CASE SERIES

Diaphragmatic rupture: A single-institution experience and literature review

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ABSTRACT

BACKGROUND: Diaphragmatic rupture (DR) is a rare and potentially life-threatening event caused by trauma or spontaneously. DR occasionally occurs several months after the injury. Chest X-ray and computed tomography are the most effective diagnostic methods. Delay in DR diagnosis occurs frequently. This study aimed to examine and improve our understanding of the etiology, clinical presentation, and management of DR.

METHODS: This study was performed at the Emergency and General Surgery Department of Fondazione I.R.R.C.S. Cà Granda, Ospedale Policlinico in Milan (Italy). Patients diagnosed with DR between 2001 and 2011 who underwent surgery were included, and their data were retrospectively collected.

RESULTS: Fourteen patients were diagnosed with DR, mainly left-sided DR. Road traffic collisions were the main causes (86%). DR diagnosis was preoperatively established in eight patients (57%). Chest X-ray was diagnostic in 50% of the patients and computed tomography in three patients (60%). Twelve patients had a diaphragmatic hernia. DR was repaired with a mesh in two patients. Mean hospital stay was 16.6 days.

CONCLUSION: Difficulty in achieving early diagnosis of DR is due to its nonspecific presentation. High index of suspicion is needed. Its treatment is using surgery involving reduction of the viscera and repair of the diaphragm defect.

Keywords: Diaphragmatic hernia; diaphragmatic rupture; spontaneous diaphragmatic rupture; traumatic diaphragmatic rupture.

INTRODUCTION

Diaphragmatic rupture (DR) is a rare pathological event that is commonly caused by trauma, as that in road traffic accidents (RTAs) or penetrating injuries.[1–3] DR diagnosis can be immediate or delayed after the main trauma. A different cause of DR is represented by spontaneous DR (SDR). Diaphragmatic hernia (DH) occurs when one or more abdominal structures protrude through the diaphragm.

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Symptoms can vary depending on the DR phase and the clinical setting, and thus, the diagnosis can be easily missed. Surgical treatment is usually required to reduce herniated organs and repair the defect.

MATERIALS AND METHODS

In this study, we evaluated all patients with DR (ICD-9 Codes: 862.XX, 552.3 and 553.3) who were admitted to the Emergency and General Surgery Department (ESD) of Fondazione I.R.C.C.S. Cà Granda, Ospedale Maggiore Policlinico, in Milan (Italy) between January 2001 and December 2011. Each patient who was diagnosed with DR with or without a history of high-energy trauma and had undergone a surgery was included. Patients with a history of hiatal hernia or congenital DH were excluded. We could not determine whether the patients admitted at our ESD were misdiagnosed with DR. DR diagnosis was attested using imaging studies or during the surgical procedure. Data were extracted retrospectively and double-checked by two authors (C.C. and R.V.). Patient data regarding age, sex, mechanism of injury, associated injuries, symptoms, diagnostic imaging methods, time to diagnosis

(time from hospital admission to correct diagnosis), size of rupture, presence of hernia, surgical treatment, postoperative complications and mortality, were evaluated.

RESULTS

Fourteen patients (nine males and five females) with a mean age of 37 (range, 19–79) years were included. Detailed data on patient characteristics, injury details, diagnosis timing, and clinical outcomes are reported in Table 1. RTA was the most common category of trauma (11 intervehicular and one pedestrian), whereas one patient had penetrating trauma. A case of spontaneous DR during a gymnastic exercise was reported in our case series. Hemorrhagic shock occurred in six of 10 patients with acute traumatic injury at admission (60%). The main symptom was dyspnea, and others common symptoms were nausea, chest pain, cough, and epigastric pain. Multiple associated injuries were detected in 10 patients (Table 2), and rib fracture was the most common injury (70%).

The diaphragm defect was left-sided in 12 patients (86%) and right-sided in two (14%); no bilateral DR was found. Herniation of the abdominal organs into thorax was detected in 12 patients (intraoperatively in nine and preoperatively in three). Detailed data on the herniated organs are presented in Table 3.

