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Original Article

Morbidity, mortality, associated injuries, and management of traumatic rib fractures

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Abstract

Background: Thoracic trauma is responsible for approximately 25% of trauma deaths, and rib fractures are present in as many as 40–80% of patients, and intensive care and/or ventilator support are frequently required for these patients. To identify their risk factors would improve treatment strategies for these patients.

Methods: Between March 2005 and December 2013, consecutive patients with blunt thoracic trauma, who were admitted to the Department of Thoracic Surgery at Tungs' Taichung Metro Harbor Hospital (Taichung, Taiwan), were reviewed in this retrospective cohort study with the approval of the Institutional Review Board. The duration of hospital stay, ventilator support, injury severity score (ISS), type of injury, associated injuries, treatments, and mortality were analyzed statistically.

Results: A total of 1621 thoracic trauma patients were included in this study, with a male majority and an age range of 18–95 years (mean age, 51.2 years). Approximately 11.7% of these patients had an ISS $\geq$ 16 and a mortality rate of 6.9%. Among them, 78.5% had rib fractures; 31.8%, traumatic hemothorax; 15.6%, pneumothorax; 9.6%, hemopneumothorax; and 4.6%, lung contusion. The most common associated injury was extremity fracture, followed by head injury and clavicle fracture. Surgery on the extremities (20.6% of patients) and chest tube placement (22.7% of patients) were the most common treatments. The number of rib fractures was associated with prolonged hospital and intensive care unit (ICU) stays ($\geq$7 days), an ISS $\geq$ 16, and pulmonary complications of hemothorax, pneumothorax, and hemopneumothorax, but not with mechanical ventilator use. Furthermore, old age was significantly associated with rib fractures in patients with thoracic trauma.

Conclusion: The severity of traumatic rib fractures was identified in this study. Therefore, a trauma team needs better preparation to provide effective treatment strategies when encountering thoracic trauma patients, especially patients who are older and have rib fractures.

Keywords: associated injury; rib fracture; thoracic trauma

1. Introduction

Trauma is the leading cause of death in Taiwan in the adult population aged < 50 years.[1] Occurring almost always as an unexpected affliction with very high mortality and morbidity, thoracic trauma is responsible for approximately 25% of trauma deaths. Thoracic trauma is also a contributing factor

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towards an additional 25% of trauma deaths worldwide.[2–6] The incidence of rib fractures owing to thoracic trauma is in the range of 10–40% among all trauma cases.[2,7,8] In studies focusing on blunt thoracic trauma, rib fractures were present in as many as 40–80% of thoracic trauma patients, who frequently require the care of an intensive care unit (ICU) and/or ventilator support.[8–10] Contrary to the previous conception that most chest wall injuries are benign, rib fractures exist in 4.4% of patient mortality within 30 days and 55% of patient mortality within 24 hours because of their precarious nature, based on a nationwide population-based study using pooled data from the Taiwan's National Health Insurance Research Database.[11]

In the present study, our aims were to understand the clinical course following traumatic rib fractures and identify risk factors for mortality and morbidity. These results may help to prepare a trauma team with better treatment strategies in the initial encounter with patients with thoracic trauma at clinical presentation, especially elderly patients with rib fractures.

2. Methods

2.1. Study population

This retrospective cohort study included consecutive patients with blunt thoracic trauma who were admitted to the Department of Thoracic Surgery at Tungs' Taichung Metro Harbor Hospital (Taichung, Taiwan, R.O.C.; a Level I trauma center) between March 1, 2005 and December 31, 2013. All data were obtained from electronic medical records. The exclusion criteria included:(1) patients treated only in an outpatient setting or transferred to another institution; (2) patients aged < 18 years; (3) patients admitted to the Department of Cardiovascular Surgery with cardiac or great vessel involvement whose care did not involve the Department of Thoracic Surgery; and (4) patients for whom the medical chart parameters under study could not be well determined.

Data such as sex, age, admission, and discharge dates, duration of hospital and ICU stay, ventilator support, injury severity score (ISS), type of injury (rib fractures were specifically identified by two independent licensed thoracic surgeons), associated injuries, treatments received, and mortality were collected from the medical records. Surgery and associated injuries were classified according to the body part involved, namely head injury, facial bone fracture, spine injury, clavicle fracture, extremity fracture, or abdomen injury. Soft tissue injuries were not included in this study.

