

## Clinical Analysis for the Correlation of Intra-abdominal Organ Injury in the Patients with Rib Fracture

Seongsik Park, M.D.

**Background:** Although it is rare for the fracture itself to become a life threatening injury in patients suffering from rib fracture, the lives of these patients are occasionally threatened by other associated injuries. Especially, early discovery of patients with rib fracture and intra-abdominal organ injury is extremely important to the prognosis. This study analyzed the link between rib fracture and intra-abdominal injury to achieve improved treatment. **Materials and Methods:** Among trauma patients that had visited the hospital emergency room from January 2007 to December 2009, a retrospective study was conducted on 453 patients suffering from rib fracture due to blunt trauma. Rib fracture was classified according to location (left, right, and bilateral), and according to level (upper rib fracture [1–2nd rib], middle rib fracture [3–8th rib], and lower rib fracture [9–12th rib]). The researched data was statistically compared and analyzed to investigate the correlation between the location, level, and number of rib fracture and intra-abdominal organ injury. **Results:** Motor vehicle injury was found to be the most common mechanism of injury with 208 cases (46%). Associated injuries accompanied with rib fracture were generated in 276 cases (61%). Intra-abdominal organ injury was discovered in 97 cases (21%). Liver injury was the most common intra-abdominal injury associated with rib fracture with 39 cases (40%), followed by spleen injury, with 23 cases (23%). Intra-abdominal injury according to level of rib fracture was presented as upper rib fracture in 11 cases (11%), middle rib fracture in 31 cases (32%), and lower rib fracture in 55 cases (57%), thus verifying that intra-abdominal injuries were commonly accompanied in lower rib fractures ( $p=0.03$ ). In particular, significant increase of intra-abdominal injury was presented in fractures below the 8th rib ( $p=0.03$ ). The number of intra-abdominal injuries requiring emergency operations was significantly higher in patients with more than 6 rib fractures ( $p=0.04$ ). **Conclusion:** Intra-abdominal organ injury is more common in patients with lower rib fracture, especially fractures below the 8th rib. Intra-abdominal organ injuries generated in multiple rib fracture patients with more than 6 fractures significantly higher severity. These cases must be thoroughly inspected and carefully observed as there is possibility of emergency operation.

Key words: 1. Blunt trauma  
2. Rib fractures  
3. Abdomen

Department of Thoracic and Cardiovascular Surgery, Dankook University College of Medicine

† This manuscript has been presented at the 42th autumn academic meeting of the Korean Society for Thoracic and Cardiovascular Surgery.

† This article was supported by the Dankook University research fund of 2010 (#89238).

Received: July 24, 2011, Revised: March 19, 2012, Accepted: June 2, 2012

Corresponding author: Seongsik Park, Department of Thoracic and Cardiovascular Surgery, Dankook University Hospital, Dankook University College of Medicine, 201 Manghyang-ro, Dongnam-gu, Cheonan 330-180, Korea  
(Tel) 82-41-550-6269 (Fax) 82-41-550-3983 (E-mail) [cardiacs@dku.edu](mailto:cardiacs@dku.edu)

© The Korean Society for Thoracic and Cardiovascular Surgery. 2012. All right reserved.

© This is an open access article distributed under the terms of the Creative Commons Attribution Non-Commercial License (<http://creativecommons.org/licenses/by-nc/3.0>) which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

## INTRODUCTION

Although thoracic trauma occupies approximately 10% to 15% of all traumas, the mortality rate of thoracic trauma is very high, measured at 25%. Rib fracture is the most common injury in thoracic trauma, occupying approximately 7% to 40% [1]. Rib fracture acts as the factor that presents the severity of trauma patients. It is common for trauma patients to experience other organ injuries; only 6% to 12% of trauma patients complain only of rib fracture [2]. Although it is rare for the fracture itself to become a life threatening injury in patients with rib fracture, the lives of these patients are occasionally threatened by other associated injuries. Although there are not many studies conducted on injuries related with rib fracture, careful observation is required as it has been reported that great vessel injury is generally associated with 1st and 2nd rib fracture while intra-abdominal organ injury is accompanied in lower rib fracture, such as 9th and 10th rib fractures [3].

In particular, early discovery of patients with rib fracture and intra-abdominal injury is extremely important to patient prognosis. This study analyzed the link between rib fracture and intra-abdominal injury to achieve improved treatment.

## MATERIALS AND METHODS

Among trauma patients that had visited the hospital emergency room from January 2007 to December 2009, this study was conducted on 453 patients suffering from rib fracture due to blunt trauma. Retrospective method based on medical records and radiologic data was selected for the research method.

