



Orjinal Araştırma / Original Article

Complications, and Requirement of Opioid Use after Rib Fractures, an Analysis of 1074 Patients

Kot Kırıkları Sonrası Komplikasyonlar ve Opioid Kullanımı Gerekliliği, 1074 Hastanın Analizi

✉ Ahmet Çağlar¹, ✉ Mehmet Ali Eryazgan², ✉ Kemal Öztürk¹, ✉ İlker Kaçer¹

¹Aksaray University Training and Research Hospital, Department of Emergency Medicine, Aksaray, Turkey

²Aksaray University School of Medicine, Department of Thoracic Surgery, Aksaray, Turkey

Abstract

Aim: This study was aimed to determine the risk factors, associated complications, opioid requirements, and mortality rates of rib fractures.

Material and Method: Patients with rib fractures who were admitted to the emergency department between January 1, 2016, and December 31, 2020, were retrospectively analyzed. Patients' demographic data, rib fracture characteristics, trauma mechanism, associated complications, length of stay in the hospital, and in-hospital mortality were recorded.

Results: A total of 1074 patients were included in the study. Most of the patients were male (n=748, 69.6%) and the mean age was 53.89 ± 15.31 years. The mean number of fractured ribs was 3.65 ± 2.06 . All patients with diaphragm laceration, atelectasis, pneumonia, ARDS, pneumomediastinum, lung herniation, flail chest, and empyema had six or more rib fractures. Comparison of died and survived patients showed statistically significant difference for age, gender, side of rib fracture, number of fractured ribs, and accompanying another organ injury. A moderate-strong correlation was found between the number of fractured ribs and pneumothorax, hemothorax, chest tube, opioid use, and length of stay in the hospital.

Conclusion: Increased number of fractured ribs were associated with increased complications, opioid use, and length of stay in the hospital. The mortality rate was 8.8% in patients with 6 or more fractures. In-vehicle traffic accidents were the most common mechanism. Many of the rib fractures can be prevented if the measures are improved.

Keywords: Flail chest, hemothorax, opioid use, pneumothorax, rib fracture

Öz

Amaç: Bu çalışma, kaburga kırıklarının risk faktörlerini, ilişkili komplikasyonları, opioid gereksinimini ve ölüm oranlarını değerlendirmeyi amaçlamaktadır.

Gereç ve Yöntem: 1 Ocak 2016 ile 30 Eylül 2020 tarihleri arasında acil servise başvuran ve kot kırığı olan hastalar retrospektif olarak incelendi. Hastaların demografik verileri, kot kırığının özellikleri, travma mekanizması, ilişkili komplikasyonlar, hastanede kalis süreleri ve hastane içi mortalite kaydedildi.

Bulgular: Çalışmaya toplam 1074 hasta dahil edildi. Hastaların çoğu erkekti (n=748, %69.6) ve ortalama yaşı 53.89 ± 15.31 yıldır. Ortalama kırık kot sayısı 3.65 ± 2.06 idi. Diyafram yırtığı, atelektazi, pnömoni, ARDS, pnömomedasten, akciğer herniasyonu, yelken göğüs ve ampiyemi olan tüm hastalarda altı veya daha fazla kot kırığı vardı. Ölen ve hayatı kalan hastaların karşılaştırılmasında, yaş, cinsiyet, kaburga kırığı tarafı, kırık kaburga sayısı ve eşlik eden başka bir organ yaralanması açısından istatistiksel olarak anlamlı farklılık mevcuttu. Kırık kot sayısı ile pnömotoraks, hemotoraks, göğüs tüpü, opioid kullanımı ve hastanede kalis süresi arasında orta-güçlü bir korelasyon bulundu.

Sonuç: Kırık kot sayısının artması, artan komplikasyonlar, opioid kullanımı ve hastanede kalis süresi ile ilişkiliydi. Altı ve daha fazla kırığı olan hastalarda ölüm oranı %8.8 idi. Araç içi trafik kazaları en yaygın mekanizmaydı. Tedbirler iyileştirilirse kot kırıklarının büyük bir kısmı önlenebilir.

