Traumatic diaphragmatic ruptures: diagnostic and therapeutic approaches

Travmatik diyafram rüptürleri: Tanı ve tedavi yaklaşımları

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Background: This study aims to evaluate the characteristics of patients with traumatic rupture of diaphragm (TDR), the diagnostic and therapeutic approaches used in these cases and and the outcomes of the patients.

Methods: Forty-one patients (31 males, 10 females; mean age 41.9 years; range 7 to 71 years) with thoracoabdominal trauma and diagnosis of TDR who were treated in our clinic between January 2000 and January 2010 were analyzed retrospectively. The patients were statistically compared in terms of age, gender, the time of diagnosis (early or late), the diagnostic procedures that were performed, whether the diagnosis of rupture was made during or after the operation, the localization of the rupture, the diameter of the rupture, accompanying injuries, the surgery performed, mortality and morbidity and the trauma injury severity score.

Results: The etiology for the diaphragmatic rupture was blunt trauma in 43.9% and penetrating trauma in 56.10% of the patients. 85.36% of the patients were diagnosed in early stage and 14.64% in late stage. Herniation dignosis was made radiologically in 18 (43.9%) patients and diaphragmatic rupture was detected during the operation in 23 patients (56.1%). Twenty-nine (70.73%) patients had thoracotomy, seven (17.02%) patients had laparatomy and five (12.19%) patients had thoracotomy plus laparatomy. The overall mortality rate was 14.63% (n=6).

Conclusion: Traumatic diaphragmatic ruptures may have a fatal course depending on the strangulation of the herniating abdominal viscera. Traumatic diaphgram rupture should be suspected in all multitraumatic patients and these cases shuld be seriously evaluated for the definitive diagnosis and treatment plan.

Key words: Diaphragm; treatment; trauma.

Amaç: Bu çalışmada travmatik diyafram rüptürü (TDR) olan hastaların özellikleri ve bu hastalarda uygulanan tanı ve tedavi yaklaşımları ve elde edilen sonuçlar değerlendirildi.

Çalışma planı: Ocak 2000 - Ocak 2010 tarihleri arasında kliniğimizde tedavi edilen TDR tanılı ve torakoabdominal travmalı 41 hasta (31 erkek, 10 kadın; ort. yaş 41.9 yıl; dağılım 7-71 yıl) retrospektif olarak analiz edildi. Hastalar yaş, cinsiyet, tanının erken veya geç konulmuş olması, tanı- amaçlı yapılmış olan incelemeler, rüptür tanısının ameliyat sırasında veya sonrasında konulması, rüptürün yerleşimi, rüptürün çapı, eşlik eden yaralanmalar, uygulanan ameliyat, morbidite ve mortalite ile travma yaralanma ciddiyet skoru yönünden istatistiksel olarak karşılaştırıldı.

Bulgular: Diyafram rüptürü, hastaların %43.9'unda künt travmaya, %56.10'unda penetre travmaya bağlı olarak meydana gelmiş idi. Hastaların %85.36'sında tanı erken dönemde, %14.64'ünde geç dönemde konuldu. Herniasyon tanısı 18 hastada (%43.9) radyolojik olarak konuldu, 23 hastada (%56.10) ise ameliyat sırasında diafram rüptürü tespit edildi. Hastaların 29'una (%70.73) torakotomi, yedisine (%17.02) laparotomi, beşine (%12.19) torakotomi+ laparotomi yapıldı. Genel mortalite oranı %14.63 (n=6) idi.

Sonuç: Travmatik diyafram rüptürleri herniye olan intraabdominal organ strangülasyonlarına bağlı olarak ölümcül seyredebilen yaralanmalardır. Tüm multitravmalı hastalarda TDR'den şüphelenilmeli ve bu olgular kesin tanı ve tedavi planı için ciddi bir şekilde değerlendirilmelidir.

Anahtar sözcükler: Diyafram; tedavi; travma.

