

# An extremely rare clinical condition: isolated post-traumatic diaphragmatic injuries

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## Abstract

**Aim:** Isolated post-traumatic diaphragmatic injuries are observed less commonly, and the preoperative diagnosis is difficult to make.

**Material and methods:** Thirteen patients with post-traumatic isolated diaphragmatic injury were treated in our department between January 2005 and June 2011. Age, sex, the cause, the location, the size of rupture, the severity of organ injury, the surgical materials used for repair, the associated morbidity and mortality, and the duration of hospitalization were all evaluated.

**Results:** There were 12 male patients (92.3%) and 1 female patient (7.7%) with an overall mean age of 28.76 years (range: 15-55 years). Blunt trauma was responsible for the injuries in 4 patients (30.8%), while 9 patients (69.2%) had penetrating injuries. The diagnosis was established preoperatively in all patients (100%) via a plain chest X-ray and/or a computed tomography (CT) scan. The location of rupture was on the left side of the diaphragm in 12 patients (92.3%) and on the right side in 1 (7.7%). Isolated post-traumatic diaphragmatic rupture was repaired with interrupted nonabsorbable sutures or polypropylene mesh. Postoperative complications were observed in 2 patients (15.3%). Mortality did not occur in any of our patients.

**Conclusions:** A meticulous physical examination and obtaining a chest X-ray should be the first steps to be taken in patients with suspicious isolated post-traumatic diaphragmatic rupture. In case of uncertainty in diagnosis, advanced modalities such as CT, ultrasonography, and magnetic resonance imaging should be utilized.

## Introduction

Traumatic diaphragmatic rupture (TDR) occurs as a result of blunt or penetrating thoracoabdominal trauma and is an indicator of trauma severity [1]. Diaphragmatic rupture rates of 0.8-8% have been reported following all abdominal injuries. Moreover, rates of 1-7% and 10-15% have been reported after blunt and penetrating traumas, respectively [2]. The TDRs, which are rare clinical entities, are not detected in 90% of cases admitted to emergency departments after trauma [3]. A definitive diagnosis cannot be made after the first evaluation in more than half of cases and may be easily missed due to other more prominent symptoms related to other organ systems [4, 5]. An asymptomatic clinical course can occur after isolated post-traumatic diaphragmatic ruptures, and the diagnosis is often established in a delayed manner after development of a herniation

that leads to progressive symptoms. Post-traumatic isolated diaphragmatic ruptures have no specific clinical symptoms and signs; therefore, cases have been reported in which the diagnosis was made years later [3].

A limited number of studies are available involving isolated post-traumatic diaphragmatic rupture, and most are case reports.

## Aim

The purpose of this study was to share our clinical experience, diagnostic methods, and surgical management for isolated post-traumatic diaphragmatic ruptures.

## Material and methods

We evaluated 13 patients with isolated post-traumatic diaphragmatic ruptures following thoracoabdominal trauma who were diagnosed, hospitalized, and received

treatment at the Dicle University Medical Faculty General Surgery Department between January 2005 and June 2011. Patients with diaphragmatic injury were graded according to the American Association for the Surgery of Trauma classification (Table I), as reported by the Organ Injury Scaling Group by Moore *et al.* [6]. The cases were evaluated based on the time of diagnosis, age, gender, trauma etiology, the diagnostic and treatment methods performed, severity of the diaphragmatic injury, injury severity score (ISS), diameter of the diaphragmatic defect, length of hospital stay, complications, and mortality. Cases with a coexisting

organ injury were not included. The time of diagnosis was categorized into two groups as early (within 24 h) and late (after 24 h). All patients admitted to our emergency service with trauma are subject to a multidisciplinary evaluation. A detailed physical examination was performed for each patient, and chest X-rays were obtained before treatment. Computed tomography (CT) scans were obtained in patients demonstrating mediastinal widening and defective lung expansion.

## Results

### Patient characteristics

The mean age of the patients (12 males and 1 female) was  $28.76 \pm 12.76$  years (range: 15-55 years), and the mean ISS was  $7.66 \pm 4.46$  (range: 4-16). Trauma resulted from traffic accidents in 4 patients (30.8%) and a cutting/penetrating injury in 9 patients (69.2%).

In only one case (7.7%), which occurred as a result of a traffic accident, was the diaphragmatic rupture located on the right side. Of the 12 left-sided diaphragmatic ruptures, three (25%) resulted from traffic accidents, and nine (75%) resulted from cutting/penetrating instrument injuries (Table II). When the patients were categorized into grades according to diaphragmatic injury severity, no diaphragmatic rupture was assigned to grade 1 or 5. Injury severity in the other patients is shown in Table III.

