ORIGINAL ARTICLE

Factors affecting mortality in patients with traumatic diaphragmatic injury: An analysis of 92 cases

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ABSTRACT

BACKGROUND: This study aims to investigate the factors associated with mortality in patients with traumatic diaphragmatic rupture (TDR).

METHODS: The records of patients who were operated on at a single hospital with the indication of blunt or penetrating thoracoabdominal injuries between January 2010 and June 2018 and who were perioperatively diagnosed with a diaphragmatic injury were evaluated retrospectively. The details of demographic characteristics, the type and localization of the trauma, presence and number of associated organ injuries, vital signs at admission, time from admission until surgery, type of operation, type of diaphragmatic repair, therapeutic approach, complications and Injury Severity Score (ISS) were analyzed.

RESULTS: A total of 92 patients were included in this study. The mortality rate throughout the postoperative period was 15.2%. A penetrating injury was detected in 77.2% of the patients. Associated organ injury was most frequently in the liver, which was significant as a factor that increased mortality (p=0.020). The mortality rate was significantly lower among patients who underwent repair of diaphragmatic rupture when compared with untreated patients (p=0.003). Atelectasis was the most common complication. An ISS ≥24 points in patients with TDR was found to be an independent risk factor associated with mortality (p=0.003).

CONCLUSION: Other organs are frequently involved in cases of TDR, and mortality increased significantly in cases with associated liver injury. An ISS of ≥24 was determined to be an independent risk factor associated with mortality. Since the main determinant of mortality was the presence or absence of additional organ injuries, it is important that this should be taken into consideration in these patients.

Keywords: Blunt and penetrating trauma; diaphragmatic injury; thoracoabdominal injury.

INTRODUCTION

Traumatic diaphragmatic rupture (TDR) usually arises from blunt thoracoabdominal trauma (such as traffic accident, falling from a height, crush injury) or penetrating trauma (such as sharp object injuries, gunshot wounds). Rarely, TDR may also occur as a result of childbirth, severe vomiting, severe cough, weight lifting, or iatrogenic injuries.[1,2] Although the incidence of TDR is not fully known due to masking or organ trauma being overlooked in the larger clinical picture, the incidence has been reported as 1% to 7% in cases of blunt trauma, and 10% to 15% in cases of penetrating trauma.[3–5]

Diaphragmatic injuries can be insidious and without any symptoms. It is typically not dominant in the clinical picture of trauma patients.[6,7] Some 7% to 66% of patients with a blunt diaphragmatic rupture are not diagnosed at admission and are followed up with conservative treatment.[8] This may be related to associated morbidity and mortality. It has been reported that 7% of the patients with penetrating thoracoabdominal trauma may have diaphragmatic injury.[9] The

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increased tendency for conservative treatment of blunt and penetrating abdominal trauma may result in delays in the diagnosis of diaphragmatic injury. However, the use of imaging methods can increase the possibility of diagnosis.

A multidisciplinary approach saves lives because of the possibility of injury to both intrathoracic and abdominal organs. The preferred first approach in the presence of hemodynamic instability is laparotomy.[10] In patients with penetrating or blunt trauma, the diaphragmatic injury may be associated with other organ injuries.[11,12] It has been reported that one-third of patients underwent laparotomy in the early period due to other organ injuries, and the injury to the diaphragm was noticed and repaired intraoperatively.[13] In the literature, the reported mortality rates related to blunt and penetrating thoracoabdominal injury range from 7.8% to 32.1%.[5,12,14] This study aims to investigate factors associated with mortality in patients with TDR.

MATERIALS AND METHODS

This research was a descriptive and analytical retrospective study of the patients who were operated on with the indication of a blunt or penetrating thoracoabdominal injury between January 2010 and June 2018 and were perioperatively diagnosed with a diaphragmatic injury. The present study was approved by the ethics committee of our hospital (2018/514/144/8).