Anahtar Kelimeler: Hemotoraks, kaburga kırığı, opioid kullanımı, pnömotoraks, yelken göğüs



INTRODUCTION

Rib fractures are the most common form of blunt thoracic injuries, constituting approximately 10% of all trauma patients; mortality rates are over 10%.^[1-3] The most common mechanisms of traumatic thoracic injury are motor vehicle accidents, falls, and crush injuries.^[4] Rib fractures can also occur due to repetitive stress and microtrauma, or severe cough.^[5] Rib fractures are an important indicator of trauma severity. The rate of morbidity and mortality increase in line with the increase in the number of fractured ribs.^[6]

Ribs can be divided into three regions, based on the severity of trauma in the injury and the associated complications. The upper region includes the first four ribs, the lower region includes the last three ribs, and the middle region includes the five ribs numbered 5 to 9.^[7-9] Upper region fractures are often resulted from high energy trauma and are associated with vascular structures or brachial plexus injury.^[7] Complications such as pulmonary laceration, pulmonary contusion, extrapleural hematoma, hemothorax, and pneumothorax are more common in the fractures of the middle rib region.^[8] Rib fractures in the lower region have been associated with liver and spleen injuries.^[9]

In this study, we aimed to determine the risk factors, associated complications, opioid requirements, and mortality rates of rib fractures in our region.

MATERIAL AND METHOD

This retrospective study was carried out in the emergency department of a regional academic hospital. The study was conducted in compliance with the principles of the Declaration of Helsinki and approved by the local ethical committee (2020/09-30).

Study Design, Setting, and Patient Selection

The medical records of patients who were admitted to the emergency department and diagnosed with rib fractures via X-ray or computed tomography between January 1, 2016, and December 31, 2020, were retrospectively analyzed. Patients with missing data, repeated admissions and younger than 18 years old were excluded from the study.

Patients' demographic data, rib fracture characteristics, trauma mechanism, associated complications, length of stay in the hospital, and in-hospital mortality were recorded.

Statistical Analysis

Data were analyzed using SPSS version 22.0 (SPSS Inc, Chicago, IL, USA). Visual (histogram and probability graphs) and analytical method (Kolmogorov-Smirnov test) were used to determine distribution normality. Descriptive analyzes were expressed as mean±standard deviation (SD) for normally distributed variables and as median and interquartile range (IQR) for non-normally distributed variables. Categorical data were expressed as n (%). Survival and death patients were compared using chi-square or Fischer's exact test for categorical variables, using

Student's t-test for normally distributed variable (age), and using the Mann-Whitney U test for non-normally distributed variable (number of fractured ribs). Spearman's Correlation Analysis was used to test the relations between the number of rib fractures and related complications, and clinical outcomes. A p value of <0.05 was considered as statistically significant.

RESULTS

A total of 1158 patients were found to be eligible for this study, and 84 of those patients were excluded because of missing data and repeated admissions. Finally, a total of 1074 patients were included. Most of the patients were male (n=748, 69.6%) and the mean age was 53.89 ± 15.31 (ranging between 18 and 94) years.

The most common mechanism of injury was in-vehicle traffic accident (n=508, 47.3%), followed by falls from ground-level (n=220, 20.5%), and non-vehicle traffic accident (n=140, 13%). It was observed that the sixth rib fractured the most (n=516, 48%), and the twelfth rib the least (n=80, 7.4%). Sternum fracture was observed in 140 (13%) patients. The chest tube was applied to 160 (14.9%) patients. A majority of the patients (n=582, 54.2%) were admitted to the thoracic surgery clinic. The mortality rate was 4.5% (n=48). Injury characteristics of the patients are summarized in **Table 1**.

288 (26.8%) patients were diagnosed with pneumothorax and 378 (35.2%) patients were diagnosed with hemothorax. Acute respiratory distress syndrome (ARDS) was developed in 18 (1.7%) patients. Liver and spleen lacerations were observed in 46 (4.3%) and 34 (3.2%) patients, respectively. Nine (0.8%) of patients had a cardiac injury, and all of these patients had sternum fractures. As a result of the first rib fracture, subclavian artery injury was observed in one patient, and brachial plexus injury was observed in one patient. Complications of rib fractures are shown in **Table 2**.

