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A comprehensive analysis of traumatic rib fractures: morbidity, mortality and management

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Abstract

Objective: A rib fracture secondary to blunt thoracic trauma is an important indicator of the severity of the trauma. In the present study we explored the morbidity and mortality rates and the management following rib fractures. **Methods:** Between May 1999 and May 2001, 1417 cases who presented to our clinic for thoracic trauma were reviewed retrospectively. Five hundred and forty-eight (38.7%) of the cases had rib fracture. There were 331 males and 217 females, with an overall mean age of 43 years (range: 5–78 years). These patients were allocated into groups according to their ages, the number of fractured ribs and status, i.e. whether they were stable or unstable (flail chest). **Results:** The etiology of the trauma included road traffic accidents in 330 cases, falls in 122, assault in 54, and industrial accidents in 42 cases. Pulmonary complications such as pneumothorax (37.2%), hemothorax (26.8%), hemo-pneumothorax (15.3%), pulmonary contusion (17.2%), flail chest (5.8%) and isolated subcutaneous emphysema (2.2%) were noted. 40.1% of the cases with rib fracture were treated in intensive care units. The mean duration of their stay in the intensive care unit was 11.8 ± 6.2 days. 42.8% of the cases were treated in the wards whereby their mean duration of hospital stay was 4.5 ± 3.4 days, while 17.1% of the cases were followed up in the outpatient clinic. Twenty-seven patients required surgery. Mortality rate was calculated as 5.7% ($n = 31$). **Conclusions:** Rib fractures can be interpreted as signs of significant trauma. The greater the number of fractured ribs, the higher the mortality and morbidity rates. Patients with isolated rib fractures should be hospitalized if the number of fractured ribs is three or more. We also advocate that elderly patients with six or more fractured ribs should be treated in intensive care units due to high morbidity and mortality.

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1. Introduction

Thoracic traumas comprise 10–15% of all traumas and are the causes of death in 25% of all fatalities due to trauma [1]. Seventy percent of the thoracic traumas are blunt and the remaining are penetrating injuries. Most commonly 4–9th ribs are fractured. On the other hand, fractures of the upper ribs (1st and 2nd ribs) usually signify a severe trauma whereby concomitant great vessel injuries are commonplace. Fracture of the lower ribs (9–12th) may result in laceration of the spleen, liver or the kidneys [2–4].

In the present study we have attempted to shed light on the clinical course, treatment strategies and the risk factors

that have an impact on the morbidity and mortality rates of rib fractures, which are the most frequent clinical scenarios in thoracic traumas.

2. Materials and methods

A total of 1417 cases who were admitted to our clinic due to thoracic trauma between May 1999 and May 2001 were reviewed retrospectively. Rib fracture was identified in 548 (38.7%) of the cases. Cases were allocated into subgroups according to the number of fractured ribs (1–2 fractures, 3–5 fractures and more than 6 fractures), age (children = younger than 12 years of age; adolescents = aged between 13 and 17; adult = aged between 18 and 59; elderly = older than 60 years of age) and status (those with or without a flail chest). Patients were also analyzed according to gender,

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etiology of the trauma, pulmonary complications, associated injuries and the modes of treatment.

Patients with poor condition or those with flail chest were admitted to the intensive care units initially. Once their conditions improved they underwent interventions for their thoracic trauma. Stable cases were evaluated with history, physical examination and chest radiograph. An injury severity score (ISS) [5] was calculated for all cases. According to their ISS, patients were followed in the intensive care unit (ICU), in the ward (ISS 9–18) or as an outpatient (ISS \leq 8). The patients were followed in the ICU if they had ISS \geq 19 or if they had respiratory insufficiency, flail chest, sternum fracture, heart or great vessel injury. Patients with flail chest had either internal (intermittent positive-pressure ventilation) or external fixation. All patients followed in the ICU were fully monitored (including fever, pulse, blood pressure, respiratory rate checked every hour, continuous pulse oximetry, electrocardiography (ECG), complete blood count (CBC) and chest X-rays (CXR) daily. The patients in the ward were followed with vital signs, CBC and CXR daily. Tube thoracostomy was performed if they had pneumothorax or hemothorax. The patients in the outpatient clinic were followed with CXR and symptomatic treatments were given.