DR was preoperatively diagnosed in eight of 14 patients (57%) and during surgery in six (43%). The interval between traumatic event and DR diagnosis ranged from 1 h to 96 months. Intraoperative diagnosis was achieved in five of 10 patients with acute blunt DR (BDR) (50%). In four of five patients with acute BDR, the preoperative diagnosis was established in less than 12 h after arrival at our ESD. Three patients without an

Table 2. Associated injuries

Body region	Injury description	No. of patients
Head	Closed head injury	3
	Facial injury	4
Chest	Pulmonary contusion	3
	Rib fracture	7
	Sternum fracture	1
	Pneumothorax	2
	Hemothorax	4
	Vertebral process fracture	2
Abdomen	Liver	1
	Bowel	1
	Renal	1
	Spleen with hemoperitoneum	3
	Spleen without hemoperitoneum	1
Orthopedics	Upper extremities	1
	Lower extremities	1
	Vertebral	2
	Spinal cord	1
	Pelvis	4

Table 1. Characteristics of patients, injury details, timing diagnosis, and clinical outcomes

No	Gender	Age (years)	Cause of injury	Haemorrhagic shock (Yes/No)	Associated injuries (Yes/No)	Time to diagnosis*	Postoperative complication
1	Male	31	Road traffic accident	Yes	Yes	i.o.	No
2	Male	31	Stab wound (11 months before)	No	No	<12 h	No
3	Female	53	Road traffic accident	No	Yes	>12 h	Yes
4	Female	79	Road traffic accident (pedastrian)	Yes	Yes	<12 h	No
5	Male	33	Road traffic accident (46 months before)	No	No	<12 h	No
6	Male	24	Road traffic accident	No	Yes	i.o.	Yes
7	Male	19	Road traffic accident	Yes	Yes	i.o.	i.o. death
8	Male	43	Road traffic accident	No	Yes	<12 h	No
9	Male	28	Road traffic accident (96 months before)	No	No	<12 h	No
10	Female	21	Road traffic accident	Yes	Yes	i.o.	No
11	Female	27	Road traffic accident	Yes	Yes	<12 h	No
12	Male	43	Road traffic accident	No	Yes	<12 h	No
13	Female	41	Gymnastiic exercise	No	No	i.o.	No
14	Male	50	Road traffic accident	Yes	Yes	i.o.	Yes

i.o.: Intra operative diagnosis; *After arrival at the ESD.

Table 3. Diaphragmatic injury and herniated organs

Variable		No. of patients
Location	Right	2
	Left	12
Size	<6 cm	3
	Between 6 and 10 cm	8
	>10 cm	3
Herniated organs	Stomach	7
	Bowel	5
	Liver	2
	Spleen	2
	Omentum	2
	None	2

acute injury presented a medical history of previous trauma: one with stab wound 11 months previously, one with RTA 46 months previously, and another with RTA 96 months previously. These patients presented delayed DR, and dyspnea was the common symptom. Diagnosis was established in these patients in less than 12 h after arrival at the ESD. The only patient with SDR was preoperatively diagnosed.

The diagnostic methods included chest X-ray, computed tomography (CT), ultrasonography (USG), and oral contrast studies. We obtained chest radiographs from 10 patients, and radiographs of five of them (50%) were reported as normal. The chest radiographs usually showed nonspecific signs as diaphragm elevation with loss of right costo-diaphragm angle (Figure 1a and 1b). Five hemodynamically stable patients underwent thoracoabdominal CT, in three of whom (60%), CT scan was diagnostic. In these three patients, chest radiograph findings were consistent with diagnosis on CT scan. Abdominal USG was performed in five patients, which provided specific information concerning DR in two patients (40%). Two patients underwent a positive X-ray oral contrast study (Figure 2).

All 14 patients underwent surgery. Laparotomy (eight emergency laparotomies) was performed in nine patients and thoracotomy in four. One patient underwent left thoracoabdominal approach. The median size of acute BDR (large diameter) and DR was 8±2.7 cm and 5±4 cm, respectively. The size of rupture in the patient with SDR was 6 cm. The herniated organs were always reduced into the abdomen. The diaphragm defect was repaired with non-absorbable direct suture in 12 patients. In two patients, a polypropylene prosthetic mesh was placed following the primary repair of DR. Splenectomy was performed in five patients: in four of whom, the spleen was herniated in the thorax, and in one, bleeding from an iatrogenic spleen occurred in the absence of herniation. A transverse colon resection with colostomy was performed because of bowel perforation.