Considering accompanying injuries among dead patients, 8 (16.7%) patients had a head injury, 4 (8.3%) patients had a vertebrae injury, 8 (16.7%) patients had an extremity injury, 22 (45.8%) patients had an abdominal injury, and 12 (25%) patients had a pelvic injury. Most of the accompanying injuries (n=21, 70%) presented with the left side rib fractures. Comparison of died and survived patients showed statistically significant difference for age, gender, side of rib fracture, number of fractured ribs, and accompanying another organ injury. There was not a statistically significant difference in length of stay in hospital (**Table 3**).

The mean number of fractured ribs was 3.65 ± 2.06 . All patients with diaphragm laceration, atelectasis, pneumonia, ARDS, pneumomediastinum, lung herniation, flail chest, and empyema had six or more rib fractures. Comparison of patients according to the number of rib fractures was summarized in **Table 4**. A moderate-strong correlation was found between the number of fractured ribs and pneumothorax, hemothorax, chest tube, opioid use, and length of stay in hospital (**Table 5**).

Table 1. Injury characteristics of rib fractures

Injury mechanism, n (%)	
Falls from ground-level	220 (20.5)
Falls from a height	66 (6.1)
In vehicle traffic accident	508 (47.3)
Non vehicle traffic accident	140 (13)
Crushing with a foreign body	32 (3)
Assault	68 (6.3)
Post-cpr	24 (2.2)
Stress fractures	16 (1.5)
Rib number, n (%)	
1	148 (13.8)
2	276 (25.7)
3	428 (39.9)
4	460 (42.8)
5	504 (46.9)
6	510 (47.5)
7	466 (43.4)
8	370 (34.5)
9	270 (25.1)
10	240 (22.3)
11	164 (15.3)
12	80 (7.4)
Side of fracture, n (%)	
Left	474 (44.1)
Right	600 (55.9)
Number of rib fractures, mean±SD	3.65±2
Number of rib fractures, n (%)	
1-2	334 (31.1)
3-5	558 (52)
≥6	182 (16.9)
Segment of rib fractures, n (%)	
Upper segment	584 (54.4)
Middle segment	782 (72.8)
Lower segment	268 (25)
Accompanying other fractures, n (%)	
Sternum	140 (13)
Clavicular	42 (3.9)
Scapula	33 (3.1)
Opioid use, n (%)	
None	274 (25.5)
Once a day	286 (26.6)
Twice a day	408 (38)
Three or more in a day	106 (9.9)
Other accompanying traumas, n (%)	380 (35.4)
Head injury	172 (16)
Extremity injury	160 (14.9)
Abdominal injury	96 (8.9)
Vertebrae injury	108 (10.1)
Pelvis injury	16 (1.5)
Length of stay in hospital, median (min-max)	4 (1-32)
Prognosis, n (%)	
Discharged from emergency department	183 (17)
Admitted to thoracic surgery clinic	582 (54.2)
Admitted to intensive care unit	261 (24.3)
Exitus	48 (4.5)

DISCUSSION

In this study, we evaluated the clinical features of patients with rib fractures admitted to the emergency department. Our results confirmed that the increased number of rib fractures was associated with increased complications, opioid use, and length of stay in the hospital. Increased age, female gender, left side rib fractures, and accompanying other organ traumas were associated with increased mortality.

