

Factors affecting mortality in traumatic diaphragm ruptures

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ABSTRACT

BACKGROUND: Traumatic diaphragm ruptures (TDR) are rarely seen. Although TDR does not cause morbidity in the acute period, undiagnosed TDR may cause clinical states, such as herniation, strangulation, pneumonia, pleural effusion, empyema, and cardiac tamponade, which have high morbidity and mortality rates in the late period. This study aims to evaluate the epidemiology, clinical characteristics, diagnosis and treatment methods of TDR encountered in thoracoabdominal trauma and to identify the factors affecting mortality.

METHODS: A retrospective examination was carried out on the patients who were operated in our clinic because of traumatic diaphragm injury between January 2012 and December 2017. Each patient operated because traumatic diaphragm injury was evaluated in respect of age, gender, manner of injury, preoperative examination findings, laboratory test results, imaging methods, time of diagnosis, operation findings, concomitant injuries to other organs, operations performed, length of stay in hospital, the development of postoperative morbidity and mortality, and the calculated Abbreviated Injury Scale (AIS) and Injury Severity Score (ISS).

RESULTS: Between January 2012 and December 2017, a total of 1066 patients were operated in our clinic because of thoracoabdominal trauma, and of 1066 patients, 45 of the patients were determined with TDR. Of the 45 patients, surgery was applied because of penetrating trauma in 32 cases (7 firearms injuries, 25 penetrating cutting injuries), blunt trauma in nine cases, and in four cases, diaphragm rupture was seen to have developed associated with iatrogenic injury during an operation. The most common injuries concomitant to traumatic diaphragm rupture were hemopneumothorax (70%), liver (43%), spleen (32%), colon (20%), stomach (17%) injuries and rib fractures (15%), respectively. Mortality developed in seven (17%) patients; five patients were lost because of hemorrhagic shock intraoperatively or in the early postoperative hours, and two because of multiorgan failure during follow-up in the intensive care unit.

CONCLUSION: In high energy blunt and penetrating thoracoabdominal traumas, diaphragm injuries should be suspected. Factors affecting mortality were found to be the AISS, ISS, number of concomitant organ injuries and the combination with pneumohemothorax.

Keywords: Diaphragmatic rupture; diaphragmatic hernia; thoracoabdominal trauma.

INTRODUCTION

Traumatic diaphragm ruptures (TDR) are rarely seen traumas with high morbidity and mortality rates due to delayed diagnosis, and for which blunt or penetrating thoracoabdominal trauma and iatrogenic injuries have a role in the etiology. Although the actual incidence of diaphragm injuries is not known in thoracoabdominal traumas, it is known to be 0.8-

8% in high-energy blunt trauma and 10–15% in penetrating trauma.^[1-4] Despite diagnostic developments, these injuries may still be overlooked at rates of 9%–41%.^[5,6] This rate further increases in cases with severe multiple organ injuries.^[6,7]

Thorax radiographs, computed tomography (CT), ultrasonography, magnetic resonance imaging (MRI), intraperitoneal injection, diagnostic peritoneal lavage, laparoscopy

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and thoracoscopy are important in diagnosis.^[3] TDR may be overlooked in patients treated conservatively and even intraoperatively at rates of 12%-66%.^[8,9] Following diagnosis, repair should be made with a patch or primary repair with absorbable or non-absorbable suture material depending on the location and size of the defect. To our knowledge, to date, there have been no reports of any cases of spontaneous diaphragm healing.^[10]

Although TDR does not cause morbidity in the acute period, undiagnosed TDR may cause clinical states, such as herniation, strangulation, pneumonia, pleural effusion, empyema, and cardiac tamponade, which have high morbidity and mortality rates in the late period.^[11,12] Early-stage mortality in thoracoabdominal traumas is generally related to the type and severity of the trauma. Especially in blunt trauma, TDR is an important indicator, which also shows the high-energy severity of the trauma.^[3] Mortality rates in thoracoabdominal trauma where there is diaphragm rupture have been reported to reach 28%.^[13]

This study aims to evaluate the epidemiology, clinical characteristics, diagnosis and treatment methods of TDR encountered in thoracoabdominal trauma and to identify the factors affecting mortality.

