

## Correlation between Rib Fractures and Intra-abdominal Organ Injuries after Blunt Chest Trauma

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### Abstract

**Introduction:** The most common thoracic injuries were rib fractures (40%) and simple lung contusions (35%) and the abdominal organs most commonly injured were the spleen (35%), liver (25%), and kidney (20%). Mortality varies from 3-22%. the thoracic-abdominal injuries,

**Purpose:** Evidence of the role of thoracic trauma in intraabdominal injuries. Evaluation of correlation between rib fractures and intra-abdominal organ injuries after Blunt Chest Trauma;

### Materials and methods:

The study has a retrospective character, conducted within the period of December 2017 - June 2019. In our study, 890 patients were included in the Emergency Department at University Hospital of Trauma, Tirana, Albania. The population sample was selected randomly without any study restrictions.

**Results:** Our study includes 890 patients; distribution of gender-based was: 196 (22%) females and 694 (78%) males. The distribution based on age: 116 (13 %); for <14 years old group; 347 (39%); for 14-40 years old; 427 (48%).for >40 years old.

**Conclusions:** In Blunt Chest trauma, the incidence of intraabdominal organ injuries is high as evidenced by our study. All patients with such injuries should be evaluated and evaluated until the possibility of such intra-abdominal damage is ruled out. Also, intra-abdominal injuries in multiple rib fractures patients with more than 6 fractures show high gravity, full inspection and observation must be achieved to prepare for possible emergency surgery or other treatment options.

**Keywords:** rib fracture, Chest trauma, abdominal, blunt, injury organ

**Abbreviations:** ChT; Chest Trauma: ChT; Blunt Chest Trauma: MVA: Motor Vehicle Accident; FfH: Fall from Hight; HwSo: Hit with Strong object; M & M; Mortality and Morbidity: NOM; Non-operative Management: OM; Operative Management: CBC; Complete Blood Count: FAST: Focused Assessment with Sonography in Trauma; ICU: Intensive Care Unit; IAI; Intra-abdominal Organ Injuries: ED: Emergency Department;

### Introduction

ChT accounts for approximately 10% to 15% of all traumas, the mortality rate of thoracic trauma is very high, it reaches up to 25%. Fracture of the ribs is the most common injury in thoracic trauma, accounting for approximately 7% to 40% [1].

Fractures of the ribs are common injuries after extensive chest trauma, and are present in 60-80% of all cases [2,3]. Fracture of the ribs acts as an assessment factor in the gravity of injury to trauma patients. They are common in patients with trauma that damage other organs; only 6% to 12% of trauma patients complain only of rib fracture without other concomitant injuries [2].

In general, rib fractures are the most damaged bones, occurring in about 10-20% of all trauma patients [4-6].

Although it is rare for a rib fracture to be life-threatening, they are dangerous for patients with rib fractures who are occasionally threatened by other concomitant injuries.

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Although there are not many studies conducted on injuries related to rib fractures, careful assessment is generally required with rib fracture while intra-abdominal organ damage is associated with lower rib fracture, such as 7<sup>th</sup> - 8<sup>th</sup> - 9<sup>th</sup> - 10<sup>th</sup> and 11<sup>th</sup> rib fractures [7].

In particular, early detection of patients with rib fractures and intra-abdominal injuries is extremely important for patient prognosis. In most cases of chest trauma, rib fractures do not arise in isolation, but cause simultaneous another injury.

In severe cases, fragments of the ribs harm internal organs, such as the lungs, liver, kidneys, or spleen [2, 4, 8, 9, 10]. Since rib fractures are often associated with specific intrathoracic and intraabdominal trauma, predictions of probability, progression, and degree of complication of internal organ damage are possible [10-13].

This study analyses the link between rib fracture and intra-abdominal injury to achieve improvement in treatment.

**Introduction:** Chest trauma ranks third behind the head and extremity trauma in major accidents in the United States. The most common thoracic injuries were rib fractures (40%) and simple lung contusions (35%) and the abdominal organs most commonly injured were the spleen (35%), liver (25%), and kidney (20%). Mortality varies from 3-22%.

In the last three decades, the way of thoracoabdominal trauma management has changed drastically.

