

Thoracic trauma in children; A retrospective study for causes, diagnosis and treatments

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Abstract

Aim: To evaluate pediatric patients subjected to thoracic trauma in terms of prognosis, diagnosis and treatment. Although studies on trauma in adults are plenty, those on the pediatric population are rarely available.

Material and Methods: 261 patients who were exposed to thoracic trauma for any reason in the last 24 hours of hospital admission were included. The patients' demographic data, etiology, treatments and results were retrospectively evaluated.

Results: Our sample consisted of 85 girls and 176 boys with a mean age of 9.73 ± 5.71 (range: 1-18 years). 228 of the patients (87%) had blunt trauma, 26 (10%) had penetrating trauma, and 7 (3%) had both penetrating and blunt trauma. Rate of penetrating trauma was about 4 times higher in boys. Traffic accidents were the most common reason for traumas. The most commonly fractured ribs were the 6th-9th ribs. 75 patients (28.7%) required tube thoracostomy, and 12 required open surgery. Rigid bronchoscopy was performed in 12 patients.

Conclusion: None of the 33 patients with penetrating trauma died, contrary to the information in the literature. We found boys to be exposed to trauma more than girls (B/G: 2.07/1), albeit at different rates compared to the findings of other research. The development of rib fractures was found to be a predisposing factor for hemothorax. Hemothorax was observed in the 6th-9th ribs and in ≥ 4 rib fractures.

Keywords: Blunt; chest; haemothorax; penetrating; pneumothorax; rib fracture

INTRODUCTION

Increasing numbers in traffic accidents, occupational accidents and violence in the society have been causing a substantial increase in thoracic traumas in children. Thoracic trauma accounts for up to 35% of trauma-related deaths in the United States and encompasses a broad range of injuries that can cause significant morbidity and mortality (1). Trauma is also the primary factor for death in children up to a year old. Most cases end up with the death of the patient before reaching the hospital. Thoracic injuries constitute 25% of total deaths caused by trauma.

The impact of trauma on children differs due to their anatomical and physiological differences. There have been previous studies on thoracic traumas in children, but our study analyzes thoracic traumas in detail by 51 parameters.

The aim of this research was to retrospectively evaluate pediatric patients subjected to thoracic trauma by any

means and to address the characteristics of thoracic trauma, thus contributing to prognosis, diagnosis and treatment in children.

MATERIALS AND METHODS

Our study sample consisted of 261 pediatric patients aged under 18 years and who were exposed to thoracic trauma for any reason in the last 24 hours of admission to the Meram Medical Faculty in Necmettin Erbakan University between January 2007 and September 2017. Patients who were admitted to the emergency department and then treated on an outpatient basis were excluded from the study.

The patients' demographic data, etiology, treatments and results were retrospectively evaluated by 51 parameters. We aimed to compare our results with those of previous publications. The patients were examined by thoracic surgeons in the emergency department, thoracic surgery clinic and other clinics. Informed consent was

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signed by the parents of all patients for hospitalization and necessary interventions by thoracic surgeons. All patients had sufficiently documented information about their medical history.

Patients were diagnosed by x-ray, computerized tomography (CT) of the thorax, ultrasonography, echocardiography and barium radiographs after physical examination. Routine complete blood counts and biochemistry tests were performed, and the patients were monitored when necessary.

Oxygen nebulization with bronchodilators (Salbutamol sulfate and ipratropium bromide) and inhaled steroids were used for bronchodilation. Pain management was done effectively with parenteral paracetamol and systemic opioids (tramadol HCl). Methylprednisolone sodium succinate was given for anti-inflammation. After the treatment, the patients were evaluated by clinicians at the time of discharge.

Approval was obtained from the local ethics committee. The data were analyzed using the Statistical Package for Social Sciences (SPSS) V16.0 for Windows. Descriptive statistics are given as mean ± standard deviation and frequency and percentage.

RESULTS

The patients consisted of 85 girls (32.6%) and 176 boys (67.4%) with a mean age of 9.73±5.71 (range: 1-18 years). Girls had a mean age of 8.52±5.58, while boys had a mean age of 10.32±5.7 (p<0.005) (Table 1). Two hundred and twenty-eight of the patients (87%) had blunt trauma, 26 (10%) had penetrating trauma, and 7 (3%) had both penetrating and blunt trauma. Eighty-one of the girls (95%) and 154 of the boys (87%) had blunt trauma. Four of the girls (%4.7) and 29 of the boys (16.4%) had penetrating trauma. Rate of penetrating trauma was about 4 times higher in boys (p<0.001).

