

Clinical Characteristics of Pulmonary Contusion in Trauma Patients and Determinants of Mortality: A Retrospective Analysis

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Abstract

Aim: Pulmonary contusion is a leading cause of morbidity and mortality in trauma patients. This study retrospectively evaluated the clinical characteristics of patients with pulmonary contusion who presented to the emergency department, as well as the factors associated with mortality.

Materials and Methods: This retrospective, cross-sectional study included patients aged 18 years and older who were diagnosed with pulmonary contusion by computed tomography and who presented to the emergency department of a tertiary university hospital between 2019 and 2024. The analysis included demographic characteristics, trauma mechanism, associated injuries, including by body region, laboratory parameters, complications, treatment approaches, and clinical outcomes.

Results: A total of 350 patients were evaluated; mean age was 47.8±18.6 years, and 79.4% were male. The most common trauma mechanism was blunt trauma. Pulmonary contusion was most frequently observed in the lower lobes. The most prevalent associated injuries were rib fractures, pneumothorax, and hemothorax. The 30-day total mortality rate was 8%. Among non-survivors, the following were significantly higher: age, chest trauma scores, complication rates, lactate levels, and pCO₂ levels.

Conclusion: In trauma patients, pulmonary contusion most frequently occurs in the lower lobes and commonly accompanies chest wall and pleural injuries. Advanced age, a higher chest trauma score, the development of complications, and elevated lactate and pCO₂ levels are risk factors for mortality. Early evaluation of these parameters may facilitate prompt identification of high-risk cases.

Keywords: Pulmonary contusion, trauma, thoracic injury, mortality, emergency department

Introduction

Trauma is a significant cause of morbidity and mortality among young and working-age individuals (1). Blunt thoracic trauma, in particular, accounts for a significant number of emergency department visits and hospital admissions. It can lead to severe intrathoracic injuries, including pulmonary contusion, pneumothorax, hemothorax, and rib fractures (2,3). The most common parenchymal injury in thoracic trauma is pulmonary contusion, which leads to respiratory failure through pathophysiological processes such as alveolar hemorrhage, edema, ventilation-perfusion mismatch, and intrapulmonary

shunting. This condition not only causes local complications but may also trigger a systemic inflammatory response, thereby adversely affecting patient prognosis (4).

Pulmonary contusions are reported in 17-75% of blunt chest trauma cases and are considered an independent risk factor for mortality (5,6). Pathologies accompanying pulmonary contusion, such as rib fractures, pneumothorax, and hemothorax, increase morbidity and the need for invasive interventions (4). Additionally, the development of complications such as pneumonia and acute respiratory distress syndrome (ARDS) is one of the main factors that worsen the clinical course and increase mortality (7). Nevertheless, the clinical course of pulmonary contusion



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is unpredictable, and varying outcomes are observed among patients (8).

Therefore, clarifying the clinical characteristics of pulmonary contusion and the factors influencing prognosis is important for enabling early risk stratification. This study aimed to retrospectively evaluate the demographic characteristics, trauma mechanisms, associated injuries, laboratory parameters, treatment approaches, and clinical outcomes of patients with pulmonary contusion presenting to the emergency department, and to identify determinants associated with mortality.

Materials and Methods

Study Design

This study was designed as a retrospective, cross-sectional analysis. Patients who presented to the emergency department of a tertiary university hospital between January 1, 2019, and December 31, 2024, and who were referred to the thoracic surgery clinic from the emergency department were included if pulmonary contusion was diagnosed by computed tomography (CT) (i.e., CT reports confirming pulmonary contusion). The study group consisted of all cases recorded within the specified time frame that met the inclusion criteria. For the analysis, only patients aged 18 years and older with complete and verifiable medical records were included. Cases with incomplete or unverifiable records, patients younger than 18 years, and patients referred to another healthcare facility for whom follow-up data were unavailable were excluded from the study.

