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# Acute Traumatic Diaphragmatic Ruptures: A Retrospective Study of 48 Cases

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**Abstract**

***Purpose.*** Traumatic diaphragmatic rupture (TDR) is associated with high rates of morbidity and mortality, and the preoperative diagnosis is difficult.

***Methods.*** Forty-eight patients with TDR were treated in our department between January 2000 and May 2009. The cause, location, size of rupture, associated morbidity and mortality, surgical material for repair, and predictive factors for overall outcome were evaluated.

***Results.*** There were 41 male patients (85%) and 7 female patients (15%) with a mean age of 33.8 years (range 17–69 years). Blunt trauma accounted for the injuries of 15 patients (31%) and 33 patients (68%) had penetrating injuries. The diagnosis was preoperatively established in 12 patients (25%) with a plain chest X-ray or/and computed tomography. The location of rupture was on the left side of the diaphragm in 35 patients (73%), on the right side in 10 (21%), and was bilateral in 3 patients (6%). Traumatic diaphragmatic rupture was repaired with interrupted nonabsorbable sutures or polypropylene mesh (8 patients). Postoperative complications were observed in 18 patients (38%). Overall mortality was observed in 7 patients (15%). The mortality was associated with hemorrhagic shock ($P = 0.002$), a high injury severity score ($P = 0.002$), and having additional injuries ($P = 0.015$).

***Conclusion.*** The outcome of the patients is associated with presence of hemorrhagic shock, a high injury severity score, and additional organ injury.

**Key words** Traumatic diaphragmatic rupture · Diaphragmatic injury · Injury Severity Score

## Introduction

Acute traumatic diaphragmatic rupture (TDR) is relatively rare and results from physical trauma. Traumatic diaphragmatic ruptures occur in from 1% to 7% of major blunt trauma victims and in 10%–15% of patients with trauma penetrating the lower chest.[1] Another common cause of rupture is iatrogenic insult as a result of medical intervention. The diagnosis of a diaphragmatic injury can be difficult, especially when other associated severe injuries are present and require a high index of suspicion. Diaphragmatic injury is frequently discovered during a laparotomy that is undertaken to examine another abdominal injury. Diaphragmatic rupture at an acute phase is rarely life threatening; however, the injuries associated with diaphragmatic rupture are commonly life threatening.[2] The delayed diagnosis of TDR is associated with increased morbidity and mortality because of herniation and strangulation of the intra-abdominal organs through the ruptured diaphragm into the thorax. All TDRs must be repaired. All penetrating injuries involving the lower chest below the nipple line, abdomen, and back have a risk of diaphragmatic injury.[3] The aim of the present retrospective study was to review the experience of our clinic as a general surgery department while evaluating the diagnostic aspects, surgical management, and treatment results of TDR.

## Patients and Methods

We reviewed the notes and radiographs of 48 patients with a diagnosis of TDR at the Inonu University Turgut Ozal Medical Center, Department of Emergency Surgery and General Surgery, between January 2000 and May 2009. The causes, location (right, left, and bilateral), size (larger diameter of rupture), associated morbidity and mortality, surgical material for repair, and

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predictive factors for the outcome of TDR were evaluated. To investigate the risk factors influencing the patient outcome, we compared the age, hemodynamic status, early (≤24 h) or late (>24 h) diagnosis, size of the diaphragmatic rupture, Injury Severity Score (ISS), and the presence of other organ injuries in survivors and in fatalities. For the statistical analyses, the SPSS 16 software program (SPSS, Chicago, IL, USA) was used. Continuous variables were compared using Student's unpaired *t*-test, and differences between categorical variables were assessed using the $\chi^2$-test. A *P* value of less than 0.05 was considered to be statistically significant.

