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Blunt Diaphragmatic Rupture a Case Report and Literature Review

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Abstract

Background: Diaphragmatic injury is a diagnostic and therapeutic challenge.

Materials and methods: We present a collective review of the clinical literature of 1167 patients treated for blunt diaphragmatic rupture (BDR) at various centres from 1957 to 2014. Furthermore, we report an unusual case of a 17-year-old man who sustained an isolated left-sided diaphragmatic rupture with visceral herniation as a result of low-velocity fall.

Results: 70% of the patients were males and the mean age was 39.1 years. The median injury severity score (ISS) was 32.9. Motor vehicle accidents (MVA) were the most frequent cause for BDR accounting for 89% of the cases. Left-sided diaphragmatic rupture occurred almost 3 times more often than right-sided. Diaphragm rupture is rarely seen as an isolated injury in blunt trauma. 95%-100% of patients with BDR have associated injuries including head injuries (30%), chest injuries (51%), pelvic fractures (39%), multiple rib fractures (46%), spleen injuries (42%), liver injuries (28%) and gut injuries (22%). Chest X-ray was diagnostic for BDR in 17%-61%, while CT had a sensitivity ranging between 82-100%. The death rate in our study was estimated to 21.6%.

Conclusion: BDR should be suspected in every case of blunt trauma even though most of the cases were related to high-velocity impact in MVA. A high index of clinical suspicion combined with repeated and selective radiologic evaluation is necessary for early diagnosis. Nevertheless, proper initial resuscitation and correction of other serious injuries may be more lifesaving in patients with BDR.

Keywords: Diaphragmatic injury; Abdomen; Oesophagus; Autopsy; Trauma

Introduction

The diaphragm is a dome-shaped structure of muscle and fibrous tissue that separates the thoracic cavity from the abdomen. It is pierced by a series of apertures permitting the passage of structures such as aorta, vena cava inferior, ductus thoracicus and oesophagus between the thorax and abdomen. In addition, the diaphragm is the most important muscle used for respiration: as it contracts the volume of the thoracic cavity increases and air is drawn into the lungs [1]. Injuries of the diaphragm are often associated with serious consequences because of its anatomical position and crucial function. The most common cause of blunt diaphragmatic rupture (BDR) is severe blunt trauma from motor vehicle accidents [2].

Already in 1541, Sennertus reported an instance of delayed herniation of viscera through an injured diaphragm [3]. In 1579, Paré made the first description of diaphragmatic rupture in a French artillery captain, who initially survived a gunshot wound of the abdomen, but died 8 months later of a strangulated gangrenous colon, herniated through a small diaphragmatic defect that would admit only the tip of the small finger. Using autopsies, Paré also described diaphragmatic rupture in people, who had suffered blunt trauma [4]. It was not until the end of the nineteenth century that surgical procedures for this condition were being undertaken. The first successful diaphragmatic repairs were reported by Riolfi, in 1886, in a patient with omental prolapse, and Naumann, in 1888, operated on a patient with herniated stomach into the left chest cavity [5].

Despite having been recognised early in the history of surgery, blunt traumatic diaphragm rupture was a rarely reported condition before the twentieth century. However, rapid motor vehicle accidents (MVA) have resulted in increasing numbers of severely traumatized patients with multiple injuries globally [5]. Although blunt traumatic diaphragm rupture is relatively no longer an uncommon entity, it still remains a diagnostic and therapeutic challenge to surgeons for several reasons:

1. By virtue of its location between the thorax and abdomen, the diaphragm is rarely injured in isolation in blunt trauma [1]. Consequently signs and symptoms of acute trauma to the diaphragm may often be masked by frequent presence of concomitant multi system injuries.
2. Clinical presentations vary from asymptomatic to hemodynamic instability, gastrointestinal obstruction and respiratory insufficiency [6].
3. Clinical presentation can occur instantly, within hours, or even many years later [7,8].
4. Diagnosis is complicated by the lack of evidence for the value of routine imaging modalities [9].

A delay or missed diagnosis at the time of the initial trauma may increase morbidity and mortality. To highlight and discuss some of the diagnostic and therapeutic challenges of BDR, we present a collective review of the clinical literature of 1167 patients treated at various centres from 1957 to 2014. Furthermore, we report an unusual case of a 17-year-old man who sustained an isolated left-sided diaphragmatic rupture with visceral herniation as a result of law-velocity fall (Appendix 1).

