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Evaluation of Thoracic Traumas Observed in Pediatric Intensive Care Unit

Çocuk Yoğun Bakım Ünitesinde İzlenen Torasik Travmaların Değerlendirilmesi

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Abstract

Introduction: To discuss findings and interventions of patients followed in the pediatric intensive care unit due to trauma accompanied by thoracic injury over a seven-year period, including the February 2023 Türkiye earthquake, with case examples.

Methods: Electronic health records of patients admitted to the pediatric intensive care unit due to trauma between March 2018 and 2025 were reviewed.

Results: Among the 375 trauma patients, 29% had accompanying thoracic trauma. The most common causes of trauma were traffic accident, earthquake-related injuries and falls from height. Tube thoracostomy was performed in 53.2% of patients, surgical treatment in 11.9%, bronchoscopy in 8.26%, and mechanical ventilation in 33.9%. The most common findings observed in these patients were pulmonary contusion and pneumothorax. The most frequent accompanying injuries in patients with thoracic trauma were head trauma, femur fracture, and liver and/or spleen laceration. Clinical findings, radiological images and interventions on five representative cases of patients followed in the pediatric intensive care unit due to trauma with accompanying thoracic injury is presented in this study.

Conclusion: During the primary assessment of patients, life-threatening conditions defined as the lethal six must be urgently investigated. In the presence of traumatic pneumothorax, hemothorax, or hemopneumothorax, early tube thoracostomy should be performed if the patient is symptomatic. Pulmonary contusion should be considered in blunt trauma, and pulmonary laceration in penetrating trauma. Persistent pneumothorax and hemothorax despite tube thoracostomy require surgical intervention. When pneumomediastinum and subcutaneous emphysema are detected, tracheobronchial injury should be suspected, and the patient should be evaluated for bronchoscopy.

Keywords: Critical pediatric patients, multiple trauma, thoracic trauma, surgical intervention, lethal six

Öz

Giriş: Şubat 2023 Türkiye depremini de içeren yedi yıllık sürede travma nedeni ile çocuk yoğun bakım ünitesinde izlenen ve toraks travması eşlik eden hastaların bulgularını ve uygulanan girişimleri olgular eşliğinde tartışmak amaçlanmıştır.

Yöntemler: Travma nedeni ile Mart 2018-2025 yılları arasında çocuk yoğun bakım ünitesine kabul edilen hastaların elektronik sağlık kayıtları incelendi.

Bulgular: Üç yüz yetmiş beş travma hastasına %29 toraks travması eşlik etmekteydi. Travmanın en sık nedeni trafik kazası, deprem ilişkili yaralanma ve yüksekten düşmedir. Toraks yaralanması olan hastalarda tüp torakostomi %53,2, cerrahi tedavi %11,9, bronkoskopi %8,26 ve mekanik ventilasyon %33,9 gerekli olmuştu. En sık komplikasyon pulmoner kontüzyon ve pnömotorakstı. Hastalarda toraks yaralanmasına en sık kafa travması, femur fraktürü, karaciğer ve/veya dalak laserasyonu eşlik etmekteydi. Toraks travması nedeniyle çocuk yoğun bakımda izlenen beş hastaya ait klinik bulgular, radyolojik görüntüler ve uygulanan tedaviler sunuldu.

Sonuç: Hastaların ilk değerlendirmesi sırasında ölümcül altılı olarak tanımlanan hayatı tehdit eden durumların acilen araştırılması gereklidir. Travmatik pnömotoraks, hemotoraks veya hemopnömotoraks varlığında hasta semptomatik ise erken tüp torakostomi uygulanmalıdır. Künt travmalarda pulmoner kontüzyon, penetran travmalarda pulmoner laserasyon akla gelmelidir. Tüp torakostomiye rağmen persiste eden pnömotoraks ve hemotoraks cerrahi müdahale gerektirir. Pnömomediastinum ve cilt altı amfizem saptandığında trakekobronşial yaralanma akla gelmeli, bronkoskopi açısından hasta değerlendirilmelidir.