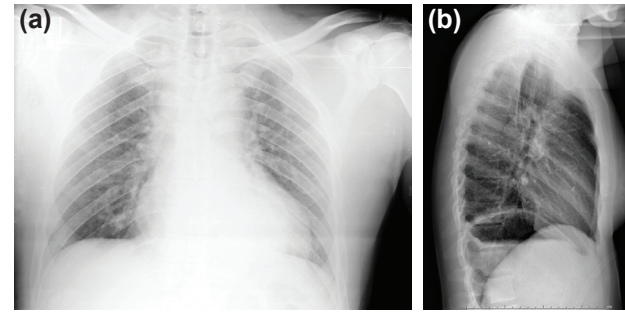

Figure 1. (a) A negative chest radiograph of a patient presenting with BDR (Case 12). **(b)** A diagnostic posteroanterior chest radiograph of a patient with a delayed DR that had occurred during gymnastic exercise. Immediate decompression with a nasogastric tube was required. An elevated left hemidiaphragm can be observed (Case 13).

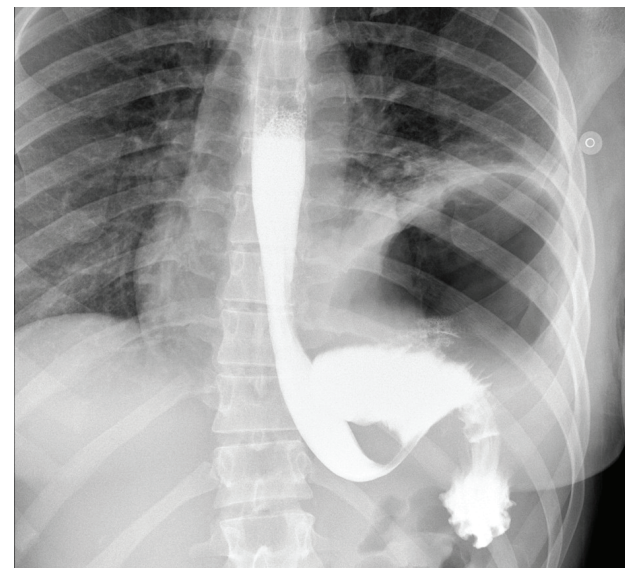

Figure 2. A gastrografin follow-through revealed an elevation and a discontinuity of left hemidiaphragm with herniated stomach into the left hemithorax (Case 13).

A polytraumatized patient died at the end of surgery for cardiocirculatory arrest following hemorrhagic shock. The mean hospital stay was 16.6 (range, 5–53) days. Three patients (27%) had postoperative pulmonary-related complications, which were successfully treated conservatively. In the other eight patients, recovery was uneventful.

DISCUSSION

Any event that can lead to a sudden increase in intra-abdominal pressure may result in DR.[4] In 1974, Grimes described three phases for DR. The acute phase denotes the onset of clinical symptoms at the time of injury. Development to the second phase may take months or even years. The delayed phase is explained by two hypotheses: delayed rupture or delayed detection. Missed diagnosis during the early period of trauma may lead to progressive herniation of intra-abdominal contents into the thorax, and occasionally, visceral obstruction or strangulation occurs.[5–7]

The incidence of diaphragmatic injuries in patients with blunt abdominal trauma is estimated to be 0.8%–5%.[8] RTAs are the most common cause of BDR.[5] In our study, 12 patients (86%) had a recent (10 patients) or previous (two patients) RTA. BDRs are usually observed in the left diaphragm (68.6%–87%) [9] because this area has a weak pleuroperitoneal membrane structure; in contrast, right-side DRs are encountered only in 5%–19% of all DR cases.[10,11] Bilateral hemiDR is rare.

