Study of 433 Operated Cases of Thoracic Trauma

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Abstract Patients with thoracic trauma constitute one third of all the trauma cases. Of traumatic patients, 20–25 % die because of thoracic trauma. Our aim was to compare our clinical experience and the results with the related literature. Four hundred thirty-three patients, who underwent surgical interventions due to thoracic trauma, were evaluated. The latest form of treatment applied were taken as the criteria for the quantitative detection of patients. Continuous variables were expressed as mean±standard deviation, while categorical variables were explained as number and percentage. The significance of the analysis results was evaluated using Fisher's exact test. *p* values <0.05 were considered as significant. Penetrating injuries were found in 258 (59 %) of the patients, and blunt trauma was identified in 175 (41 %). Depending on the trauma, pneumothorax was discovered in 130 patients (30.02 %), hemothorax in 117 (27.02 %), hemopneumothorax in 61 (14.08 %), pulmonary contusion in 110 (45 %), pneumomediastinum in 14 (3.23 %), and pericardial tamponade in 1 patient (0.23 %). It was demonstrated that 385 of 433 patients examined in the study underwent tube thoracostomy, 41 were treated with thoracotomy, while 6 of them underwent video-assisted thoracoscopic surgery (VATS), and 1 underwent sternotomy. No correlation was observed between mortality, morbidity, and gender and type of trauma and location of trauma (*p*>0.05). However, statistically significant correlation was found between mortality, morbidity, and the presence of concomitant injuries, the duration

between injury and admission being more than 1 h (*p*<0.05). Urgent intervention, early diagnosis, and fast transport are vital for patients with thoracic injuries.

Keywords Blunt · Penetrating · Trauma · Thorax · Tube thoracostomy · Thoracotomy

Introduction and Purpose

Thoracic trauma is divided into two parts as blunt trauma (traffic accidents, falls from height, pounding) and penetrating injuries (stab wounds, gunshot wounds). In patients with thoracic trauma, penetrating injuries occur less frequently than blunt trauma. In addition, the mortality rate is less for penetrating wounds. However, the mortality rate varies according to the mechanisms of trauma and developing organ damage after trauma. The mortality rate for stab wounds is 14–20 %. However, this rate is 1–8 % after the gunshot. The mortality rate is the highest in patients with cardiac injury. Mortality rate is around 25–28 % in the case of diaphragmatic, lung, and vascular injury after trauma [1]. In patients exposed to trauma, major surgical interventions are approximately 10 % for blunt trauma, while it is 15–30 % for penetrating thoracic trauma. In thoracic trauma, the mortality rate changes depending on the damage in the major vascular and visceral structures [2].

Symptoms developing after thoracic trauma depend on the respiratory and hemodynamic changes due to trauma. The most common pathology is hypoxia. Hypoxia develops owing to reasons such as bleeding, collapse or compression of lungs, respiratory or cardiac failure, pulmonary contusion, intrathoracic pressure changes, and mediastinal flutter. Therefore, the first response must be to ensure tissue oxygenation. The airway must be kept open, the underlying causes must be removed, and oxygen need must be met [1].

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The first and most valuable diagnostic tool in establishing the pathologies developing after thorax trauma is chest radiograph. By means of chest radiograph, subcutaneous emphysema, rib fractures, mediastinal shift, mediastinal widening, pneumomediastinum, pneumothorax, hemothorax, hemopneumothorax, changes in the lung parenchyma, and diaphragmatic pathologies can be detected. Computerized tomography is also helpful for revealing the pathology undetectable by chest X-ray. Additionally, rib fractures, sternum fractures, sternoclavicular dislocations, retrosternal hematomas, anteromedial-subpulmonic pneumothorax, pneumomediastinum, and fluid collections are easily recognizable. Computerized tomography has the advantage in the recognition of pericardial effusion and hemopericardium. In contrast tomography, vascular structures and hematomas in periaortic region can easily be evaluated. The other diagnostic methods commonly used are echocardiography for the assessment of cardiac status, contrast studies with barium for evaluating the esophagus, and endoscopic procedures (bronchoscopy and esophagoscopy). Endoscopic procedures should be performed carefully as it may increase the laceration in patients with thorax trauma [1, 2].

Supportive care such as pain control, volume replacement, antibiotics, mechanical ventilation, and surgical treatment methods like tube thoracostomy, thoracotomy, video-assisted thoracoscopic surgery (VATS), and sternotomy are performed in patients with thoracic trauma [1, 3–5].

The mortality rate might be reduced by means of fast recognition of the pathophysiological changes developing due to thoracic trauma, appropriate resuscitation, or simple surgery procedures. In thoracic injuries requiring emergency intervention, early diagnosis and appropriate transport are critically important.

