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Correlation Between Rib Fractures and Prognosis in Multiple Trauma Patients

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Abstract

Background: Thoracic trauma is an important cause of morbidity and mortality in trauma patients and rib fracture due to blunt trauma to the chest wall is the most common etiology.
Objectives: This study analyzed the correlation between rib fractures and prognosis in multiple trauma patients.
Methods: One hundred eighty-four trauma patients suffering from rib fracture due to the blunt trauma were studied. Demographic data, injury characteristics, rib fracture characteristics, the associated injuries, and injury severity score (ISS) were recorded. The rib fracture was classified according to location (left, right, and bilateral) and level (upper [1st - 2nd rib], middle [3rd - 8th rib], and lower [9th - 12th rib]); it also was categorized as lateral and posterolateral.
Results: The rib fractures were posterolateral (69.6%), lateral (30.4%), upper (4.3%), middle (92.4%), and lower (3.3%). Patients with posterolateral fracture had significantly more complications leading to airway intubation and more intensive care support, higher ISS, associated with pelvic and clavicular fracture. Upper rib fractures were associated with more length-of-stay (LOS) while lower rib fractures were associated more with abdominal trauma and lumbar/thoracolumbar vertebral fractures. A significant positive correlation was seen between the number of fractured ribs and ISS, hospital, and ICU LOS. There were no complications during a two-month follow-up.
Conclusions: Upper rib fractures are associated with severe traumas requiring more hospitalization and ICU support due to the greater surgical and medical complications. Morbidity is higher in posterolateral fractures and these patients need more medical care.

Keywords: Thoracic Trauma, Blunt Injury, Rib Fracture, Complication

1. Background

Thoracic traumas account for 10% to 15% of all traumas, with a measured mortality rate of 25% (1, 2). Blunt trauma is the common cause of thoracic traumas (3). The rib fracture is common in blunt chest trauma, ranging from 10% to 40% of all cases of thoracic trauma (1, 2, 4).

The rib fracture itself mostly requires only conservative treatment, but it could be an indicator of other injuries as other organ injuries are common in blunt trauma (5-7). The rib fracture can show the severity of trauma patients. The increase in the number of fractures is associated with the severe injury, as well as higher mortality rate, which may be accompanied by other injuries, such as head, abdomen, and extremities (1-3). The patients with rib fractures should be treated and followed up to prevent associated complications.

2. Objectives

In this study, we aimed to evaluate the outcome of rib fracture in multiple trauma patients and their course during the hospital stay and a two-month follow-up.

3. Methods

In this cross-sectional study, 184 multiple trauma patients with rib fracture visiting the emergency department of Imam Reza hospital, Tabriz, Iran, between January 2016 and July 2016 were included. Pregnant patients, patients with any penetrating chest trauma and/or burns, patients

diagnosed with any respiratory disease which compromised the pulmonary function, patients with malignancy and end-organ damage, and patients with GCS < 13 at admission were excluded. The study was approved by the ethics committee of Tabriz University of Medical Sciences, and patients gave written informed consent.

Data gathered in the study included demographic characteristics such as age, gender, the number of fractured rib, the history of chronic lung disease, injury characteristics such as the mechanism of injury, the damaged area of the body, and the necessary information to calculate the injury severity score (ISS). The number of fractured ribs was determined by reviewing chest X-ray and/or CT scans. Rib fracture was classified according to location (left, right, and bilateral) and level (upper [1st - 2nd rib], middle [3rd - 8th rib], and lower [9th - 12th rib] rib fracture). The fractures were also categorized as anterior, anterolateral, lateral, posterolateral, and posterior by bisecting the ribcage in the mid-sagittal plane and constructing radii at 36° intervals to divide each half of the ribcage into 5 equal segments, according to the method published by Ritchie et al. (8). However, in our cases, there were no more than six cases with anterior, anterolateral, and posterior fractures; so they were all excluded and the study was conducted on cases with lateral and posterolateral fractures.

The severity of the injury was graded by the injury severity score (ISS) (9). The ISS was evaluated based on the information available at admission. Patients were admitted to the ward or ICU according to the ISS. All patients followed in the ICU were fully monitored for fever, pulse, blood pressure, and respiratory rate every hour, as well as continuous pulse oximetry, electrocardiography (ECG), and complete blood count (CBC) daily. The patients in the ward were followed by measuring the vital signs and CBC daily. Tube thoracostomy was performed if they had pneumothorax or hemothorax. All injuries were classified by the trauma surgeon, who was routinely scoring the injury severity.