Definitive diagnoses were established by CXR and thoracic computed tomography (TCT).

For the management of pain due to the fractures, narcotic and non-narcotic analgesics, intercostal nerve block, patient-controlled analgesia and epidural analgesia were utilized.

3. Results

Reviewing the records of the 2-year period, we identified rib fracture(s) in 548 cases among 1417 cases (38.7%) presented to the hospital with thoracic trauma. There were 331 males (60.4%) and 217 females (39.6%) ranging in age between 5 and 78 years (mean = 43 years). 57.4% of our cases ($n = 813$) initially presented to other, non-specialized hospitals following thoracic trauma and were referred to our hospital. The remaining 42.6% of the cases ($n = 604$) were seen in our hospital first where they were attended by a thoracic surgeon in the emergency room.

The leading cause of the trauma was road traffic

accidents ($n = 330$, 60.2%). This finding was true for all four age groups. 72.4% of these cases were injured while they were in the vehicle while 27.6% were pedestrians hit by a motor vehicle. The second most common cause of thoracic trauma was falls ($n = 122$, 22.3%). The third and fourth most common causes of trauma were assault ($n = 54$, 9.8%) and work-related accidents ($n = 42$, 7.7%), respectively. While the incidence of traumas due to being hit by a vehicle was highest in children (67.3%), injuries sustained within the vehicle were higher in the adolescent (61.4%) and adult age (76.7%) groups. The type and severity of the traumas resulting in morbidity are given in Tables 1 and 2.

Two hundred and twenty (40.1%) patients who had fractured ribs due to a thoracic trauma were treated in the intensive care unit with an ISS \geq 19. The mean duration of their stay in the intensive care unit was 11.8 ± 6.2 days. The majority of the cases followed in the intensive care unit were elderly patients (68.3%) or patients with six or more fractured ribs (88.6%). The 235 (42.8%) patients with an ISS between 9 and 18 were treated in the ward with a mean duration of hospital stay of 4.5 ± 3.4 days. Ninety-three (17.1%) patients with an ISS \leq 8 were seen at the outpatient clinic.

Patients who were followed up in the ICU had their ECGs taken daily. Signs of anterior ischemia in 14 cases (minimal S-T segment depression in leads V1–V6 in four cases and inverted T waves in ten cases), signs of inferior ischemia in three cases (minimal S-T segment depression in leads II, III, and aVF and inverted T waves) were noted. Intravenous nitroglycerin, nitrates PO and β -blockers were given to the patients. Four patients had serious chronic obstructive pulmonary disease (COPD) that necessitated prescription of Ca-channel blockers instead of β -blockers. Forty-one cases (18.6%) had sinus tachycardia that prompted monitoring but did not require any medical treatment, and 17 cases (7.7%) had atrial fibrillation and had either β -blockers or Ca-channel blockers. In 8.2% of the cases ventricular extrasystoles producing ventricular bigeminy or trigeminy was noted. These patients were followed and only one developed ventricular fibrillation that responded well to defibrillation with 300 J and turned to normal sinus rhythm. Afterwards, intravenous Cordarone infusion was started. No additional problems were encountered in this or any other patients with ventricular extrasystoles. No mortality was observed in patients with ECG aberrations.