MATERIALS AND METHODS

Approval for this study was granted by the Local Ethics Committee. A retrospective examination was carried out on the patients who were operated in our clinic because of traumatic diaphragm injury between January 2012 and December 2017. The data related to the patients were retrieved from patient files, operation reports, and laboratory and imaging reports in the automated hospital system. Each patient who were operated because of traumatic diaphragm injury was evaluated in respect of age, gender, manner of injury, preoperative examination findings, laboratory test results, imaging methods, time of diagnosis, operation findings, concomitant injuries to other organs, operations performed, length of stay in hospital, the development of postoperative morbidity and mortality, and the calculated Abbreviated Injury Scale (AIS) and Injury Severity Score (ISS).

Laparotomy was applied to patients with shock, as a significant finding of peritoneal irritation, organ or omentum herniation, and organ injuries confirmed by imaging methods. In patients with suspicious clinical and examination findings, diagnostic laparoscopy or laparotomy was applied.

TDR diagnosis was reached from preoperative thorax radiographs and CT findings of diaphragm elevation, loss of diaphragm integrity, or the appearance of abdominal organs in the thorax. Diaphragmatic ruptures were classified according to the organ injury classification defined by the American Association for the Surgery of Trauma (AAST).

Statistical Analysis

Data obtained in the study were analysed statistically using SPSS v11.5 software (SPSS, Chicago, IL, USA). Descriptive statistics related to continuous variables were stated as mean±standard deviation, median, minimum and maximum values. In the comparison of two groups of continuous variables, the Mann-Whitney U-test was used, and in the comparison of nominal variables, the Chi-square test or Fisher's Exact test. A value of $p < 0.05$ was accepted as statistically significant.

RESULTS

As our hospital is a tertiary level trauma centre, approximately 60.000 trauma cases present per year. Between January 2012 and December 2017, a total of 1066 patients were operated in our clinic because of thoracoabdominal trauma, and of these, 45 were determined with TDR.

These patients comprised 34 male (75.5%) and 11 female (24.5%) patients with a mean age of 37.6 ± 11.75 years. Of these 45, surgery was applied because of penetrating trauma in 32 cases (7 firearms injuries, 25 penetrating cutting injuries), blunt trauma in nine cases, and in four cases, diaphragm rupture was seen to have developed associated with iatrogenic injury during operation for intra-abdominal mass. The clinical characteristics of the patients are shown in Table 1.

The diagnosis of diaphragm injury was reached from tests applied preoperatively in the early period in nine (22%) cases, intraoperatively in 30 (73%) cases and in the late period in two (5%) cases (Table 2). The rate of diagnosis in the first 24 hours was 95%.

Following presentation at the Emergency Department, diaphragm rupture diagnosis was made in a total of nine patients in the early period from physical examination findings and examination of postero-anterior pulmonary radiograph (PAPR) and/or CT; diaphragm elevation was seen on PAPR in three patients, contrast dye administered from the thoraco-abdominal region was seen in the chest cavity and to have passed into the abdomen, the diaphragm integrity was not complete on CT, there were organ herniation, diaphragm elevation and hemopneumothorax in one patient. The preoperative diagnosis rate was determined as 22%.

CT evaluation was made of 30 patients who were hemodynamically stable. No pathology was determined in five patients. Intra-abdominal free fluid was determined in 17 patients, suspected solid organ injury in 15, loss of diaphragm integrity in two, and pneumohemothorax in 10.

Ultrasonography (USG) was applied to nine of 41 patients; no pathology was determined in two and free fluid was determined in seven patients. USG was observed not to be specific for any referral on the subject of diaphragm injury. Pulmonary

radiographs were taken of 39 patients; diaphragm elevation was seen in three cases and in 27, the diagnosis was made from pneumohemothorax and/or hemothorax.

The most common injuries concomitant to traumatic diaphragm rupture were hemopneumothorax (70%), liver (43%), spleen (32%), colon (20%), stomach (17%) injuries and rib fractures (15%), respectively (Table 3).