In order to relieve the pain in these patients, analgesics were used; if there were three or lower rib fractures, they were treated with intravenous opioid and if there were more than three fractures or other underlying disease or if patients were over 60 years old, epidural analgesia was used.

In-hospital complications were evaluated. Data collection for this outcome was completed from the time the patient presented to the ED through to the discharge from the hospital. Patients were followed up for two months after discharge for possible complications and the need for readmission.

3.1. Statistical Analysis

All data were analyzed using SPSS16. Results are expressed as means $\pm$ SD or percentage. Student's t- and chi-square or Fisher's exact tests were applied to compare the parameters between groups of patients. Pearson's correlation was used to determine possible correlations with the number of fractured ribs. P value < 0.05 was considered statistically significant. We also investigated the correlation between the location, level and the number of fractured ribs and intra-abdominal organ injury.

4. Results

In this study, 184 patients with rib fracture (152 males and 32 females with a mean age of 46.53 $\pm$ 15.19 years) were evaluated. All patients had GCS $\geq$ 13. Patients had some underlying diseases including asthma in two cases (1.1%), ischemic heart disease in four cases (2.2%), hypertension and diabetes mellitus each in 26 cases (14.1%), and hyperlipidemia in 18 cases (9.8%). 64 cases (23.9%) were smokers.

The causes of trauma were motor vehicle accidents in 136 cases (70.9%) including 116 as drivers and 20 as passengers and falls in 48 cases (26.1%).

Patients had multiple traumas including neck trauma (36 cases, 19.6%), chest trauma (156 cases, 84.8%), abdominal trauma (22 cases, 12%), pelvic fracture (10 cases, 5.4%), limb fracture (64 cases, 34.8%), scapula fracture (18 cases, 9.8%), clavicle fracture (26 cases, 14.1%), adjacent vertebrate fracture (2 cases, 1.1%), and non-adjacent vertebrate fracture (14 cases, 7.6%). The cases of abdominal trauma had ecchymosis on the abdomen or abdominal tenderness, among which 10 cases had intra-abdominal organ injuries (spleen laceration led to splenectomy in five cases, liver injury in five cases, and right kidney laceration led to nephrectomy in one case).

The rib fracture was posterolateral in 128 cases (69.6%) and lateral in 56 cases (30.4%). The mean number of fractured ribs was 4.29 $\pm$ 2.08 (range 1 - 10). Evaluating the level of rib fracture, eight cases (4.3%) had an upper rib fracture, 170 cases (92.4%) had a middle rib fracture and six cases (3.3%) had a lower rib fracture.

Twenty-eight patients (15.2%) needed a surgery. A chest tube was placed in 130 cases (70.7%) including one-sided in 108 and two-sided in 22 cases. The causes of chest tube placement were pneumothorax (52 cases), hemothorax (34 cases), hemopneumothorax (18 cases), and flail chest (24 cases). Seven (3.8%) patients had a pulmonary contusion. 22 patients (12%) were intubated due to the progressive oxygen saturation decrease.

The mean values of the hospital and ICU length of stay (LOS) were 10.26 $\pm$ 9.55 (2 - 71 days) and 11.77 $\pm$ 1.79 (2 - 44

days), respectively. Forty-four patients (23.9%) needed ICU care.

The mean of injury severity score (ISS) was 17.39 ± 10.22 (4 - 50); 84 patients (45.7%) had a severe injury (ISS ≥ 16). Complications during admission occurred in 18 cases (9.8%) including atelectasis in 12, infection in two and mortality in four cases.

Demographic information and clinical data in patients with posterolateral and lateral rib fractures are shown in Table 1. Table 2 shows demographic information and clinical data in patients with different levels of rib fractures. Patients with posterolateral fracture compared to those with lateral fracture had significantly more complications.

We observed significant differences between different levels of rib fracture so that intubation rate, clavicle fracture, and hospital LOS was more in upper rib fracture and abdominal trauma and the non-adjacent vertebral fracture was more in lower rib fracture (Table 2). There were also significant differences between upper and middle rib fractures in terms of ISS (P = 0.018), hospital LOS (P < 0.001) and between upper and lower rib fracture hospital in terms of LOS (P < 0.001). All cases leading to splenectomy had middle rib fractures.