Anahtar Kelimeler: Kritik çocuk hasta, çoklu travma, toraks travması, cerrahi tedavi, ölümcül altılı

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Introduction

Traumas are sudden injuries that pose a threat to life. Across all age groups, they are the third leading cause of death after cardiovascular diseases and cancer. Thoracic trauma occurs in 4-10% of children and has a mortality rate of approximately 5%. However, thoracic injuries are more frequently associated with multiple traumas, in which case the mortality rate may rise as high as 40%. Blunt trauma resulting from traffic accidents and falls from height accounts for 60-85% of thoracic injuries. Penetrating trauma caused by sharp objects (e.g., knives) or firearms less frequently causes thoracic injury.[1-3]

Major thoracic injuries are referred to as the "deadly dozen". During the primary assessment of patients, six life-threatening conditions, collectively known as the lethal six (airway obstruction, tension pneumothorax (PTX), PTX, massive hemothorax (HTX), flail chest, and pericardial tamponade), must be investigated urgently. During the secondary assessment, potential life-threatening conditions known as the hidden six (thoracic aortic injury, tracheobronchial injury, blunt myocardial injury, diaphragmatic injury, esophageal injury, and pulmonary contusion) should be examined.[4,5] Patients are generally treated with airway management, supplemental oxygen, tube thoracostomy, and analgesia, while approximately 10% require surgical intervention. In children, because of the greater elasticity of the thorax and bones, pulmonary injury may occur even in the absence of chest wall damage. Clinical findings may range from mild respiratory distress to respiratory arrest. Therefore, the diagnosis of life-threatening conditions depends on a high index of suspicion early surgical consultation, and timely intervention.[6-8]

Over the past 20 years, the world has had to cope with numerous disasters such as pandemics, earthquakes, tsunamis, and floods. Children, owing to their unique anatomical and developmental characteristics, constitute the population most affected by trauma. The most recent example of this is the February 2023 Türkiye earthquake, which resulted in the deaths and injuries of thousands of people in our country. Healthcare professionals were required to intervene simultaneously in hundreds of trauma cases. Physicians dealing with critically ill patients must be well-equipped to recognize conditions such as thoracic injuries that require urgent evaluation and intervention.[9-11] This study aimed to discuss the findings and interventions for patients admitted to the pediatric intensive care unit (PICU) for trauma accompanied by thoracic injury over a seven-year period, including cases from the February 2023 Türkiye earthquake, illustrated with case examples.

Materials and Methods

This cross-sectional study was conducted in the PICU of University of Health Sciences Türkiye, Adana City Training and Research Hospital, a tertiary referral center with 30 beds.

Inclusion Criteria

The study period covered admissions between March 2018 and March 2025. The study included children aged 1-216 months who were admitted to the PICU for trauma. Patient data were obtained retrospectively from the electronic health record system. Age, sex, admission date, medical history, cause of trauma, trauma region, medical or surgical interventions, pediatric trauma scores (PTS), radiological imaging findings, medical and surgical treatments, length of stay in the PICU, and clinical outcome were recorded.

Exclusion Criteria

Patients who were followed in the PICU for non-traumatic causes. Patients who were monitored in other intensive care units such as anesthesia or neurosurgery ICUs. Patients whose follow-up and treatment were completed in the pediatric emergency department were subsequently discharged.

Ethical approval was obtained from the Ethics Committee for Scientific Research of University of Health Sciences Türkiye, Adana City Training and Research Hospital (approval no: 733, date: 25.09.2025). Due to the retrospective design of the study, informed consent was not obtained from the patients' relatives.

Statistical Analysis

Data were analyzed using IBM SPSS Statistics, version 25.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as median (25^{th}-75^{th} percentile, interquartile range) or mean ± standard deviation, depending on their distribution. Normality was assessed separately for each group using the Shapiro-Wilk test. For group comparisons, the Mann-Whitney U test was applied to non-normally distributed variables. Categorical variables were presented as frequencies and percentages, and comparisons were performed using the Pearson chi-square test. When expected cell counts were below 5, the Fisher's exact test or the Fisher-Freeman-Halton exact test was used. A p-value <0.05 was considered statistically significant.

Results

Characteristics of Traumatic Patients and Trauma Etiology

Among the 375 patients included in the study, 254 (67.7%) were male, and the median age was 116.91 months (range:

5-216). The most common causes of trauma were traffic accidents (41.86%), earthquake-related injuries (24.8%), and falls from height (21.34%). Injuries caused by sharp objects such as knives or glass, and crush injuries resulting from heavy blunt objects such as televisions or cabinets, were observed less frequently. The mean PTS value was 9.09±1.51; PTS was less than 9 in 69.3% of cases and 10 or higher in 30.7% of cases. The trauma-related length of stay in the PICU was 6.15±7.34 days, and the mortality was 7.73% (Table 1).

The annual distribution of patients is shown in Figure 1. The sudden increase in the number of cases in 2023 is associated with the February 2023 Türkiye earthquake and with our hospital serving as a central medical facility in the earthquake-affected region.