The patient information was obtained from the hospital database. Details of the demographic characteristics of the patients, the type of injury (blunt/penetrating), lateralization of the trauma (right, left, bilateral), presence of associated organ injury (liver, spleen, hollow organ, pancreas, kidney), number of additional organ injuries (none, 1, 2, 3), the patient's blood pressure at the time of admission (normotensive, hypotensive, shock), the timing of surgery (within the first 2 hours, 2-24 hours, more than 24 hours after admission), type of operation (laparotomy, thoracotomy, thoracolaparotomy, laparoscopic exploration), diaphragmatic repair (non-repair, primary repair, repair with mesh), therapeutic approach (transdiaphragmatic aspiration, thoracic drainage) and complications (atelectasis, pneumonia, empyema, bile fistula) were evaluated. An Injury Severity Score (ISS) was calculated for all of the patients. The primary focus of this study was mortality-related factors.

Statistical Analysis

IBM SPSS Statistics for Windows, Version 20.0 (IBM Corp., Armonk, NY, USA) was used to calculate a t-test for age and ISS, as well as a chi-square test for the other variables. Posthoc tests (Bonferroni, Tukey) were performed for comparisons between groups. Normally distributed data were defined by mean±SD (? X±s) and analyzed using t-tests. Data with a non-normal distribution were defined using the median and interval and analyzed with the Mann-Whitney U test. Numerical data were analyzed using a chi-square test or Fisher's exact test, as necessary. The normality of the data was analyzed using the Kolmogorov-Smirnov test.

RESULTS

A total of 92 patients who underwent surgery for a blunt or penetrating thoracoabdominal injury between January 2010 and June 2018 and had a perioperative diaphragmatic injury detected were included in this study. Of these patients, 81 (88%) of them were male and 11 (12%) of them were female; the overall mean age was 34.98 years (±14.681 years). The mortality rate throughout the postoperative period was 15.2%. A penetrating injury (n=71; 77.2%) was more common than a blunt injury (n=21; 22.8%). However, there was borderline significance for a blunt trauma association with mortality (p=0.052). The localization of the trauma was specified as unrelated to the lesion in three cases (3.3%), to the right of the midline in 26 (28.3%) cases, left of the midline in 54 (58.7%), and bilateral in 9 (9.8%) cases. The mortality rate was significant in patients with left-sided and bilateral injuries (p=0.012).

The most frequent organ injury involved the liver (n=35; 29.4%), followed by a hollow organ (n=33; 27.7%) and the spleen (n=30;25.2%). A liver injury was a statistically significant factor that increased mortality (p=0.020). Fifteen (16.3%) patients had isolated diaphragmatic injuries. The mortality rate was significantly higher in patients with a single-organ injury accompanying diaphragmatic injury (n=52; 56.5%). Patients who were hypotensive and in shock at admission had a higher rate of mortality. The mean ISS score was 19.12±6.890 points (range: 9–38 points). The mean ISS score was 18.21 points (±6.350 points) among the patients who survived and 24.21 points (±8.346 points) among the patients who died (p=0.001). Fifteen (19.2%) patients who survived and eight (57.1%) deceased patients had an ISS score of ≥24 (Table 1). An ISS score of ≥24 points in TDR patients was determined to be an independent risk factor associated with mortality (p=0.003) (Table 1).

The approach to the diaphragmatic injury applied was primary repair in 81 (88.0%) patients, two (2.2%) patients had a mesh repair, and seven (7.6%) patients did not undergo any repair. Non-repaired patients were either patients undergoing damage control surgery or with small lacerations that were difficult to reach behind the liver dome. Two patients (2.1%) died during the perioperative period and were excluded from the evaluation of diaphragm repair. The mortality rate was significantly lower in patients who underwent diaphragm repair (p=0.003). Drainage with a thoracic tube was performed in 79 (85.9%) patients and transdiaphragmatic pleural aspiration in 11 (12%) patients. The emerging complications observed were atelectasis (n=11; 11.9%), pneumonia (n=5; 5.4%), empyema (n=5; 5.5%) and biliary fistula (n=1; 1%). The pa-