## Results

A total of 3668 patients were treated for abdominal and thoracic injuries, and 48 (1.3%) patients were observed to have TDR. The study identified 41 male patients (85%) and 7 female patients (15%) ranging in age from 17 to 69 years of age (mean 33.8 years). The causes of injury included stab wounds ($n$ = 17, 35%), gunshot wounds ($n$ = 15, 31%), traffic accidents ($n$ = 9, 19%), falling from a height ($n$ = 6, 13%), and iatrogenic causes ($n$ = 1, 2%). Rupture of the diaphragm was left-sided in 35 patients (73%), right-sided in 10 (21%), and bilateral in 3 patients (6%). Detailed data on the cause of injury and the location of TDR are presented in Table 1.

The most common symptoms were dyspnea in 30 patients (65%) and upper abdominal pain in 25 patients (52%). Hemorrhagic shock occurred in 22 (46%) patients when they were admitted to the hospital. Forty patients' (83%) TDR diagnoses and treatments were established less than 24 h after the trauma occurred. In the remaining 8 patients, the diagnostic and treatment delay ranged from 1 to 10 days. Traumatic diaphragmatic rupture was preoperatively diagnosed in 12 (25%) patients and perioperatively diagnosed in 36 (75%) patients. All 12 preoperatively diagnosed patients had herniation of the abdominal organs into their thorax.

The diagnostic methods included a chest X-ray, computed tomography (CT), ultrasonography (USG), and oral contrast studies. We obtained chest X-rays from all patients, except one who sustained an iatrogenic diaphragm rupture during a hepatic hydatid cyst operation. The patient's rupture was primarily repaired with nonabsorbable suture material during the same operation. The chest X-rays of 19 patients were reported as normal. There was hemothorax and/or pneumothorax with or without diaphragmatic elevation in 22 patients (47%), and on plain chest X-ray gastric or colon gas was seen in the thorax in 6 (13%) patients.

Computed tomography scans of the chest were performed in 19 hemodynamically stable patients. Twelve of the 19 (63%) patients' CT scans were reported as diaphragmatic discontinuity, herniation of abdominal viscera, or omental fat into the chest. All 12 patients had herniation of the abdominal organs into the thorax. Abdominal USG was performed in 19 patients, which reported intra-abdominal free fluid in 18 patients but did not give specific information concerning TDR.

The patients were operated on by different surgeons in our clinic. The median sizes of the rupture (larger diameter of rupture) for blunt and penetrating traumas were 7.3 ± 3.6 and 3.8 ± 1.8 cm, respectively ($P < 001$). Several patients had multiple associated injuries, as shown in Table 2. Nine of 11 patients with sustained right-side TDR had liver injuries, and 24 of 33 patients who had sustained left-side TDR had a spleen injury and/or gastric injuries. Herniation of the intra-abdominal organs into the thorax through a ruptured diaphragm occurred in 16 (34%) patients, all of whom had left-side TDR (Table 1). The most herniated organs were the

**Table 1.** Causes and types of trauma, herniation, and location of traumatic diaphragm rupture sustained in 48 patients

| Cause of trauma | Side of diaphragm rupture | | | Total, *n* | *P* value |
|---|---|---|---|---|---|
| | Bilateral, *n* (%) | Right side, *n* (%) | Left side, *n* (%) | | |
| Iatrogenic | 0 | 0 | 1 (100) | 1 | NS |
| Gunshot | 2 (13) | 4 (27) | 9 (60) | 15 | |
| Stab wound | 0 | 6 (35) | 11 (65) | 17 | |
| TA | 0 | 0 | 9 (100) | 9 | |
| Fall | 1 (17) | 0 | 5 (83) | 6 | |
| Type of trauma | | | | | |
| Blunt | 1 (7) | 0 | 14 (93) | 15 | <0.05 |
| Penetrating | 2 (6) | 10 (30) | 21 (64) | 33 | |
| Herniation (+, –) | | | | | |
| Herniation (+) | 1[a] (6) | 0 | 15 (94) | 16 | <0.05 |
| Herniation (–) | 2 (6) | 10 (31) | 20 (63) | 32 | |

TA, traffic accident; NS, not significant
[a] Left side herniation

stomach (15), omentum (11), spleen (4), colon (3), and the small intestine (3).