### Time of diagnosis and methods

The diagnosis of isolated post-traumatic diaphragmatic rupture was divided into two categories: early (within 24 h) and late (after 24 h). Eight patients (61.5%) were diagnosed within the first 24 h after admission, and 5 (38.5%) were diagnosed more than 24 h after admission. Of the cases diagnosed late, 2 (40%) were diagnosed after 48 h, whereas the other 3 (60%) were diagnosed at 1, 3, and 7 years following the injury.

All patients ( $n = 13$ ) were diagnosed preoperatively. Chest X-ray and thorax CT scans were utilized for the diagnoses. Of 8 patients diagnosed early, 5 (62.5%) were diagnosed through chest-X ray examinations, and the remaining 3 (37.5%) were diagnosed by thoracic CT. All cases diagnosed late underwent surgery after being diagnosed by thoracic CT (Figure 1).

### Surgical procedure

The mean diameter of the diaphragmatic rupture defect was  $3.57 \pm 3.37$  cm (range: 1-10 cm). Defects with diameters < 10 cm were repaired with primary sutures, whereas dual-mesh repair was used for those with defect diameters > 10 cm. Defects in the diaphragm were repaired with non-absorbable sutures.

**Table I.** Grading of diaphragm injuries

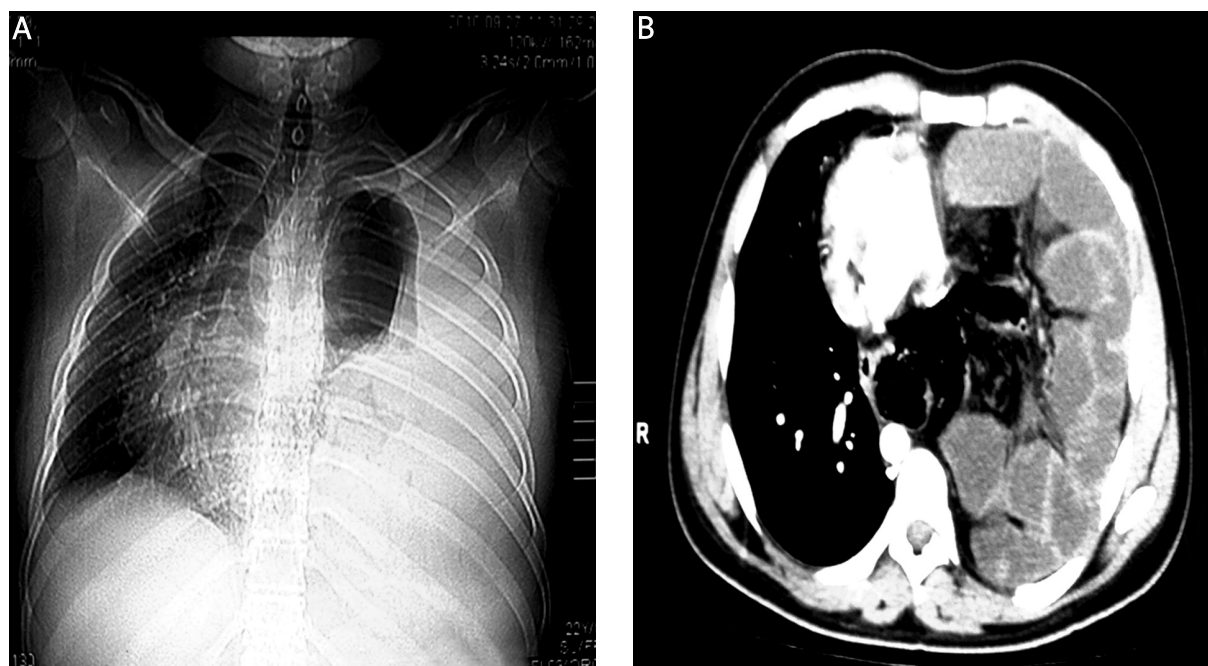
Grade	Finding
I	Contusion. This grade is a very unusual diagnosis and would be unlikely to be described very often. It might be described on CT as an enlarged, localized area of diaphragm muscle seen on the CT images
II	Laceration < 2 cm. This grade would be typical of a bullet hole through the diaphragm
III	Laceration 2–10 cm. This grade is typical of a blunt tear to the diaphragm and would be the most common for blunt tears
IV	Laceration > 10 cm with tissue loss of < 25 cm <sup>2</sup> . This grade would be common for very large blunt tears to the diaphragm
V	Laceration with tissue loss of > 25 cm <sup>2</sup> . This grade would be an unusually large diaphragmatic injury