In our study, patients with thoracic trauma admitted to our clinic and treated surgically were examined retrospectively. The results obtained are discussed with references to the literature.

Material and Method

Between January 2004 and December 2014, 433 patients, who were admitted to our clinic and underwent surgical interventions (tube thoracostomy, urgent thoracotomy, thoracotomy, VATS, sternotomy) due to thoracic trauma, were evaluated retrospectively. The results of chest trauma patients, who underwent emergency thoracotomy, were excluded because those results were used in another study of mine. Patients with chest trauma, who were evaluated in the emergency service, outpatient clinics, or other services and not treated with surgical procedures, were excluded from the study as they were not recorded because in our study, only the records of the patients operated were evaluated. All patients' files were examined.

Gender, age, injury type, trauma etiology, clinical features, associated injuries, diagnostic procedures, traumatic bone fractures such as rib, clavicle, sternum, and scapula fractures and intrathoracic pathologies, surgical procedures, complications, length of stay in intensive care unit, and duration of hospitalization were investigated in terms of mortality. Tube thoracotomies applied before thoracotomy-VATS-sternotomy were ignored (the number of the patients who were successfully treated through tube thoracostomy, thoracotomy, VATS, or sternotomy methods was determined. On the other hand, tube thoracotomies applied before the surgical procedure under general anesthesia were ignored as they affected the numbers and rates.).

During the statistical analysis, continuous variables were expressed as mean±standard deviation, while categorical variables were explained as number and percentage. The significance of the analysis results were evaluated using Fisher's exact test. *p* values <0.05 were considered as significant.

Findings

The average age of the patients was 44.7 (8–73). Penetrating injuries were most frequently seen between the ages of 20–40, whereas blunt injuries were mostly encountered between the ages of 40–60 years. Fifty-eight of the patients (13 %) were female. On the other hand, 375 (87 %) of them were male. Site of injury was the right hemithorax in 180 patients (42 %) and the left hemithorax in 253 (58 %).

Penetrating injuries were found in 258 (59 %) of the patients, and blunt trauma was identified in 175 (41 %). While 79 % (*n*=204) of the penetrating injuries were stab wounds (SW), 21 % (*n*=54) were gunshot wounds (GW). As for the blunt trauma, 45 % (*n*=79) were caused by traffic accidents (TA), 43 % (*n*=76) were falling from height (FH), and 12 % (*n*=20) were assault (A). The most frequent cause of trauma was stab wounds.

Most common complaints were shortness of breath and chest pain. During physical examination, tenderness was detected in 42 % of patients (*n*=211), cuts in various places on the body in 47 % (*n*=204), bullet entry and exit holes in 15 % (*n*=64), skin ecchymosis in 12 % (*n*=52), subcutaneous emphysema in 9 % (*n*=40), subcutaneous hematoma in 9 % (*n*=41), bullets under the skin in 3 % (*n*=15), and flail chest in 1 % (*n*=4).

Of our patients, 33 % (*n*=143) had rib fractures, 8 % (*n*=34) of them suffered from clavicle fracture, 3 % (*n*=12) of them had sternum fracture, and 2 % (*n*=8) experienced scapula fracture.

Depending on the trauma, pneumothorax was discovered in 130 patients (30.02 %), hemothorax in 117 (27.02 %), hemopneumothorax in 61 (14.08 %), pulmonary contusion

in 110 (45 %), pneumomediastinum in 14 (3.23 %), and pericardial tamponade in 1 patient (0.23 %) (Fig. 1).

It was demonstrated that 385 of 433 patients examined in the study underwent tube thoracostomy (SW: 172, GW: 48, TA: 75, FH: 70, A: 20), 41 of the patients were treated with the standard posterolateral thoracotomy (SW: 27, GW: 4, TA: 4, FH: 6), while 6 of them underwent VATS (SW: 4, GW: 2), and 1 underwent sternotomy (SW: 1) (in the next 6 h after the hospitalization (1–6)). It was found that operations under general anesthesia such as thoracotomy, sternotomy, and VATS were performed in the operating rooms, while the tube thoracostomies under local anesthesia were performed in the emergency rooms or intensive care units.

When surgical procedures, conducted in patients who were operated, were evaluated, the most common procedures were lung parenchyma laceration repair in 23 patients (48 %), intercostal artery repair in 9 (19 %) patients, diaphragmatic repair in 4 patients (8 %), splenectomy in 3 patients (6 %), RIMA ligation in 2 patients (4 %), lobectomy in 2 patients (4 %), liver repair in 2 patients (4 %), gastric repair in 2 patients (4 %), column repair in 2 patients (4 %), ventricle repair in 1 patient (2 %), and LIMA repair in 1 patient (2 %) (Fig. 2).