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Traumatic diaphragmatic rupture (TDR) is seen in 4.5-6% of trauma patients. It occurs due to thoracoabdominal injuries. One-fourth of patients were classified as penetrating trauma and three-fourths as non-penetrating.[1-3]

Stab and gunshot wounds are the most common causes of penetrating injuries while motor vehicle accidents are responsible for many of the non-penetrating ones. Rib fractures after trauma may cause TDR via a penetrating effect. Diaphragmatic ruptures can be masked by the effects of accompanying injuries of the internal organs.[4-6]

Traumatic diaphragmatic rupture alone rarely causes death, but if it is misdiagnosed, gastrointestinal herniations may cause severe complications and death.[6] The rupture is mostly seen in the left leaf (80-90%) after blunt and penetrating trauma.[6,7] Associated organ injuries occur more than 90% of the time[8] and may cause misdiagnosis. Posteroanterior (PA) chest X-rays are the most helpful tool for diagnosis.[5,8] Also, ultrasound (US), computed tomography (CT), magnetic resonance imaging (MRI), upper gastrointestinal imaging using barium, and peritoneal lavage can be used.[9] The most common herniating organs are the stomach and colon. Associated injured organs are the spleen, liver, and other hollow organs.[1-8]

Stab and gunshot wounds and motor vehicle accidents have been increasing; thus, TDR is also on the rise. We present our clinical approach, treatment modalities, and eight-year experience with TDR patients and discuss the current literature.

PATIENTS AND METHODS

Eight hundred and sixty-three patients with thoraco-abdominal trauma were treated in University of Yüzüncü Yıl Hospital between January 2000 and January 2008. Out of these patients, 41 (31 male, 10 female; mean age 41.9 years; range 7 to 71 years) had a diagnosis of TDR. We analyzed the medical records of these patients retrospectively.

Group 1 consisted of "initial recognition" (IR) patients: (n=34; 85.6%), and group 2 was of the "late recognition" (LR) patients: (n=6; 14.6%). In the IR patients, there were 23 patients with penetrating trauma (group 1A; 56.1%) and 12 with blunt trauma (group 1B; 29.3%) cases. The LR patients of group 2 all had blunt trauma.

The trauma and injury severity score (TRISS) is a combined score which includes the anatomical and physiological parameters of the patients along with their injury severity score (ISS). Patients with an ISS score between 0-14 were classified as having minor trauma (preventable death), those with a score between 16-66 as having major trauma (potential preventable death), and those with a score of more than 75 as having injuries incompatible with life. The groups were statistically compared on the basis of ISS.

The patients were analyzed by age, gender, time of diagnosis, procedures performed, the timing of the diagnosis of the rupture (before surgery or during surgery), the localization and diameter of the rupture, accompanying injuries, the type of surgery, mortality, and morbidity rate. The diagnosis was established by physical examination and radiological evaluation.

In patients with hemodynamic instability, we performed fast resuscitation and a laparotomy. In the laparotomy, the space was cleared, and then the bleeding was controlled. The organs herniating to the thorax by the rupture area were placed in the abdomen, and the blood supply of the organs was checked.

In cases of hemorrhagic drainage from the thorax, a chest tube was inserted. In six patients, we performed a thoracotomy in addition to the laparotomy due to the amount of drainage. Where there was no hemorrhagic drainage, the last two stitches on the diaphragm were tightened while the anesthesiologist was inflating the lungs maximally. Injuries to the herniating organs and intrathoracic structures were repaired. The material used for repair was nonabsorbable polypropylene grafts in seven patients (17.1%) and number one nonabsorbable sutures by mattress suturing in 34 (82.9%).

Comparison between the groups regarding mortality and morbidity was calculated by the Z test. A one-way analysis of variance (ANOVA) test was performed to identify the difference between the mean values of the groups about ISS. According to the one-way ANOVA test, we used Duncan's multiple range test to define the separate groups and assumed $p<0.05$ as statistically significant. Calculations were performed using the Statistical Package for the Social Sciences (SPSS Inc., Chicago, Illinois, USA) for Windows version 13.0 program.

RESULTS

Traumatic diaphragmatic rupture was caused by blunt trauma in 43.9% of the patients and by penetrating trauma in 56.10%. The penetrating trauma was classified as upper abdominal in 18 (78.3%) and lower thoracic involvement in five (21.7%). The blunt trauma was caused by motor vehicle accidents (26.8%), falling (12.1%), and entrapment under collapsed structure and

Table 1. Trauma groups causing diaphragmatic rupture

	n	%
Blunt trauma (n=18)		
Motor vehicle accident	11	26.8
Falling	5	12.1
Entrapment under collapsed structure and debris	2	4.9
Penetrating trauma (n=23)		
Gunshot wounds	13	31.7
Stab wounds	10	24.3

debris (4.9%) while the penetrating trauma was caused by either gunshot wounds (31.7%) or stab wounds (24.3%; Table 1).

