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Evaluation of pneumonia incidence and risk factors after rib fracture

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Abstract

Rib fractures are one of the risk factors for pneumonia development. Still, it is often underestimated or neglected. We wanted to determine both the incidence of pneumonia after rib fracture and the risk factors. This study was conducted prospectively and as single-centered. Demographic and clinical data were analyzed to determine the incidence of pneumonia and risk factors in cases applied with isolated chest trauma and diagnosed with rib fractures between January 1, 2022, and January 1, 2023. The mean age of 412 patients in the study was 43.06±17.85 years and 82.3% were male. Rib fractures were present in 18.4% of the patients. Pneumonia incidence was found to be high in patients with a history of Diabetes Mellitus (DM) and Chronic Obstructive Pulmonary Disease (COPD), smokers, multiple rib fractures and those who needed hospitalization. Again, it was observed that the development of pneumonia was not significantly related to the process in patients who developed pneumonia. There was no relationship between other parameters and the incidence of pneumonia. Rib fracture is an important risk factor for the incidence of pneumonia. The incidence of pneumonia increases in smokers, patients with DM and COPD, and those with multiple rib fractures. It is important to be alert for pneumonia in these patients.

Keywords: Emergency department, pneumonia, rib fracture, risk factors, incidence

Introduction

Pneumonia is a pathology that causes an inflammatory process in the alveolar region of the lung and is triggered by microbial factors. It is an important pathology because it causes death and mortality. When evaluated according to United States data, it was found to be the 8th most common cause of mortality [1-3]. Predisposing factors for pneumonia include aspiration risk, endotracheal intubation, alcoholism, smoking, inadequate oral hygiene, advanced age, cancer, immune suppression, lung diseases, trauma and diabetes, and these factors also increase the incidence of the disease [4,5].

Thoracic injuries are the most common etiological cause of mortality following head injuries [6]. Among thoracic injuries, rib fractures are the most frequently observed and can be seen in 85% of direct chest traumas [7]. Additionally, posterior wall instability and flail chest pathologies that can arise after rib fractures are neglected, and these pathologies can lead to respiratory and circulatory problems. If appropriate follow-up and treatment are not conducted, these pathologies can result in mortality and morbidity. Rib fractures cause thoracic muscle spasms due to pain, limiting the patient's thoracic movements. This condition hinders the patient from taking deep breaths and disrupts the cough reflex that develops in response to secretions or pathogens. Therefore, pneumonia can develop in cases of rib fractures [8]. In these patients, age, the number of fractured ribs, complications, and the severity of thorax-related injury are among the risk factors that increase mortality [9,10].

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In our study, we aimed to determine the incidence of pneumonia development in the early period and identify risk factors in cases presenting to the emergency department with thoracic trauma and diagnosed with rib fractures. We intended to contribute to the literature with the data we obtained.

Material and Methods

Study setting and study population

Our study was conducted at a tertiary referral hospital in Erzurum province, as a prospective and single-center study. A total of 429 patients who presented to our study between January 1, 2022, and January 1, 2023, and met the inclusion criteria were included.

Data collection

The study included screening cases that presented to the emergency department with isolated thoracic trauma (traffic accident, direct blow to the thorax, impingement injuries, and sports injuries) and were subsequently diagnosed with rib fractures. Multi-trauma patients were not included in our study because of changes in consciousness due to head trauma and the risk of aspiration, shadowing the signs of infection, and abdominal injuries that may impair the respiratory and coughing mechanism, and the study was conducted with patients with isolated thoracic trauma. When the outcome of 29 cases out of 493 cases could not be followed; They were excluded from the study because 11 patients did not come for the control on the 7th day, 6 patients did not come for the control on the 15th day, and 18 patients wanted to quit the study while the study was in progress. The study was conducted with the remaining 429 patients. Among the obtained cases, 429 patients who met the inclusion criteria (including those with isolated thoracic trauma, diagnosed with rib fractures, willing to participate in the study, presenting for follow-up evaluation on the 7th and 15th day after the trauma, no missing data identified, and able to be followed up until the endpoint) were included in the study. Demographic information (age, gender) and medical history (history of chronic diseases, smoking and alcohol habits), number of complaint days, number of rib fractures, location of rib fracture (right hemithorax, left hemithorax, bilateral), development of pneumonia, and subsequent progression (duration of treatment, need for hospitalization, and outcome) of the cases were recorded on a previously prepared study form.