**The purpose of the study:** Epidemiological assessment of thoracoabdominal trauma. Presentation of the causes and pathophysiology of thoracic trauma. Discussion of patient evaluation, diagnostic procedures, imaging examinations. Evidence of thoracic trauma's role in intraabdominal organ injuries. Assessment of the correlation between rib fractures and intra-abdominal organ injuries in BChT.

## Materials and methods

The study is retrospective for a period of time from December 2017 to June 2019. Our study includes 890 patients who are presented to the ED in our Hospital. The population sample was randomly selected without any study constraints. Study variables obtained from clinical charts are: Distribution of gender-based injuries; The mean age of patients was 40.8±14.5 years (range, 13 to 85 years) The division into three groups based on age- groups: < 14 years old; 14-40 years old; > 40 years old; Type of thoracic trauma; isolated chest trauma or associated with other extrathoracic injuries; Distribution of trauma cases according to its mechanism: MVA; FfH; HwSo; Time of admission in ED, immediately, and after 6 hours from Trauma: Routine and special examinations performed; intraabdominal organs injured in chest trauma; intraabdominal organ injuries after BChT with and without rib fractures; Location or level of rib fractures, upper, middle, lower, and intraabdominal organ injuries; Number of rib fractures, one, 2-5, more than 6 and intraabdominal organ injuries. The number of damaged organs; one damaged organ or two and more organs: The way of management of the traumatized patient:

NOM or OM, where the intervention time was distributed at these intervals: within 2 hours; within 2-6 hours; within 6-24 hours and after 24 hours.

## Data analysis

Data was presented in absolute and in percentage value; to see the relationship between the two variables was used the correlation coefficient of Kendal's tau-b; linear regression method was used to analyze the relation of the dependent variable on the independent one; the data were presented through various tables and graphs.

The values of p were considered significant when  $p < 0.05$  (or 5%). SPSS statistical package (Statistical package for social science, version 16.0) and Microsoft Excel were used for data analysis.

## Results

Our study includes 890 patients; the gender-based distribution was: 196 (22%) females and 694 (78%) males. The distribution based on age: 116 (13 %) for <14 years old group; 347 (39%) for 14-40 years old; 427 (48%) for > 40 years old.

Starting from the combination of BChT with other injuries we have this distribution: isolated BChT constitutes 329 (37%) of cases, and 561 (63%) of cases are BChT related with extrathoracic injuries.

Based on the causing mechanism we have this distribution: 583 (65.5%) of cases was after MVA; 161 (18.1%) of cases were after FfH, and 146 (16.4%) of cases were after HwSo.

Distribution based on the Time of admission in ED was: immediately in 733 (82.4%) of cases and after six hours in 157 (17.6 %) of cases.

Distribution of routine and special examinations is: the Complete Blood Count (CBC) was done in 100% of patients;

According to the trauma protocol of the hospital, chest x-ray is performed in patients suffering from chest trauma, except in cases of hemodynamical instability or in cases requiring emergency surgery. In our study Chest X-ray is performed in 764 (85.9%) of cases. FAST has resulted to be positive in 786 (88.3%) and negative in 104 (11.7%) of cases. CT-scanner was performed in 578 (64.9%) of cases.

In our study the presence of BChT with rib fracture was found in 552 (62%) of cases, and BChT without rib fracture was found in 338 (38 %) of cases. Hemo / pneumothorax was the most common concomitant injury with 427 (48%) of cases.

In our study, the distribution of other damages was as follows; Sternal fracture 71(8%); Clavicle fracture 160(18%); Scapular fracture 98 (11%); Spine injury 98 (11%); Head injury 240 (27%); Facial bone fracture 133(15%); Pelvic bone fracture 80(9%); Long bone fracture 98(11%);

Intra-abdominal organ injury was detected in 222 cases (25%) (Table 2).

To study the correlation between rib fracture and intra-abdominal injuries, rib fractures were classified as follows; by location (left, right, and bilateral), and by level (upper rib fracture [1-2 ribs], middle rib fracture [3-8th ribs], and lower rib fracture (9 -12<sup>th</sup> ribs)).

The number of fractures has been studied based on reading and confirmation by radiology staff.

The correlation between intra-abdominal organ damage and location, level and number of rib fractures has been statistically compared and analyzed based on the researched data.

According to the analysis on 222 cases (25%) 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: in upper rib fracture 21 (9.5%) of cases, in middle rib

fracture 61 (27.5%) of cases, and in lower rib fracture 140 (63 %) of cases ( $p=0.05$ ) (Table 1).