The Institutional Review Board of Karadeniz University, Faculty of Medicine, approved the study (decision number: 2025/125, date: 14.05.2025). The study had a retrospective design, and patient data were obtained solely from medical records. Patient names and identifying information were not used; all data were anonymized before analysis. The study was conducted in accordance with the principles of the Declaration of Helsinki, and patient confidentiality was maintained.

As this was a retrospective study, informed consent was waived. Patient records were anonymized, and no personal identifiers were used.

Data Collection Process

Eligible patients were identified through the hospital's information management system and Picture Archiving and Communication System. Patient lists were generated using the ICD-10 code S20.2 (Thorax Contusion). Additionally, patients referred from the emergency department to the thoracic surgery clinic were included in the study group. The collected variables included:

- Demographic data: age and sex.
- Trauma characteristics: mechanism of trauma (blunt, penetrating, fall from height, other).
- Associated injuries: rib fracture, sternal fracture, clavicle fracture, pneumothorax, hemothorax, contusion, subcutaneous emphysema, pneumomediastinum, diaphragmatic injury, pulmonary laceration, and cardiac contusion.
- Laboratory parameters included blood gases (pO_2 , pCO_2), hemoglobin, lactate, and troponin.
- Treatment process: conservative management, tube thoracostomy, thoracotomy, and need for surgical intervention.
- Clinical outcomes include discharge, ward admission, intensive care admission, hospital length of stay, development of complications, and mortality.
- Chest injury score: Chest trauma score (CTS)(9).
- Contusion localization: right upper, right lower, right middle, left upper, and left lower lung zones.

All data were recorded in an electronic spreadsheet, verified using a double-check method, and prepared for analysis.

Statistical Analysis

Data analysis was performed using Jamovi software (version 2.6.24.0). The distribution of continuous variables was assessed using the Kolmogorov-Smirnov test. Continuous variables with a normal distribution were expressed as the mean \pm standard deviation, while those without a normal distribution were expressed as the median (minimum-maximum). Categorical variables were presented as numbers and percentages.

For comparisons between groups, the Independent Samples t-test was used for continuous variables with normal distribution, while the Mann-Whitney U test was applied for those without normal distribution. The chi-square test or Fisher's exact test, as appropriate, was used to analyze categorical variables. A p value <0.05 was considered statistically significant in all analyses.

Results

A total of 350 patients were included in the study. The mean age was 47.8 ± 18.6 years, and 79.4% of the patients were male. The majority of patients sustained blunt trauma (96.3%, $n=337$), followed by penetrating trauma (3.7%, $n=13$). The most common associated injuries were rib fractures (68.9%), pneumothorax (44.3%), and hemothorax (28.6%). Severe intrathoracic injuries, such as diaphragmatic rupture or esophageal injury, were infrequent (less than 1%). The most frequently injured sites

were the right lower lobe (57.7%) and the left lower lobe (54.3%). The overall 30-day mortality rate was 8% (n=28). A subgroup analysis revealed that mortality was exclusively observed in the polytrauma group (10.4%, n=28), whereas no deaths occurred in the isolated pulmonary contusion group (0%, n=0). Among the 350 patients with pulmonary contusion, the majority had associated extra-thoracic injuries. The most frequently affected body regions were the extremities (39.1%, n=137) and the spine (34.0%, n=119). Other associated injuries included traumatic brain injuries n=(23.4%, n =82), maxillofacial injuries (18.9%,

n=66), abdominal injuries (16.0%, n=56), and pelvic fractures (10.9%, n=38). Less common injuries were vascular injuries (1.4%, n=5) and cardiac injuries (0.6%, n=2). The demographic and clinical characteristics of the patients are presented in Table 1.