In the diagnosis of pneumonia, supportive clinical and microbiological features, as well as the detection of infiltrations in imaging studies (such as chest X-ray and thoracic computed tomography (CT)), are considered the gold standard [11]. Therefore, in our study, imaging studies were conducted after clinical evaluation for pneumonia assessment in cases. In cases suspected of contusion, thoracic CT planning was performed. In order to confirm the diagnosis of pneumonia in all patients with complaints, consultation was requested from a pulmonologist with at least 3 years of experience. The first 7 and 15 days after the trauma were considered as the evaluation periods to detect early pneumonia incidence in patients. Patients were requested to come for follow-up on the 7th and 15th day after the trauma for early detection of pneumonia. Patients were informed about pneumonia and instructed to contact the researchers if they had any complaints. The day when symptoms began in cases where pneumonia was detected was considered as day one.

After the evaluation, cases with diagnosed rib fractures were started on similar doses of non-steroidal anti-inflammatory tablet treatment for pain control (oral diclofenac sodium 50 mg, 2x1). Among the cases suspected of pneumonia following rib fractures, sputum and respiratory tract cultures were obtained from cases with clinical suspicion after the evaluation. Empirical antibiotic treatment was initiated for these patients, and in cases with positive cultures and identified resistance based on the antibiogram, antibiotic therapy was adjusted. Patients received at least 72 hours of antibiotic therapy. In cases where no progression was observed 72 hours after treatment (if fever persisted and/or there was no improvement in symptoms and/or no decrease in C-reactive protein (CRP)), and if sputum and respiratory cultures had not been obtained, they were sent for culture, and changes in antibiotic therapy were made by an infectious disease's specialist.

Statistical analysis

Power analysis was performed using G-Power 3.1.9.7 software. The minimum sample size required for the study, with an effect size of d=0.5, an alpha error rate of 0.05, and a power (1-Beta error rate) of 0.80, was determined to be 51 individuals. In our study, the number of cases was kept above the number of cases obtained in the power analysis.

The statistical analysis of the study was performed using SPSS software version 26. Descriptive statistical measures such as frequency, percentage, mean, median, standard deviation, and interquartile range were used to present the descriptive statistical data. The Kolmogorov-Smirnov test was used to assess the normality of the data distribution. Pearson's chi-square test and Fisher's exact test were used for the comparison of categorical variables. Independent t-test was used for the evaluation of two independent quantitative variables. Correlation analysis was used to assess the relationship between rib fractures and the development of pneumonia, while multiple regression analysis was used to evaluate the risk factors for pneumonia development in cases with rib fractures.

A significance level of $p<0.05$, an error margin of 80%, and a confidence interval of 95% were accepted.

Ethical considerations

The study was initiated after obtaining ethical approval from the Ethics Committee of a tertiary training and research hospital in Erzurum province (Ethics Committee decision dated 06.12.2021, with reference number 2021/21-269). Informed consent was obtained from all participants included in the study.

The entire study was conducted in accordance with the Helsinki

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Declaration and Good Clinical Practice guidelines.

Results

The study was conducted with 412 cases. The mean age of the cases was 43.06±17.85 years, and 82.3% of them were male. Pneumonia was determined to have developed in 18.4% of the cases during the evaluation following rib fracture. It was found that there was a significant association between the development of pneumonia and a history of diabetes mellitus (DM) and chronic obstructive pulmonary disease (COPD) (p=0.027 and p<0.001, respectively). While there was no association between alcohol use and the development of pneumonia, the incidence of pneumonia was significantly higher in cases of cigarette smokers. However, it was observed that this relationship was independent of the number of cigarettes consumed by the cases. Hospitalization was required in 20.9% (n=86) of the cases, and the hospitalization rate in cases without pneumonia was 16.7% (n=56) (Table 1).