Liver injury with 93(42%) of cases, was the most common intra-abdominal organ injury associated with rib fracture, followed by spleen injury in 67(30%) of cases, intestine injury in 35 (16%) of cases, pancreas injury in 11 (5%) of cases, and kidney injury in 16 (7%) of cases.

In particular, intra-abdominal organ injury was significantly increased from fractures below the 8th rib ( $p=0.05$ )

However, statistical differences were not presented according to the number of rib fractures (Table 2).

The distribution of the data according to the number of rib fractures, 110 (20%) of cases were single rib fractures, 303 (55%) of cases were 2 to 5 fractures, and 139 (25%) of cases presented more than 6 rib fractures.

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

Table 1. Intraabdominal organ injury associated with level of rib fracture

Level of Rib Fracture	Intra- abdominal Organ Injury						p-value
	LIVER	LIEN	INTESTINE	PANCREAS	KIDNEY	TOTAL	
Upper	16	5	0	0	0	21 (9.5%)	0.05
Middle	30	20	7	0	4	61 (27.5%)	
Lower	47	42	28	11	12	140 (63%)	
<b>TOTAL</b>	<b>93(42%)</b>	<b>67(30%)</b>	<b>35(16%)</b>	<b>11(5%)</b>	<b>16(7%)</b>	<b>222 (100%)</b>	

\*Values are presented as number and percentage

Table 2. Intraabdominal organ injury associated with number of rib fracture

No. of Rib Fracture	% of Rib Fracture	Intra - abdominal Organ Injury						p-value
		LIVER	LIEN	INTESTINE	PANCREAS	KIDNEY	TOTAL	
1	110 (20%)	16	5	0	0	0	21 (9.5%)	0.03
2-5	303 (55%)	30	20	7	0	4	61 (27.5%)	
≥ 6	139 (25%)	47	42	28	11	12	140 (63%)	
<b>TOTAL</b>	<b>552 (100%)</b>	<b>93(42%)</b>	<b>67(30%)</b>	<b>35(16%)</b>	<b>11(5%)</b>	<b>16(7%)</b>	<b>222 (100%)</b>	

\*Values are presented as number and percentage.

Table 3. Intraabdominal organ injury associated with number of rib fracture and mode of Management

No. of Rib Fracture	% of Rib Fracture	Mode of Management	
		NOM	OM
1	110 (20%)	30 (30%)	10 (8%)
2-5	303 (55%)	51 (51%)	28 (23%)
≥ 6	139 (25%)	19 (19%)	84 (69%)
<b>TOTAL</b>	<b>552 (100%)</b>	<b>100 (45%)</b>	<b>122(55%)</b>

\*Values are presented as number and percentage.

Table 4. Most common intra-abdominal organ injury associated with location of rib fracture

Intra- abdominal Organ Injury			
Location of Rib Fracture	Values	LIVER	LIEN
Right Side fracture	69 (31%)	57(61%)	5 (7%)
Left Side fracture	114 (51%)	9 (10%)	53(79%)
Bilateral fracture	39 (18%)	27 (29%)	9 (14%)
P-value		0.438	0.041

\*Values are presented as number and percentage.

injuries requiring emergency operation was significantly high in patients with more than 6 rib fractures (Table 3).

According to the analysis on 222 cases (25%) patients with rib fracture and intra-abdominal organ injury (IAOI), it was found that the association of IAOI was statistically significant from the lower rib fracture when observing the IAOI according to level: 21 (9.5%) of cases in upper rib fracture, 61 (27.5%) of cases in middle rib fracture, and 140 (63%) of cases in lower rib fracture ( $p=0.03$ ) (Table 6).

Although the incidence of liver injury presented high frequency in right rib fracture patients 57(61%), it was not statistically significant ( $p=0.438$ ). On the other hand, the incidence of spleen injury was statistically significant in left rib fracture patients ( $p=0.041$ ) (Table 4).

Regarding the location of rib fracture in our study it was found that: 69 (31%) of cases were found at the right side, 114 (51%) of cases were left, while 39 (18%) of cases were bilateral.

According to the level of rib fracture we had this distribution; 21 (9.5%) of cases were found at the upper rib, 61 (27.5%) of cases were middle ribs, while 140 (63%) of cases were lower rib.