Materials and Methods

A search was conducted in PubMed database using the following

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search string: Traumatic diaphragm rupture and Blunt trauma. The headlines and abstracts were screened and the relevant articles were selected for full-text reviewing. The reference lists of these articles were screened as well to find additional publications. The search was conducted on 2014-11-21 and resulted in, the inclusion of 22 studies (Figure 1).

Study selection

Inclusion criteria were:

1. Articles written in English or one of the Scandinavian languages.
2. Articles available at the homepage of "Det Kongelige Bibliotek" or could be ordered.
3. Articles with relevant data about blunt diaphragmatic rupture.

Exclusion criteria were:

1. Case reports. To use case reports, which mainly present only 1 or 2 patients, would have given a false picture, since deaths or poor results rarely get published.
2. Duplicate publications.
3. Missing data.
4. Main focus on penetrating trauma.

Discussion

There are no reliable data to estimate the incidence of BDR except in general terms. Most of the retrospective reviews included in this paper suggest an overall incidence less than 1% of blunt thoracoabdominal trauma [7,9,11,13,29] (Table 1).

BDR has been identified in 1167 patients treated at various centres from 1957 to 2014. Of these patients, 70% were male aged from 14 to 80 years with a mean age of 39.1 years. The median injury severity score (ISS) was 32.9.

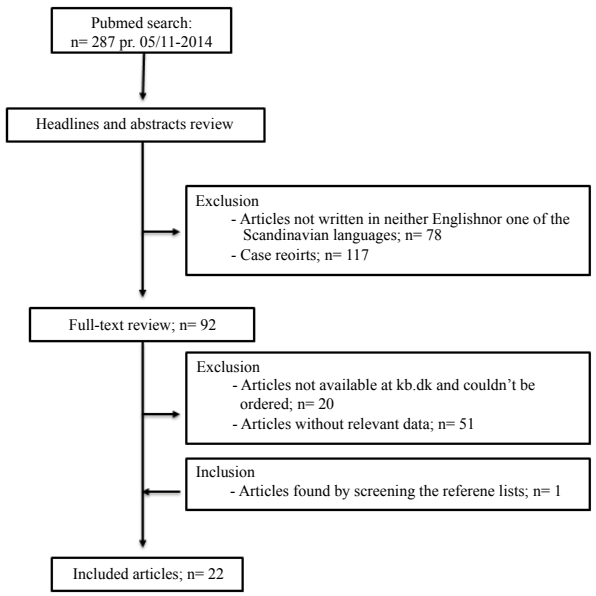

Figure 1: The selection process illustrated in a flow diagram. The headlines and abstracts were screened, and the relevant articles were chosen for full-test reviewing.

Traumas caused by high-velocity motor vehicle accidents (MVA) are the most frequent cause of BDR (Figure 2). Other causes include crush injury and fall from a height [7] - unlike our reported case (Appendix 1). The exact mechanism is not completely understood, but it is hypothesized that the pattern of BDR depends partly on the direction of impact. A lateral impact results in distortion of the chest wall, which may cause shearing of the diaphragm or avulsion of its attachment. In direct frontal impact increased intraabdominal pressure may lead to the rupture [30].

BDR occurs more often on the left side than the right, with a mean left to right ratio of approximately 3:1 (Figure 3). The greater frequency of occurrence of left-sided rupture is thought to result from a combination of the protective effect of the liver on the right side and an area of congenital embryologic weakness in the left hemidiaphragm [12]. The predominance of the left-sided BDR may also be related to the fact that it results from a laterally directed impact and most countries contributing to the medical literature have the steering wheel on the left side of the vehicles. Additionally, the predominance of the left-sided BDR may be partly due to underdiagnosis of right-sided BDR [31]. The radiologic signs are more subtle on right side: The defect in right-sided BDR may be sealed by the liver, and herniation may therefore be delayed or absent [32]. Our results show that cases of bilateral BDR are less than 3% (Figure 3) and the literatures suggest a strong association with severe trauma and high mortality [7].