There was no association between the presenting complaint and the development of pneumonia. The incidence of pneumonia was found to be higher in cases with a high number of rib fractures (p<0.001). The incidence of pneumonia was higher in cases with multiple rib fractures compared to those with a single rib fracture (p<0.001). Pneumonia incidence was higher in hospitalized cases. Other demographic and clinical data are presented in Table 1.

Table 1. Examination of the relationship between the pneumonia development and demographic and clinical data of the cases

Parameter		All cases n (%)/Mean±SD	Cases with pneumonia (n=76) n (%)/Mean±SD	No pneumonia (n=336) n (%)/Mean±SD	P value
Age (Years)		43.06±17.85	47.14±17.56	42.13±17.81	**0.027**
Age group	<65 years	350 (85.0)	61 (80.3)	289 (86.0)	0.206
	≥65 years	62 (15.0)	15 (19.7)	47 (14.0)	
Gender	Female	73 (17.7)	13 (17.1)	60 (17.9)	0.877
	Male	339 (82.3)	63 (82.9)	276 (82.1)	
History of DM	Present	77 (18.7)	21 (27.6)	56 (16.7)	**0.027**
History of HT	Present	65 (15.8)	13 (17.1)	52 (15.5)	0.725
CVA	Present	21 (5.1)	5 (6.6)	16 (4.8)	0.515
CHF	Present	20 (20)	4 (5.3)	16 (4.8)	0.854
COPD	Present	45 (10.9)	21 (27.6)	24 (7.1)	**<0.001**
Smoking	Present	104 (25.2)	34 (44.7)	70 (20.8)	**<0.001**
Alcohol use	Present	105 (25.5)	20 (26.3)	85 (25.3	0.854
Smoking frequency	<10 piece/day	10 (9.6)	3 (8.8)	7 (10)	0.958
	10-20 piece/day	47 (45.2)	15 (44.1)	32 (45.7)	
	>20 piece/day	47 (45.2)	16 (47.1)	31 (44.3)	
Chief Complaint	Dyspnea	44 (10.7)	6 (7.9)	38 (11.3)	0.083
	Pain	349 (84.7)	63 (82.9)	286 (85.1)	
	Cough	19 (4.6)	7 (9.2)	12 (3.6)	
Number of fractured ribs (number)		1.97±0.835	2.61±0.925	1.83±0.744	**<0.001**
Rib fracture	Single	125 (30.3)	7 (9.2)	118 (35.1)	**<0.001**
	Multiple	287 (69.7)	69 (90.8)	218 (64.9)	
Rib fracture group	≤3 Fractured ribs	396 (96.1)	66 (86.8)	330 (98.2)	**<0.001**
	>3 Fractured ribs	16 (3.9)	10 (13.2)	6 (1.8)	
Outcome	Discharged	326 (79.1)	46 (60.5)	280 (83.3)	**<0.001**
	Hospitalized	86 (20.9)	30 (39.5)	56 (16.7)	

DM: diabetes mellitus, HT: hypertension, CVA: cerebrovascular accident, CHF: congestive heart failure, COPD: chronic obstructive pulmonary disease, SD: standard deviation, Pearson $\chi 2$ test, Fisher's Exact test and T test used

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The demographic and clinical data of the cases were analyzed according to the duration of pneumonia development. It was observed that the incidence of pneumonia was significantly higher in cases with a history of DM during the 15-day period. No relationship was found between other demographic and clinical data and the incidence of pneumonia (Table 2).

In the correlation test; it was determined that the incidence of pneumonia increased as the number of broken ribs increased ($p<0.001$; r:0.360).

In the regression analysis performed to evaluate the risk factors for pneumonia in cases with rib fractures; COPD (OR:0.144, 95% CI:0.065-0.322), smoking (OR:0.319, 95% CI:0.173-0.588), and the number of fractured ribs (OR: 3.476, 95% CI:2.412-5.010) were found to be significant risk factors. There was no significant relationship between gender, age, presence of DM history, alcohol use and pneumonia development in cases with rib fractures. ($p>0.05$) (Table 3).