The diaphragm rupture was on the left side in 27 patients, on the right in 17 and bilateral in one patient. The mean defect

size was 9.6 ± 5.63 cm in blunt trauma cases and 3.3 ± 1.9 cm in penetrating trauma cases. The diaphragm rupture classifications according to the AAST and the AIS and ISS scores are shown in Table 4.

In the treatment, primary diaphragm repair with laparotomy was performed to 35 patients, laparoscopic repair under elective conditions was applied to five years after the trauma in one patient, laparoscopic repair was made during diagnostic laparoscopy in the acute period in one patient, primary repair with laparotomy and thoracotomy was applied to three

Table 1. Characteristic of the patient with diaphragmatic rupture

	Penetrating		Blunt		p*
	n	%	n	%	
Gender					
Male	27	84.4	6	66.7	0.236
Woman	5	15.6	3	33.3	
Side					
Right	13	40.6	2	22.2	0.563
Left	18	56.2	7	77.8	
Bilateral	1	3.1	0	0	
Diaphragmatic laceration					
Grade 2	12	37.5	1	11.1	0.000
Grade 3	20	62.5	2	22.2	
Grade 4	0	0	6	66.7	
Diagnosis time					
Preoperative	6	18.8	3	33.3	0.350
Intraoperative+Late period	26	81.2	6	66.7	
Pneumothorax					
No	8	25	4	44.4	0.576
Yes	13	40.6	2	22.2	
Hemothorax	3	9.4	0	0	
Pneumo-hemothorax	8	25	3	33.3	
Diaphragm elevation					
No	32	100	4	44.4	0.000
Yes	0	0	5	55.6	
Thorax tube					
No	15	46.9	3	33.3	0.470
Yes	17	53.1	6	66.7	
Mortality					
Exitus	3	9.4	4	44.4	0.031
Survive	29	90.6	5	55.6	
Morbidity (n=38)					
No	18	62.1	3	60	1.000
Yes	11	37.9	2	40	

* Chi-square test/Fisher's Exact test

Table 2. Diagnosis time

	Preoperative (22%)	Intraoperative (73%)	Delayed diagnosis (5%)
Blunt (n=9)	3	5	1
Gunshot (n=7)	1	6	
Stab wound (n=25)	5	19	1

patients and repair with mesh was applied to one patient because of the large size of the defect (Table 5).

In the postoperative period, pulmonary complications developed in six patients, wound site infection in six patients, intra-abdominal abscess that was treated with percutaneous drainage in one patient and a bile fistula that regressed spontaneously with monitoring in one patient. The mean length of hospital stay was 9.48 ± 8.17 days for patients with penetrating injuries and 16.80 ± 13.75 days for those with blunt trauma injuries (Table 5).

Mortality developed in seven (17%) patients; five patients were lost because of hemorrhagic shock intraoperatively or in the early postoperative hours, and two because of multiorgan failure during follow-up in the intensive care unit. Factors affecting mortality were found to be the AISS, ISS, number of concomitant organ injuries and the combination with pneumohemothorax (Table 6).

DISCUSSION

The diaphragm, which plays a critical role in respiratory functions, is a layer of muscle and tendon in the form of a dome,

separating the chest and abdominal cavity.^[14] TDR is generally seen in blunt trauma and more often in penetrating trauma. It has been reported to be seen at the rate of 0.8-8% in blunt trauma and at 10-15% in penetrating trauma.^[1-4] Although incidence varies according to the socio-economic region served by hospitals, the actual incidence is not known as many cases cannot be diagnosed.^[13]

In the present study, the diaphragm rupture rate was determined as 4.2% in patients who were operated for thoracoabdominal trauma. Of these, in 3% of the patients, diaphragm rupture occurred following penetrating trauma and 0.8% after blunt trauma. In the literature, 75% of the TDRs have been reported to occur after blunt trauma and 25% after penetrating trauma.^[15]

Several studies have reported higher rates of TDR in males in the 4th decade of life.^[16] In the present study, the median age was 37.6 years and 75.5% of the patients were male, and these rates were consistent with the findings in the literature.

Diaphragm rupture is seen on the left side approximately 10-fold more, especially in blunt trauma, because the left medial and posterolateral sections of the diaphragm remain weaker during embryological development and the liver has a protective effect on the right-side.^[3,17] In the present study, left-side diaphragm rupture was seen at the rate of 77.8% in blunt trauma and at 56.2% in penetrating trauma, which was consistent with data in the literature.