Grimes [33], in 1974, described the 3 clinical phases of the rupture of the diaphragm. The first or initial acute phase begins with the injury. If not diagnosed early, the second or latent phase occurs, which is asymptomatic but may evolve into gradual herniation of abdominal contents. The diagnosis may be made later because of complications of abdominal contents herniating into the thorax. The third or obstructive phase is characterized by bowel or visceral herniation, obstruction, incarceration, strangulation and possible rupture of the stomach and colon. If herniation causes significant lung compression, it can lead to tension pneumothorax [32]. Such herniation of organs may be delayed for days or years [6,7]. In agreement with our reported case (Appendix 1) the most commonly herniated organs in case of left-sided BDR are the stomach, colon and spleen. Multiple organs are often involved in herniation [16,27].

The anatomic location of the diaphragm, its close relationship to adjacent intrathoracic and intraabdominal organs, and the severity of the trauma play a major role in the fact that BDR rarely occurs in isolation [11]. Patients with BDR have associated injuries, especially in the acute clinical phase, in 95%-100% of cases [5,11-13,24]. The rates, extracted from this present review, for the most common associated injuries in BDR are demonstrated in the following graph (Figure 4).

Due to the extremely high incidence of associated injuries the diagnosis of BDR is frequently missed and symptoms of acute trauma to the diaphragm may often be masked in the acute phase [1].

Since chest x-rays (CXR) are widely available and routinely obtained on blunt trauma patients, it remains valuable in the acute phase for detection of BDR. According to the examined literature CXR is diagnostic for BDR in 17%-61% of the cases (Table 2).

Right-sided injuries of the diaphragm are more difficult to detect on CXR since the liver serves to block herniation of the abdominal contents into the right side of the chest [32]. Specific diagnostic findings of diaphragmatic rupture on CXR include intrathoracic herniation of

First author	Period	Total cases	Mean age (y)	Male	Left	Bilateral	ISS	MVA	Positive radiological diagnosis, %	Head injury	Chest injury	Pelvic-fracture	Multiple rib fractures	Spleen injury	Liver injury	Gut injury	Mortality
Alexandersson et al. [6]	1995-2012	19	47	15	15	0	36	14	38 CXR 93 CT	6	13	11	9	5	4	4	2
Kuo et al. [7]	2001-2009	43	40	34	24	5	18 (9-41)	33	20 CXR.	5	25	6	13	9	10	5	4 - High ISS - Shock - Bilateral DR
Tan et al. [10]	2002-2008	14	38	12	9	0	41	10	64 CXR* 83 CT	3	5	4	4	8	3	6	5 - Age - High ISS
Gwely [11]	1998-2007	44	42	37	30	2	-	35	74 CXR* 82 CT	10	18	10	8	10	8	5	5 - Associated injuries - Clinical status
Ozpolat et al. [12]	1996-2007	20	42	16	14	0	-	9	-	-	5	-	4	2	5	-	4 - Head injuries - High ISS
Matsevych [13]	2003-2006	12	37	7	9	1	-	9	50 CXR	4	5	3	1	0	3	1	3 - Head injuries
Hsee et al. [9]	1996-2005	28	-	25	17	1	28,5	21	17 CXR 90 CT	9	10	-	3	11	5	4	7
Chughtai et al. [14]	1986-2003	208	42	134	135	4	38	178	39 CXR	-	131	-	157	110	64	133	60 - Head injuries: 25%
Bergeron et al. [15]	1984-1999	160	40	91	126	3	26,9	136	61 CXR	65	63	86	69	59	37	39	23 - High ISS
Athanassiadi et al. [16]	1988-1997	41	41	35	24	2	31	32	72 CXR* 77 CT	10	11	10	17	18	14	7	6 - High ISS - Hemodynamical status
Brasel et al. [17]	1987-1994	32	41	18	25	0	32	-	28 CXR.	13	10	13	10	16	15	12	7 - High ISS -Head injuries
Shapiro et al. [18]	1988-1993	20	34	16	14	0	36	19	59 CXR. 42 CT	12	15	10	8	8	8	-	5 - High ISS - Shock
Smithers et al. [19]	1975-1990	85	-	-	65	3	-	75	54 CXR	28	53	36	51	33	21	11	16
Ilgenfritz et al. [20]	1983-1989	52	33	39	39	2	43	49	50 CXR	22	47	20	13	31	18	6	7 - Head injuries - ISS=71
Wilkinson [21]	1965-1986	55	14-80	40	40	0	-	53	50 CXR	2	19	13	25	28	15	-	10 - Head injuries
Carter [22]	1975-1985	33	46	23	24	0	-	27	45 CXR	13	21	11	-	10	10	13	4 - Head injuries
Morgan et al. [23]	1979-1984	44	34	33	33	1	-	41	33 CXR	18	27	-	16	13	10	7	9
Christophi [24]	### (15 years)	63	34	50	56	0	-	63	62 CXR*	8	27	23	34	36	17	4	14 - Associated with many injuries
Rodriguez-Morales et al. [25]	1974-1983	60	35	35	39	1	-	53	40 CXR	20	31	33	?	28	25	5	16
Brown et al. [5]	1957-1982	41	16-72	31	27	2	-		58 CXR	12	25	15	11	19	16	4	17
Troop et al. [26]	1977-1981	42	35	24	27	1	-	39	33 CXR	-	21	19	23	16	15	2	19
Beauchamp et al. [27]	1970-1981	24	-	22	20	1	-	22	63 CXR*	4	11	7	8	11	2	1	3