The study protocol was approved by the Institutional Review Board of Tungs' Taichung Metro Harbor Hospital, Taichung, Taiwan, R.O.C. (Approval Number, #102039).

2.2. Statistical analysis

We retrospectively performed statistical analysis on the database of all thoracic trauma patients admitted to the hospital. The χ^2 test was employed for the statistical analysis of the variables. The relationships between the total number of rib fractures and various associated injuries were statistically analyzed using χ^2 for trend and the t test for comparison. The Pearson correlation was calculated to determine the relationships between the total number of rib fractures in patients with thoracic trauma and prolonged hospital stay of ≥7 days, ICU stay, mechanical ventilator use, or mortality. Multivariate logistic regression was also performed to explore the relationship between rib fractures and patients' age, sex, and comorbidities. All statistical results were significant when $p < 0.05$. Statistical analysis was performed using the SPSS statistical package (Version 17.0; SPSS, Inc., Chicago, IL, USA).

3. Results

During the 9-year study period, there were 1621thoracic trauma patients, excluding eight patients who were younger than 18 years old. The majority (72.5%) of thoracic trauma patients were male (Table 1). The patients' age ranged from

Table 1
Demographic and clinical characteristics of 1621 thoracic trauma patients.

	No. or mean no.	SD or %
Total	1621	100
Sex/male	1176	72.5
Patient age (y)	51.2	17.1
18–44	589	36.3
45–64	613	37.8
65–74	251	15.5
≥75	168	10.4
Injury type		
Thoracic		
Rib fracture	1272	78.5
Sternum fracture	14	0.9
Lung contusion	75	4.6
Hemothorax	515	31.8
Pneumothorax	253	15.6
Hemopneumothorax	156	9.6
Associated injury		
Head injury	425	26.2
Facial bone fracture	53	3.3
Spine injury	111	6.8
Clavicle fracture	349	21.5
Extremity fracture	432	26.7
Abdomen injury	205	12.6
Treatments		
Surgery		
Thoracic surgery	38	2.3
Head surgery	98	6.0
Facial bone surgery	36	2.2
Spine surgery	51	3.1
Clavicle surgery	193	11.9
Extremity surgery	334	20.6
Abdomen surgery	83	5.1
Chest drain		
Chest tube	368	22.7
Pig tail	52	3.2
ISS ≥ 16	190	11.7
Death	112	6.9

ISS = injury severity score; SD = standard deviation.

18 years to 95 years with a mean age of 51.2 years (standard deviation, 17.1 years).

When classified according to the type of injury the thoracic trauma patients had sustained, 1272 (78.5%) patients had rib fractures, 515 (31.8%) patients had traumatic hemothorax, 253 (15.6%) patients had pneumothorax, 156 (9.6%) patients had hemopneumothorax, and only 75 (4.6%) patients had lung contusions (Table 1). Extremity fracture was the most common site of injury, followed by head injury and clavicle fracture. As the most common treatment the patients received, chest tubes were placed in 368 (22.7%) thoracic trauma patients. The most common surgeries were for injuries to an extremity, followed by the clavicle and the head. Only 2.3% of all patients received thoracic surgery. Surgeries for facial bone fractures were the least common.

Approximately 11.7% of patients with thoracic trauma had an ISS of >16, indicating the severity of harm in thoracic trauma patients, which was further demonstrated by a mortality rate of 6.9% in this group of patients (Table 1).

To examine the impact of rib fractures in patients with thoracic trauma, we categorized patients by the location of fractured ribs (Fig. 1). These patients presented with a normal distribution in the location of fractured ribs, and the peak was at the 5th and 6th ribs bilaterally, with a trend of more fractured ribs on the left than on the right; this finding was not statistically significant. Patients with thoracic trauma were further grouped according to the total number of rib fractures, as illustrated in Fig. 2. Most (74.8%) thoracic trauma patients had three or fewer rib fractures.

We investigated the relationships between the number of rib fractures in patients with thoracic trauma and prolonged hospital stay of ≥7 days, ICU stay, mechanical ventilator use, and mortality. In patients with thoracic trauma with rib fractures, the relationship between prolonged hospital stay of ≥7 days and the number of rib fractures was statistically significant at $p = 0.000$ and $r = 0.174$ (Fig. 3). The relationship between the number of rib fractures and ICU stay was also statistically significant at $p = 0.000$ and $r = 0.113$ (Fig. 4). However, the relationship between the number of rib fractures and mechanical ventilator use was not statistically significant ($p = 0.417$). There was also no significant relationship between the number of rib fractures and mortality ($p = 0.426$).