Traumatic diaphragmatic rupture was on the left side in 78% of the patients and on the right side in 22%. Traumatic diaphragmatic rupture for penetrating trauma was on the left side for 66.67% (Table 2). There was no definitive description of "initial recognition" in the literature, so we defined "initial" as being the first five days of consultation in the hospital. The term "late recognition" is used for the patients with a history of trauma who were diagnosed due to symptoms (respiratory dysfunction, nausea and vomiting due to strangulation of the small intestine and colon, etc.) following the trauma. These patients did not go to the hospital, or if they were hospitalized and treated, they never had a diagnosis of TDR. The cases were grouped as 85.36% for early diagnosis and 14.64% as late-term diagnosis (Table 3).

Radiological diagnosis of the herniation of intra-abdominal organs was established in 11 (61.11%) of 18 cases of TDR with non-penetrating trauma and seven (30.43%) of 23 with penetrating trauma. There was diaphragmatic eventration in 11 of the patients (26.82%) and irregularity of the borders in 10 (24.39%; Table 2). The most common symptoms were dyspnea (53.65%), chest pain (46.34%), and abdominal pain (36.58%). In 5% of the cases, diagnosis was established according to clinical signs. Diagnostic peritoneal lavage was performed on 15 patients, and seven of those had positive results. Of the group of patients with negative results, one had a diagnosis of isolated diaphragmatic rupture afterwards. The four patients with hemorrhaging in the abdomen and hemodynamic instability underwent emergency surgery (Table 2). Two patients (4.87%), one a child with a diagnosis of TDR by clinical signs, had emergency surgery. Eighteen (43.90%) cases with a radiological diagnosis of herniation (Figure 1, 2) had surgery. For the rest, the indication for surgery was intra-abdominal bleeding (24.39%). The diagnosis of TDR was established during surgery in 23 (56.10%) patients (Table 3). The most common intra-abdominal organ herniating was the stomach in 14 patients (34.14%) followed by the omentum, small intestine, colon, and liver (Figure 3-5). The most commonly affected organ incurred through a non-thoracic injury with penetrating trauma was the stomach (26.08%), and for blunt trauma, it was the head crash (50%; Table 2).

The surgical approach was a thoracotomy in 70.73%, a laparotomy in 17.02%, and both in 12.19% patients. The mean dimension of the defect was 1.2x3.1 cm in penetrating trauma and 3.0x9.7 cm in blunt trauma. They were repaired by polypropylene mesh in seven cases (17.1%) and in 34 (82.9%) with number 0 and 1 non-absorbable suture material primarily by mattress suturing.

The associated intra-abdominal organ injuries were as follows: liver- nine (21.95%), spleen- eight (19.51%), stomach- seven (17.07%), small intestine- five (12.19%), colon- two (4.87%), and kidney- one (2.43%). These were mostly seen associated with penetrating trauma (46.34%) (Table 2). The degree of injuries for the spleen, liver, and kidneys are shown in Figure 6, and the surgical interventions are shown in Table 4.

In the postoperative follow-up, there were eight patients with atelectasis. Three of these needed fiberoptic bronchoscopy. Four patients had mechanical ventilation for respiratory insufficiency (Table 2). The total mortality rate for the patients was 14.63%. The rate was higher in blunt trauma patients at 22.22% (Table 2). The high mortality may be due to the accompanying head crash (Table 2). There were no statistically significant differences when comparing the rates for mortality and morbidity in the groups. The morbidity rates between IR blunt trauma (group 1-B) patients and LR blunt trauma (group-2) patients were statistically different ($p<0.014$) (Table 5).

When comparing the groups according to the ISS, there was no statistical difference between penetrating and blunt traumas. The ISS of the IR blunt trauma group 1-B patients was higher than the two other groups, and the difference was statistically significant ($p<0.01$; Table 6). The mean hospital stay was 5.0 days for patients having primary repair via the transabdominal approach and 7.3 for those undergoing the transthoracic approach.