Table 1. Mortality-related factors in patients with diaphragmatic rupture

	Survived	Exited	Total	p
Age (years), mean±SD	34.12±14.265	39.79±16.558	34.98±14.681	0.405
Gender				0.771
Male	69 (88.5)	12 (85.7)	81 (88.0)	
Female	9 (11.5)	2 (14.3)	11 (12.0)	
Trauma, n (%)				0.052
Blunt	15 (19.2)	6 (42.9)	21 (22.8)	
Penetrating	63 (80.8)	8 (57.1)	71 (77.2)	
Laterality, n (%)				0.004
No lesion	3 (3.8)	0	3 (3.3)	–
Right-sided	19 (24.4)	7 (50.0)	26 (28.3)	0.06
Left-sided	51 (65.4)	3 (21.4)	54 (58.7)	0.012
Bilateral	5 (6.4)	4 (28.6)	9 (9.8)	0.012
Diaphragmatic lesion				0.0358
Right-sided	27 (34.7)	6 (42.8)	33 (35.9)	
Left-sided	48 (61.5)	7 (50.0)	55 (59.8)	
Bilateral	3 (3.8)	1 (7.1)	4 (4.3)	
Associated organ injury, n (%)				0.001
None	15 (16.3)	0	15 (12.6)	–
Liver	25 (27.2)	10 (10.9)	35 (29.4)	0.020
Hollow organ	24 (26.1)	9 (9.8)	33 (27.7)	0.318
Spleen	24 (26.1)	6(6.5)	30 (25.2)	0.339
Vascular	3 (3.3)	0	3 (2.5)	–
Pancreas	1 (1.1)	1 (1.1)	2 (1.7)	0.472
Kidney	0	1 (1.1)	1 (0.8)	–
Additional organ injury, n (%)				0.015
None	15 (19.2)	0	15 (16.3)	–
1	48 (61.5)	4 (28.6)	52 (56.5)	0
2	10 (2.8)	4 (28.6)	14 (15.2)	0.15
3	5 (6.4)	6 (42.9)	11 (12.0)	0.201
Injury Severity Score, mean±SD	18.21±6.197	24.21±8.478	19.12±6.890	0.001
Injury Severity Score >24, n (%)	15 (19.2)	8 (57.1)	23 (25.0)	0.003
Blood pressure at admission				0
Shock	3 (3.8)	4 (28.6)	7 (7.6)	0
Hypotensive	43 (55.1)	10 (71.4)	53 (57.6)	0.034
Normotensive	32 (41.0)	0	32 (34.8)	–

SD: Standard deviation.

tient who developed biliary fistula underwent bile duct repair surgery on the sixth postoperative day. Two (2.2%) patients died during surgery, and 12 (15.2%) patients died during the postoperative period (Table 2).

DISCUSSION

Diaphragmatic rupture is likely in most penetrating thoracoabdominal injuries.[4,12] However, early diagnosis of penetrating diaphragmatic injuries can be quite difficult. Early diagnosis is typically made either during the detection of a large defect and exploration for a herniation or an accompanying organ injury. In patients with a diaphragmatic injury and a small defect, this condition may be missed more frequently and may have dangerous outcomes.[11,15] In these patients, occlusion/ischemia of hollow visceral organs in the long term, generally due to herniation, and respiratory failure/ischemia