The mean age of deceased patients was significantly higher than that of survivors: 57±19.3 years versus 47±18.2 years (p=0.006). There was no significant difference in sex distribution between the groups (p=0.712). The proportion of patients with a CTS

	Age (mean ± SD)	n (%)
Gender		
Male	45.7±18	278 (79.4%)
Female	55.7±18.7	72 (20.6%)
Trauma characteristics		n (%)
Blunt trauma		337 (96.3%)
Penetrating trauma		13 (3.7%)
Patient group		
Isolated thorax trauma		80 (22.9%)
Polytrauma		270 (77.1%)
Associated injuries		
Rib fracture		241 (68.9%)
Pneumothorax		155 (44.3%)
Hemothorax		100 (28.6%)
Subcutaneous emphysema		57 (16.3%)
Clavicle fracture		30 (8.6%)
Pneumomediastinum		18 (5.1%)
Pulmonary laceration		18 (5.1%)
Sternal fracture		17 (4.9%)
Diaphragmatic injury		1 (0.3%)
Contusion location		
Right lower lobe		202 (57.7%)
Left lower lobe		190 (54.3%)
Right upper lobe		113 (32.3%)
Left upper lobe		113 (32.3%)
Right middle lobe		77 (22.0%)
Associated injuries by body region		
Extremity		137 (39.1%)
Spinal		119 (34.0%)
Brain		82 (23.4%)
Maxillofacial		66 (18.9%)
Abdominal		56 (16.0%)
Pelvis		38 (10.9%)
Vascular		5 (1.4%)
Cardiac		2 (0.6%)

	n (%)
Complications	
Total number of patients with complications	98 (28.0%)
Pneumonia	22 (6.3%)
Pneumothorax	15 (4.3%)
Hemothorax	16 (4.6%)
Atelectasis	5 (1.4%)
ARDS	4 (1.1%)
Hemoptysis	1 (0.3%)
Other	58 (16.6%)
Treatment methods	
Observation/follow-up	268 (76.8%)
Tube thoracostomy	77 (22.1%)
Surgery	4 (1.1%)
Hospitalization and outcomes	
Number of hospitalized patients	288 (82.3%)
Discharged from ED	54 (15.4%)
Ward admission	170 (48.6%)
ICU admission	116 (33.1%)
Death in ED	10 (2.9%)
30-day mortality	
Isolated thorax trauma	0 (0%)
Total polytrauma	28 (8.0%)
	Median (minimum-maximum)
Average length of stay (days)	5 (0-67)
ED: Emergency department, ICU: Intensive care unit, SD: Standard deviation, ARDS: Acute respiratory distress syndrome	

greater than five was 92.9% in the mortality group and 56.2% among survivors, a statistically significant difference ($p < 0.001$). Complications during clinical follow-up also occurred more frequently in the mortality group (89.3%) than in the survivor group (22.7%), with a statistically significant difference ($p < 0.001$).

We then compared the patients who survived ($n = 322$) with those who died ($n = 28$) to identify factors associated with mortality. When examining treatment methods, tube thoracostomy was required significantly more often in the mortality group than among survivors ($p = 0.002$). Regarding laboratory parameters, the median lactate level was 28 mg/dL in patients who died, compared with 15 mg/dL in survivors ($p = 0.001$). Similarly, pCO_2 levels were higher in the mortality group ($p < 0.001$). In contrast, troponin, pO_2 , and hemoglobin values were not significantly associated with mortality ($p > 0.05$). A comparison of variables associated with mortality is summarized in Table 2.

Discussion

This study retrospectively evaluated the clinical characteristics of patients with pulmonary contusion who presented to the emergency department and the factors associated with mortality. Our findings suggest that advanced age, CTS, and the development of complications are key determinants of mortality. These results demonstrate both similarities and differences relative to previous studies of factors influencing the prognosis of pulmonary contusion.

In this study, which evaluated 350 patients, the majority of patients were male, with a mean age of 47.8 years. Similarly, in a 10-year retrospective study conducted by Demirhan et al., the proportion of male patients was 85%, and the mean age was 36.2 years (10). This finding is consistent with the literature reporting that trauma occurs among young and middle-aged males (3,11).