We also examined the relationship between associated injuries and the number of rib fractures in patients with thoracic trauma (Table 2). We categorized patients with rib fractures into four groups: (1) 1–2 rib fractures; (2) 3–4 rib fractures; (3) 5–6 rib fractures, and (4) ≥7 rib fractures. Statistical analysis using the χ^2 for trend showed that head injury and clavicle fracture were significantly associated with an increased number of rib fractures, whereas facial bone fracture, spine injury, extremity injury, and abdominal injury were not significantly associated (Table 2).

With regard to pulmonary complications, the number of rib fractures was positively associated with hemothorax, pneumothorax, and hemopneumothorax (all, $p < 0.001$; Table 2). The number of rib fractures was also significantly associated with ISS ≥ 16 ($p < 0.001$). Mortality was not significantly associated with an increased number of rib fractures, even though we observed a greater proportion of mortality in patients with ≥7 rib fractures (11.4%; Table 2).

Table 3 further shows the adjusted odds ratios for rib fracture, based on patient characteristics, using multivariate analysis. Correlation analysis revealed that old age and clavicle fracture were associated with rib fractures in patients with thoracic trauma ($p < 0.001$). Similar to results presented in Table 2, head injury and clavicle fracture were significant factors associated with rib fractures ($p = 0.010$ and $p = 0.003$, respectively). In addition, extremity fracture was a significant factor associated with rib fractures ($p < 0.001$).

4. Discussion

The present study's results showed that most patients with thoracic trauma were men aged 18–95 years (mean age,

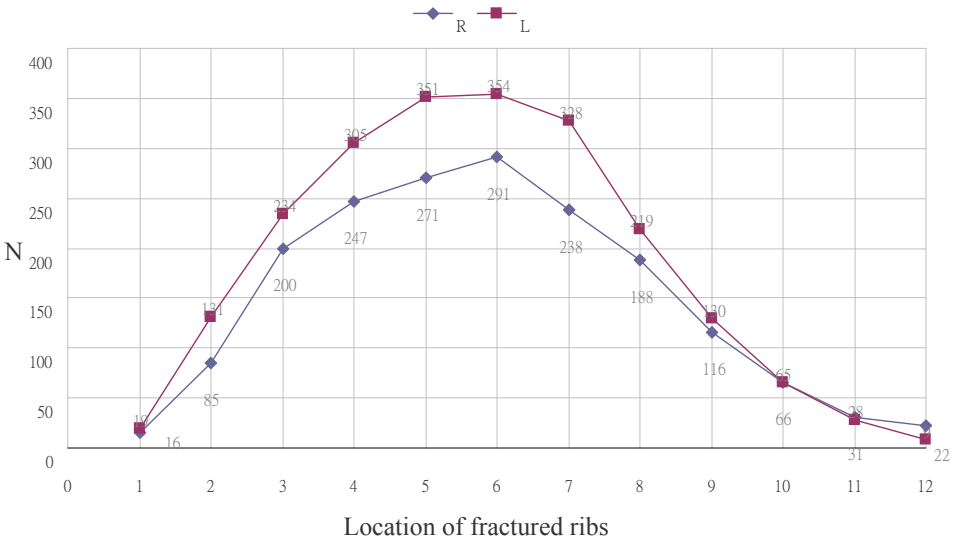

Fig. 1. Distribution of the location of fractured ribs in patients with thoracic trauma.