Table 2. Surgical outcomes of diaphragmatic rupture patients

	Survived	Exited	Total	p
Timing of the surgery				0.015
0–2 hours	47 (60.3)	14 (100.0)	61 (66.3)	0
2–24 hours	15 (19.2)	0	15 (16.3)	–
>24 hours after admission	16 (20.5)	0	16 (17.4)	–
Type of surgery				0.56
Laparotomy	62 (79.5)	13 (92.9)	75 (81.5)	
Thoracotomy	1 (1.3)	0	1 (1.1)	
Thoracolaparotomy	6 (7.7)	1 (7.1)	7 (7.6)	
Laparascopic surgery	9 (11.5)	0	9 (9.8)	
Approach to the diaphragmatic rupture*				0.004
Nonrepairable	5 (6.4)	2 (14.3)	7 (7.6)	0.063
Primary repair	71 (91.0)	10 (71.4)	81 (88.0)	0.003
Prosthesis	2 (2.6)	2 (14.3)	2 (2.2)	0.025
Thoracic drainage*	70 (89.7)	9 (64.3)	79 (85.9)	0.001
Transdiaphragmatic aspiration	8 (10.3)	3 (21.4)	11 (12.0)	0.008
Complications				0.065
Atelectasis	7 (46.7)	4 (57.1)	11 (50.0)	
Pneumonia	4 (26.7)	1 (14.2)	5 (22.7)	
Empyema	3 (20.0)	2 (28.7)	5 (22.7)	
Bile fistula	1 (6.6)	0	1 (4.6)	

*2 patients exited during the perioperative period were excluded from the study.

or presentation of the patient with symptoms related to respiratory failure due to pulmonary atelectasis may be diagnostic. Diaphragmatic injury may occur in blunt trauma due to the development of a sudden pressure difference between the thorax and the abdomen or high kinetic energy caused by the trauma.[5]

Diaphragmatic injuries are rare, but they may cause diagnostic problems for surgeons. A delay in diagnosis, the presence of additional organ injury, and the severity of injury increase mortality and morbidity rates.[5,12,14] The incidence of TDR is higher in the fourth decade of life, and in young male patients.[16] Penetrating injuries are approximately twice more frequently seen relative to blunt traumas.[17] The median age of our patients was 34.98 years; 88% were male and 77.2% of them had a penetrating injury, which was consistent with the literature. It has been reported that left-sided diaphragmatic injuries are more common than injury to the right side.[16] The liver has a protective effect on the right diaphragm after blunt trauma, while the left diaphragm is congenitally weaker.[16,18] In this study, 59.9% of the diaphragmatic injuries were left-sided.

Perioperatively detected TDR was due to penetrating trauma in 77.2% and blunt trauma in 22.8% of the patients in this study. The mortality rate was 15.2%. Although patients with penetrating trauma were predominant, the mortality rate associated with blunt and penetrating trauma was 6.5% and 8.7%, respectively.

In the literature, the mortality rate in patients with diaphragmatic injury due to blunt trauma is greater than that of penetrating trauma.[19] The main factor that will determine mortality and morbidity in the early period due to trauma is visceral organ injury. In patients with blunt trauma, spleen, bladder, lung, and large vascular injuries are observed, where as in penetrating traumas, liver, hollow organ, and pancreatic injuries and haemothorax are observed.[12,14] The reported mortality rates due to blunt and penetrating thoracoabdominal injuries have ranged from 7.8% to 32.1%.[5,12,14]

In our study, since the patients were more often exposed to penetrating trauma, liver, hollow organ, and spleen injuries were frequent. Mortality was statistically significantly greater in patients with liver injury compared with other organ injuries. The diaphragm is associated with other organ injuries because of its close relationship with intra-abdominal and intrathoracic organs. Therefore, organ injuries are associated with diaphragmatic rupture in 50% to 100% of cases.[20,21] In our study, 85% of our patients had additional organ injuries. The ISS score also increases in parallel with associated organ injuries. There was a significant increase in mortality in patients with an ISS score of ≥24 points.

This finding was consistent with the literature data.[3,14] Although blunt traumas are most often observed in the right half of the body, they are most frequently reported on the left side in penetrating injuries. This is a result of most people being right-handed.[22] There were more left- sided injuries in the present study, likely due to the predominance of penetrating injuries.

For the diagnosis of TDR, first, the physician who initially sees a patient should maintain suspicion of diaphragmatic injury in appropriate cases. According to the hemodynamic status of the patient, diagnostic tools and methods, as well as non-invasive methods, such as thorax graphy, contrast-enhanced radiographs, ultrasonography, and computed tomography, and minimally invasive methods, such as laparoscopy and thoracoscopy may be used.