Examination of trauma mechanisms showed that nearly all cases were caused by blunt-force trauma or falls, whereas penetrating injuries occurred at very low rates. Previous studies have reported that most thoracic injuries result from blunt force, with traffic accidents and falls from heights being the most common causes (2,11-13). In our study, falls also emerged as the most significant mechanism associated with blunt trauma.

Pulmonary contusions were most frequently localized in the lower lobes: the right lower lobe (57.7%) and the left lower lobe (54.3%). This may be explained by the larger anatomical volume of the lower lobes and their greater exposure to trauma (14). The literature also reports that the lower lobes are more susceptible to contusion (13,15).

The most common associated injuries were rib fractures, pneumothorax, and hemothorax. These findings demonstrate that pulmonary contusion is frequently accompanied by chest wall and pleural pathologies. According to Tyburski et al. (16), rib fractures were the most frequent associated injury, occurring in 67% of pulmonary contusion cases. In a study by Dumanlı evaluating pulmonary contusions, pneumothorax was detected in 51.9% of cases and hemothorax was detected in 45.4% (2). Our findings are consistent with previous research.

When complications were evaluated, 28% of cases exhibited complications; the most prominent were respiratory problems, including pneumonia (6.3%), pneumothorax (4.3%), hemothorax (4.6%), and ARDS (1.1). Pulmonary contusion has also been reported in the literature as an important risk factor, particularly for the development of pneumonia and ARDS (5,7,11,17). In the study by Lee et al. (18), 38% of patients with contusions developed pneumonia, while 6.8% developed ARDS. Our study, observed lower rates, possibly owing to effective patient monitoring, early diagnosis and intervention, and the widespread use of

Variable	Mortality (-) (n = 322)	Mortality (+) (n = 28)	p-value
Age (years, mean \pm SD)	47.0 \pm 18.2	57.1 \pm 19.3	0.006
Gender (M/F)	256/66	22/6	0.712
Complication (%)	22.7	89.3	<0.001
CTS score >5 (%)	56.2	92.9	<0.001
Treatment: tube thoracostomy (%)	19.6	53.6	0.002
Troponin (ng/L, median)	19.3 (3.1-4761.0)	18.8 (3.5-216.1)	0.632
pCO_2 (mmHg, mean \pm SD)	41.0 \pm 9.5	47.0 \pm 11.2	<0.001
pO_2 (mmHg, mean \pm SD)	69.2 \pm 58.0	65.8 \pm 63.4	0.253
HGB (g/dL, mean \pm SD)	13.7 \pm 2.0	13.3 \pm 2.1	0.053
Lactate (mg/dL, median)	14.0 (0.7-219.0)	28.5 (0.9-81.0)	0.001

SD: Standard deviation, M/F: Male/female, CTS: Chest trauma score, HGB: Hemoglobin

conservative treatment approaches. However, the development of respiratory complications remains an important factor in determining the clinical course. Close monitoring and effective management of these complications are critical to the success of treatment in such patients.

Examination of laboratory findings revealed that lactate levels were significantly higher in the mortality group. However, troponin and hemoglobin values were not associated with mortality. Previous studies have also emphasized the importance of lactate levels as prognostic biomarkers (19-21). The higher pCO₂ values observed in the mortality group demonstrate the impact of ventilatory impairment on prognosis (22). These results show that respiratory failure is a critical factor in determining mortality in patients with pulmonary contusion. Elevated lactate levels, an indicator of tissue hypoperfusion and oxygen deficiency, stand out among laboratory parameters as strong biomarkers of mortality (19). Elevated pCO₂ values reflect impaired alveolar ventilation and demonstrate the impact of respiratory failure on mortality. In contrast, troponin, hemoglobin, and pO₂ levels were not significantly associated with mortality. These results suggest that cardiac biomarkers and oxygenation parameters may play only a secondary role in contusion-related mortality (23). These findings are consistent with those of earlier studies that identified similar parameters as risk factors for mortality (24).