Table 1
Occurrence of pulmonary complications associated with the types of trauma

	Pneumothorax	Hemothorax	Hemo-pneumothorax	Lung contusion	Flail chest	Isolated subcutaneous emphysema
Motor vehicle	93	69	30	57	18	2
Falls	44	24	15	26	7	6
Assault	20	13	10	6	1	4
Industrial accidents	14	10	7	5	6	

Table 2
Association between the types of the traumas, pulmonary complications and median injury severity score (ISS)

	Pneumothorax	Hemothorax	Hemo-pneumothorax	Lung contusion	Flail chest	Isolated subcutaneous emphysema
Motor vehicle	16	17	17	19	26	12
Falls	13	14	13	15	23	10
Assault	12	12	11	12	19	9
Industrial accidents	15	16	17	18	25	

Isolated rib fracture was diagnosed only in 72 (13.1%) cases during the admittance. Forty-three of these cases had one or two, and 29 had 3–5, fractured ribs. Within the first 48 h of admission, seven patients developed hemothorax and four patients developed pneumothorax. Five patients who developed hemothorax had 3–5 fractured ribs while the remaining two patients had 1–2. On the other hand, of the four patients who developed pneumothorax, three were in the 3–5 and the other was in the 1–2 fractured-ribs subgroup. Among these 11 patients with secondary complications, seven were found to be handled in an outpatient fashion and they had 3–5 rib fractures.

Pulmonary complications with respect to the age groups and the number of fractured ribs are summarized in Tables 3 and 4.

Pneumothorax, hemothorax or hemo-pneumothorax was noted in 396 (72.3%) of the cases with rib fracture and they had tube thoracostomy. Twenty-seven of them subsequently underwent surgery. Ten of them had persisting air leak. Parenchymal laceration was found and repaired. Five cases underwent explorative thoracotomy for hemorrhage. In four cases, the intercostal artery was found lacerated while the locus of bleeding could not be identified in the fifth. In the early stages of 11 cases, Video-assisted thoracoscopy (VATS) was performed to drain pleural hematoma. One patient underwent decortication in the later stages.

Unstable cases (those with flail chest) comprised 5.8% of all cases ($n = 32$). The most common etiology for flail chest was traffic accidents (56.2%, $n = 18$). Flail chest was most common (46.9%, $n = 15$) when there were six or more fractured ribs. The number of fractured ribs in flail chest cases and their mean ISSs are given in Table 5. All flail chest cases were followed in the intensive care unit. Clinical approach towards these patients based on arterial blood gas measurements. Analgesia was attained in these patients with

parenteral narcotic analgesics and epidural anesthesia. Nine adult and three elderly cases needed external fixation while four adult and 11 elderly patients developed respiratory insufficiency (PO_2 : 60 ↓, PCO_2 : 45 ↑) that required intermittent positive-pressure ventilation. Mean hospitalization period of flail chest cases was 16.8 ± 7.3 days. Mortality rate was calculated as 18.7% ($n = 6$).

On the follow-up of the cases with rib fracture, 39 cases developed atelectasis, 23 developed pneumonia, eight developed adult respiratory distress syndrome (ARDS), and six developed pulmonary embolism. Nasotracheal aspiration and fiberoptic bronchoscopy (FOB) were performed to clear the secretions in cases with atelectasis.

Other types of injuries accompanying the rib fractures are given in Table 6.

We calculated the overall mortality rate in patients with rib fracture as 5.7% ($n = 31$). The mortality due to pulmonary complications per se was 3.3% ($n = 18$). Pneumonia, ARDS, pulmonary embolism and flail chest were the causes of death in four, six, two and six patients, respectively. Thirteen cases had suffered severe head injuries in addition to the rib fractures and died shortly after their hospitalization. Thirteen of the 18 cases were in the elderly (72.2%) and five (27.8%) were in the adult subgroup. Eighty-eight percent of these cases ($n = 16$) had six or more fractured ribs while only 11.2% ($n = 2$) had 3–5 fractured ribs. Twenty-four cases of traffic accidents, four cases of falls and three cases of work-related accidents resulted in mortality, with ISSs of ≥ 38 , ≥ 35 , and ≥ 32 , respectively.