In blunt or penetrating thoracoabdominal injuries, surgery may be performed using open or minimally invasive methods or through abdominal, thoracic, or thoracoabdominal approaches, according to the localization of the trauma. Shaw et al.[23] reported that they performed laparoscopic examinations for the diagnosis and treatment of patients with suspect isolated diaphragmatic injury after 24 hours of follow-up. In this study, diaphragm repair was performed via laparoscopy before discharge in nine patients after at least 24 hours of follow-up. Repair of the diaphragmatic rupture is recommended after the establishment of a diagnosis. Non-absorbable suture materials are preferred for repair.[24] Surgical repair is easy at the time of diaphragmatic rupture, and this is the main rationale for the surgical approach. However, relevant animal studies have shown that spontaneous scarring occurs, especially in small and right-sided diaphragmatic injuries.[25] In our study, the mortality rate was higher in patients who underwent diaphragm repair. Mortality is often related to the severity of the trauma, accompanying organ injury, or prolongation of the operation time, rather than the diaphragmatic injury alone. In the literature, atelectasis has been reported as the most common complication after diaphragmatic injuries. Other complications include pneumonia, sepsis, intra-abdominal abscess, wound infection, and respiratory failure. [17] In our study, atelectasis, pneumonia, empyema, and biliary fistula were observed most frequently, which was consistent with the literature.

In cases of TDR, other organs are frequently affected, and especially in those with liver injury, mortality rates increase significantly. Moreover, the presence of an ISS of ≥24 was determined to be an independent risk factor associated with mortality. Since the main predictive factor for mortality is the presence or absence of additional organ injuries, this finding should not be overlooked.

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ORİJİNAL ÇALIŞMA - *ÖZET*

Travmatik diyafragma yaralanması olan hastalarda mortalite ile ilişkili faktörler: Doksan iki olgunun analizi

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AMAÇ: Travmatik diyafragma rüptürü (TDR) olan hastalarda mortalite ile ilişkili faktörleri irdelemektir.
GEREÇ VE YÖNTEM: Ocak 2010 ile Haziran 2018 tarihleri arasında künt ve penetran torakoabdominal yaralanma nedeniyle ameliyata alınıp peroperatif diyafragma yaralanması tespit edilen hastalar geriye dönük olarak değerlendirildi. Hastaların demografik özellikleri, travmanın tipi, lokalizasyonu, ilişkili organ yaralanması varlığı, ek organ yaralanması sayısı, hastanın geliş anındaki tansiyon durumu, ameliyata alınma zamanı, operasyon şekli, diyafragma onarım şekli, terapötik yaklaşım türü, komlikasyonlar ve Yaralanma Şiddet Skorları (ISS) değerlendirildi.
BULGULAR: Çalışmaya 92 hasta alındı. Mortalite oranı %15.2 idi. Yaralanmanın şekli %77.2 penetran travma ile idi. İlişkili organ yaralanması en fazla karaciğer olup mortaliteyi arttırıcı faktör olarak anlamlıydı (p=0.020). Diyafragma tamiri yapılan hastalarda mortalite yapılmayanlara göre anlamlıydı (p=0.003). En sık komplikasyon atelektazi idi. TDR olan hastaların ISS'nin 24 ve üzerinde olması mortalite ile ilşkili bağımsız bir risk faktörü olarak tespit edildi (p=0.003).
TARTIŞMA: Travmatik diyafragma rüptürü sıklıkla diğer organlar ile birliktelik gösterip özellikle karaciğer yaralanmasının eşlik ettiği durumlarda mortalite anlamlı derecede artmaktadır. Ayrıca ISS'nin 24 ve üzerinde olması mortalite ile ilşkili bağımsız bir risk faktörü olarak tespit edilmiştir. Mortaliteyi belirleyen asıl sebep ek organ yaralanmaları olduğu için diyafragma yaralanması olan hastalarda bu durum göz ardı edilmemesi kanısındayız.
Anahtar sözcükler: Diafragma yaralanması; künt ve penetran travma; torakoabdominal yaralanma.

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