McCune et al.[28]	###	27	37	23	21	0	-	25	52 CXR	8	3	7	14	7	5	1	6 - Shock
Total; n=	1957-2014	###	##	760	833	29	###	943		272	596	337	498	488	330	270	252
Percentage; %			39	70.2	71	3	33	86		30	51	38.9	46	42	28.3	25.2	21.6

Table 1: Demography and associated injuries. ISS = injury severity score; MVA = motor vehicle accidents. CXR = chest x-ray. CXR* = diagnosis based on CXR and physical examination

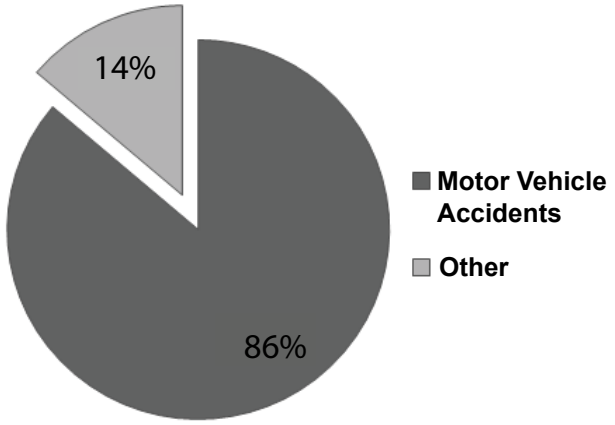

Figure 2: Mechanism of Injury.

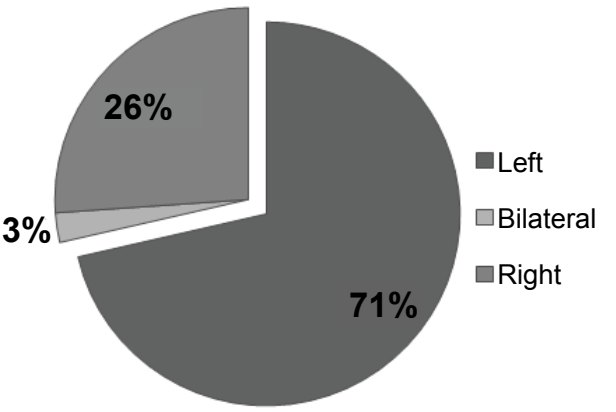

Figure 3: Side of the rupture.

the abdominal contents and visualisation of nasogastric tube above the diaphragm. Suggestive findings include elevation of the hemi diaphragm, irregularity of the diaphragmatic outline and contralateral shift of the mediastinum without pulmonary or intrapleural cause [16]. However, concurrent pulmonary abnormalities related to the trauma such as pleural effusion, pulmonary contusion or laceration and phrenic nerve palsy could mimic or mask the diagnosis on CXR [30].