	N	%	Mean age (Years)	Min-max age (Years)
Girl	85	%32.6	8.52 ± 5.58	1-18
Boy	176	%67.4	10.32 ± 5.7	1-18
Total	261	%100	9.73 ± 5.71	1-18

Traffic accidents were the most common reason for traumas. 129 patients (49.4%) had traffic accidents, 75 (28.7%) fell from a height, and 24 (9.1%) had iatrogenic reasons for thoracic trauma. Animal traumas, bike and work accidents, weapon and penetrating tool traumas and suicides were some other reasons of thoracic traumas (Figure 1). Eighty-two of all traffic traumas were pedestrian traffic accidents, and 47 were motor vehicle accidents. Although pedestrian traffic accident rate was higher for boys (B:35.2%, G:23.0%), motor vehicle accident rate was higher for girls (B:12.5%, G:29.4%)

(p<0.005). However, causes of injuries were similar between boys and girls. All work accidents, suicides and animal traumas were seen in boys (p>0.1).

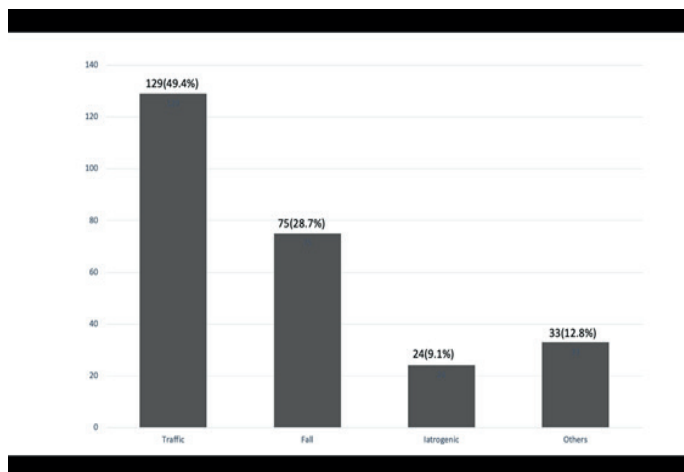


Figure 1. Causes of trauma

One hundred and ten patients had pneumothorax (42.1%), 45 had hemothorax (17.2%), and 32 had hemopneumothorax (12.3%). Chylothorax and tension pneumothorax were seen only in one boy patient (0.4%). Pneumothorax, hemothorax and hemopneumothorax rates were similar between boys and girls.

Forty-two patients (16.1%) had rib fractures, 5 of which (1.9%) had flail chest. Other bone fractures were clavicle (29 patients), sternum (3 patients) and scapula (3 patients). Bone fractures and flail chest rates were similar in boys and girls (Table 2). The most commonly fractured ribs were the 6th-9th ribs in 14 patients (5.4%). 6 patients (2.3%) had more than 4 fractured ribs. Children with hemothorax and hemopneumothorax had their 6th-9th ribs fractured and had more than 4 rib fractures.

	Girl(n)	Boy(n)	Total(n)
Rib fracture	15	27	42
Rib fracture %	17.6	15.3	16.1
Clavicle fracture	12	17	29
Clavicle fracture %	14.1	9.6	11.1
Sternum fracture	1	2	3
Sternum fracture %	1.1	1.1	1.1
Scapulae fracture	0	3	3
Scapulae fracture %	0	1.7	1.1
Flail chest	2	3	5
Flail chest %	2.3	1.7	1.9

One hundred and seventy-seven patients had thoracic trauma with additional organ injuries, 33 of which had rib fractures. Head injury was the most common trauma in this group with 67 patients. Other associated extra thoracic injuries were extremity traumas in 26 patients (10%) and abdomen traumas in 20 (7.7%) (Table 3).