The most common complication in our patients was atelectasis (5 %, $n=18$). These patients performed breathing exercises, and secretions were aspirated by applying fiber optic or rigid bronchoscopy. The second most frequent complication was empyema (3 %, $n=6$) and pneumonia (3 %, $n=6$).

Mortality rate in our study was 0.92 % ($n=4$). It was identified that all patients were received to emergency operation in more than 1 h, and they had concomitant injuries apart from thoracic ones. The duration of hospital transportation for the patients who died was more than 1 h. On the other hand, the hospital transportation and admittance time for the patients who survived was less than 1 h and was approximately half an hour (Table 1).

In the evaluation of patients who underwent thoracotomy/sternotomy/VATS, variables such as gender, type of trauma, presence of concomitant injuries, hospital transportation time, and the location of trauma were used. No correlation was

Fig. 1 Intrathoracic pathology occurs after trauma

Fig. 2 The surgical procedures performed on the operation

observed between mortality, morbidity, and gender (p value: 0.522) and type of trauma (p value: 0.999) and location of trauma (p value: 0.1212) ($p>0.05$). However, statistically significant correlation was found between mortality, morbidity, and the presence of concomitant injuries (p value: 0.006), the duration between injury and admission being more than 1 h ($p<0.05$) (p value: 0.0025) ($p<0.05$) (Table 2). Our patients' average length of stay including intensive care was 8 days.

Discussion

Patients with thoracic trauma constitute about one third of patients coming to the emergency service due to trauma. These rates were reported as blunt 72 % and penetrating 28 % by Battistella et al. [6]. In our study, the rate of blunt trauma was 41 %, and penetrating thoracic trauma rate was determined as 59 % as the patients in our study were only patients who underwent surgical treatment and the majority of them suffered penetrating injuries.

Symptoms developing after trauma depend on respiratory and hemodynamic changes related to trauma. The most commonly experienced pathology was shortness of breath depending on hypoxia. Hypoxia was caused by reasons such as bleeding, lung collapse or compression, respiratory or cardiac failure, pulmonary contusion, intrathoracic pressure changes, and mediastinal flutter. So, the first response must be to ensure the tissue oxygenation. Airway must be kept open, underlying causes must be removed, and oxygen needs must be met [1].

It was reported that the rate of rib fractures was over 50 %, and these fractures caused pain in the patients with thoracic trauma [7, 8]. Yoruk et al. stated that clavicle fractures were 24 (10 %), sternum fractures were 8 (3.3 %), and scapula fractures were 4 (1.7 %) in the series of 239 patients [9]. In our cases, the rate of rib fractures were 33 % ($n=143$), clavicle fracture was 8 % ($n=34$), sternum fracture was 3 % ($n=12$), and scapular fracture was 2 % ($n=8$). Low rate was due to the low number of blunt trauma patients enrolled in the study.

It was reported that the most frequent intrathoracic complications of thoracic trauma were hemothorax, pneumothorax, and hemopneumothorax [10, 11]. According to this study, the rate of intrathoracic injuries was 26.3 % for pneumothorax,

Table 1 Analysis of patients undergoing thoracotomy/VATS/sternotomy

Localization	Number of patients	M/F	Associated injuries	Number of patients	ex
Right (SW)	12	M/F: 10/2	Liver laceration	2	–
			Diaphragmatic rupture	2	–
Left (SW)	20	M/F: 18/2	Spleen injury	3	1
			Diaphragmatic rupture	1	–
			Gastric injury	1	1
Right (GW)	4	M/F: 3/1	Cardiac injury	1	1
Left (GW)	2	M: 2	–	–	–
Right (Blunt)	4	M/F: 3/1	Liver contusion	1	–
Left (Blunt)	6	M/F: 5/1	Diaphragmatic rupture	1	1
			Stomach herniation	1	–
			Colon herniation	1	–
Total	48	41/7		14	4

SW stab wounds, GW gunshot wounds, M male, F female, N number

23.6 % for hemothorax, and 14.5 % for hemopneumothorax. In this study, consistent with the literature, pneumothorax was discovered in 130 (30.02 %) patients, hemothorax in 117 (27.02 %) patients, and hemopneumothorax in 61 (8.14 %).

In thoracic trauma, chest radiography is the first and most valuable diagnostic method. In cases such as pericardial effusion and hemopericardium, computed tomography has an advantage. Echocardiography and endoscopic procedures (bronchoscopy, esophagoscopy) are the other diagnostic methods. Endoscopic procedures should be performed carefully as it may increase the chest laceration in patients with thoracic

trauma [1, 2]. In our study, chest radiography and computed tomography were used as the primary diagnostic tools.