In our study, when treatment approaches were evaluated, the majority of cases were managed conservatively. However, the rate of tube thoracostomy was significantly higher among patients who died. This finding suggests that pleural complications negatively affect prognosis and increase the need for invasive interventions. Most patients with thoracic trauma recover clinically within 5-7 days with conservative management; however, a subset may require invasive treatment (5). In particular, tube thoracostomy is the first-line intervention for managing complications of pulmonary contusion. At the same time, the need for surgical intervention arises in a limited number of cases (5,8). Accordingly, the low rate of surgical treatment in our study is consistent with existing literature. However, a greater frequency of invasive interventions in cases of high CTS with complications underscores the importance of early risk assessment in treatment strategies.

Our study found a mortality rate of 8%, which is notably lower than the 14-40% reported in the literature for pulmonary contusion (5,12,16). Reasons for this difference may include the centre's advanced intensive care facilities, early diagnosis and effective resuscitation strategies, a predominance of younger patients, and a relatively low incidence of major concomitant trauma. Examination factors affecting mortality identified advanced age, the development of complications, higher CTS, and elevated

lactate and pCO₂ levels as the strongest determinants of mortality. Reduced physiological reserves, increased prevalence of comorbidities, and diminished recovery capacity can explain the impact of advanced age on mortality (5). Similarly, the presence of complications, particularly pneumonia and ARDS, prolongs the hospital stay, worsens the clinical course, and increases mortality (8). The correlation between a high CTS and mortality underscores the pivotal role of trauma severity and associated injuries in informing prognosis (25). Therefore, early evaluation of age, trauma score, lactate, and pCO₂ levels in patients with pulmonary contusion may facilitate the rapid identification of high-risk cases and contribute to the implementation of treatment strategies aimed at improving prognosis.

Study Limitations

This study has several limitations. First, because of its retrospective design, data were obtained from existing medical records; therefore, the possibility of missing or incomplete information cannot be excluded. Second, since the study was conducted at a single center, the results may not be generalizable to other patient populations. Third, while we utilized the CTS to assess thoracic injury severity, global trauma scores such as the injury severity score or TRISS were not calculated. The impact of multi-trauma was instead evaluated through the analysis of specific associated injuries. Additionally, the clinical effects of trauma severity and associated injuries may not have been evaluated uniformly.

Conclusion

Pulmonary contusion most commonly occurs after blunt trauma or falls and is frequently accompanied by rib fractures, pneumothorax, and hemothorax. In our study, the mortality rate was 8%; advanced age, development of complications, higher CTS, elevated pCO₂, and increased lactate levels were identified as risk factors. These results highlight the critical importance of early clinical and laboratory assessments in the emergency department for identifying high-risk patients and planning appropriate treatment strategies.

Ethics

Ethics Committee Approval: The Institutional Review Board of Karadeniz University, Faculty of Medicine, approved the study (decision number: 2025/125, date: 14.05.2025). The study had a retrospective design, and patient data were obtained solely from medical records. Patient names and identifying information were not used; all data were anonymized before analysis. The study was conducted in accordance with the principles of the Declaration of Helsinki, and patient confidentiality was maintained.

Informed Consent: As this was a retrospective study, informed consent was waived. Patient records were anonymized, and no personal identifiers were used.

Footnotes

Authorship Contributions

Concept: A.S.S., B.K.A., İ.D., Design: A.S.S., E.D., İ.D., S.P., Data Collection or Processing: S.Ö., B.K.A., İ.D., S.P., Analysis or Interpretation: A.S.S., E.D., B.K.A., İ.D., Literature Search: S.Ö., S.P., Writing: A.S.S., S.Ö., E.D., S.P.

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