Intervention and Findings in Patients with Thoracic Trauma

Among the 375 patients followed up for trauma, 29% (n=109) had thoracic trauma. Tube thoracostomy was performed in 53.2% (58/109) of these patients; surgical treatment in 11.9% (13/109); bronchoscopy in 8.26% (9/109); and mechanical ventilation in 33.9% (37/109) (Table 2). The most common complications observed in these patients were pulmonary contusion (59.6%) and PTX (42.2%). The most frequent concomitant injuries among patients with thoracic trauma were head trauma, femur fracture, and laceration of the liver and/or spleen (Table 3).

No significant differences were observed between patients with and without thoracic trauma with respect to age, cause of trauma, or clinical outcomes. A statistically significant difference in length of stay in the PICU was found between patients with and without thoracic injury (p=0.002) (Table 1).

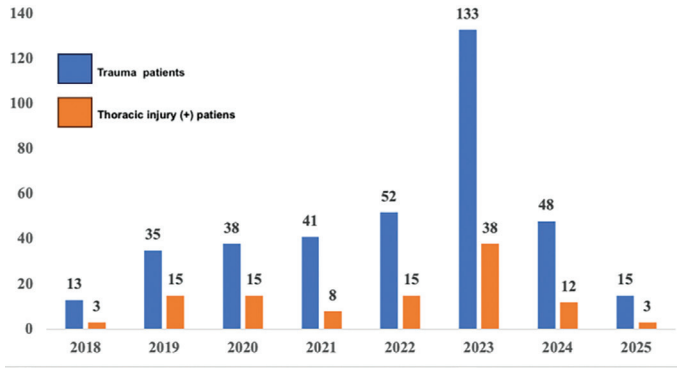

Figure 1. Distribution of trauma and thoracic injury (+) patients by year

Case Reports

Information on five representative patients followed in the PICU for trauma with accompanying thoracic injury is presented in Table 4.

Discussion

Young children are prone to trauma because of a lack of attention, whereas adolescent males are more susceptible because of greater activity and mobility.[5] Similarly, in our study, the mean age of patients was 116.91 months; among patients with thoracic trauma, the median age was 132 (66-190) months, and there was a male predominance of 2:1. In the study by Jung et al.[12] traffic accidents and falls from height were reported as the most frequent causes of thoracic trauma, with the thorax being the third most commonly injured region following head-neck and extremity injuries. In contrast, because of the February 2023 Türkiye earthquake in our region, earthquake-related injuries ranked second and

Table 1. Characteristics of patients

	Trauma patients n=375 (100%)	Thoracic injury (+) patients n=109 (29%)	Thoracic injury (-) patients n=266 (71%)	p-value*
Age (months) Median (IQ1-IQ3)	116.91 (5-216)	132 (66-190)	111 (55.75-174.25)	0.055
Length of stay in PICU (days) median (IQ1-IQ3)	6.15 (1-57)	4 (3-8)	4 (2-6)	**0.002**
	n (%)	**n (%)**	**n (%)**	
Trauma reason				0.082
Traffic accident	157 (41.86)	59 (54.1)	98 (36.84)	
Earthquake-related injury	93 (24.8)	19 (17.4)	74 (27.82)	
Fall from height	80 (21.34)	19 (17.4)	61 (22.93)	
Firearm injury	21 (5.6)	5 (4.6)	16 (6.1)	
Sharp object injury	16 (4.27)	3 (2.8)	13 (4.81)	
Injury with blunt object	8 (2.13)	4 (3.7)	4 (1.5)	
Clinical outcome				0.504
Discharge	346 (92.97)	99 (90.80)	247 (92.90)	
Exitus	29 (7.73)	10 (9.20)	19 (7.10)	

*: Mann-Whitney U test was applied to non-normally distributed variables. Categorical variables were presented as frequencies and percentages, and comparisons were performed using the Pearson chi-square test. When expected cell counts were below 5, the Fisher's exact test or Fisher-Freeman-Halton exact test was used. P<0.05 was considered statistically significant
PICU: Pediatric intensive care unit

Table 2. Interventional procedures of thoracic injury (+) patients

Intervention	n (%)
Surgical treatment Diaphragm repair Pulmonary repair Lung resection Chest wall repair	 4 (3.7) 3 (2.7) 1 (0.9) 5 (4.58)
Tube thoracostomy	58 (53.2)
Bronchoscopy	9 (8.26)
Mechanically ventilated	37 (33.9)