4. Discussion

The incidence of rib fractures due to trauma has been

Table 3
Relationship between the ages and pulmonary complications of the cases

Age group	Pneumothorax	Hemothorax	Hemo-pneumothorax	Lung contusion	Flail chest	Isolated subcutaneous emphysema
Child ($n = 68$)	14	8	7	21	–	1
Adolescent ($n = 103$)	40	28	16	23	–	2
Adult ($n = 235$)	92	79	37	32	18	6
Elderly ($n = 142$)	58	32	24	18	14	3
Total ($n = 548$)	204	147	84	94	32	12

Table 4

Relationship between the number of fractured ribs and number of pulmonary complications of the cases

No. of fractured ribs	Pneumothorax	Hemothorax	Hemo-pneumothorax	Lung contusion	Flail chest	Isolated subcutaneous emphysema
1–2	34	25	7	15	–	9
3–5	67	45	25	32	12	3
6 or more	103	77	42	47	20	–
Total	204	147	74	94	32	12

reported by various studies to range between 7 and 40% [1–6]. We found this rate to be 38.7%. The treatment and follow-up of rib fractures are critical due to its high incidence and serious complications associated with it. Our hospital is a tertiary referral center in the field of thoracic surgery. Therefore many patients are referred to our hospital for thoracic traumas.

The most common cause of rib fractures is motor vehicle accidents [1,2], which comprised 60.2% of our cases; 72.4% of them were injured while they were traveling in the vehicle and 27.6% of them were pedestrians hit by a vehicle.

Children's ribs are more flexible in nature compared to the adults. Hence the consequences of a thoracic trauma may be different in children than in adults. A simple trauma in children can cause injury to the intra-thoracic viscera [8]. A study on rib fractures in children found that the mortality rate in children with multiple rib fractures was 20 times higher than those who do not have a fractured rib [6]. In the present study, more than half of the children had one or two fractured ribs. However, the pulmonary complications were discordantly high. Generally, it is agreed that there is a positive correlation between the number of fractured ribs and the severity of the injury. However, one should bear in mind that a serious trauma can occur with a few number of fractured ribs. Therefore the number of fractured ribs may be a misleading indicator in children of the severity of the trauma.

In the elderly, even a moderately severe injury can result in multiple fractures. This can be explained by the fragility of the bones. In the elderly, complications are more likely to occur as the number of fractures increase [1,4]. With a mortality rate of 67.7% ($n = 21$), we found highest morbidity (94.4%, $n = 134$) and mortality (67.7%, $n = 21$) rates in the elderly group. Therefore elderly patients

with six or more fractures were followed-up in the intensive care units.

The incidence of isolated rib fractures has been reported to range between 6 and 12% by different studies [1,2,9,10]. The incidence of isolated rib fracture was 13.1% in this study, which is in agreement with other studies. Eleven of the 72 cases with isolated rib fractures developed pulmonary complications within 48 h of admission to the hospital. These eleven patients had three or more rib fractures and seven of them had been followed in an outpatient fashion, therefore we suggest that patients with three or more fractured ribs should be hospitalized and their pulmonary functions be monitored closely since complications are likely to occur after isolated rib fractures.

Pulmonary complications due to rib fractures include pneumothorax, hemothorax, pulmonary contusion, flail chest, pneumonia and atelectasis [1,2,6–8]. Ziegler et al. [1] reported that there was not a significant difference between the pulmonary complication and the increased number of the fractured ribs. They calculated the complication rates as 31, 38, 41.7 and 38% for 1–2 fractures, 3–4 fractures, 5–6 fractures and 7 or more fractures, respectively [1]. In our study, we calculated these rates as 16.4, 33.6 and 52.7% for 1–2 fractures, 3–5 fractures and 6 or more fractures, respectively. We found that the complication rates increased with the increased number of fractured ribs.