Additional trauma	(n)	Percentage(%)
None	84	32.2
Head	67	25.7
Abdomen	20	7.7
Pelvis	6	2.3
Extremity	26	10.0
Head+extrm	17	6.5
Head+abdom	8	3.1
Head+pelvis	5	1.9
Abdom+ext	3	1.1
Multitrauma	15	5.7
Pelvis+extrm	6	2.3
Vertebrae	3	1.1
Head+verteb	1	.4
Total	261	100.0

Seventy-five patients (28.7%) required tube thoracotomy, and 12 required open surgery. Right thoracotomy was used to repair a right main bronchial rupture in one patient who fell from a tractor and a tracheal rupture after intubation in another patient. Left pneumonectomy was performed in a patient who had extensive lung and vascular damage after a gunshot injury. Lung and diaphragmatic repair and hematoma evacuation were performed in other patients exposed to trauma. Surgery requirement rates were similar between boys and girls. Rigid bronchoscopy was performed in 12 patients. Bronchoscopy was most frequently performed for atelectasis that developed after suicide, traffic accident and gunshot injury. Other patients underwent bronchoscopy due to tracheobronchial evaluation and prolonged air leak. Thirty-two patients died due to thoracic trauma. Nine patients died in isolated thoracic traumas, and two patients were sent to other hospitals for various reasons. One was a donor for organ transplantation. In the extra thoracic trauma group, 22 patients died, and 5 were sent to other hospitals for various reasons. 31 patients died of blunt trauma, one of which was a donor for organ transplantation. There was no mortality in patients with penetrating trauma ($p < 0.001$).

Lung contusion was seen in 153 patients. One hundred forty-seven of the 235 patients with blunt trauma had

lung contusion. The mean ages were 9.37 ± 5.66 in patients with blunt trauma and 12.12 ± 5.18 in patients with penetrating trauma. The mean ages were 10.64 ± 5.50 in the 47 patients exposed to motor vehicle traffic accidents (1-18 years) and 11.40 ± 4.80 in the 82 patients exposed to pedestrian traffic accidents (3-18 years). Mean hospital stay was 4.39 ± 4.2 days (0-26 days), and mean time in intensive care unit was 3.15 ± 3.42 days (0-21 days). Mean hospital stay and intensive care unit stay times were similar between isolated/non-isolated thoracic traumas. The overall mortality rate was found to be 12.6% in our study. Deaths were most commonly seen at the mean age of 9.73 ± 5.71 . Mean age of death was lower in girls.

DISCUSSION

Increasing numbers in traffic accidents, occupational accidents and violence in the society have been causing a substantial increase in thoracic traumas in children. Cevik et al. reported that 87.5% of their patients had blunt trauma, and the remaining 12.5% had penetrating trauma. (2) Their rates were similar in our study, where 87% of the patients had blunt trauma, 10% had penetrating trauma, and 3% had both penetrating and blunt trauma. Rate of blunt thoracic trauma was relatively higher in girls compared to boys (G/B: 1.1/1), but rate of penetrating thoracic trauma was significantly higher in boys (G/B: 1/4.1) ($p < 0.001$). Mean age of exposure to trauma was relatively higher in boys than girls (G/B: 8.52/10.32). Blunt thoracic trauma was often seen in infancy and childhood, but penetrating thoracic trauma was more common in adolescents (3). Turan et al. reported that 57.4% of their patients with blunt trauma were younger than 9 years, and 66.7% with penetrating trauma were older than 9 years (4). We think these rates may be associated the individual behaviors of younger children.

In our study, 235 patients had blunt trauma with a mortality rate of 13.6%. None of the 33 patients with penetrating trauma died, contrary to the information in the literature ($p < 0.001$). We think that this difference was due to the sufficiency in reaching the hospital and emergency conditions and early and accurate intervention to the patients. Our hospital is located in a big city, although there is no difficulty in transportation. However, patients in the surrounding cities are referred to our tertiary health care facilities for treatment. This leads to an increase in the mortality and morbidity rates.