The diaphragm was repaired by laparotomy in 46 patients (96%). Thoracotomy was performed because of the presence of heart torsion in one patient. Another patient who was diagnosed with shock underwent laparotomy, but we did not observe any noticeable intra-abdominal bleeding. The patient had active arterial bleeding from a branch of the internal iliac artery that we could not perioperatively halt. The bleeding was stopped via angiographic coiling. Ten days after the operation, we discovered a rupture of the diaphragm and herniation of abdominal content into the thorax. The ruptured diaphragm was repaired via thoracotomy.

We used propylene mesh in 8 patients whose mean rupture size was an average of 7.87 cm, whereas nonabsorbable sutures were used to repair TDR in 40 patients whose mean rupture size was 4.35 cm. There were no diaphragmatic hernias or prosthetic material-induced complications in the postoperative follow-up periods of the patients in this study.

Postoperative complications were encountered among 16 (34%) patients (Table 3). One patient died from sepsis 20 days after surgery. Other complications were successfully treated either surgically or conservatively. Seven patients died (14.8%), six in the operating room due to nonreversible hemorrhagic shock, and the remaining one from pulmonary complications and sepsis in the intensive care unit (ICU). The patients' mean hospital stay was 17 days (range 1–60 days). Sixteen patients (34%) were treated in the ICU. The follow-up times ranged from 2 to 109 months.

We observed a statistically significant association between the outcome of patients and hemorrhagic shock ($P = 0.002$), and between the outcome of patients and the ISS ($P = 0.002$). Having an additional organ injury to TDR was another factor that affected the outcome of patients ($P = 0.015$). Neither age nor delay in diagnosis or the size of diaphragmatic rupture posed a statistically significant risk to the outcome of our patients (Table 4).

**Table 2.** Multiple associated injuries observed in 48 patients who sustained traumatic diaphragmatic rupture

| Type of injury | No. of patients |
|---|---|
| Spleen laceration | 16 |
| Stomach rupture | 15 |
| Liver laceration | 14 |
| Colon laceration | 11 |
| Small bowel laceration | 5 |
| Gallbladder rupture | 4 |
| Pelvis Fracture | 4 |
| Kidney rupture | 3 |
| Pancreas injury | 3 |
| Head injury | 3 |
| Inferior vena cava injury | 2 |
| Bladder injury | 2 |
| Pericardial laceration | 1 |
| Cardiac injury | 1 |
| Clavicle fracture | 1 |
| Internal iliac artery | 1 |
| Femoral vein | 1 |
| Rib fracture | 1 |
| Lung laceration | 1 |
| Extremity fracture | 1 |

## Discussion

The true incidence of TDR is unknown because of either missing or overlooked diagnoses.[4] The proportion of diaphragmatic injury in patients with abdominal and thoracic injuries was 1.3% in our hospital. In conservatively managed patients, the rate of initially missed diaphragmatic injuries ranged from 12% to 66%, which may be overlooked at laparotomy.[1,5] A large collective review in 1995 by Shah et al. suggested that 75% of the injuries to the diaphragm are caused by blunt trauma and 25% by penetrating trauma.[4] Although blunt trauma was the primary cause of TDR in the literature, penetrating injuries were the principal cause of TDR in the present study. This may reflect the demography of our patients or sociological conditions of our region. This injury predominantly affects males (males:females = 4:1) in the third decade of life.[4] Forty-one (85%) of our patients were male, and the mean age of the entire series of patients was 33.8 years.