Table 2. Complications associated with rib fractures

Pneumothorax	288 (26.8)
Hemothorax	378 (35.2)
Pulmonary contusion	506 (47.1)
Subcutaneous emphysema	21 (2)
Pneumomediastinum	28 (2.6)
Lung herniation	3 (0.3)
Chest tube	160 (14.9)
Flail chest	5 (0.5)
Pneumonia	25 (2.3)
Acute respiratory distress syndrome	18 (1.7)
Atelectasis	49 (4.6)
Empyema	9 (0.8)
Heart injury	9 (0.8)
Subclavian artery injury	1 (0.1)
Brachial plexus injury	1 (0.1)
Diaphragm laceration	8 (0.7)
Liver laceration	46 (4.3)
Spleen laceration	34 (3.2)
Kidney laceration	28 (2.6)

Data were presented as n (%)

Table 3. Comparison of survival and death patients

	Survival (n=1026)	Death (n=48)	P value
Age (years), mean±SD	53.65±15.3	59.02±12.5	0.017
Gender, n (%)			
Male	722 (70.4)	26 (54.2)	0.017
Female	304 (29.6)	22 (45.8)	
Side of fracture, n (%)			
Right	583 (56.8)	17 (35.4)	0.004
Left	443 (43.2)	31 (64.6)	
Number of rib fractures, mean±SD	3.57±2	5.19±1.7	0.000
Other accompanying traumas, n (%)			
No	676 (65.9)	18 (37.5)	0.000
Yes	350 (34.1)	30 (62.5)	
Length of stay in hospital, median (IQR)	4 (4)	3 (2)	0.145

Table 4. Comparison of patients according to the number of rib fractures.

Number of fractured ribs	1-2 (n=334)	3-4-5 (n=552)	≥6 (n=182)	P value
Pneumothorax	44 (13.2)	108 (19.4)	136 (74.7)	0.000
Hemothorax	34 (10.2)	216 (38.7)	128 (70.3)	0.000
Lung contusion	84 (25.1)	284 (50.9)	138 (75.8)	0.000
Chest tube	8 (2.4)	40 (7.2)	112 (61.5)	0.000
Liver laceration	9 (2.7)	25 (4.5)	12 (6.6)	0.107
Spleen laceration	9 (2.7)	17 (3)	8 (4.4)	0.558
Mortality	3 (0.9)	29 (5.2)	16 (8.8)	0.000

Data were presented as n (%)

Table 5. Correlations between number of rib fractures and complications, and clinical outcomes

	Correlation coefficient	P value
Number of rib fractures - pneumothorax	0.406	<0.001
Number of rib fractures - hemothorax	0.398	<0.001
Number of rib fractures - chest tube	0.450	<0.001
Number of rib fractures - liver laceration	0.072	<0.05
Number of rib fractures - spleen laceration	0.055	0.072
Number of rib fractures - opioid use	0.793	<0.001
Number of rib fractures - length of stay in hospital	0.524	<0.001

Conservative treatment is usually sufficient for patients with uncomplicated single rib fractures; however, multiple rib fractures with complications are an important indicator of morbidity and mortality.^[6] In a large retrospective cohort conducted at level 1 trauma center, mortality rates were 5% in patients with one or two rib fractures, 15% in patients with three to five rib fractures, and 34% in patients with six or more rib fractures.^[10] Flagel et al.^[11] reported that every additional rib fracture increases the mortality rate. In addition, six or more rib fractures were an independent risk factor for mortality in trauma patients. The results of the present study indicate a linear relationship between the number of fractured ribs and length of stay in the hospital, and prognosis, similar to the literature. However, the mortality rates were lower than the literature. This may be due to trauma mechanisms in our region (Central Anatolia Region). There were 220 (20.5%) patients who fell down from the ground level, and none of them died.

Pulmonary complications are important causes of morbidity and mortality in patients with rib fractures.^[6] A retrospective analysis of 64,750 patients with rib fractures showed that 13% of patients experienced one or more complications including pneumothorax, pneumonia, ARDS, pulmonary embolism, and empyema.^[11] Liman et al.^[12] demonstrated that 81% of patients with two or more rib fractures had pneumothorax or hemothorax. In this study, pneumothorax, hemothorax, and contusion rates were 26.8%, 35.2%, and 47.1% respectively. Acute respiratory distress syndrome was presented in 18 (1.7%) patients, and these patients needed admission to the ICU. These rates are in line with the literature. In addition, each additional rib fracture increased the pulmonary complications, and related mortality.