Table 3. Thoracic and extrathoracic injuries of thoracic injury (+) patients

Thoracic injury	n (%)	Extrathoracic injury	n (%)
Pulmonary contusion	65 (59.26)	Head and neck injury	46 (42.2)
Pulmonary laceration	8 (7.4)	Femur fracture	24 (22)
Pneumothorax	46 (42.2)	Humerus fracture	16 (14.6)
Hemopneumothorax	9 (8.2)	Multiple extremity fracture	5 (4.6)
Hemothorax	8 (7.4)	Pelvic fracture	11 (10)
Pneumomediastinum	8 (7.4)	Vertebra fracture	7 (6.4)
Tracheobronchial injury	7 (6.4)	Liver laceration	24 (22)
Diaphragm rupture	4 (3.7)	Splenic laceration	18 (16.5)
Rib fracture	11 (10)	Bladder rupture	6 (5.5)
Clavicula fracture	5 (4.6)	Colon-duodenum rupture	6 (5.5)
Scapula fracture	4 (3.7)	Renal laceration	4 (3.7)
Subcutaneous emphysema	14 (12.8)		
Chest wall laceration	5 (4.6)		

falls from height ranked third. The increase in the number of cases in 2023 was also associated with the earthquake. Despite technological advances and safety measures, traffic accidents remain the leading cause of traumatic injury, while earthquakes cause simultaneous severe injuries in large populations due to widespread destruction. Because of their physiological characteristics, children constitute the group most affected by trauma, and thoracic injuries can be life-threatening in these cases.[13-15] When the same amount of kinetic energy is applied to a child's thoracic wall, the resulting organ damage is more severe than in an adult with greater muscle mass. Because of the elastic structure of the chest wall, organ injury may occur without rib fracture. The mediastinum of children is mobile, allowing positional shifts during compression. While mediastinal shift reduces the risk of injury to the heart and great vessels, it increases the risk of PTX and HTX. Since children have higher metabolic demands and lower pulmonary reserves, rapid decompensation may develop. All these factors require early recognition and prompt intervention in pediatric patients with life-threatening conditions.[2-16]

PTX is a life-threatening condition observed in 40-50% of thoracic trauma cases. X-ray imaging, bedside ultrasonography, and computed tomography (CT) are useful for diagnosis. Treatment involves a comprehensive approach, including close monitoring, oxygen therapy, and tube thoracostomy. The gold-standard treatment is tube thoracostomy. Advanced life support algorithms prioritize tube thoracostomy in traumatic cases due to the risk of tension PTX.[4] HTX is defined as pleural fluid with a hematocrit value equal to or greater than 50% of peripheral blood hematocrit. HTX and hemopneumothorax occur in approximately one-third of thoracic injuries. A

Table 4. Cases followed in PICU due to thoracic trauma

Case	Age*	Trauma reason	Diagnosis	Treatment	Clinical outcome
1	102	Traffic accident	Pediatric surgery: pulmonary contusion, pneumothorax Brain neurosurgery: no pathology Orthopedics: no pathology	- Right tube thoracostomy	Discharge
2	86	Traffic accident	Pediatric surgery: pulmonary contusion, hemopneumothorax Brain surgery: no pathology Orthopedics: femur fracture	- Left tube thoracostomy	Discharge
3	164	Thoracic firearm injury	Pediatric surgery: entry wound on the right scapula, exit wound on the left shoulder, pulmonary contusion: hemopneumothorax Brain surgery: cerebral edema	- Lung and chest wall repair - Left tube thoracostomy	Brain death
4	204	Traffic accident	Pediatric surgery: bronchial injury, pneumothorax Brain surgery: cerebral edema Orthopedics: right tibia and fibula fractures	- Pulmonary resection - Right tube thoracostomy	Brain death
5	187	Cranial firearm injury, fall from height	Pediatric surgery: pulmonary contusion, bilateral pneumothorax, pneumomediastinum, subcutaneous emphysema Brain surgery: displaced fracture, subarachnoid hemorrhage, parenchymal hemorrhage Orthopedics: no pathology	- Bilateral tube thoracostomy - Bronchoscopy	Discharge

*: Months, PICU: Pediatric intensive care unit

significant volume of blood may accumulate in the pleural cavity, leading to hypovolemic shock. In addition, HTX may cause atelectasis and respiratory distress, which is a life-threatening clinical condition. For diagnostic purposes, CT is the gold-standard, whereas ultrasound is the recommended method. The most critical step in the treatment of HTX is the early performance of a tube thoracostomy to prevent hypovolemia and lung compression. Providing analgesia in patients with thoracic trauma is essential. In our unit, paracetamol or pethidine hydrochloride is commonly preferred. During invasive procedures such as tube thoracostomy, wound suturing, or catheter insertion, ketamine is used. After monitoring, oxygenation, and sedation, bedside tube thoracostomy is performed in unstable patients; tube thoracostomy is conducted in the pediatric emergency department. Consequently, tube thoracostomy was required in 53.2% of the patients. Figures 2A and 2B show X-ray images of two patients who underwent tube thoracostomy due to PTX and HTX.