In our study, the most common form of trauma was traffic accidents, similar to other studies (49.4%). Eighty-two patients were exposed to pedestrian traffic accidents, and 47 were exposed to motor vehicle traffic accidents. Mean ages were 11.4 years for patients exposed to pedestrian traffic accidents and 10.64 years for those exposed to motor vehicle traffic accidents. These values were not statistically significant ($p > 0.10$). The second most common form of trauma was fall from heights (28.7%), followed by

iatrogenic causes (9.1%). While the rate of exposure to pedestrian traffic accidents was higher in boys than girls (B/G: 35%/23%), the rate of exposure to motor vehicle traffic accidents was higher in girls (B/G: 12.5%/29.4%). Ceran et al. reported that boys were exposed to trauma more than girls (B/G:7.5:1) (5). This rate was 1.6/1 in the study of Cevik et al. (6). Although our rates were different from other studies, we also found boys to be exposed to trauma more than girls (B/G: 2.07/1) ($p<0.001$)(7). We think that this was due to the socio-cultural structure of our city. Boys are more active in both social and working life and take more risks in their behaviors within the city. All patients exposed to animal trauma, suicide, work and bicycle accidents were boys.

Thoracic trauma is known to occur highly with multi-trauma in children. Therefore, it should be examined in detail with other systems in patients with thoracic trauma. Physical examination must be performed with the required radiological and laboratory tests during the evaluation in emergency services. Eichelberger reported that 82% of thoracic trauma cases were seen with multiple trauma and that the most common additional injury was head trauma (3). The rate of exposure to multi-trauma was found to be 52.5% in the study of Turan et al. (4). In this study, the most common type of additional injury was extremity trauma (20%), followed by abdominal trauma (17.5%) and head trauma (12.5%). In the study of Cevik et al., abdominal trauma was most frequently associated with thoracic trauma at a rate of 66%, followed by extremity trauma (65%)(2). In our study, the most common type of additional injury was head injury (25.7%), followed by extremity trauma (10%). We think that this variation from the literature may have been due to our clinic being in a tertiary health care institution, as most patients who need mechanical ventilation are directed to our hospital in the city. Being a university hospital also enables us to communicate more closely with other clinics, and consultations can be resolved very quickly. Only two of the isolated thoracic trauma patients were referred voluntarily.

The energy due to thoracic trauma reflects to parenchyma in intrathoracic organs without any division and often causes lung and myocardial contusion due to inadequate ossification and a high ratio of cartilage in the thoracic structure of children, unlike adults. Therefore, patients should be evaluated carefully in terms of myocardial and lung contusion, especially after blunt trauma. Chest x-ray and CT of the thorax should be performed on suspicion of lung contusion, but the diagnostic accuracy of x-ray is limited in the evaluation of acute trauma of the truncal skeleton (8). Despite frequent oxygen saturation follow-up, respiratory distress may not be recognized until a blood gas test in children. Therefore, it is extremely important to analyze the blood gas test of each child in thoracic trauma. Pulmonary contusion is the most common chest injury in children, occurring in more than half of all blunt chest traumas (9). In our study, lung contusion was seen in 153

patients (58.6%), 31 of which had rib fractures. In patients with lung contusion, the most commonly fractured ribs were the 6th-9th ribs. Rib fractures were seen in 9 of the 84 patients with isolated thoracic trauma, and the most commonly fractured ribs were the 3rd-9th. 177 patients had thoracic trauma with additional organ injuries, 33 of which had rib fractures. The most commonly fractured ribs were the first-5th in this group. The most commonly seen organ injury was head trauma, similar to the other studies. In children, rib fractures are the most commonly seen thoracic wall injuries due to trauma (10). Rib fractures may occur by direct impact or by anteroposterior compression to the chest wall (11). In our study, rate of rib fracture was found to be 16.1%. The risk of mortality and incidence of multisystem injury increase with the number of fractures (12,13). The first 3 ribs are protected by the scapula, the humerus and the clavicle, so a significantly major blow is required to break them. Fracture of the first and second ribs are rare but may be associated with serious damage to the cervical vertebrae, intrathoracic vessel, head and facial injuries (14,15,16,17). In our study, the most commonly fractured ribs were the 6th-9th, and the first two ribs were fractured in 4 patients, similar to the literature.