**Table II.** Etiology of the traumas and localization of the diaphragmatic ruptures

Etiology	N	Right	Left
Blunt Trauma			
Traffic Accident	4	1 (25%)	3 (75%)
Penetrating Trauma			
Stab Wounds	9	–	9 (100%)
Total	13	1 (7.7%)	12 (92.3%)

**Table III.** Injury grades in cases with trauma-related diaphragmatic injury

Grade	Blunt trauma, n (%)	Penetrating trauma, n (%)
1	–	–
2	5 (71.4%)	2 (28.6%)
3	3 (75%)	1 (25%)
4	1 (50%)	1 (50%)
5	–	–



**Fig. 1.** Herniation of intra-abdominal organs into the thoracic cavity, as detected by chest X-ray (A) and thorax computed tomography (B) in a patient who received a late diagnosis

Of the patients diagnosed with isolated post-traumatic diaphragmatic rupture, 9 (69.2%) injuries were approached by laparotomy, 3 (23.1%) by thoracotomy, and 1 (7.7%) injury was approached through both thoracotomy and laparotomy. A tube thoracostomy was performed in all patients.

The primary repair of the diaphragmatic rupture was sufficient for all patients diagnosed early ( $n = 8$ ), whereas three of the cases diagnosed late underwent primary repair, and the remaining two were supported with dual-mesh. No obstruction or necrosis was observed in the organs herniated through the diaphragmatic defect in three of the patients diagnosed late (60%), and sleeve gastrectomy, splenectomy, and primary sutures of the diaphragm were used due to iatrogenic splenic injury and gastric fundus necrosis in one of the remaining 2 cases (40%). The other case was treated by hemicolectomy and primary sutures due to necrosis in the transverse and left colon.

The mean length of hospital stay was  $11.84 \pm 10.14$  days (range: 2-31 days). No mortalities occurred. Pneumonia developed in 1 patient, and an intra-abdominal abscess was observed in another patient on day 8 post-operatively. These patients were treated medically.

## Discussion

Traumatic diaphragmatic hernias are categorized according to etiology and the time of admission. These

characteristics may have pivotal effects on the signs and symptoms at admission and on the selection of methods for diagnostic evaluation and surgical intervention [7]. Diaphragmatic ruptures usually result from penetrating or blunt trauma. Additionally, pregnancy can be a causative factor in rare circumstances. Diaphragmatic ruptures are detected in 10-19% of cases with penetrating trauma to the thorax and the abdomen. Gunshot and stab wounds are the leading causes of penetrating injuries. Diaphragmatic ruptures are observed in 0.8-7% of major blunt trauma cases. Blunt trauma most often occurs due to a motor vehicle accident. Penetrating trauma is the most common cause of a diaphragmatic rupture and is observed twice as often as blunt trauma in patients with diaphragmatic ruptures [8]. In this study, penetrating injuries were identified as the most common cause of diaphragmatic injuries (penetrating injury/blunt injury = 2.25). These kinds of injuries are observed often in the third decade of life and mostly in men [9]. Twelve (92.3%) of our patients were male, and the mean age of the entire series of patients was 28.76 years.

Ruptures of the left posterolateral aspect of the diaphragm are the most commonly seen ruptures after blunt trauma. This area of the diaphragm originally stems from the pleuroperitoneal membrane and is structurally weak. The right diaphragm is congenitally stronger than the left and is partially protected by

the liver, which can dissipate pressure over a large area. The incidence of left-sided diaphragmatic ruptures is higher after blunt injuries, and rates range from 68.5% to 87% [1]. Left-sided diaphragmatic ruptures were more prevalent than right sided ruptures in our study, by a ratio of 3 : 1. This ratio shifted to 100% in favor of left-sided diaphragmatic ruptures in cases with penetrating injuries.