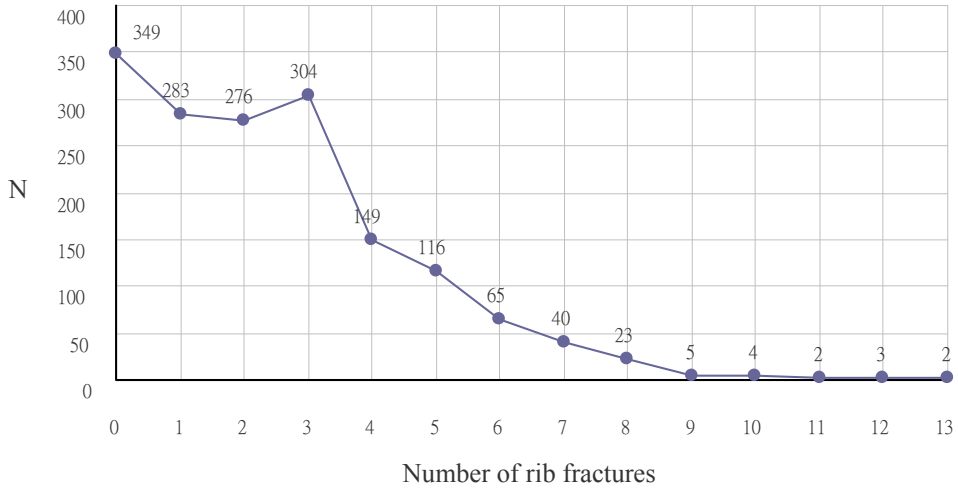

Fig. 2. Distribution of the total number of rib fractures in individual patients with thoracic trauma.

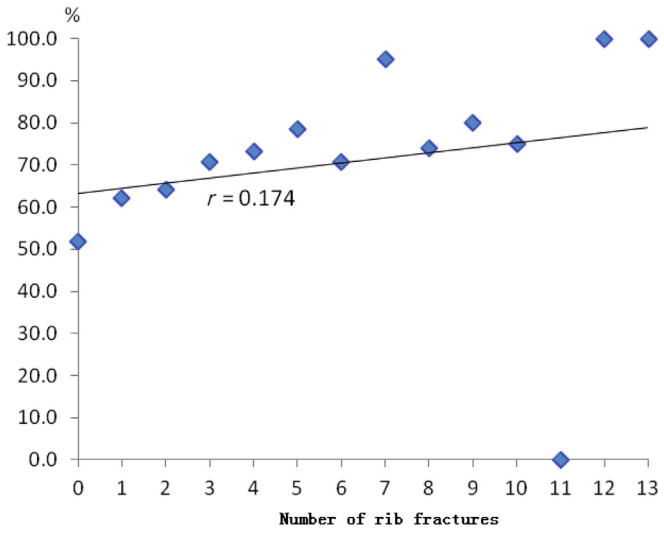

Fig. 3. The effect of the number of rib fractures on prolonged hospital stay of ≥7 days is statistically significant at $p = 0.000$ and $r = 0.174$.

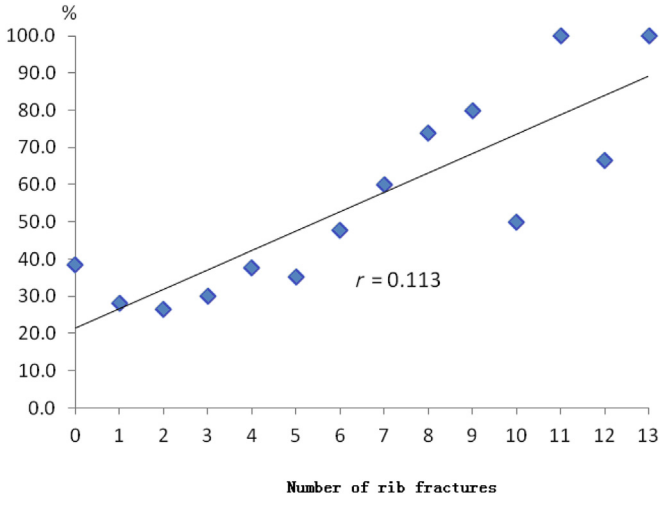

Fig. 4. The effect of the number of rib fractures on the intensive care unit stay is statistically significant at $p = 0.000$ and $r = 0.113$.

51.2 years). This finding is similar to trends reported by the National Trauma Data Bank and the statistics of the Department of Health that indicate that male individuals account for most thoracic trauma patients.[1,12] Motor vehicle crash is the leading cause of rib fractures, but this problem cannot be easily solved because of the size of the motorcycling population in Taiwan and elsewhere.[12,13]

The incidence of rib fractures among all trauma cases is in the range of 10–40%.[2,7,8] These patients frequently require the care of an ICU and/or ventilator support.[8–10]In the present study, approximately 11.7% of such patients had an ISS ≥ 16 and a mortality rate of 6.9%. Among these individuals, 1272 (78.5%) patients had a rib fracture; 31.8% of patients, traumatic hemothorax; 15.6% of patients, pneumothorax; 9.6% of patients, hemopneumothorax; and 4.6% of patients, lung contusion. The severity was associated with the number of rib fractures: 40.5% of the patients had a severe ISS (i.e., ≥16) with a number of rib fractures >7. In addition, associated injuries including head injury, extremity fracture, and clavicle fracture are common in motorcycle and motor vehicle accidents.[14] These complications may have a significant clinical impact.