DISCUSSION

Traumatic diaphragmatic ruptures are rare cases that cannot be diagnosed in 90% of patients in emergency rooms.[1-8] More than half of the 90% are not accurately diagnosed due to the prioritization of the symptoms

Table 2. Clinical specialities of patients with diaphragmatic rupture

	Initial diagnosis		Late diagnosis
	Group 1A	Group 1B	Group 2
Type of trauma	Penetrating trauma (n=23)	Blunt trauma (n=12)	Late diagnosis (blunt trauma) (n=6)
Localization	Right (n=6) Left (n=17)	Right (n=3) Left (n=9)	Right (n=0) Left (n=6)
Timing of diagnosis 0-6 hours 6-12 hours 12-24 hours ≥7 days	19 4 - -	7 3 2 -	- - - 6
Morbidity	Respiratory insufficiency (mechanical ventilation), (n=1) - Atelectasis (n=4) - Infection at the thoracotomy incision site reauiring revision and skin graft (n=1) - Gastrocutaneous fistula - Requiring re-laparotomy (n=1) - Intraabdominal abscess (n=1)	Respiratory insufficiency (mechanical ventilation) (n=3) - Atelectasis (n=2) - Empyema (n=2) - Pneumonia (n=1)	- Atelectasis (n=2)
Mortality	- Hemothorax + liver, stomach and bowel laceration (n=1) - Spleen pounding + hemorrhagic shock (n=1)	- Lung contusion + bilateral hemothorax + - Head injury (n=2) - Multiple rib fracture + head injury (n=1) - ARDS + head injury + multi organ failure (n=1)	-
Symptoms	Dyspnea (n=7) Chest Pain (n=9) Abdominal pain (n=8) Shock (n=4) Hematemesis (n=2)	Dyspnea (n=9) Chest pain (n=6) Abdominal pain (n=5) Shock (n=2)	Dyspnea (n=6) Chest pain (n=4) Abdominal pain (n=2) Dyspepsia (n=2) Distension (n=1) Constipation (n=1)
Radiological findings	Herniation (n=7) Pneumothorax (n=5) Hemothorax (n=4) Hemopneumothorax (n=7) Rib fracture (n=4) Irregularity in diaphragmatic borders (n=2) Diaphragmatic elevation (n=7)	Herniation (n=5) Pneumothorax (n=3) Hemothorax (n=2) Hemopneumothorax (n=2) Rib fracture (n=11) Sternal fracture (n=2) Lung contusion (n=5) Organized hematoma (n=1) Consolidation in the lung (n=3) Irregularity in diaphragmatic borders (n=6) Diaphragmatic elevation (n=3)	Herniation (n=6) Organized hematoma (n=1) Consolidation in the lung (n=5) Rib fracture (n=2) Irregularity in diaphragmatic Borders (n=2) Diaphragmatic elevation (n=1)
Corresponding non-thoracic injury	Liver (n=1) Stomach (n=6) Spleen (n=5) Small intestine (n=5) Colon (n=2) Fractured extremity (n=2)	Liver (n=7) Stomach (n=1) Spleen (n=3) Head injury (n=9) Pelvic fracture (n=3) Fractured extremity (n=6) Kidney (n=1)	Liver (n=1)
Corresponding thoracic trauma	Lung parenchymal laceration (n=12) Intrathoracic vascular pounding (n=2) Intercostal arterial rupture (n=3) Rib fracture (n=4)	Lung parenchymal laceration (n=7) Intrathoracic vascular pounding (n=1) Intercostal arterial rupture (n=2) Lung contusion (n=5) Sternal fracture (n=2) Rib fracture (n=11)	

Table 3. Indications for surgical intervention

Indications for surgery	n	%
Diaphragmatic herniation	18	43.9
Intraabdominal hemorrhage	10	24.3
Thoracic wall defect	2	4.9
Hemothorax	8	19.5
Pneumothorax and prolonged air leak	3	7.4

of injuries from other injured organs, or they may be misdiagnosed.[10] Diaphragmatic injuries are mostly seen in young adults and occur four times more often in males than females.[10] In our study, 75.60% of the patients were male and 24.40% were female, which is compatible with the literature. They had a median age of 41.9 years (range 7-71 years). Diaphragmatic injuries generally occur by blunt or penetrating trauma to the thoracoabdominal region, and blunt trauma is usually caused by motor vehicle accidents.[5,11]

The incidence of diaphragmatic injury in thoracoabdominal injuries is 5%.[11] In two studies, the incidence rates were 3.8% and 2.4%.[12,13] Rubikas[10] examined autopsy cases and reported the rate as 2.1% for blunt trauma and 3.4% for penetrating trauma. In our study, there were 863 patients with thoracoabdominal trauma and 41 (4.75%) had TDR.