Associated organ injury often correlated with the fractured ribs' anatomical location.^[13,14] Lower rib fractures are related with upper abdominal solid organ injury.^[9] The presence of left lower rib fractures is considered as an indicator of further radiographic evaluation to rule out the splenic injury.^[15] The fracture of the first or second ribs is an important indicator of severe trauma.^[6,7] The presence of upper rib fractures is considered as an indicator of further radiographic evaluation to rule out intrathoracic major blood vessels injuries.^[7] In the present study, liver, spleen and kidney laceration rates were 4.3%, 3.2%, and 2.6% respectively. In addition, left side fractures were more common among dead patients. These fractures may have resulted in a spleen laceration and so life-threatening bleeding. We did not observe any complication related to upper rib fractures except for two patients (one patient with subclavian artery injury and one patient with brachial plexus injury). There were 9 patients with heart injury, all of them had sternum fractures, and the trauma mechanisms were in-vehicle traffic accidents. The seat belt usage habits in our region should be reviewed and all drivers should be regularly trained in specific periods.

The flail chest is the most important life-threatening complication of rib fractures, with high mortality rates. Patients with flail chest often require admission to ICU and mechanical ventilation.^[16] An another life-threatening complication of rib fractures is lung herniation, and requires nonemergent thoracotomy.^[6] In the present study, we observed 5 patients with flail chest and 3 patients with lung herniation. All patients with flail chest were intubated, 3 of them needed surgical fixation, and one of operated patients were died after surgery. Thoracotomy was performed in all three patients with lung herniation. One of them died after surgery because of accompanied subarachnoid hemorrhage.

Patients who are 65 years old and over have higher rates of pneumonia and associated deaths after rib fractures.^[17,18] Ziegler et al.^[1] reported that mortality rates were higher in the elderly even though the injury severity score was lower. The reasons for these high mortality rates may be the increasing incidence of comorbid diseases and osteopenic changes with aging.^[19] In this study, the mean age of survived patients was significantly lower than dead patients, however there was not such a relationship in pulmonary complications.

Pain is often the predominant symptom of a rib fracture.^[6] Pain management in patients with rib fractures is important because severe pain may cause shallow breathing, impaired coughing, leading to atelectasis, and finally respiratory failure.^[18,21] Early parenteral nonsteroidal anti-inflammatory drug administration may reduce opioid requirement, the incidence of pneumonia, number of ventilator days, length of stay in the hospital, and length of stay in the ICU.^[22,23] Opioid requirement increases with the number of fractured ribs.^[24] A multicenter analysis of rib fractures showed that patients-controlled pain management may decrease the mortality rates.^[25] In our study, 274 (25.5%) patients treated with nonsteroidal anti-inflammatory drugs, and did not require opioids. Increased number of fractured ribs were resulted in increased opioid requirement.

Although the present study's strength is its large sample size, it is a retrospective and single-center study and has some limitations. First, we evaluated in-hospital mortality as the primary endpoint of the study. However, some of complications can affect mortality even after the hospital period. Second, data of injury severity score was not available, and the impact of ISS on mortality could not be evaluated. Furthermore, the lack of detailed data limited the analysis about chronic diseases that can effect mortality after rib fractures. There is a need for multicenter, prospective studies in order to better understand rib fractures and related complications.

CONCLUSION

Increased number of fractured ribs were associated with increased complications, opioid use, and length of stay in the hospital. The mortality rate was 8.8% in patients with 6 or more fractures. In-vehicle traffic accidents were the most common mechanism. Many of the rib fractures can be prevented if the measures are improve.

ETHICAL DECLARATIONS

Ethics Committee Approval: The study was conducted in compliance with the Declaration of Helsinki and approval by Aksaray University School of Medicine, Aksaray Training and Research Hospital Scientific Research Evaluation Committee (2020/09-30).

Informed Consent: Because the study was designed retrospectively, no written informed consent form was obtained from patients.

Referee Evaluation Process: Externally peer-reviewed.

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