Pulmonary contusion is characterized by alveolar hemorrhage, edema, and inflammation in the absence of pulmonary vascular injury, resulting from transmission of kinetic energy to the lung parenchyma during blunt trauma. It has been reported to occur over a wide range (17-75%) in blunt thoracic trauma. In our study, this rate was found to be 59.26%. The definitive diagnosis is made by CT. Treatment should include monitoring of vital signs, oxygen supplementation, pain control, early mobilization, and chest physiotherapy.[2-17,18]

Pulmonary laceration usually results from penetrating trauma that causes injury to the pulmonary parenchyma. If the laceration extends to the pleura, HTX or PTX may accompany the injury. Tube thoracostomy is recommended as supportive treatment when necessary. Surgical intervention should be considered for patients presenting with hemoptysis or persistent major air leakage.[2] Pulmonary laceration is less common than contusion, but patients suspected of having a laceration should be evaluated early for possible surgical complications. In our study, pulmonary laceration was detected in 7.4% of patients. A patient with a gunshot-induced thoracic injury underwent primary repair of the left lung, chest wall reconstruction, and tube thoracostomy and was followed postoperatively in the PICU (Figure 2C).

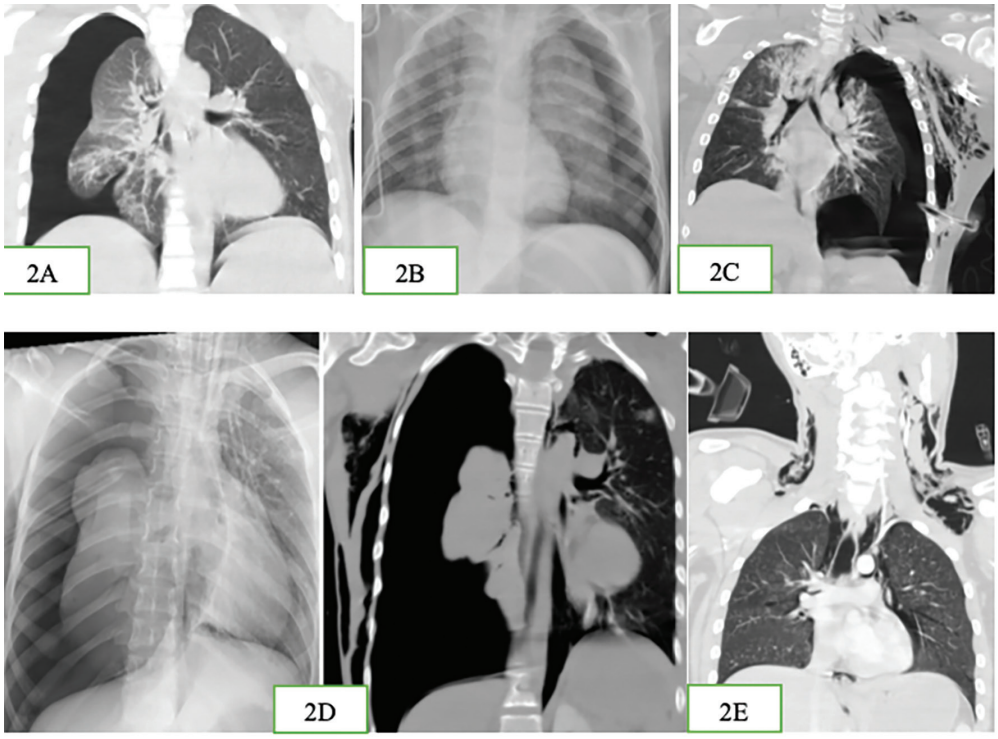

Figure 2. Radiological images of cases. **A)** A right pneumothorax is seen on computed tomography of Case 1. **B)** Left hemopneumothorax is seen on the PA radiograph of Case 2. **C)** Thoracic computed tomography image of Case 3 shows pneumomediastinum, pneumothorax, subcutaneous emphysema, and collapsed lung tissue. The pediatric surgery team performed surgical repair on the patient's left lung and chest wall. **D)** Persistent massive pneumothorax and collapsed lung tissue are seen on PA chest radiography and thoracic computed tomography performed after tube thoracostomy in Case 4. When the patient underwent a thoracotomy performed by the pediatric surgery team, complete separation of the right main bronchus was observed, necessitating a total resection of the right lung. **E)** Thoracic computed tomography shows pneumomediastinum and subcutaneous emphysema. The patient was followed for a displaced occipital fracture, subarachnoid hemorrhage, parenchymal hemorrhage, pulmonary contusion, pneumothorax, pneumomediastinum, and subcutaneous emphysema sustained in a fall that followed a cranial gunshot wound. The patient underwent bilateral tube thoracostomy and bronchoscopy for persistent pneumomediastinum. The tracheobronchial structures were normal. Pulmonary findings resolved during follow-up. The patient was extubated 2 weeks later
PA: Posteroanterior

Tracheobronchial injury refers to damage to the trachea and bronchi (the tracheobronchial tree). Its incidence has been reported as 0.8-5%; however, the true frequency remains uncertain because it is typically observed in patients with severe trauma who often die before hospital admission. Diagnosis is challenging due to coexisting traumatic injuries. The presence of dyspnea, hemoptysis, stridor, subcutaneous or mediastinal emphysema, pneumomediastinum, tension PTX, and massive air leaks should raise suspicion for tracheobronchial injury (Figures 2D and 2E). CT and bronchoscopy are the preferred diagnostic tools.[2-4]