Although TDR symptoms are related to the associated injuries during the acute phase, most of the patients suffer from dyspnea and pain in the upper abdomen. Other factors are suggestive of TDR, and prompt further diagnostic investigations: pericostal injury, diminishing breath sounds, orthopnea and dyspnea that occur when lying flat, auscultation of bowel sounds in the chest, and

**Table 3.** Postoperative complications

| Complications | No. of patients |
|---|---|
| Empyema | 1 |
| Anastomosis leak | 2 |
| Diaphragm paralysis | 1 |
| Evisceration (open abdomen) | 3 |
| Evisceration (open abdomen)+empyema | 1 |
| Nosocomial pneumonia | 3 |
| Pulmonary embolus | 1 |
| Sepsis | 1 |
| Cerebrovascular event | 1 |
| Wound infection+pneumonia | 1 |
| Empyema+pleurobiliary fistula | 1 |

**Table 4.** Risk factors influenced the outcome in 48 patients with sustained traumatic diaphragmatic rupture

| | Survivors ($n = 41$) | Fatalities ($n = 7$) | $P$ value |
|---|---|---|---|
| Age (years) | Mean: 38, range: 17–69 | Mean: 33, range: 18–61 | 0.431 (NS) |
| Hemorrhagic shock | 15 (36.6%) | 7 (100%) | 0.002 |
| Early diagnosis (≤24 h) | 33 (80.5%) | 7 (100%) | 0.200 (NS) |
| Late diagnosis (>24 h) | 8 (19.5%) | 0 (0%) | |
| Size of rupture (cm) | 4.90 | 5.14 | 0.848 (NS) |
| Injury Severity Score | Mean: 16.80, range: 9–34 | Mean: 31.60, range: 30–69 | 0.002 |
| Additional organ injury (+) | 37 (90%) | 7 (100%) | 0.015 |
| Additional organ injury (–) | 4 (10%) | 0 | |

dullness on percussion of the chest and cough.[6–8] Specific signs and symptoms may not be present during the acute phase in patients with a small diaphragmatic rupture without herniation.[9]

Most TDRs (68.6%–87%) occur on the left side of diaphragm after blunt truncal trauma, because these areas have a weak pleuroperitoneal membrane structure.[4,10,11] The right diaphragm is stronger than the left side, and is partially protected by the liver. Left-sided TDR occurred in 14 patients with blunt trauma, and the other one patient with blunt trauma had bilateral TDR (Table 1).

The size of TDR was smaller in penetrating traumas than in blunt traumas. Small ruptures are potentially more dangerous because of a tendency to overlook the wound, the progression of diaphragm herniation, and strangulation in the late phase. However, large ruptures have high probability for herniation of intra-abdominal organs into thorax in the acute phase. The stomach was the most herniated organ into thorax through TDR in our patients in the acute phase.

The early diagnosis of TDR is a diagnostic dilemma, and a late diagnosis may result in serious complications in patients.[12] Many investigative techniques have been described for the diagnosis of TDR, including plain chest X-ray, CT scan, USG, magnetic resonance imaging, upper gastrointestinal oral contrast study, diagnostic peritoneal lavage (DPL), fluoroscopic evaluation of diaphragmatic motion, intraperitoneal injection of radioisotopes, laparoscopy, and video-assisted thoracic surgery.[6] The two techniques most commonly used are chest X-ray and CT scan. It has been reported that only 25%–50% of the initial chest X-rays are diagnostic of TDR.[5,7] Repeated chest radiographs may also increase the sensitivity of diagnosis.

A CT scan is probably the diagnostic modality of choice in a resuscitated, stable patient. Sensitivity and specificity for CT scan ranges between 33% and 83% and 76% and 100%, respectively, and may be different for the right and left sides.[8] A diagnosis can be made if herniations of abdominal contents are visualized in the thorax (Fig. 1). Spiral CT reconstruction in the coronal and sagittal plane is a simple and effective technique, and can