Based on the way of treatment we have these conclusions: OM is performed in 122(55%) of cases and NOM in 100 (45%) of cases.

Depending on the time of the intervention: within 2 hours - 19 (15.5%) of cases; within 2-6 hours - 54 (44.2%) of cases; within 6-24 hours- 23 (19%) of cases and after 24 hours in 26 (21.3%) of cases.

Mortality rate in our study was 5 % i.e. 11 patients, where most of them were with middle rib fracture with 5 (45%.4) of cases, 4 (36.3%) with lower rib fracture and in 2 (18.7%) of cases were with upper rib fracture.

Based on the value of the correlation coefficient of Kendal's tau-b we note that there is a statistically significant correlation between the intraabdominal organ injured and the rib fracture. (Figure 1)

## Discussion...

Fractures of the ribs are most often present after BChT, as an indicators of serious injury. The increase in the number of fractures of the thoracic cage also increases the degree of damage and the level of its mortality and can accompany various chest traumas, as well as other concomitant injuries to the head, abdomen and extremities [2, 4, 14].

The frequency of the presence of rib fractures in our study was very high and reaches 552 (62%) of the cases presented in the emergency department with BChT.

Clinical Suspicion, and Evaluation of Risk Factors that increase the chance of Intra-Abdominal Injury in patients with BChT are extremely important in trauma management.

This is because such injuries at first glance seem mild and can be easily overlooked, because the clinical signs are not clear due to bleeding in the early stage of trauma due to the volume of the abdominal cavity, and patients with BChT and corresponding clinical symptoms can be easily masked.

According to current reports, the frequency of Intra-abdominal injuries associated with rib fractures have been reported to range from 16 % to 22 % [4, 14].

Our study presents a higher frequency of up to 222 (25%) as concomitant intra-abdominal injuries were investigated in patients with rib fractures.

Kim et al. [15] also reports approximate results with our study, where patients with intra-abdominal injury fractures after ribs reach 21.7% of cases.

Our study highlights the high probability of intra-abdominal injury that patients with lower rib fracture have in BChT.

This is due to the possibility of direct impact, from fractured ribs, directly to the liver, spleen or elsewhere, which are located at this level of the lower chest. Fractures located at the level of the lower ribs 10 - 12 (floating ribs) are assessed as trauma caused by extremely strong forces,

			Ribs fracture
Kendall's tau-b	i/abdominal organ injured	Correlation coefficient	.566
			.001

Figure 1. Correlation between the intraabdominal organ injured and the rib fracture.



and make you suspect damage to the intra-abdominal organs, therefore in such patients it is mandatory to carry out a complete inspection, palpation and auscultation to detect bypassed lesions during the primary assessment.

On the other hand, it is not uncommon to suspect abdominal damage to the 4th to 8th ribs, which are the most common areas of rib fractures, as well as when considering elevated liver or spleen levels associated with diaphragmatic elevations up to the 5th intercostal space during expiration, BChT management should be achieved taking into account the possibility of abdominal damage even in fractures of the mid-level ribs.

The increase in intra-abdominal injuries on the 8th Rib is also considered an important issue to note when treating patients with rib fractures.

Shweiki et al [11] analyzing 476 patients with rib fractures reported that the incidence of liver damage was increased in patients with fractures of the lower right rib, or all patients with fractures of the lower ribs, but the incidence of spleen damage increases only in patients with left lower rib fracture.

According to the analysis on 222 cases (25%) 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: in upper rib fracture 21 (9.5%) of cases, in middle rib fracture 61 (27.5%) of cases, and in lower rib fracture 140 (63 %) of cases ( $p=0.05$ ) (Table 4).

It is known that the severity of trauma, complications and post-traumatic mortality increases with increasing number of fractured ribs.

In a study by Bergeron et al. [16] It was reported that the mortality rate from 4% in cases with 1 to 2 rib fractures, while in cases with more than 6 rib fractures mortality was 32%.

Mortality rate in our study was 5 % i.e. 11 patients, where most of them were with middle rib fracture with 5 (45.4) of cases, 4 (36.3%) with lower rib fracture and in 2 (18.7%) cases were with upper rib fracture.

Sirmali et al [8] found that pulmonary complications increased with an increase in the number of fractured ribs.