Traumatic diaphragmatic rupture should be considered in penetrating trauma below the third and fourth intercostal space and in blunt and penetrating trauma to the upper abdominal region.[13] Wounds to the lower thorax and upper abdomen may cause TDR without clinical findings and can be diagnosed during surgery.[11] Early diagnosis in penetrating injuries is by early exploration.[5,10]

Keeping the possibility of diaphragmatic rupture in mind is important. Posteroanterior chest X-rays and thoracic CT scans may aid in the diagnosis, especially in herniation cases.[1,2,7] The findings of pneumothorax, hemothorax, elevation, irregularity in the borders of the diaphragm, and fractures and contusions in the lung parenchyma are all warning signs. We used PA chest X-ray, ultrasound, peritoneal lavage, and CT for diagnosis. The diagnostic value of peritoneal lavage was 80% in the early diagnosis of TDR. The false negative results were about 20%.[8,9] In our patients, the false negative rate was 75%; therefore, we believe that peritoneal lavage is not helpful in the diagnosis.

Laparoscopy and video-assisted thoracic surgery (VATS) have recently been advocated as tools to establish the diagnosis in stable patients with a high index of suspicion for injury of the diaphragm.[14]

The authors feel that VATS is best reserved for stable patients when intra-abdominal and contralateral diaphragmatic injuries are excluded.[15]

Divisi et al.[16] recommended VATS for the diagnosis of traumatic rupture of the diaphragm, especially in cases involving liver herniation into the thorax.

Patients with penetrating injuries to the left lower chest with no indication of a need for a laparotomy should undergo videoscopic evaluation of the left hemidiaphragm.[17]

Nel and Warren[18] reported the reliability of thoracoscopy in evaluating the diaphragm in their study of 55 patients.

Freeman et al.[19] analyzed 171 patients who underwent a VATS assessment of a hemidiaphragm following

Figure 1. Herniated stomach on the left side (posteroanterior chest X-ray view).

Figure 2. Herniated stomach on the left side (thoracic CT view).

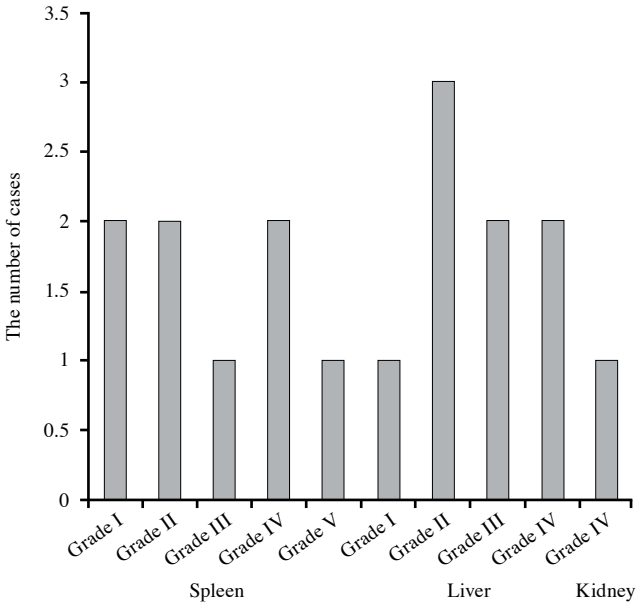

Figure 3. Herniated intraabdominal organs.

penetrating chest trauma and identified five independent risk factors for TDR. These were an abnormal chest radiograph, associated intra-abdominal injuries, high velocity mechanism of injury, a penetrating injury inferior to the nipple line or scapula, and a right-sided penetrating injury.

They concluded that those patients without clear-cut indications for a thoracotomy or laparotomy should be considered for VATS if they had two or more predictors of TDR.