The rupture dimension in penetrating trauma is smaller than in blunt trauma. Therefore, it is potentially more dangerous as there is a risk that diagnosis will not be made and herniation and strangulation will develop with growth in the future.^[15,18] In this study, the mean defect diameter of 9.67 cm in

Table 3. Frequency of associated injuries

	Blunt n=9	%	Penetrating n=32	%	Total %
Pneumohemothorax	5	55	24	75	70
Liver laceration	3	33	15	46	44
Spleen laceration	5	55	8	25	32
Small bowel laceration	1	11	4	12	12
Colon laceration	2	22	6	19	20
Gastric perforation	0	0	7	22	17
Rib fracture	5	55	1	3	14
Vertebra fracture	1	11	1	3	4
Adrenal and kidney rupture	2	22	1	3	7
Head injury	1	11	0	0	2
Pelvic fracture	1	11	0	0	2
Pancreas injury	0	0	2	6	4
Vascular injury	0	0	2	6	4

Table 4. Comparisons and descriptive statistics on age, Abbreviated Injury Scale, Injury Severity Score, defect size and length of stay of the patients with blunt and penetrating injuries

	Penetrating (n=32)		Blunt (n=9)		p*
	Average±SD	Mean (Min-max)	Average±SD	Mean (Min-max)	
Age	35.41±11.28	33.5 (20-65)	41.00±12.54	40 (25-57)	0.230
Abbreviated Injury Scale	3.09±0.29	3 (3-4)	3.67±0.87	3 (3-5)	0.092
Injury Severity Score	16.72±4.87	18 (9-27)	24.00±9.11	25 (9-38)	0.024
Size of rupture (cm)	3.33±1.91	3 (1-10)	9.67±5.63	10 (2-20)	0.001
Hospital stay (day)	9.48±8.17	7 (1-42)	16.80±13.75	14 (4-40)	0.149
Number of additional organ injuries	1.62±1.24	1 (0-5)	2.11±2.20±	1 (0-7)	0.889

*Mann-Whitney U Test

Table 5. Clinical features of the patients

	Blunt n=9	Penetrating n=32
Morbidity		
Wound infection	1	5
Abscess	0	1
Fistula	0	1
Pulmonary problems	0	6
Mortality	4	
Hemorrhagic shock	2	3
Organ failure	2	3
Operation		
Transabdominal primary repair	7	28
Transabdominal mesh	1	0
Laparoscopic repair	1	1
Laparotomy and thoracotomy	0	3

blunt trauma was approximately 3-fold larger than the mean of 3.33 cm in penetrating trauma cases. The size of the defect in the diaphragm is directly proportional to the severity of the trauma but was not determined to have any effect on mortality (Table 6).

Early diagnosis of TDR remains a problem, and in this study, the early diagnosis rates were determined as 22% preoperatively and 73% intraoperatively. These rates have been reported as 34% and 88%, respectively in experienced trauma centres.^[19] The most important stage in diagnosis is suspicion with accompanying clinical findings, such as dyspnea, chest pain, reduced respiratory sounds and abdominal pain. Although thorax radiographs and thoraco-abdominal CT are the most frequently requested methods, diagnosis may not always be able to be confirmed with these two methods.

On pulmonary radiographs, signs, such as elevation of the diaphragm, a change in the shape of the curve of the diaphragm, gas and fluid shadow in the thoracic cavity, atelectasia in the inferior lobes, pleural effusion, pneumothorax, hydro-pneumothorax and mediastinal shift, can be signs of rupture.^[20] CT

Table 6. Comparisons and descriptive statistics on age, Abbreviated Injury Scale, Injury Severity Score, defect size, and number of additional organ injuries in patients with exitus and survivor