Several studies in the present review suggest that careful physical examination of the patient together with CXR is diagnostic for BDR in 62%-72% of the cases (Table 3). Even though the clinical presentations vary the usual clinical signs in case of diaphragmatic hernia include diminished expansion of the chest wall, absent respiratory sounds and tympany/dullness on percussion [13]. Matsevych reported that the diagnosis of BDR was improved to 90% with a repeated CXR in the following 12hrs after the trauma [13]. Smithers et al. [34], who found that initial CXR was preoperatively diagnostic in 54% of 85 patients with BDR, emphasised that correct assessment of the initial CXR is the most useful tool to make the diagnosis and mentioned that up to 90% of the CXR of patients diagnosed with BDR are found to be abnormal when reviewed retrospectively.

Currently, CT scan is the cornerstone of diagnostic work-up for patients with severe blunt trauma. According to the literature in the present review CT is diagnostic for BDR in 82-100% of the cases, which is a much higher sensitivity compered to CXR (Table 4).

However, it takes 20-30 minutes to perform a CT scan and patients need to be hemodynamically stable [6]. Some of the typical CT signs for BDR include direct visualisation of injury to diaphragm, segmental non-visualisation of the diaphragm and intrathoracic herniation of the abdominal contents [30].

To the best of our knowledge, spontaneous healing of the diaphragmatic rupture has never been reported. The normally negative pressure gradient along with continuous diaphragmatic motion, contributes to the persistence of the lesion. Because of negative intrapleural pressure, abdominal structures generally herniate into the thorax [31]. Operation is indicated whenever the diaphragmatic rupture is diagnosed, and the patient is able to sustain the surgery. The repair should be performed as soon as possible because of the increased morbidity and mortality associated with this injury. The choice of surgical approach includes thoracotomy, laparotomy or both if necessary. A laparotomy is recommended for patients' diagnosed early allowing exploration of the intraabdominal organs for associated injuries. Thoracotomy is necessary for delayed diagnosed diaphragmatic rupture to safely separate adhesions between abdominal organs and the thoracic wall [11,27]. The diaphragm is usually sutured with non-absorbable suture, but there are currently no studies that provide evidence that it is better than absorbable suture [6].

The death rate in our study is estimated to be 21.6%. Mortality strictly related to diaphragmatic rupture is minimal. Predictors of mortality include associated injures (head injuries, chest injuries), high ISS, age, bilateral BDR and initial clinical status. Delayed diagnosis may increase mortality up to 30% [31,32].

In conclusion BDR should be suspected in every case of blunt trauma even though most of the cases were related to high-velocity impact from MVA. Young males are the usual victims indicating their more frequent involvement in MVA. A high index of clinical suspicion combined with repeated and selective radiologic evaluation is necessary for early diagnosis. Nevertheless, proper initial resuscitation and correction of other serious injuries may be more lifesaving in patients with BDR.

Appendix 1

Posted to weekly for physicians.

Diaphragmatic rupture due to low-energy trauma case

Traumatic Diaphragmatic rupture is a diagnostic challenge and is usually caused by severe blunt or penetrating trauma to the thorax

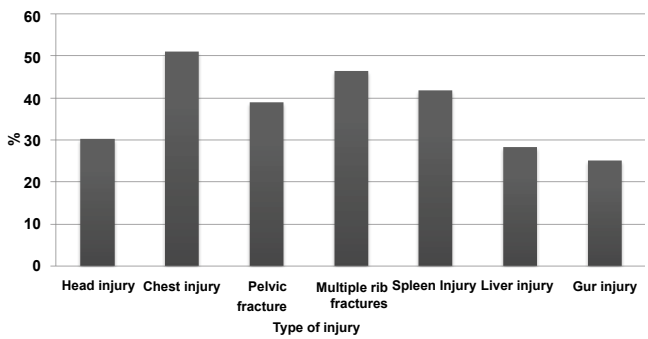

Figure 4: Associated injuries.

First author	CXR
Alexandersson et al. [6]	38%
Kuo et al. [7]	20%
Hsee et al. [9]	17%
Chughtai et al. [14]	39%
Bergeron et al. [15]	61%
Brasel et al. [17]	28%
Smithers et al. [19]	54%
Wilkinson [21]	50%
Carter [22]	45%
Morgan et al. [23]	42%
Rodriguez et al. [25]	40%
Brown et al. [5]	58%
Troop et al [26]	33%
McCune et al. [28]	52%

Table 2: Preoperative diagnosis based on CXR.