Flail chest is a serious problem faced by patients with rib fractures since paradoxical chest movement causes a decrease in the vital capacity and ineffective ventilation. This in turn results in pulmonary insufficiency. Compliance of the ribs is an equally important factor as the force of the impact to cause flail chest. In the elderly, low-energy

Table 5

Number of rib fractures and median injury severity score (ISS) that occurred in flail chest patients

No. of rib fractures	<i>n</i>	ISS
3	1	19
4	6	22
5	10	25
6 and more	15	26

Table 6

Other systemic injuries associated with rib fractures

Associated injuries	<i>n</i>	%
Extremity injuries	253	46.2
Head injuries	192	35
Splenic injuries	39	7.1
Hepatic injuries	28	5.1
Sternum fractures	16	2.9
Thoracic aorta injuries	8	1.5
Scapula fractures	8	1.5
Heart injuries	4	0.7

traumas can cause flail chest whereas in the children only 1% of serious impacts result in flail chest [11]. It is argued in some recent publications that operative fixation lowers the mortality and morbidity rates [12,13] but this argument is not widely agreed upon [14]. We usually use operative fixation only in cases who need thoracotomy for other reasons and used the fixation with mechanic ventilation (intermittent positive-pressure ventilation) in 15 cases with pulmonary insufficiency. The mortality rate in patients with flail chest varies between 11 and 40% [15–18]. This rate was calculated 18.7% in our study.

Tube thoracostomy can, by itself, be curative in pneumothorax and hemothorax secondary to rib fractures. Small loci of bleeding usually stop spontaneously when the lungs are expanded and exert pressure on these loci. Nevertheless, hemorrhage from an intercostal artery or a pulmonary vessel requires urgent thoracotomy [1,8]. We performed tube thoracostomy in 396 cases. This procedure alone was sufficient in 381 cases. The remaining 15 cases underwent explorative thoracotomy due to persistent air leak or hemorrhage.

Less than 5% of the patients with blunt thoracic trauma need thoracotomy [18] and among our cases only 2.9% ($n = 16$) needed thoracotomy. Furthermore, we performed VATS in 11 cases to drain pleural hematoma. This procedure is an effective tool in draining the pleural hematomas. VATS performed in the early stages for pleural hematomas will usually be able to spare the patient from decortication in the later stages. We performed decortication in only one case in the late period.

One of the factors affecting the mortality, or the overall outcome of the patients is concomitant injuries to other systems. The most important of these accompanying injuries are the ones to the central nervous system. The incidences of injuries to other systems reported in different studies vary considerably [1–4,6–8]. In this study the incidence of accompanying injuries to other systems was somewhat lower than those reported in the literature. We believe that, since our hospital is a tertiary referral center for thoracic surgery, only the patients with mainly thoracic injuries, instead of multiple system injuries are brought to our hospital.

Pain due to the rib fractures adversely affects the pulmonary functions and morbidity. Therefore the analgesia for rib fractures is very important [19,20]. In the previous studies it is confirmed that epidural analgesia is superior to the patient controlled analgesia and intravenous narcotic administration to supply analgesia and improve pulmonary functions [21,22]. We also agree with this opinion.

The mortality rate varies between 8 and 12% in different studies and usually occurs within the first 24 h of the trauma [8–10]. The mortality rate in this study was 5.7%. We believe that the 'real' mortality rate due to thoracic injuries is higher since a greater proportion of fatalities due to serious injuries occur on-scene and the victims never reach

to our clinic. Thirteen of our cases that resulted in mortality had central nervous system trauma.

Age is also an important determinant of mortality. A less severe trauma may be fatal in the elderly [1,4,23]. In our study, of the 31 patients who died, 21 belonged to the elderly (67.7%) and ten to the adult age group. The number of fractured ribs has been found to correlate with the morbidity and mortality [1,6,9]. We found that 86.3% of those who died had six or more fractures. Therefore, patients with six or more fractured ribs, especially the elderly patients since they carry the highest risk, should be observed and treated in the intensive care units.

In sum, we conclude that rib fractures are indicators of severe trauma. Morbidity and mortality increase as the number of fractured ribs increase. We underscore the necessity of ISS for evaluating the severity of the trauma also for deciding about the treatment protocol onwards. Pain management is critical to prevent respiratory depression due to pain. The number of fractured ribs alone may be a misleading factor in determining the severity of the trauma in children. Patients with three or more isolated fractured ribs have an indication for hospitalization. In elderly patients, morbidity and mortality are higher when there are six or more fractured ribs. Therefore these patients should be closely followed up in the intensive care units.

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