Suspicion about diaphragmatic trauma constitutes the first step in establishing the diagnosis [1]. A definitive diagnosis may be difficult because the clinical course is often asymptomatic in cases with isolated post-traumatic diaphragmatic ruptures. Approximately 12-69% of such cases cannot be diagnosed during the preoperative period [10]. We made the diagnoses preoperatively in all patients in our study, which we attribute to their hemodynamic stability and sufficient time to diagnose. Herniations of the intra-abdominal organs toward the thoracic cavity may be observed if the diagnosis and treatment are delayed. Therefore, meticulous attention should be paid to establish the diagnosis on the first admission to decrease the likelihood of the patient's developing a gastrointestinal obstruction or strangulation [11]. In general, the diagnosis of TDR can easily be made by direct X-ray. Among the diagnostic methods, chest X-ray is of topmost importance [12]. Repeat radiological investigations increase the chance of establishing a diagnosis [9]. A CT scan is a reasonable diagnostic method in resuscitated and clinically stable patients, as the sensitivity and specificity are 33-83% and 76-100%, respectively. The aforementioned ratios of right- to left-sided injuries may vary. A diagnosis can be established after visualizing herniated abdominal organs in the thoracic cavity. Spiral reconstruction of CT images in the coronal and sagittal plane is an easy and useful way to establish the definitive diagnosis of a diaphragmatic rupture [13]. Chest X-ray was performed as a priority for the cases in our study. In suspicious cases with ongoing symptoms (dyspnea or chest pain), the diagnosis was made based on repeat chest X-rays and CT scans. Other diagnostic methods include ultrasonography, fluoroscopy, magnetic resonance imaging (MRI), hepatic and splenic scintigraphy, thoracoscopy, and laparoscopy [14], which we did not utilize in our patients.

Penetrating trauma is less commonly observed than blunt trauma (2 : 1) and leads to the formation of small holes in the diaphragm, which are generally ~1 cm in diameter, excluding gunshot injuries, which can leave defects of 10 cm in diameter. Hence, penetrating injuries can be responsible for diaphragmatic herniations in cases with a delayed diagnosis [15]. The defect diameters in patients with blunt trauma in our study were lar-

ger (5.75 cm) than those in cases with penetrating trauma (2.88 cm). Surgery is mandatory as soon as the diagnosis is made, as any treatment delay is likely to result in herniation of an abdominal organ. Herniation develops due to the pressure difference between the two cavities. If herniation occurs, it may result in strangulation and perforation of abdominal organs, thereby increasing the rates of morbidity and mortality. Thoracotomy, laparotomy, or both are the surgical approach of choice [16]. A laparotomy is preferred for cases with an early diagnosis, as it allows surgeons to carefully explore the intra-abdominal organs for any associated injury. A thoracotomy is necessary for late cases to surgically release the adhesions between abdominal organs and the thoracic wall [17]. We prefer a laparotomy approach in patients diagnosed early, and we repaired the diaphragmatic ruptures in our patients with a delayed diagnosis through thoracotomy and a thoracoabdominal approach.

Various methods and suture materials can be utilized to repair diaphragmatic injuries. Some surgeons prefer to use interrupted or horizontal mattress sutures, whereas others use a running suture technique. Current surgical practice adopts the use of either absorbable or nonabsorbable sutures. Nevertheless, one group has recently criticized the use of absorbable suture materials based on follow-ups of patients after repair of diaphragmatic injuries [18]. The mattress technique with nonabsorbable sutures was used to repair the diaphragmatic ruptures in our patients. Dual-mesh repair was used in two patients with defect diameters > 10 cm.

Morbidity related to diaphragmatic trauma varies from 30% to 68% and is dependent on the presence of related injuries [19]. Blunt trauma cases develop higher rates of complications (60%) than do those with a penetrating trauma (40%) [12]. Pulmonary complications are the most commonly encountered complications in cases undergoing surgery. Urgent repair generally has a good prognostic effect on cases with TDR. Failure to provide a diagnosis or a delayed diagnosis can lead to significantly increased levels of morbidity or death due to herniation of abdominal contents. Mortality during the early period is usually caused by coexisting injuries, not by the diaphragmatic rupture itself. Mortality rates range from 1% to 28% [13]. Contrary to the literature, the cases that were complicated in our series were largely those diagnosed late and with a penetrating trauma. Two cases developed complications of pneumonia and an intra-abdominal abscess, respectively. No mortality occurred among our patients, which may have been related to the occurrence of isolated diaphragmatic ruptures in the absence of any coexisting organ injury.

## Conclusions

Isolated post-traumatic diaphragmatic ruptures are rare, and the diagnosis can easily be missed. Clinical suspicion is the key to prompt the diagnosis. Strict scrutiny including a physical examination and chest X-ray represents the first step for diagnosing patients with suspected isolated post-traumatic diaphragmatic rupture. Advanced methods such as CT, ultrasonography, and MRI should be utilized in cases of diagnostic uncertainty. Both parts of the diaphragm should be examined during surgical exploration, and a laparotomy should be used during the early period for cases without any accompanying pathology, whereas a thoracotomy may be necessary for repair in addition to a laparotomy during the late period.

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