The incidence of intra-abdominal injuries did not increase based on the number of rib fractures in this study, they present the highest rate of intra-abdominal injuries requiring surgery, which means that while intra-abdominal injuries associated with rib fractures are affected by localization or anatomical level, the severity of intra-abdominal injuries is also dependent on the number of rib fractures. Thus, through inspection and observation, the possibility of concomitant intra-abdominal injuries is assessed in patients with more than 6 rib fractures.

The distribution of the data according to the number of rib fractures, 110 (20%) of cases cases were single rib fractures, 303 (55%) of cases were 2 to 5 fractures, and 139 (25%) of cases cases presented more than 6 rib fractures.

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 (Table 6).

Al-Hassani et al. [12] had the number of rib fractures, as the majority (78%) of cases had < 5 fractured ribs., and regarding the location of ribs fracture they had this distribution as follows; to middle and upper rib zones (42%) followed by overlapping lower and middle rib zones (26%). IAI were mainly encountered in patients with pelvic fracture in the presence of overlapping lower and middle rib zones (62%) followed by isolated lower rib zone (50%).

An increased risk of abdominal IAI in patients of lower rib fracture has been reported earlier [17, 18, 19].

The literature data as well as our study show a higher degree of SOI at the level of the lower and middle rib fracture [18].

Broken ribs 4 and 10 are more common in trauma, while broken ribs 8 & 12 increase the chance of the presence of the associated abdomen Injuries. [19]

Liver injury with 93(42%) of cases, was the most common intra-abdominal organ injury associated with rib fracture, followed by spleen injury in 67(30%) of cases, intestine injury in 35 (16%) of cases, pancreas injury in 11 (5%) of cases, and kidney injury in 16 (7%) of cases.

In particular, intra-abdominal organ injury was significantly increased from fractures below the 8th rib ( $p=0.05$ ) (Fig. 4).

Shweiki et al [11] examined 476 hospitalized patients with traumatic rib fracture and found that in patients with rib fractures, the presence of pelvic fractures and long bone fractures does not increase the likelihood of associated with IAI.

Regarding the location of rib fracture in our study it was found that: 69 (31%) of cases were found at the right side, 114 (51%) of cases were left, while 39 (18%) of cases were bilateral.

Regarding the level of rib fracture we had this distribution; 21 (9.5%) of cases cases were found at the upper rib, 61 (27.5%) of cases were middle ribs, while 140 (63%) of cases were lower rib.

Based on the way of treatment we have these conclusions: OM is performed in 122(55%) of cases and NOM in 100 (45%) of cases.

Parriera et al., demonstrated that the outcome was more closely related to the associated injuries than to the pelvic injuries per se [20] Demetriades et al., also showed high incidence of associated abdominal injuries among adults and pediatric trauma patients and liver was the most common injured organ. [21, 25]

In patients with complex pelvic fractures, the spleen was found to be the most frequently injured solid organ followed by liver. [22, 23]

In our study, the incidence of Liver injury with 93(42%) of cases, was the most common intra-abdominal organ injury associated with rib fracture, followed by spleen injury in 67(30%) of cases.

In our study the other damages were distributed as follows; Sternal fracture 71(8%); Clavicle fracture 160(18%); Scapular fracture 98 (11%); Spine injury 98 (11%); Head injury 240 (27%); Facial bone fracture 133(15%); Pelvic bone fracture 80(9%); Long bone fracture 98(11%);

The association of intra-abdominal injuries with pelvic fractures is well recognized. Bond et al., reported an incidence of 20% of associated intra-abdominal injuries in pediatric pelvic fractures patients.[24] In our study we had this distribution based on age: 116 (13 %) for <14 years old group; 347 (39%) for 14-40 years old; 427 (48%) for >40 years old.

## Conclusions

In BChT the incidence of intraabdominal injuries is quite high; it is also shown in our study.

The incidence of intra-abdominal injuries is high in patients with lower rib fractures, in particular patients with rib fracture below the 8th rib.

All patients with such injuries should be evaluated and evaluated until the possibility of such IA damage is ruled out. Also IAI in multiple rib fractures patients with more than 6 fractures show high gravity, full inspection and observation must be achieved to prepare for possible emergency surgery or other treatment options.

There is a statistically significant relation between the intraabdominal organ injured and the rib fracture.

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