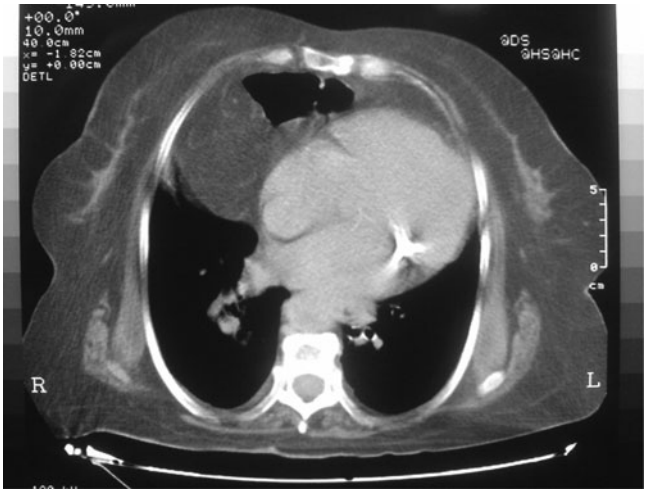


**Fig. 1.** Herniation of abdominal contents (colon gas) into the thorax as visualized by thorax computed tomography

provide a definitive diagnosis of diaphragmatic rupture.[13] Ultrasonography is commonly used for trauma patients, and may allow the visualization of large disruptions or herniation; however, it may miss small tears from penetrating injuries. Magnetic resonance imaging with breath-hold acquisition permits good visualization of diaphragmatic abnormalities, but this technique cannot be performed in emergency situations.[14,15]

Thoracoscopy has been used to visualize the diaphragm when the diagnosis is unconfirmed and a laparotomy is not required.[3] When considering a delayed diagnosis, a chest X-ray and contrast studies (via nasogastric tube or enema) can be used. We did not use DPL or thoracoscopy for the diagnoses; however, a contrast study was used in the diagnosis of one of our patients.

In another of our patients, iatrogenic perforation of a herniated stomach through a ruptured diaphragm into the left thorax occurred during chest tube placement.[9] Before the insertion of the thorax tube, it should be verified whether there is any herniation of intra-abdominal organs into the thorax.

A surgical repair is necessary, even for small tears, because the defect will not spontaneously heal, and a

surgical repair is easier to achieve before fibrosis develops. A conservative approach is not recommended for ruptured diaphragms. The first stage of treatment is solving the shock and the second stage is the surgical approach. As soon as the patient has been evaluated and stabilized as much as possible, the associated injuries require prompt operative attention. In the uncommon case of massive herniation into either the pleural space or luxation of the heart, the diaphragmatic injury requires urgent attention.[4] Surgical management can be performed via laparotomy or thoracotomy or through a combination of these procedures. Shaw et al. have described the laparoscopy-assisted repair of diaphragmatic injuries.[16] We usually employ the transabdominal approach to allow for complete trauma laparotomy to search for any other injuries.

Pulmonary complications are the most common complications in the group undergoing surgery.[17] Eight of the 16 present patients with postoperative complications had pulmonary-related complications (Table 3). The prognosis of TDR is generally good with immediate repair. Failure in diagnosis or a delayed diagnosis may result in significant morbidity or death, due to the herniation of the abdominal contents. Early deaths usually are a result of associated injuries, not the diaphragmatic tear itself. The mortality rates vary from 1% to 28% in the literature.[4] Our six patients succumbing to early death all died in the operating room due to nonreversible hemorrhagic shock.

Although chest X-rays and CT are helpful if the patients have gross herniation, a preoperative diagnosis of TDR can be easily overlooked. Specific signs and symptoms may not be present during the acute phase, especially in patients with a small diaphragmatic rupture. Therefore, we believe that the most important factor in the diagnosis of TDR caused by blunt injury is a skeptical approach by the physician. For patients with penetrating injury, a decision to perform a laparotomy is extremely important. A thorough examination of both hemidiaphragms is recommended for all patients undergoing emergency laparotomy in all cases, even if the patients have normal findings on radiological examinations. Prosthetic material can be used safely in TDR patients with a large tear size. The mortality is associated with the presence of hemorrhagic shock, a high ISS, and the association of additional organ injuries.

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