	Exitus(n=7)		Survive (n=34)		p*
	Average±SD	Mean (Min-max)	Average±SD	Mean (Min-max)	
Age	40.86±13.92	36 (25-65)	37.10±11.42	37.5 (20-57)	0.591
Abbreviated Injury Scale	4.00±0.82	4 (3-5)	3.06±0.24	3 (3-4)	0.004
Injury Severity Score	29.28±4.92	27 (25-38)	16.06±4.31	18 (9-25)	0.000
Size of rupture (cm)	6.71±6.92	5 (1-20)	4.22±3.04	3 (1-13)	0.657
Number of additional organ injuries	3.00±2.08	3 (1-7)	1.31±1.23	1 (0-5)	0.019

*Mann-Whitney U Test

is an imaging method with high sensitivity and specificity compared to direct radiographs, especially in patients with stable vital signs. Findings, such as impairment of the integrity of the diaphragm, the observation of abdominal organs in the thorax, hemothorax, and pneumothorax, support a diagnosis of TDR. Other methods that can be used include ultrasonography, MR examination of the gastrointestinal system with barium, diagnostic peritoneal lavage, diagnostic laparoscopy and laparotomy, and diagnostic thoracoscopy and thoracotomy.

Laparoscopy may be preferred, especially in isolated diaphragm injuries. Diagnostic laparoscopy is more sensitive and specific in TDR diagnosis compared to other methods. However, as approximately one in three patients in the early period is operated with laparotomy or thoracotomy because of related injuries, the diagnosis of diaphragm rupture is made during surgery and the necessary treatment is applied. Diagnosis is made with physical examination in 44% of cases with penetrating diaphragm injuries and in 55% of those with blunt trauma diaphragm injuries.^[21] In injuries of the lower region of the chest and the upper region of the abdomen, it must always be kept in mind that there could be TDR. As there may be no findings in the early stage, especially in small defects, taking serial pulmonary radiographs in the subsequent period may be necessary to ensure that TDR diagnosis is not overlooked. Significant findings cannot always be obtained in the physical examination and radiological evaluations carried out in the early period, especially in small defects.

However, the diagnostic ability is reduced in right-side ruptures and small ruptures. In small injuries of the diaphragm, diagnosis is extremely difficult in the absence of herniation and when there are pleural fluid and movement artefacts.^[22-24] Of the patients who were operated in this study, synthetic graft was used in one case with a defect size of 12 cm. Laparoscopic exploration may be an appropriate option when contrast dye administered for tomography in thoraco-abdominal penetrating injuries is seen within the abdomen or to have passed to the thorax, and small defects can be repaired laparoscopically.^[25]

As complications may develop later, a conservative approach is not recommended. The operation strategy varies according to the wound localisation, the size, manner of forming, the clinical status of the patient and additional injuries. In one patient in this study with blunt trauma who was determined in the later period and to whom explorative laparoscopy was applied, diaphragm repair was performed laparoscopically. While small defects are repaired with non-absorbable sutures, synthetic grafts are used in large defects.^[26,27] Of the operations in this study, 87% were performed with laparotomy.

TDR is a sign that the trauma was high energy and is a warning of intra-abdominal and intrathoracic organ injuries. In both penetrating and blunt trauma, diaphragm injuries are

generally accompanied by other organ injuries.^[28] The most frequently seen injuries are to the liver (approximately half of patients), lungs and spleen.^[28] In 50-80% of cases with blunt trauma diaphragm injury, additional intra-abdominal injuries are determined. The most common concomitant organ injuries are of the spleen, liver and internal hollow organs. In this study, pneumothorax was determined most often followed by spleen injury (32%) in blunt trauma and liver injury (43%) in penetrating trauma cases.

Following diaphragm repair, pulmonary and wound site complications are the most frequently seen complications. Morbidity and mortality rates vary according to the extent of concomitant organ injury, bleeding and shock status, and whether or not there are states such as hernia-related strangulation, incarceration, perforation or contamination, and damage to the respiratory or cardiovascular system. In this study, the morbidity rate following repair of diaphragm rupture was 60% in cases with blunt trauma injuries and 62.1% in those with penetrating trauma. Mortality rates for diaphragm injuries have been reported in the literature as 10-35%.^[27,29,30] In the current series, mortality was determined at the rate of 17%; in 3/32 patients with penetrating injuries and in 4/9 of those with blunt trauma. In five of these cases, mortality was due to hemorrhagic shock, and in two cases, to organ failure (generally associated with concomitant injuries).