Table 2. Evaluation of the relationship between pneumonia development timing and demographic and clinical data

Parameter		All cases n (%)/Mean±SD	First 7 days n (%)/Mean±SD	First 15 days n (%)/Mean±SD	P value
Age (Years)		47.14±17.56	46.12±17.38	49.24±18.08	0.470***
Gender	**Female**	13 (17.1)	8 (15.7)	5 (20.0)	0.639*
	Male	63 (82.9)	43 (84.3)	20 (80.0)	
History of DM	**Present**	21 (27.6)	10 (19.6)	11 (44.0)	**0.025***
History of HT	**Present**	13 (17.1)	6 (11.8)	7 (28.0)	0.077*
CVA	**Present**	5 (6.6)	3 (5.9)	2 (8.0)	0.726*
CHF	**Present**	4 (5.3)	1 (2.0)	3 (12.0)	0.101**
COPD	**Present**	21 (27.6)	13 (25.5)	8 (32.0)	0.551*
Smoking	**Present**	34 (44.7)	22 (43.1)	12 (48.0)	0.689*
Alcohol use	**Present**	20 (26.3)	11 (21.6)	9 (36.0)	0.179*
Smoking frequency	**<10 piece/day**	3 (8.8)	2 (9.1)	1 (8.3)	0.217**
	10-20 piece/day	15 (44.1)	12 (54.5)	3 (25.0)	
	>20 piece/day	16 (47.1)	8 (36.4)	8 (66.7)	
Chief complaint	**Dyspnea**	6 (7.9)	3 (5.9)	3 (12.0)	0.114**
	Pain	63 (82.9)	41 (80.4)	22 (88.0)	
	Cough	7 (9.2)	7 (13.7)	0 (0.0)	
Number of fractured ribs (number)			2.61±0.77	2.60±1.19	0.973***
Outcome	**Discharged**	46 (60.5)	30 (58.8)	16 (64.0)	0.664*
	Hospitalized	30 (39.5)	21 (41.2)	9 (36.0)	

DM: diabetes mellitus, HT: hypertension, CVA: cerebrovascular accident, CHF: congestive heart failure, COPD: chronic obstructive pulmonary disease, SD: standard deviation, Pearson $\chi 2$ test, Fisher's Exact test and T test used

Table 3. The results of the regression analysis to determine the risk factors for the development of rib fracture

Parameter	OR	%95 CI	P value
Age	1.004	0.987-1.021	0.664
Gender	1.038	0.460-2.342	0.928
History of DM	0.643	0.315-1.312	0.224
History of COPD	0.144	0.065-0.322	**<0.001**
Smoking	0.319	0.173-0.588	**<0.001**
Alcohol use	0.975	0.498-1.910	0.941
Number of fractured ribs	3.476	2.412-5.010	**<0.001**

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Discussion

In our study, pneumonia development after rib fracture was investigated and it was observed that pneumonia developed after rib fracture in 18.4% of the patients. In studies of literature, the incidence of pneumonia after rib fracture is in the range of 1.4 to 10% [12,13]. Bulger et al. in their study, the rate of pneumonia development was 19% in their study with cases over 65 years of age with rib fractures [7]. In our results, we detected that the rate of pneumonia development is higher than in the literature. Chest pain was the first reason for admission to the emergency department in 84.7% of the patients. The cough reflex may be impaired due to pain, or the patient may limit coughing. As a result, limiting coughing may create a predisposing factor for the development of pneumonia in patients who cannot remove secretions. Elderly patients are particularly susceptible to rib fractures due to insufficient physiological reserves and poor functional residual capacity [14]. Again, in these patients, pre-existing comorbidities and low immunity are possible factors contributing to this increase. In our results, it is predicted that the incidence of pneumonia increased due to this reason.

Comorbid diseases may be risk factors for pneumonia development after rib fracture. Especially in patients with a history of asthma or COPD, deterioration in lung function rapidly increases [15]. Ho et al, in their study; reported an increased incidence of pneumonia in COPD patients with rib fractures [16]. In our results, the incidence of pneumonia was significantly higher in patients with a history of DM and COPD comorbid disease. In this context, our study supports the results of Ho et al.'s study. Although there is no similar data in the literature for DM; we think that the presence of DM increases the incidence of pneumonia because in patients with DM, the healing process prolongs in case of an injury and also host defense is impaired.