Video-assisted thoracic surgery techniques require a patient who is able to withstand one-lung ventilation; however, this is not tolerable in the majority of multi-trauma patients. Consequently, laparoscopy seems to be a more feasible diagnostic tool than VATS.[14]

The disadvantages of VATS are related to using a double-lumen endobronchial tube and the fact that the contralateral hemidiaphragm cannot be visualized. In some cases, laparoscopy following VATS can help to assess the intra-abdominal viscera and inspect the contralateral hemidiaphragm.[20,21] Laparoscopy allows for the assessment and repair of the diaphragm.[22]

In a prospective study involving penetrating injuries to the left lower chest which did not require a laparotomy, routine diagnostic laparoscopy identified occult diaphragmatic injuries in 24% of the patients.[23] For hemodynamically stable patients, diagnostic laparoscopy is utilized for patients sustaining left thoracoabdominal penetrating trauma.

According to the localization, dimension, and time of diagnosis, there is a risk for the herniation of intra-abdominal organs due to pressure differences between peritoneal and thoracic spaces.[5] The most common herniating organs are the stomach, small intestine, and colon. In rare cases, the liver and spleen have a potential for herniating.[1-8] The stomach was the most common organ in our study (34.14%). Traumatic diaphragmatic rupture may have three clinical presentations: the acute, latent, and obstructive phases depending on the herniating organ, the time period after trauma, and clinical symptoms.[2] In the acute phase, the patients have dyspnea, cyanosis, orthopnea, cough, and chest pain. If the herniating organ is the stomach and if there is progressive dilatation due to obstruction, the lung on the same side becomes atelectatic due to compression. The mediastinum moves towards the other side and venous

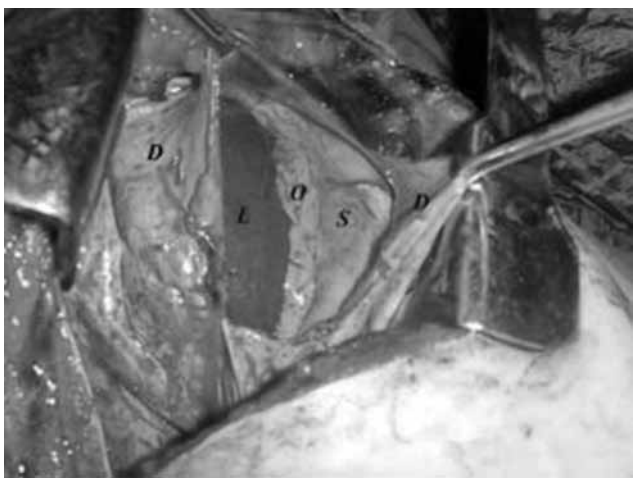

Figure 4. Herniated stomach, omentum, and liver on the left side. D: Diaphgram; L: Liver; O: Omentum; S: Stomach.

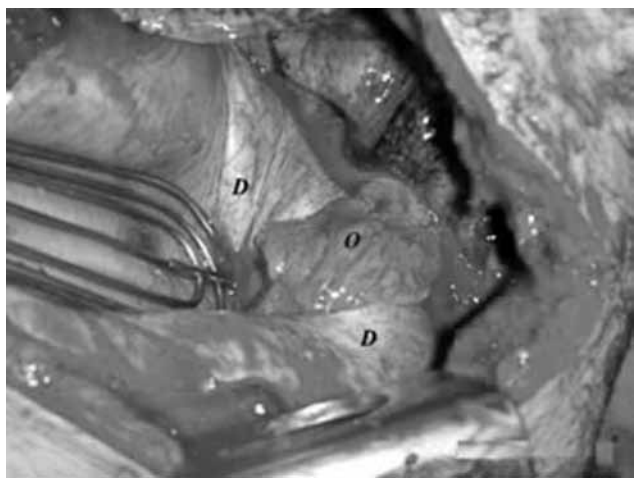

Figure 5. Herniated omentum on the left side. D: Diaphgram; O: Omentum.