According to the trauma protocol of the hospital, chest computed tomography (CT) scans were ordered for all patients that were suspected of rib fracture, except in cases of hemodynamical instability or in cases requiring emergency operation.

To research the correlation between rib fracture and intra-abdominal injury, rib fracture was classified as the following. Rib fracture was classified according to location (left, right, and bilateral), and according to level (upper rib fracture [1–2nd rib], middle rib fracture [3–8th rib], and

**Table 1.** Patients characteristics in 453 episode of rib fracture

Parameter	Episode
No. of patients	453
Age (yr, mean)	52.8 (13–91)
Gender	
Male	323 (71)
Female	130 (29)
Mechanism of injury	
Motor vehicle	208 (46)
Cultivator	72 (16)
Pedestrian	101 (22)
Fall down	69 (15)
Other	3 (1)

Values are presented as number (%).

lower rib fracture [9–12th rib]). All overlapped levels were checked each other. The number of fractures was studied based on the reading of the radiology staff.

The correlation between intra-abdominal organ injury and the location, level, and number of rib fracture was statistically compared and analyzed based on the researched data.

For statistical treatment, SPSS ver. 12.0 (SPSS Inc., Chicago, IL, USA) was used to conduct analysis of variance for continuous variables, while chi-square test was used for nominal variables. A p-value below 0.005 was judged to hold statistical significance.

## RESULTS

The mean age of patients was 52.8±14.5 years (range, 13 to 91 years), with 323 male (71%) and 130 female (29%). The mechanism of injury was presented in the following order: motor vehicle injury in 208 cases (46%), pedestrian injury in 101 cases (22%), cultivator injury in 72 cases (16%), fall down in 69 cases (15%), and miscellaneous injury in 3 cases (1%) (Table 1). Injuries associated with rib fracture were generated in 276 cases, with the frequency of association injury measured at 61% in rib fracture patients. Hemo/pneumothorax was the most common associated injury with 216 cases (48%), followed by spine bone injury with 142 cases (31%) and facial bone fracture with 136 cases (30%). Intra-abdominal organ injury was discovered in 97 cases (21%) (Table 2).

For location of rib fracture, 156 cases were found at the right side (34%), 229 cases were left (50%), while 68 cases were bilateral (16%) (Table 3). For level of rib fracture, 97 cases were found at the upper rib (13%), 404 cases were middle rib (55%), while 236 cases were lower rib (32%). For number of rib fractures, 106 cases were single rib fractures (23%), 218 cases were 2 to 5 fractures (48%), and 129 cases presented more than 6 rib fractures (29%).

Liver injury was the most common intra-abdominal organ injury associated with rib fracture in 39 cases (40%), followed by spleen injury in 23 cases (23%), intestine injury in

16 cases (16%), pancreas injury in 10 cases (11%), and kidney injury in 9 cases (10%).

According to the analysis on 97 patients with rib fracture and intra-abdominal organ injury, it was found that the association of intra-abdominal injury was statistically significant from the lower rib fracture when observing the intra-abdominal organ injuries according to level: 11 cases in upper rib fracture (11%), 31 cases in middle rib fracture (32%), and 55 cases in lower rib fracture (57%) (p=0.03) (Table 4). However, statistical differences were not presented according to the number of rib fractures (Table 5). In particular, intra-abdominal organ injury was significantly increased from fractures below the 8th rib (p=0.03) (Fig. 1).

Although the incidence of liver injury presented high frequency in right rib fracture patients (51%), but there was not statistically significant. On the other hand, the incidence of

**Table 2.** Association injury with rib fracture

Associated injury	No. (%)
Hemo/pneumothorax	216 (48)
Sternal fracture	98 (22)
Spine injury	142 (31)
Facial bone fracture	136 (30)
Head injury	123 (27)
Clavicle fracture	108 (24)
Abdominal organ injury	97 (21)
Pelvic bone fracture	91 (20)
Long bone fracture	82 (18)
Scapular fracture	52 (11)

**Table 3.** Level and location of rib fracture

	No. (%)	Upper	Middle	Lower
Right	156 (34)	35	164	103
Left	229 (50)	51	192	112
Bilateral	68 (16)	11	48	21
Total	453 (100)	97	404	236