We also evaluated the role of the number of fractured ribs in patients outcome and observed a significant positive correlation between the number of fractured ribs and ISS (r = 0.374, P < 0.001), hospital LOS (r = 0.328, P < 0.001), and ICU LOS (r = 0.363, P = 0.01). In addition, the mean number of fractured ribs was significantly higher in patients with complications compared to those without (5.66 ± 2.32 vs. 4.14 ± 2.01, P = 0.003) and with ICU care compared to without (4.93 ± 2.24 vs. 2.09 ± 2.00, P = 0.02).

The pain was successfully managed with intravenous opioids in 64 cases (34.8%) or epidural analgesics in 120 cases (65.2%). We observed no associated diaphragm rupture in our patients with rib fractures.

During two months of follow-up, there were no complications or re-admission need in the patients.

Table 1. Demographic Information and Clinical Data in Patients with Posterolateral and Lateral Rib Fractures[a]

Variables	Lateral Fracture	Posterolateral Fracture	P Value
Gender			0.59
Male	45 (80.4)	107 (83.6)	
Female	11 (19.6)	21 (16.4)	
Age	44.92 ± 19.43	47.23 ± 12.94	0.34
Trauma type			0.83
Driver	37 (66.1)	79 (61.7)	
Passenger	6 (10.7)	14 (10.9)	
Falling	13 (23.2)	35 (27.3)	
Complication	1 (1.8)	17 (13.3)	0.03[b]
Need for surgery	7 (12.5)	21 (16.4)	0.49
Chest tube insertion	37 (66.1)	93 (72.7)	0.36
Intubation	2 (3.6)	20 (15.6)	0.02[b]
ICU admission	8 (14.3)	36 (28.1)	0.04[b]
Neck trauma	10 (17.9)	26 (20.3)	0.69
Abdominal trauma	9 (16.1)	13 (10.2)	0.25
Pelvic fracture	0	10 (7.8)	0.03[b]
Extremity fracture	20 (35.7)	44 (34.4)	0.86
Scapula fracture	6 (10.7)	12 (9.4)	0.77
Clavicle fracture	5 (8.9)	21 (16.4)	0.18
Adjacent vertebrate fracture	0	2 (1.6)	-
Non-adjacent vertebra fracture	2 (3.6%)	12 (9.4)	0.17
Number of fractured ribs	4.00 ± 1.62	4.42 ± 2.25	0.2
ICU LOS	9.00 ± 3.82	12.38 ± 2.03	0.47
Hospital LOS	8.32 ± 5.10	11.12 ± 10.88	0.06
Injury severity score	14.60 ± 6.29	18.60 ± 11.34	0.01[b]

Abbreviations: ICU, intensive care unit; LOS, length of stay.
[a]Values are expressed as mean ± SD or No. (%).
[b]P value is two-sided significant.

5. Discussion

In this study, we observed that the incidence of rib fracture was higher in males. Motor vehicle accidents are the main cause of the blunt chest trauma causing rib fracture. In the literature, it is reported that blunt chest trauma causing rib fractures is higher in males (10, 11). In addition, motor vehicle accidents are the leading cause of rib fractures (2, 10). The higher rate of motor vehicle use among males could be the cause of the higher rate of rib fracture.

In this study, we included patients with multiple traumas and rib fractures. These patients had no underlying cardiopulmonary disease, paving the way for evaluating the effect of rib fracture on the patients. Common associated injuries were extremity fracture (34.8%), neck trauma (19.6%), clavicle fracture (14.1%), and abdominal trauma (12%). In the study by Lin and colleagues (12), the most common associated injury was extremity fracture, followed by head injury and clavicle fracture. Coexistence of injuries in other systems and organs is the main factor affecting mortality and adverse outcome in chest trauma. Therefore, in the evaluation of the patients with blunt chest trauma and rib fracture, we should consider possible injuries in other organs to decrease mortality.