In thoracic trauma patients, treatment options change according to the clinical condition of the patient. During the support therapy, painkillers are used for pain, which is one of the primary problems encountered. On the other hand, antibiotics are generally used in patients undergoing tube thoracostomy or after the penetrating thoracic trauma. Grover et al. [3] demonstrated that the incidence of pneumonia, empyema, and fever might be reduced by giving clindamycin to patients for 5 days, and at 6 hours intervals. All of our patients were given antibiotic treatment and painkillers. Despite this, empyema was observed in six patients. Moreover, it was seen that six patients also developed pneumonia.

Wilson et al. stated that the need for intubation in patients with chest trauma was 11 %, and the mortality rate for these patients was 58 % [4]. The indications for intubation include pathologies such as large parenchymal injury, acute respiratory distress syndrome, flail chest, and multiple injuries. Supporting mechanical ventilation contributes to the stabilization of the chest wall and the normalization of the damage in parenchyma. In our study, there were no patients requiring follow-up with intubation.

Tube thoracostomy is the most commonly performed surgical procedure in patients with chest trauma. It is in order to drain the air or fluid accumulation in the chest cavity. Bilateral anterior thoracotomy (clamshell incision) is the most useful thoracotomy method used in patients with trauma [12]. This method is the most commonly used thoracotomy incision for immediate intervention or resuscitation. Median sternotomy is applied in suspected cardiac or vascular injury cases after thoracic trauma. Video-assisted thoracoscopic surgery (VATS) is a commonly used method in patients who develop hemothorax after the trauma and suffer from residual hematoma in spite of the application of tube thoracostomy [13]. In our study, it was found that 41 patients underwent posterolateral

Table 2 Outcome analysis of prognostic factors in patients treated with thoracotomy/VATS/sternotomy

Variable	Outcome	Alive/Dead	P value
Sex			
Male	41	38/3	0.522
Female	7	7/1	
Total	48	45/3	
Type of chest trauma			
Blunt	10	9/1	0.999
Penetrating	38	35/3	
Total	48	44/4	
Associated injury			
Present	14	11/4	0.006
Not present	34	34/0	
Total	48	44/4	
Duration between injury and arrival			
<1 h (approximately 30 min)	36	36/0	0.0025
>1 h	12	8/4	
Total	48	44/4	
Location of chest trauma			
Right	20	19/1	0.6309
Left	28	25/3	
Total	48	44/4	

thoracotomy, 1 patient underwent sternotomy, and 6 patients underwent VATS. Anterolateral thoracotomy was not preferred because the patients admitted to our study did not require emergency service thoracotomy and any resuscitation. Sternotomy was performed to the patients with suspected cardiac injuries. Thoracoscopic surgery was performed on patients with suspected diaphragmatic injury.

Washington et al. found the survival in isolated thoracic trauma patients as 95 %, and it was 53 % when associated injuries were present [14]. In our study, different organ injuries existed in 14 patients with concomitant injuries. Although the liver, diaphragm, stomach, colon, and ventricle repairs were performed, it was shown that four patients lost organs (lobectomy in two patients, splenectomy in two patients).

The mortality rate in thoracic trauma was 15.5 % in the study by Shore et al. [15] and 7 % by Gopinath et al. [16]. The morbidity rate was declared as 36 % by Shore et al. [15] and 4.6 % by Cakan et al. [7] in the series of 987 cases. It was reported that in the case of concomitant injuries, the rate of mortality increased [1]. Mortality rate in our study was 0.92 % ($n=4$). All non-survivors were received after more than 1 h and they had concomitant injuries. In the assessment of patients who underwent thoracotomy/sternotomy/VATS, variables such as gender, type of trauma, existence of concomitant injuries, the time of transportation, and the location of trauma were used. No correlation was found between mortality, morbidity and gender (p value: 0.522), type of trauma (p value: 0.999), and location of trauma (p value: 0.1212) ($p>0.05$). On the other hand, a statistically significant correlation was found between mortality, morbidity, and the existence of concomitant injuries (p value: 0.006), the duration between injury and admission being more than 1 h (p value: 0.0025) ($p<0.05$).

The mortality rate might be reduced by means of early recognition of the pathophysiological changes developing due to thoracic trauma, appropriate resuscitation, and simple surgical procedures. Fast transport, early diagnosis, and urgent intervention are vital for the patients with thoracic injuries.

Compliance with Ethical Standards

Source of Funding This study was not funded by any department.

Conflict of Interest The authors declare that they have no competing interests.

Ethics Approval Our retrospective study has been approved by the Ethics Committee of Dicle University of Medicine (Confirmation number: 117).

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