First author	CXR*
Tan et al. [10]	64%*
Matsevych [13]	67%*
Athanassiadi et al. [16]	72%*
Christophi [24]	62%*
Beauchamp et al. [27]	63%*

Table 3: Preoperative diagnosis based on CXR and physical examination (CXR*).

First author	CT
Alexandersson et al. [6]	93%
Tan et al. [10]	83%
Gwely [11]	82%
Hsee et al. [9]	90%
Athanassiadi et al. [16]	100%

Table 4: Preoperative diagnosis.

or abdomen [9]. We report here a case of congestive Diaphragmatic rupture with displacement of the spleen, stomach and intestines to the thorax by low energy decrease trauma.

Medical history

17-year-old, previously healthy man turned to the emergency room with severe diffuse abdominal pain, tachycardia, tachypnea and acute malaise. Chest X-ray (Figure 5A) and subsequent trauma CT (Figure 5B) showed a left-side Diaphragmatic rupture with the displacement of the spleen, the stomach and intestines to the thorax. In acute laparotomy organs were mobilized back into the abdomen and diaphragm was sutured.

Upon closer examination of history, it turned out that the patient 10 days earlier stumbled coming down the staircase by which he fell a few steps down and settled on the left flank. By the fall he heard a ''cracking'' and experienced immediate pain. Because of a painful, sleepless night the patient was referred by 1813 to the emergency room. After clinical examination, he was finished with painkillers over the counter medicines and diagnosis '' contusion costae ''.

Over the following days, the patient experienced increasing malaise, sleep problems due. Increasing pain, this was described as turvise "stomach cramps", nausea by eating and lack of bowel movements (in the first 5 days after the fall). For more inquiries and 1813, the patient was asked to rest and take more painkillers. Eventually he turned to the emergency room with the above clinical picture.

10 weeks after the surgery the patient had pain easier genes from incisionstedet, but had largely resumed his normal daily activities.

Discussion

Diaphragmatic rupture due to a blunt abdominal trauma is abnormally with an incidence of less than 1% [9]. Furthermore, Diaphragmatic rupture as a result of a decrease trauma to meet the above case is very rare, in contrast to højenergitraumer of road accidents that make up the most common etiology [9,34]. Congestive Diaphragmatic rupture are more frequent than right-sided regardless of injury mechanism, which probably can be explained by left hemi diaphragm is congenital weaker and that the liver has a protective effect on the right hemi diaphragm [1].

The diagnosis is difficult to make both clinically and radiological. Conventional chest X-ray often shows nonspecific changes and has a sensitivity of less than 40% [6]. However, it is crucial that diaphragmatic rupture are discovered and operated acute as it can lead to life-threatening acute complications and increased morbidity due to late complications such as gastrointestinal herniation and strangulation [35].

A recent Swedish study shows that CT scan with a sensitivity of over 90%, could be crucial to diagnose Diaphragmatic rupture after blunt trauma [6]. Thus, uncharacteristic and persistent symptoms even after low-energy trauma lead to additional diagnostic measures.

Summary

Traumatic rupture of the diaphragm following blunt trauma is rare. It is most commonly seen in high-velocity impact from motor

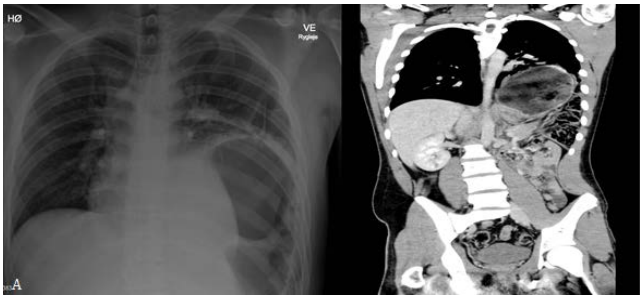

Figure 5: (A) Preoperative chest X-ray. (B) Preoperative CT scan of the chest and abdomen. Both images show congestive diaphragmatic rupture with abdominal contents located in the left chest wall.

vehicle accidents. However, we present a case report of a 17-year-old man who sustained an isolated left-sided diaphragmatic rupture with visceral herniation as a result of low-velocity fall.

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