In a retrospective study of 262 patients with flail chest, the rate of patients aged 0-14 years was found to be 2% (18). In our study, the rate of flail chest after thoracic trauma was 1.9% (5 patients), similar to other studies. One study found that surgical fixation is associated with good outcomes for flail chest in adults (19). The medial epiphysis ossifies later than the rest of the clavicle, beginning at the age of 12-19, and may not completely fuse until the age of 22-25. (20). As a result, injury is typically observed in the medial clavicle. In our study, clavicle fracture was observed in 29 patients (11.11%). Sternum fractures are rare but are often associated with serious damage such as traffic accidents. Common injuries related with lap and shoulder seat belt include contusion of the chest wall and spinal, abdominal and pelvic injuries.(21). In our study, one girl and two boys had sternum fracture (1.1%), similar to other studies. Scapula fractures are rare in children (22). In an epidemiologic and prognostic study, injured children with blunt scapular fracture were found to have a 10-fold greater risk of having a great vessel injury compared to children without scapular fracture (23). Anatomic position, chest wall compliance and surrounding muscles protect the scapulae. As a result, the scapulae require significant force to break. In our study, all of the three patients with scapulae fractures were boys (1.1%). Sternum and scapulae fractures caused by major trauma occur more frequently in boys, although this difference is not statistically significant.

Pleural space is a potential gap for pneumothorax, hemothorax, pleural effusion and chylothorax. In a study on 104 children younger than 15 years old, the mortality rate was 57.1% in 14 cases with hemothorax and 26% in

15 cases with hemopneumothorax. The study reported that many of these children had other severe extra thoracic injuries (13). Penetrating injuries are also seen with increasing frequency in children. Although shooting and stabbing are considered as a model of adult behavior, their incidence occupies a significant place (27). In our study, hemothorax occurred in 45 patients (17.2%), and hemopneumothorax occurred in 32 (12.3%). There was no significant difference between boys and girls in terms of hemothorax development. Chylothorax occurred in one boy, and none of the girls had chylothorax. Chest tube was used for drainage in 32 of the 45 patients with hemothorax and 29 of the 32 patients with hemopneumothorax. Among the 42 patients with rib fractures, hemothorax occurred in 14, and hemopneumothorax occurred in 10. The development of rib fractures was found to be a predisposing factor for hemothorax. Hemothorax was observed in the 6th-9th ribs and in ≥ 4 rib fractures.

Unlike recent studies, none of our 8 patients with the first and second rib fractures had hemothorax. The most common invasive treatment method was tube thoracotomy in thoracic trauma. Tube thoracotomy was performed in 75 patients (28.7%), while 12 required open surgery. Rigid bronchoscopy was performed in 12 patients. Surgery requirement rates were similar between boys and girls. In the study of Cevik et al., 78% of the patients were treated conservatively, and 20% required tube thoracotomy, where thoracotomy was performed only in one patient (2). A review study suggested that emergency department thoracotomy (EDT) should be withheld in patients aged 0-14 years and presenting with no signs of life following blunt trauma (25). Shafi et al. evaluated 5 major trauma centers during the last decade and identified that EDT was performed in only 13% of patients when indicated (26). Trauma is also the primary factor for the death of children up to one year old. The mortality rate is about 15% in isolated chest traumas. In our study, mortality rate was 12.6%, which is low compared to other studies. We had a mortality rate of 11.9% in isolated chest traumas and up to 12.4% in additional system injuries. We believe that this decrease was due to the improved intensive care in our hospital. In a study that retrospectively evaluated 140 patients with thoracic trauma, Bellone et al. reported that only 10 patients were admitted to the intensive care unit due to clinical and radiological deterioration (27). The impact of trauma differs among children due to their anatomical and physiological differences. Although studies on trauma in adults are plenty, studies on the pediatric population are rarely available.

CONCLUSION

Patients with thoracic trauma should be examined in detail with other systems. Since head trauma can be observed in a quarter of patients with thoracic trauma, brain imaging is particularly required. The development of rib fractures was found to be a predisposing factor for hemothorax. Quickly

reaching the hospital and early and accurate intervention to patients reduce mortality and morbidity rates. We think that operable trauma patients can have better outcomes. Our study showed that mortality rates due to external causes were high in patients aged 10-18 years, while iatrogenic mortality rates were common before 4 years of age. Thoracic surgeons involved in pediatric trauma care should be knowledgeable about the age-specific anatomy of children. .

Conflict of interest: The authors declare that they have no competing interest.

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Ethical approval: This study was performed with the approval of the local ethics committee in Necmettin Erbakan University.

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