**Table 4.** Intra-abdominal organ injury associated with level of rib fracture

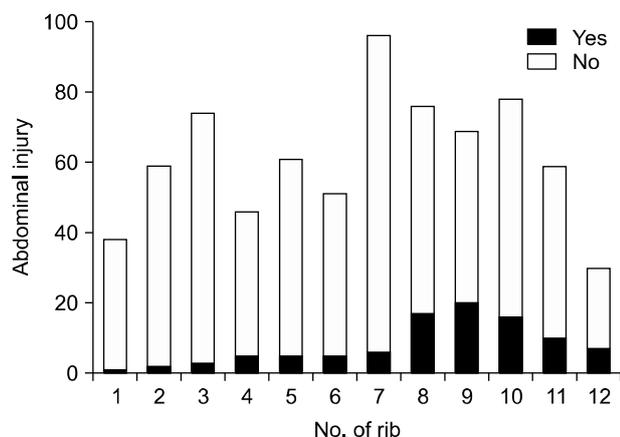
Level of fracture	Abdominal injury						Total	p-value
	Liver	Spleen	Intestine	Pancreas	Kidney			
Upper	5	1	1	2	2	11 (11)	0.03	
Middle	16	7	3	3	2	31 (32)		
Lower	18	15	12	5	5	55 (57)		
Total	39 (40)	23 (23)	16 (16)	10 (11)	9 (10)	97 (100)		

Values are presented as number or number (%).

**Table 5.** Intra-abdominal organ injury associated with number of rib fracture

No. of fracture	No. (%)	Abdominal injury					Total	p-value
		Liver	Spleen	Intestine	Pancreas	Kidney		
1	106 (23)	8	5	4	3	2	22 (23)	0.512
2-5	218 (48)	18	9	5	4	4	40 (41)	
≥6	129 (29)	13	9	7	3	3	35 (36)	
Total	453 (100)	39	23	16	10	9	97 (100)	

Values are presented as number or number (%).



**Fig. 1.** This diagram shows the fracture under 8th rib is statistically significant increase the intraabdominal injury ( $p=0.03$ ).

**Table 6.** Most common intra-abdominal organ injury associated with location of rib fracture

	Liver	Spleen
Right fracture (156)	20 (51)	5 (21)
Left fracture (229)	11 (28)	17 (75)
Bilateral fracture (68)	8 (21)	1 (4)
p-value	0.438	0.041

Values are presented as number (%).

spleen injury was statistically significant in left rib fracture patients ( $p=0.04$ ) (Table 6). Although there were no differences in the incidence frequency of intra-abdominal injuries according to the number of rib fractures, the incidence frequency of intra-abdominal injuries requiring emergency operation was significantly high in patients with more than 6 rib fractures ( $p=0.03$ ) (Table 7).

## DISCUSSION

Rib fractures are most commonly generated in thoracic blunt trauma act as the indicator for serious injuries. The increase in the number of fractures also heightens the level of injury and its mortality rate and may accompany various thoracic trauma, as well as other injuries, such as head, abdomen, and extremities [2,4,5]. The frequency of association injury of rib fracture patients was very high in this study, measured at 61%.

**Table 7.** Emergency operative cases of intra-abdominal organ injury associated with number of rib fracture

No. of fracture	Conservative treatment	Emergency operation	p-value
1	19 (31)	3 (8)	0.043
2–5	32 (53)	8 (23)	
$\geq 6$	10 (16)	25 (69)	
Total	61 (100)	36 (100)	

Values are presented as number (%).

In particular, clinical suspicion for classifying risk factors that increase the possibility of intra-abdominal organ injury in blunt traumatic rib fracture patients is extremely important. This is because such injuries can be easily overlooked as the signs are not clearly shown due to bleeding in the early phase of trauma due to volume of abdominal cavity, and thoracic trauma patients and relevant clinical symptom can be easily masked. According to current reports, the frequency of associated intra-abdominal injury in rib fracture patients is reported as 10% to 16% [4,6,7]. This study presented a slightly higher frequency at 21% as the associated injuries of intra-abdominal injury were researched with rib fracture. This is possibly related with cultivator injuries. Cultivator injuries are common in Korea, and patients with cultivator injuries receive more outside exposure than other vectors, thus presenting higher possibility of direct injuries and abdominal blunt traumas during accident. Kim et al. [8] also reported similar results with this study, presenting 21.7% for frequency of rib fracture patients that experienced intra-abdominal injury.

