton, D. and Steiner, C.A.: Fractures of the Ribs. *J. Bone Joint Surg.*, 22:597, 1940.
11. Holmes, T. W. and Netterville, R. E.: Complications of First Rib Fracture, Including One Case Each of Tracheoesophageal Fistula and Aortic Arch Aneurysm. *J. Thorac. Surg.* 32:74, 1956.
12. Kulkowski, J. and Ryan, J. H.: Isolated Bilateral Fracture of the First Rib; Case with Unilateral Horner's Syndrome. *South Med. J.* 33:1149, 1940.
13. Milligan, E. T. C. and Ford, R. E.: Fracture of the First Rib. *Br. Med. J.*, 1:191, 1921.
14. Mulder, D. S., Greenwood, F. A. H. and Brooks, C. E.: Post-traumatic Thoracic Outlet Syndrome. *J. Trauma*, 13:706, 1973.
15. Perry, J. F., Jr.: A Five Year Survey of 152 Acute Abdominal Injuries. *J. Trauma*, 5:53, 1965.
16. Richardson, J. D., Belin, R. P. and Griffen, W. O.: Blunt Abdominal Trauma. *South Med. J.*, 64:719, 1971.
17. Richardson, J. D., Franz, J. L., Grover, F. L. and Trinkle, J. K.: Pulmonary Contusion and Hemorrhage—Crystalloid Versus Colloid Replacement. *J. Surg. Res.*, 16:330, 1974.
18. Strum, J. T., Strate, R. G., Nowlem, A., et al.: Blunt Trauma to the Subclavian Artery. *Surg. Gynecol. Obstet.*, 138:915, 1974.
19. Trinkle, J. K., Furman, R. W., Hinshaw, M. A., et al.: Pulmonary Contusion—Pathogenesis and Effect of Various Resuscitative Measures. *Ann. Thorac. Surg.*, 16:568, 1973.