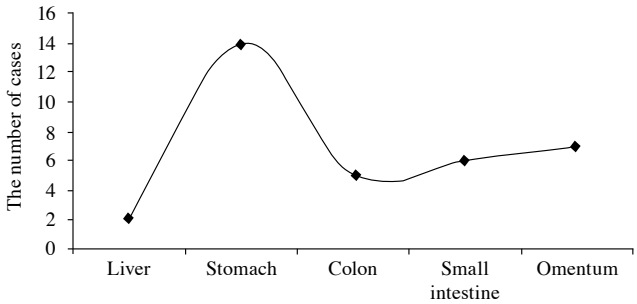

Figure 6. Associated intra-abdominal organ injury.

return to the heart is blocked. This clinical situation is mortal, like tension pneumothorax, and becomes fatal if untreated. The application of a nasogastric tube may decrease the symptoms. Before herniation, the symptoms are minimal, but after it has occurred, sounds of peristalsis instead of breathing sounds are typical.[2] The most common symptoms in our patients were dyspnea, chest pain, abdominal pain, and lack of breathing sounds. Our study group made the definitive diagnosis by clinical findings in 5% of the cases, which is similar to what has been reported in the literature.[1,2,9]

Even if the diaphragm is found intact during a laparotomy, there is the risk of delayed rupture due to insufficient blood being supplied to the diaphragm by the tension during trauma, which causes it to be weakened. The incidence rate is 5-62% in blunt trauma cases.[13] The latent period may last for months or even years as patients have symptoms of dyspepsia, distension, and constipation due to the intermittent incarceration of herniated organs. The timing depends on the dimension of the rupture. Right diaphragmatic rupture periods take longer than left ones.[2,13] Patients should have PA chest X-rays daily in the first week after trauma or surgery and again at the third month.[2,13,24] A diagnosis was made in 85.4% of the cases due to the higher number of patients with penetrating trauma who had an early laparotomy.

The obstructive phase can arise at any moment of the latent period. Obstruction of an incarcerated organ may cause strangulation and perforation. Patients suffer from abdominal pain, distension, nausea, and vomiting. If only the stomach is obstructed within the thorax, the physical findings are nearly normal. If the bowel is obstructed, a mechanical bowel obstruction may develop.[2] Patients who were diagnosed late were all in the latent period. There was no patient in the obstruction phase.

On deep inspiration, the gradient difference between the thorax and abdomen reaches 10 cm H_2O causing a risk for radial style rupture in the posterolateral portion of the diaphragm, which is the weakest point for blunt

Table 4. Treatment modalities in associated injuries

Corresponding organ injury/surgical intervention	n	%
Liver	9	21.95
Primary repair + application of hemostatic patch (grade 1, grade 2)		
Debridement + selective ligation + omental support (grade 3, grade 4)		
Deep mattress suturing		
Resectional debridement		
Perihepatic packing		
Spleen	8	19.51
Splenorrhaphy (grade 1, grade 2)		
Partial splenectomy (grade 3)		
Splenectomy (grade 4, grade 5)		
Kidney	1	2.43
Primary repair (grade 4)		
Stomach	7	17.07
Primary repair		
Distal gastric resection + gastroenterostomy		
Small intestine	5	12.19
Resection + anastomosis		
Primary repair		
Colon	2	4.87
Primary repair		
Lung	22	53.65
Primary repair		
Resection		

Table 5. Statistical comparison of the groups regarding morbidity and mortality

	Morbidity			Mortality		
Group 1A/Group 1B	8/23	8/12	(p=0.058)	2/23	4/12	(p=0.096)
Group 1A/Group 2	8/23	2/6	(p=0.947)	2/23	0/6	(p=0.139)
Group 1B/Group 2	8/12	2/6	(p=0.157)	4/12	0/6	(p=0.014)

Table 6. Statistical analysis of the groups regarding injury severity score

Variable	n	Mean	Mean±SD	Minimum	Maximum
C1 (group 1A)	23	10.811	0.793±4.120	5.148	19.171
C2 (group 1B)	12	17.540	1.370±4.750	12.630	24.500
C3 (group 3)	6	6.694	0.277±0.679	5.967	7.841

Difference between differently-named groups is meaningful (p<0.01).

trauma. Due to the supportive power of the liver, TDR incidences on the right side are less. Our rate of left TDR (78%) was higher than the right side (22%), which is in concordance with the literature.[1-9] The higher incidence rate of left TDR in penetrating trauma as a result of stabbing was because most assailants were right-handed.[1,5] The herniation from the defect depends on the dimension, physical condition, and volume of the abdominal organs. The diameter of the defect in blunt trauma is larger than in penetrating trauma.[1,5,13] In our study, the diameter of defects in blunt trauma were three times larger than in penetrating trauma.