DH is an unusual condition; it occurs in 1%–7% of patients with DR following major blunt trauma and in 10%–15% of patients with penetrating trauma and DR.[3] Our case series describes 12 DHs: three DHs with delayed presentation, one DH due to SDR, and eight DHs detected after acute traumatic injury. The organs most commonly involved in left-sided DH are the stomach and colon (Table 3). In our study, DH was a common event because the study mainly involved polytraumatized patients. The displacement of abdominal organs was more common in delayed hernias, which is consistent with the results in literature. Bowel obstruction, without any evidence of ischemia, was observed in two patients, both with delayed presentation of DH.

SDR is an extremely rare condition accounting for less than 1% of cases of DR.[9] SDR is defined as a damage of the diaphragm due to an increased pressure in the chest or abdominal cavity without direct trauma. In our case series, a single case of SDR was observed and it was associated with DH.

Symptoms in patients with DR may vary depending on the DR phase.[12] In blunt or penetrating trauma, DR is usually associated with reduced breath sounds, orthopnea, and dyspnea.[10,13–15] In the study by Popovic et al.,[16] the main presenting symptoms were epigastric pain, nausea, vomiting, and meteorism.[11] These evidences demonstrated that the diagnosis can be easily missed. In the literature, a great variability in diagnosis timing has been reported.[8,11] The rate of initially missed diaphragmatic injuries range from 12% to 66% after an acute trauma.[17,18] Many investigation techniques have been described for DR diagnosis, but no diagnostic method has a higher sensitivity or specificity than other methods; nonetheless, CT can be considered as the gold standard in an emergency setting in stable patients.[13,19] In our study, the two most commonly used techniques were chest X-ray and CT. In the literature, consistent with our results, it has been reported that only 25%–50% of the initial chest radiographs are diagnostic for BDR.[18,20] Furthermore, sensitivity of CT in diagnosing acute DR ranges between 33% and 83%, and its specificity ranges between 76% and 100%.[18,21] CT findings in acute DR are hemidiaphragmatic discontinuity, intrathoracic herniation of the abdominal content, and the dependent viscera sign.[22,23] In our series, CT revealed a DR in three of five stable polytraumatized patients. A chest X-ray was performed in these three patients, and the findings were consistent with diagnosis on CT. USG may allow the visualization of large DR or DH, but this imaging method is rarely used for first-time investigation. Magnetic resonance imaging can be a good diagnostic tool, but it cannot be performed in an emergency setting.[21] Oral follow-through study was performed in two patients, and it revealed positive results; chest X-ray results in both these patients were negative. The patients with SDR demonstrated negative results on chest X-ray, chest CT, upper gastrointestinal endoscopy, and abdominal USG before being diagnosed using oral follow-through. In our patients with delayed DR, the diagnostic approaches were varied: two patients underwent X-ray barium enema because of bowel obstruction presentation, and in one patient, CT scan was diagnostic for right-sided DH associated with liver and colon herniation. As frequently observed, the preoperative diagnostic rate of DR was lower in polytraumatized patients than in others. This was because of the high complexity in these patients and their difficult management. On exposed evidence, we believe that CT with oral water-soluble contrast can be useful in patients in whom DR is highly suspected.

Surgical management is mandatory and requires the reduction of herniated content, repair of the defect, and occasionally, drainage of the pleura. This surgical management can be achieved by thoracic or abdominal approach.[24] Our most common surgical approach was laparotomy (four median and six subcostal) because of the type of trauma and hemodynamic instability of the patients. Surgical procedure included thoracotomy only in four patients and laparotomy was added for one patient to reduce herniated contents. Thoracotomy was the preferred approach described by Schummer[25] and Kotoulas.[26] Igai[27] chose posterolateral thoracotomy plus right subcostal laparotomy.

Thoracoscopy, laparoscopy, or both approaches combined have been described in the literature as useful methods to diagnose and treat DR, even in acute trauma.[28,29] Some authors have reported that endoscopic freeing is often difficult in chronic DH (CDH) because of the strong adhesions between the herniated viscera and pleura.[30] However, several authors have reported good results of the laparoscopic repair of CDH.[8,31–35] Liao et al have reported rapid recovery and decreased postoperative hospital stay after applying the pledgeted suture method in CDH treatment that involves compressing and approximating the edges of the diaphragm together and releasing the shearing force when applying ties.[36]

In our opinion, considering the addition of a thoracotomy in an unmanageable patient, laparotomy represents the best choice of treatment in cases of complex thoracic and abdominal acute trauma because it allows the widest abdominal view to search for any other injuries. In our case series, thoracotomy alone was performed in two patients with delayed DR and in one patient with acute DR. This last patient had exhibited hemodynamic stability at arrival and the presence of a negative abdominal CT scan.