In blunt chest trauma, the factors influencing mortality and morbidity include age, bone fractures, need for mechanical ventilation, preexisting lung disease, head injury, hypotension, and extra-thoracic organ injury. A low Glasgow Coma scale is an important predictor of mortality.[3,5,10] The mortality rate in thoracic trauma is approximately 5%, but when accompanied by injuries to other systems, it rises to 25-40%.[1] In the study by Jung et al.[12] overall trauma mortality was 14.9%, the incidence of thoracic trauma was 12.4%, and thoracic trauma-related mortality was 4.8%. In contrast, in the study by Sweet et al.[3] the incidence of thoracic trauma was 2.4%, with a mortality rate of 5.5%. In our study of 375 patients, overall trauma mortality was 7.73% (29/375); the incidence of thoracic trauma was 29% (109/375); and thoracic trauma-related mortality was 2.7% (10/375). Thoracic trauma was more frequent in our patient group, while mortality was lower than that reported by Jung et al.[12] and similar to Sweet et al.[3] This difference can be attributed to variations in the causes and severity of trauma.

Study Limitations

In addition to being retrospective and single-center, this study's most significant limitation is the exclusion of patients followed in the emergency department and other intensive care units. Due to the chaotic environment following the earthquake and issues with patient identification, patient records may have been missing.

Conclusion

Trauma is the most common emergency encountered by physicians managing critically ill patients. In the aftermath of disasters, many patients must be managed simultaneously. In trauma cases involving thoracic injury, reducing mortality and morbidity depends on prompt identification of the need for appropriate medical and surgical interventions. In the presence of traumatic PTX, HTX, or haemopneumothorax, early tube thoracostomy should be performed if the patient is symptomatic. Pulmonary contusion should be considered in blunt trauma, and pulmonary laceration should be considered in penetrating trauma. PTX and HTX persisting despite tube thoracostomy require surgical intervention. When pneumomediastinum and subcutaneous emphysema are detected, tracheobronchial injury should be suspected.

Ethics

Ethics Committee Approval: Ethical approval was obtained from the Ethics Committee for Scientific Research of University of Health Sciences Türkiye, Adana City Training and Research Hospital (approval no: 733, date: 25.09.2025).

Informed Consent: Due to the retrospective design of the study, informed consent was not obtained from the patients' relatives.

Footnotes

Authorship Contributions

Surgical and Medical Practices: İ.A., Z.Ö., C.P., Concept: K.İ., M.D.E., İ.A., Z.Ö., C.P., Design: K.İ., M.D.E., İ.A., Z.Ö., C.P., Data Collection or Processing: K.İ., M.D.E., İ.A., Analysis or Interpretation: K.İ., M.D.E., İ.A., Literature Search: K.İ., M.D.E., İ.A., Writing: K.İ., M.D.E., İ.A., Z.Ö., C.P.

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