This study verified high possibility of intra-abdominal injury in lower rib fracture patients. This is due to the high possibility of direct shock exerted on the liver and spleen, which are organs that protect the lower rib as well as the direct damage of fractured rib segments on organs. Fractures in 10th to 12th lower ribs (floating ribs) are regarded traumas caused by extremely strong force, and must suspect intra-abdominal organ injury in such patients to conduct thorough inspection. On the other hand, it is common to not suspect abdominal injury for 4th to 8th ribs, the most common area of rib fracture. However, when considering the rise in the position of the liver or spleen with the rise of the diaphragm to the 5th intercostals space during expiration, treatment must be

achieved by considering the possibility of abdominal injury even in middle rib fractures. The increase of associated intra-abdominal injuries in large frequency differences from the 8th rib is also regarded as an important matter to note during treatment of rib fracture patients.

Furthermore, although the left rib fracture and spleen injury presented a significant correlation in this study, the correlation between the right rib fracture and liver injury was not significant, in spite of increasing frequency. Furthermore, liver injury was commonly generated in left and bilateral rib fractures when compared with spleen. This is probably due to the domino effect interaction continued to the ipsilateral soft tissue, rib, dominant organ injury by the external force of working area in liver injuries. The large size of the liver presents high possibility of injury through the impact delivered by acceleration/deceleration even during interaction of the external force from the left, and there is higher possibility of injury than spleen in case external force has been exerted by the thorax and abdomen. By analyzing 476 rib fracture patients, Shweiki et al. [9] reported that the incidence of liver injury increased in right side lower rib fracture patients, or all lower rib fracture patients, but the incidence of spleen injury only increases in left side lower rib fracture patients.

It is known that trauma severity, complication, and mortality rate increases with the increase in the number of rib fractures. Bergeron et al. [10] reported that 4% mortality rate was presented in 1st to 2nd rib fracture, while 32% mortality rate was presented in more than 6 rib fractures. Sirmali et al. [11] reported that pulmonary complication increased with increase in the number of rib fractures. Although the frequency of intra-abdominal injury did not increase according to the number of rib fractures in this study, it presented higher frequency of intra-abdominal injuries that required operation. This implies that whereas intra-abdominal injuries related to rib fractures are influenced by anatomical location or level, the severity of intra-abdominal injuries is influenced by the number of rib fractures. Thus, through inspection and observation is required for intra-abdominal injuries that are accompanied in patients with more than 6 rib fractures.

## CONCLUSION

The incidence of intra-abdominal injuries presents high possibility in lower rib fracture patients, in particular patients with rib fracture below the 8th rib. Thus, a test for checking abdominal injury must be conducted on such patients. Furthermore, as intra-abdominal injuries in multiple rib fracture patients with more than 6 fractures signify high severity, thorough inspection and observation must be achieved to prepare for possible emergency operation. As this study was conducted by using two years of data gained from a single hospital, larger-scale research must be achieved in the future.

## REFERENCES

1. Gabram SG, Schwartz RJ, Jacobs LM, et al. *Clinical management of blunt trauma patients with unilateral rib fractures: a randomized trial.* World J Surg 1995;19:388-93.
2. Shorr RM, Crittenden M, Indeck M, Hartunian SL, Rodriguez A. *Blunt thoracic trauma: analysis of 515 patients.* Ann Surg 1987;206:200-5.
3. Harris GJ, Soper RT. *Pediatric first rib fractures.* J Trauma 1990;30:343-5.
4. Ziegler DW, Agarwal NN. *The morbidity and mortality of rib fractures.* J Trauma 1994;37:975-9.
5. Wilson RF, Murray C, Antonenko DR. *Nonpenetrating thoracic injuries.* Surg Clin North Am 1977;57:17-36.
6. Wilson JM, Thomas AN, Goodman PC, Lewis FR. *Severe chest trauma: morbidity implication.* Arch Surg 1978;113:846-9.
7. Poole GV Jr, Myers RT. *Morbidity and mortality rates in major blunt trauma to the upper chest.* Ann Surg 1981;193:70-5.
8. Kim JH, Do BS, Lee SB, Jung TE. *The correlation of abdominal organ injury in rib fracture patients.* J Korean Soc Emerg Med 2005;16:562-5.
9. Shweiki E, Klana J, Wood GC, Indeck M. *Assessing the true risk of abdominal solid organ injury in hospitalized rib fracture patients.* J Trauma 2001;50:684-8.
10. Bergeron E, Lavoie A, Clas D, et al. *Elderly trauma patients with rib fractures are at greater risk of death and pneumonia.* J Trauma 2003;54:478-85.
11. Sirmali M, Turut H, Topcu S, et al. *A comprehensive analysis of traumatic rib fractures: morbidity, mortality and management.* Eur J Cardiothorac Surg 2003;24:133-8.