As the number of fractured ribs increases, it causes pain and limitation of chest movements in the patient. Therefore, studies are reporting that the number of fractured ribs is associated with pneumonia [17,18]. In the study conducted by Bergeron et al with elderly patients with rib fractures; it has been reported that the presence of multiple rib fractures is a risk factor for pneumonia [17]. Again, Marco et al reported that high number of fractured ribs had a significant effect on the development of pneumonia [8]. Flagel et al in their study; found that the number of fractured ribs was associated with increased pneumonia and mortality [18]. Van Vledder et al. reported that the incidence of pneumonia increased in cases of multiple rib fractures [13]. Ziegler et al. reported in their study that the number of broken ribs was not associated with either pneumonia, pneumothorax, or pulmonary contusion [19]. In our results, it was determined that the incidence of pneumonia was positively correlated with the number of broken ribs. In our results, we found that the incidence of pneumonia was significantly higher in patients with multiple rib fractures than in patients with single rib fractures.

Grigorian et al in their study; found that the incidence of pneumonia was higher in smokers with rib fractures [20]. Also, there are studies indicating that the development of pneumonia is decreased after rib fracture in alcohol users and smokers [21]. Marco et al reported that smoking was not associated with the development of pneumonia in their study [8]. Alcohol use could be associated with pneumonia due to various pathophysiological mechanisms [22]. One of them is the increased risk of aspiration; another is impaired pulmonary host defense and decreased upper airway mucociliary clearance [23,24]. Some studies found that alcohol use is associated with the development of pneumonia in patients with rib fractures, as it affects many systems [8,9]. Gongola et al found that the incidence of pneumonia was significantly lower in alcohol users with rib fractures [21]. In our study, it was found that smoking was significantly associated with increased pneumonia in patients with rib fractures; while no statistically significant correlation was found between the number of cigarettes smoked per day and the development of pneumonia. In addition, no significant relationship was found between alcohol use and pneumonia. In this context, our results differ from the results of Gongola et al. [21] No significant relationship was found between alcohol use and amount and pneumonia. Although we think that these results in our study are different from the literature due to the small number of patients included in this study and the fact that the alcohol use of the population included in the study varies from region to region; we think that this confusion could be eliminated with a larger patient population in a multicentered study.

Patients with higher fractured ribs or patients that are not suitable for home care are hospitalized and followed up. In patients with multiple rib fractures, treatment planning is also made for both pain control and oxygenation. In our study, 20.9% of the cases were hospitalized, treated, and followed up. The incidence of pneumonia in hospitalized patients was found to be significantly higher than in discharged patients. The relationship between the number of fractured ribs and pneumonia incidence was mentioned above. We think that the incidence of pneumonia is high in hospitalized patients, due to the presence of multiple rib fractures and their high comorbidities.

Limitations

There are some limitations in our study. One of these is the number of patients included in our study. Although this number is high as it is the number of patients per year, it is still a limitation of our study. Another limitation is that it was conducted as a single-center study. The high incidence of pneumonia in hospitalized patients in this study may have been due to the inability to exclude hospital-acquired infections, and the fact that those cases were included in our results as well. However, we think that these numbers will not be high enough to cause a change in the results of the study.

Conclusion

According to the results of our study, the development of pneumonia in patients with rib fractures is a frequently

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overlooked issue that needs attention. In addition, the number of fractured ribs, smoking and history of COPD were found to be independent risk factors for the development of pneumonia in patients with rib fractures. For this reason, we think that especially pain control in the follow-up period and appropriate treatment planning for patients with rib fractures will cause a decrease in the incidence of pneumonia.

Conflict of Interests
The authors declare that there is no conflict of interest in the study.

Financial Disclosure
The authors declare that they have received no financial support for the study.

Ethical Approval
The study was initiated after obtaining ethical approval from the Ethics Committee of a tertiary training and research hospital in Erzurum province (Ethics Committee decision dated 06.12.2021, with reference number 2021/21-269).

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