For treatment, extremity surgery (20.6% of patients) and chest tube therapy (22.7% of patients) were the two most common treatments patients with thoracic trauma received, followed by clavicle surgery (11.9% of patients) and head surgery (6% of patients). Chest tube placement is a common procedure used to treat traumatic chest injuries, although its complication may vary, depending on the severity of injury. Therefore, the severity of the thoracic injury, as measured by the Chest Abbreviated Injury Score and ISS, should be incorporated into the development of chest tube management guidelines for chest tube complications after thoracic trauma.[15]

In our study, the number of rib fractures was associated with prolonged hospital and ICU stays (≥7 days), but not with mechanical ventilator use. The number of rib fractures was also significantly associated with an ISS ≥ 16. In addition, old

Table 2
The relationships between the number of rib fractures and selected parameters in patients with thoracic trauma.

	Number of rib fractures				*p*
	1–2	3–4	5–6	>7	
Total ($N = 1272$)	559 (100)	453 (100)	181 (100)	79 (100)	
Associated injury					
Head injury	139 (24.9)	101 (22.3)	47 (26.0)	30 (38.0)	0.030 *
Facial bone fracture	22 (3.9)	13 (2.9)	3 (1.7)	1 (1.3)	0.314
Spine injury	34 (6.1)	31 (6.8)	14 (7.7)	5 (6.3)	0.879
Clavicle fracture	124 (22.2)	98 (21.6)	51 (28.2)	28 (35.4)	0.020 *
Extremity injury	115 (20.6)	101 (22.3)	43 (23.8)	22 (27.8)	0.462
Abdomen injury	61 (10.9)	52 (11.5)	31 (17.1)	9 (11.4)	0.153
Pulmonary complications					
Hemothorax	98 (17.5)	146 (32.2)	88 (48.6)	54 (68.4)	<0.001 *
Pneumothorax	33 (5.9)	70 (15.5)	37 (20.4)	31 (39.2)	<0.001 *
Hemopneumothorax	20 (3.8)	43 (10.3)	22 (13.3)	26 (35.1)	<0.001 *
ISS ≥16	43 (8.7)	42 (10.4)	43 (25.7)	30 (40.5)	<0.001 *
Mortality	32 (5.7)	28 (6.2)	12 (6.6)	9 (11.4)	0.286

Data are presented as *n* (%).
* $p < 0.05$.
ISS = injury severity score.

age was associated with rib fractures ($p < 0.001$) in patients with thoracic trauma. These results agreed with the findings in the literature for thoracic trauma with the precarious features of associated injuries, complications, mortality, and morbidity.[16–20] Taken together, it is critical for a trauma team to accurately and efficiently detect and diagnose traumatic rib fractures and improve treatment strategies in the initial encounter with thoracic trauma patients.[21,22]

Table 3
Results of multivariate logistic regression analysis of factors associated with rib fractures ($n = 1272$).

	OR	95% CI	*p*
Sex	1.22	0.92–1.61	0.161
Patient age (y)			
18–44 (reference group)	1.00		
45–64	2.24	1.68–2.99	<0.001 *
65–74	2.41	1.60–3.61	<0.001 *
≥75	1.37	0.91–2.07	0.133
Associated injuries			
Head injury			
No (reference group)	1.00		
Yes	0.69	0.53–0.92	0.010 *
Facial bone fracture			
No (reference group)	1.00		
Yes	0.80	0.42–1.54	0.511
Spine injury			
No (reference group)	1.00		
Yes	0.80	0.50–1.28	0.355
Clavicle fracture			
No (reference group)	1.00		
Yes	1.68	1.19–2.37	0.003 *
Extremity fracture			
No	1.00		
Yes	0.39	0.30–0.51	<0.001 *
Abdominal injury			
No	1.00		
Yes	0.92	0.64–1.31	0.635

* $p < 0.05$.
CI = confidence interval; OR = odds ratio.

In conclusion, the severity of traumatic rib fractures was identified in this study. Therefore, a trauma team needs better preparation to respond to patients with thoracic trauma with effective treatment strategies, especially patients who are old and/or have rib fractures.

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