The incidence of associated organ injury is 80-95% in penetrating ruptures.[1,2,5] The most commonly injured structures are the lungs in penetrating trauma and the lungs, ribs, sternum, clavicle, and vertebral fractures in blunt trauma.[5] In our study, the most common injury in penetrating trauma was lung (52.17%), and in blunt trauma, rib fractures occurred most frequently (61.11%). This was as expected according to the literature. The rate of additional intra-abdominal organ injury was 50-80%.[11,24] Our rates of intra-abdominal organ injury were 82.60% for penetrating trauma and 72.22% for blunt trauma. The most common organ for both groups was the liver.

There may be accompanying organ injuries outside the abdomen. Intracranial hematomas (25-55%), pelvic fractures (15-55%), and long bone fractures (45-85%) have also been diagnosed in these cases.[1,11,24] Our cases had two fractures of the extremities caused by gunshot wounds. For blunt trauma, patients had an incidence rate for head crash of 50%, for fractures of the extremitities of 33.33%, and for pelvic fracture of 16.66%. Even if the diaphragm can be explored best from the thorax, the surgical incision is done according to the site that needs emergency surgery. Patients having surgery should be inspected carefully for the possiblity of TDR. In our patients, 56.09% had the diagnosis of TDR in the operating room. In patients with an early diagnosis, an abdominal approach is advised. If this is not adequate or the patient was diagnosed later, a thoracic or thoracoabdominal approach is needed.[11,24]

There were 18 (43.9%) patients who had thoracotomies. Additionally, 13 (31.70%) patients with hemothorax, defects on the thoracic wall, and persistent air leakage due to pneumothorax also underwent thoracotomies. Of these 31 patients, six had an abdominal organ laceration diagnosed during surgery and had a laparotomy, and 10 (24.39%) had an emergency laparatomy due to intra-abdominal hemorrage.

The defect in the diaphragm is closed by single, raw U sutures with nonabsorbable material. Two raw sutures are sometimes used for the repair. In large defects, alloplastic material (dacron, marlex patch), a rectus sheet, or a latissimus dorsi flap is chosen.[10-12] Our preference was a polypropylene graft in seven (17.1%) patients and in 34 (82.9%), mattress suturing with nonabsorbable materials.

There are three group of problems which may lead to complications following surgery for TDR. The first group is related to technical problems with surgical repair, such as a failure of the suture line, respiratory insufficiency due to diaphragm paralysis, empyema, or subphrenic abscess formation due to strangulation and perforation. The second group includes clinical situations like atelectasis, pneumonia, and ileus which arise postoperatively. The third group consists of adult respiratory distress syndrome (ARDS), acute renal failure, fat embolisms, brain edema, and stress ulcers.[1,2,7] The morbidity rate for the lung is about 55%.[10] We had five (12.19%) patients with empyema, infection on the site of surgical incision, intra-abdominal abscess formation, and gastrocutaneous fistula, four (9.75%) patients with respiratory insufficiency, and eight (19.51%) patients

with atelectasis (Table 2). Three patients with atelectasis needed fiberoptic bronchoscopy. In patients with blunt trauma, if there is an additional associated trauma, ISS is over 15.[2,13,24] In our study, the TDR patients with early diagnosis (group 1-B) had higher ISS than the other two groups (Table 6). Blunt trauma patients with head crash presented a worse clinical situation than expected. In the TDR series, the mortality rate is between 2-50%[2,10-13,24] in blunt traumas, and this rate increases in cases of multi-organ injuries. Our mortality rate was 17.07% due to a high rate of accompanying organ injuries.

Traumatic diaphragmatic rupture is not life-threatening by itself. Due to visceral herniation, problems with circulation and respiration may arise. Incarceration and strangulation of the herniating organ may also become life-threatening. We had 56.10% of cases classified as penetrating trauma. An important point for early diagnosis and treatment is to keep the possibility of TDR in mind in multi-trauma patients. Traumatic diaphragmatic rupture itself is less commonly involved with mortality, but it can effectively mask other clinically serious situations. These patients may have morbidity and mortality in the late follow-up period. The way to decrease morbidity and mortality in these patients depends on the clinical follow-up, even if diagnostic tools show no results in the first hospital admission. In all patients who undergo surgery after trauma, the diaphgram should be explored carefully. Traumatic diaphragmatic rupture should be diagnosed and treated quickly. The most commonly used and most effective treatment is primary repair using nonabsorbable sutures.

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