Primary repair is the gold standard for small- or moderate-

size diaphragmatic defects, whereas large defects (larger than 10 cm) may require patch closure with a mesh. In emergency surgery, patch closure is not usually recommended. Polytetrafluoroethylene, polyethylene terephthalate, and polypropylene are the most common materials used in prosthetic patches to repair DR; some cases with patch infection followed by hernia recurrence have been reported in the literature.[37] We believe that primary repair with non-absorbable sutures is the best technique for diaphragm repair and that prosthetic mesh should be placed when a lack of substance is detected, as usually occurs in delayed presentation of DR.

Pulmonary complications are reported to be the most common postoperative occurrence.[38] Our experience supports this evidence. Associated organ injuries, hemorrhagic shock, missing or delayed diagnosis, rather than the DR itself, result in increased morbidity and mortality.[5,39] Other authors have reported no worsening of prognosis with delayed diagnosis followed by surgical repair.[19] In the literature, mortality rates in patients with acute diaphragm injury differ from those in patients with delayed DH.[3,5,38] In our case series, delayed diagnosis and age were not factors affecting patient outcomes. Furthermore, the low mortality rate recorded (one patient) did not reveal a significant association between reported associated injuries and outcomes.

In conclusion, we can affirm that DR remains a diagnostic challenge because of nonspecific symptoms and signs and low sensitivity of imaging methods. DR repair is mandatory, and prosthetic mesh should be placed when a large DR is detected. It is not possible to define the best management considering the low incidence of DR, the acute setting, and variety of presentation, and diagnostic and treatment options. It is fundamental to maintain high clinical suspicion index in high-risk and compromised trauma patients.

Conflict of interest: None declared.

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OLGU SERİSİ - *ÖZET*

Diyafragma rüptürü: Tek bir kurum deneyimi ve literatürün gözden geçirilmesi

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AMAÇ: Diyafragma rüptürü (DR) seyrek görülen, travma sonucu veya kendiliğinden oluşan yaşamı tehdit edici potansiyeli olan bir olaydır. Bazen DR yaralanmadan birkaç ay sonra oluşur. Göğüs filmi ve bilgisayarlı tomografi en etkili tanısal yöntemlerdir. Sıklıkla DR tanısı gecikir. Bu çalışmanın amacı DR etiyoloji, klinik tablosu ve tedavisini incelemek ve daha iyi anlamaktır.

GEREÇ VE YÖNTEM: Bu çalışma İtalya, Milano I.R.R.C.S. Vakfı Cà Granda Hastanesi Acil ve Genel Cerrahi Bölümü Polikliniği'nde [Emergency and General Surgery Department of Fondazione I.R.R.C.S. Cà Granda, Ospedale Policlinico in Milan (Italy)] gerçekleştirildi. 2001 ila 2011 yılları arasında DR tanısı konup ameliyat geçirmiş hastalar çalışmaya dahil edilip geriye dönük olarak hastaların verileri toplandı.

BULGULAR: Çoğu sağ tarafta DR olan 14 hastaya tanı konmuştur. Başlıca neden trafik kazalarıydı (%86). Sekiz hastada (%57) ameliyat öncesi DR tanısı konmuştu. Göğüs filmi hastaların %50'sine tanı koydurmuş, üç olguda (%60) bilgisayarlı tomografi yararlı olmuştur. On iki hastada diyafragma hernisi mevcuttu. İki olguda DR meş ile onarılmıştır. Ortalama hastanede kalış süresi 16.6 gün idi.

TARTIŞMA: Nonspesifik kliniği nedeniyle erken tanı koymada zorluk yaşanmaktadır. Çok kuşkucu olmak gerekir, tedavisi cerrahidir. İç organlar içeri itilir ve diyafragma defekti onarılır.

Anahtar sözcükler: Diyafragma hernisi; diyafragma rüptürü; spontan diyafragma rüptürü; travmatik diyafragma rüptürü.

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