It is widely accepted that the number of fractured ribs

Table 2. Baseline Demographic Information and Clinical Data in Patients with Different Levels of Rib Fractures[a]

Variables	Upper Rib Fracture	Middle Rib Fracture	Lower Rib Fracture	P Value
Gender				
Male	8 (100)	138 (81.2)	6 (100)	
Female	0	32 (18.8)	0	
Age, y	51.50 ± 12.47	46.63 ± 15.46	37.00 ± 0.89	0.2
Complication	2 (25)	16 (9.4)	0	0.25
Need for surgery				
Chest tube insertion	8 (100)	118 (69.4)	4 (66.7)	-
Intubation	4 (50)	18 (10.6)	0	0.002
ICU admission	4 (50)	38 (22.4)	2 (33.3)	-
Neck trauma	6 (75)	30 (17.6)	0	-
Abdominal trauma	0	18 (10.6)	4 (66.7)	< 0.001
Pelvic fracture	0	10 (5.9)	0	0.64
Extremity fracture	2 (25)	60 (35.3)	2 (33.3)	-
Scapula fracture	2 (25)	16 (9.4)	0	0.25
Clavicle fracture	4 (50)	22 (12.9)	0	0.008
Adjacent vertebrate fracture	0	2 (1.2)	0	-
Non-adjacent vertebra fracture	0	10 (5.9)	4 (66.7)	< 0.001
Hospital LOS	32.75 ± 25.57	9.19 ± 6.69	10.33 ± 6.94	< 0.001
Injury severity score	25.70 ± 8.82	16.98 ± 10.24	17.66 ± 7.22	0.06

[a]Values are expressed as mean ± SD or No. (%).

indicates the severity of trauma and closely correlates with morbidity and mortality (1, 3, 13, 14). In fact, it is noted that with an increase in the number of fractured ribs, the associated morbidity and mortality also increases (1). In our study, the number of fractured ribs ranged from 1 to 10. We observed that with an increase in the number of fractured ribs, the injury was severe (higher ISS) and there was longer ICU and hospital LOS, as well as a higher rate of complications. Similar to our findings, Lin and colleagues (12) reported that the number of fractured ribs was associated with hospital and ICU LOS, as well as higher ISS, but not with mechanical ventilator use. Dunham and colleagues (7) also reported that the increased number of fractured ribs is associated with higher adverse outcomes in multiple trauma patients.

Most rib fracture cases (69%) are associated with other thoracic injuries mainly hemo/pneumothorax and lung contusion, 5% of which diagnosed after 24 hours of trauma (15). In our study, a chest tube was inserted in 70.7%, mostly due to pneumothorax, hemothorax, or hemopneumothorax.

Most cases in our study had a middle rib fracture, which was not accompanied by severe complications. However, upper rib fracture caused more intubation and clavicle fracture and it was accompanied by longer hospital LOS, while abdominal trauma and adjacent vertebrate fracture were higher in lower rib fracture. ISS was higher in upper rib fracture than in middle and lower rib fractures.

The most common fractures are 4th to 8th rib fractures, which are not accompanied by severe organ injury (6). Similar to our findings, Park (6) found that the risk for organ injury is significantly higher when fractures are present in the 8th rib or lower, specifically in the liver. In addition, rib fractures have been observed to be the cause of soft tissue organ injuries in the thoracic and abdominal region (16, 17).

We also presumed that the place of rib fracture has a role in patients' outcome. In our cases, most ribs were fractured posterolaterally (69.6%). These patients compared to patients with lateral rib fracture had significantly more complications.

It is essential to follow patients with rib fractures. During two months of follow-up, there were no complications or re-admission reported in these patients.

Pain due to rib fractures adversely affects the pulmonary function and morbidity and pain management is

one of the most important issues that should be considered in patients with rib fractures. The management of rib fractures includes pain control, as well as adequate oxygenation and ventilation. Narcotics, anti-inflammatory analgesics, epidural analgesia, and intercostal blockade are used to control the pain. By proper pain management, we can relieve the pain and discomfort due to fractured ribs, as well as reduce the incidence of complications (18). In our study, the pain was successfully controlled with intravenous opioid or epidural analgesia. Therefore, we strongly recommend using adequate and indicated analgesia and pain management in these patients.

In conclusion, patients with rib fractures have other organ injuries. The increased number of fractured ribs and the upper level of rib fracture are accompanied by more severe injury, longer hospital and ICU stay, and more complications. Posterolateral fractures are associated with higher morbidity rates. However, patients' clinical outcomes are great with proper care and management during hospital and outpatient follow-ups. In all rib fracture patients, a meticulous clinical approach and great quality of care are required and early and late clinical outcomes are desired.

5.1. Limitations

In this study, we only included those patients with no missing data; however, the relatively small sample size is the main limitation of the study.

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