The ISS and time of diagnosis were determined to affect mortality in this study, but in contrast to reports in the literature, age and the size of the defect were not found to have any effect on mortality.

This study has some limitations. This study was conducted in a single centre, was retrospective in nature and the study population was small. Patients who could not be diagnosed were not operated on and the total number of trauma patients was not known.

CONCLUSION

In high-energy blunt and penetrating thoracoabdominal traumas, diaphragm injuries should be suspected. Diaphragmatic injuries are seen more often on the left side and require surgical treatment. As trauma scores and the number of additional organ injuries increase, the mortality rate also increases.

Ethics committee approval: Ethics Committee Approval has received for this study from the Ethics Committee of University of Health Sciences, Dışkapı Yıldırım Beyazıt Research and Training Hospital.

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ORIJİNAL ÇALIŞMA - ÖZET

Travmatik diyafragma yaralanmalarında mortaliteye etkili faktör**Dr. Serhat Tokgöz, Dr. Muzaffer Akkoca, Dr. Yasin Uçar, Dr. Kerim Bora Yılmaz, Dr. Özgür Sevim, Dr. Görkem Gündoğan**

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AMAÇ: Travmatik diyafragma rüptürleri (TDR) nadir görülür. Genellikle akut dönemde morbiditeye neden olmazlar, ancak klinik tanı konulamayan tüm TDR'ler geç dönemde herniasyon, strangülasyon, pnömoni, plevral effüzyon, ampiyem, kalp tamponadı ve solunum bozuklukları gibi morbidite ve mortalitesi yüksek klinik durumlara neden olabilir. Bu çalışmada travmatik diyafragma rüptürünün epidemiyolojisi, klinik özellikleri, tanı, tedavi yöntemleri ve mortalite üzerine etkili faktörleri değerlendirildi.

GEREÇ VE YÖNTEM: Ocak 2012-Aralık 2017 tarihleri arasında kliniğimizde travmatik diyafragma yaralanması nedeni ile ameliyat edilen hastaların kayıtları geriye dönük olarak incelendi. Travmatik diyafragma rüptürü nedeni ile ameliyat edilen hastaların; yaş, cins, yaralanma şekli, operasyon öncesi muayene bulguları, laboratuvar tetkikleri, görüntüleme yöntemleri, tanı konulma zamanları, ameliyat bulguları, eşlik eden diğer organ yaralanmaları, yapılan ameliyatlara, hastane kalış süreleri, ameliyat sonrası dönemde gelişen mortalite ve morbiditeler Abbreviated Injury Scale (AIS) ve Injury Severity Score'ları (ISS) incelendi.

BULGULAR: Ocak 2012-Aralık 2017 tarihleri arasında kliniğimizde torakoabdominal travma nedeniyle 1066 hasta ameliyat edildi ve bu hastalardan 45'ine diyafragma rüptürü tanısı konuldu. 45 hastanın 32'sinde penetran travma (7 ateşli silah 25 delici kesici alet yaralanması), 9'unda künt travma ve 4 hastada ise karinici kitle nedeniyle ameliyat edildiği sırada oluşan iyatrojenik yaralanma nedeni diyafragma rüptürü geliştiği görüldü. Travmatik diyafragma rüptürüne en sık eşlik eden yaralanmalar sırasıyla hemopnömotoraks (%70), karaciğer (%43), dalak (%32), kolon (%20), mide (%17), ve kot fraktürü (%15) yaralanmalarıydı. Mortalite toplamda yedi (%17) hastada görüldü; beş hasta hemorajik şok nedeniyle intraoperatif veya ameliyat sonrası erken saatlerde kaybedilirken, iki hasta yoğun bakım takiplerinde çoklu organ yetersizliği nedeniyle kaybedildi.

TARTIŞMA: Yüksek enerjili künt ve penetran torako-abdominal travmalarda diyafragma rüptüründen şüphelenmek gerekir. Mortalite üzerine etkili faktörler AIS, ISS, eşlik eden organ yaralanması sayısı ve pnömo-hemotoraks birlikteliği olarak bulundu.

Anahtar sözcükler: Diyafragma rüptürü; diyafragmatik herni; torakoabdominal travma.

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