American Journal of Case Reports

e-ISSN 1941-5923
© Am J Case Rep, 2020; 21: e919442
DOI: 10.12659/AJCR.919442

Received: 2019.08.15
Accepted: 2019.09.27
Published: 2020.01.03

Traumatic Diaphragmatic Rupture with Transthoracic Organ Herniation: A Case Report and Review of Literature

Authors' Contribution:
Study Design A
Data Collection B
Statistical Analysis C
Data Interpretation D
Manuscript Preparation E
Literature Search F
Funds Collection G

ABCDEF 1 Youssef Shaban
ABCDEF 1 Adel Elkbuli
BCDEF 1,2 Mark McKenney
ABCDEF 1,2 Dessy Boneva

1 Department of Surgery, Kendall Regional Medical Center, Miami, FL, U.S.A.
2 University of South Florida, Tampa, FL, U.S.A.

Corresponding Author: Adel Elkbuli, e-mail: Adel.Elkbuli@hcahealthcare.com
Conflict of interest: None declared

Patient: Female, 59-year-old
Final Diagnosis: Axillo-subclavian vessel injuries
Symptoms: Shortness of breath
Medication: —
Clinical Procedure: —
Specialty: Surgery

Objective: Rare disease

Background: Diaphragmatic rupture is a rare pathology that reported in less than 0.5% of all trauma cases, with signs and symptoms that can easily be misdiagnosed. Clinicians must maintain a high index of suspicion to correctly diagnose and manage this pathology. We present a rare case of a large diaphragmatic rupture with transthoracic gastric and colon herniation that was successfully repaired, along with a literature review.

Case Report: A 59-year-old woman presented to our Trauma Center after being involved in a motor vehicle collision. She complained of chest and abdominal pain, with decreased breath sounds on the left side. CT imaging revealed discontinuity of the left hemidiaphragm, with intrathoracic herniation of stomach and colon with multiple other injuries. The patient was taken for an emergent laparotomy. The diaphragmatic rupture measured 20 cm in length, with a stellate component. After ensuring complete reduction of the herniated organs, the diaphragmatic defect was primarily repaired. The patient recovered from her injuries and was doing well at last follow-up in the clinic.

Conclusions: This case highlights the importance of diaphragmatic rupture and its associated intra-abdominal injuries when treating trauma patients. With missed diaphragmatic injuries leading to a potential morbidity rate of 30% and mortality rate as high as 10%, the clinician must have a high index of suspicion to correctly diagnose and manage this pathology in a timely fashion. More research is needed to provide surgeons with evidence-based standardized therapies for dealing with these rare pathologies to ensure optimal patient outcomes.

MeSH Keywords: Abdominal Injuries • Hernia, Diaphragmatic, Traumatic • Rupture

Abbreviations: **TDI** – traumatic diaphragmatic injuries; **BTDI** – blunt traumatic diaphragmatic injury; **DI** – diaphragmatic injuries; **FAST** – focused assessment with sonography for trauma; **CT** – computed tomography; **ISS** – injury severity score; **VATS** – video-assisted thoracic surgery; **AAST** – American Association for the Surgery of Trauma; **OIS** – organ injury scaling

Full-text PDF: https://www.amjcaserep.com/abstract/index/idArt/919442

2430 — 8 16

Indexed in: [PMC] [PubMed] [Emerging Sources Citation Index (ESCI)] [Web of Science by Clarivate]

Background

First described by Sennertus in 1541, diaphragmatic rupture is a rare pathology that is difficult to diagnose [1]. It presents in less than 0.5% of all trauma cases, with the majority caused by a penetrating mechanism (67%), followed by blunt injuries (33%) [2,3]. The most common side injured is the left side, with the stomach being the most common organ to herniate, followed by the spleen. The most common cause of blunt diaphragmatic injuries is motor vehicle collisions [1].

The pathophysiology of this type of injury is not well understood, but the most accepted hypothesis describes an increased intra-abdominal pressure following a blunt mechanism creating a sufficiently high pressure gradient between the chest and abdomen to cause rupture and subsequent visceral intrathoracic herniation [1]. Normally, there is a positive gradient of 7–20 cmH_2O between the intraperitoneal and intrapleural pressures, but during blunt injuries, this positive pressure gradient can exceed 100 cmH_2O, leading to rupture and herniation [4].

The most common signs and symptoms include dyspnea, chest pain, abdominal distention, and loss of breath sounds over the affected hemithorax [5]. This can be misdiagnosed for a pneumothorax, which could lead to incorrect interventions such as a chest tube through a herniated organ. The clinician must have a high index of suspicion to correctly diagnose and manage this pathology in a timely fashion.

In cases with a blunt mechanism, a high-energy force is required for the diaphragm to rupture, which is often associated with other life-threatening injuries. Therefore, when a diaphragmatic rupture is diagnosed, the clinician should expect and investigate for other injuries. This pathology serves as a marker for severe trauma [6].

We present a rare case of a large diaphragmatic rupture with transthoracic gastric and colon herniation that was successfully repaired primarily, along with a literature review, to understanding this clinical entity and better understand management of diaphragmatic rupture. More research is needed to provide surgeons with evidence-based standardized methods for dealing with this rare pathology to ensure optimal patient outcomes.

Case Report

A 59-year-old unrestrained woman presented to our Level 1 Trauma Center after being involved in a motor vehicle collision. The patient was tachycardic, with a marginal blood pressure (90/60 mmHg) and an oxygen saturation in the 90s on room air, which improved with supplemental oxygen. The patient was GCS 15, complaining of epigastric abdominal, lumbar, and left hip pain. On examination, the patient had slightly decreased breath sounds on the left, with diffuse abdominal tenderness, but there were no signs of peritonitis. The initial chest radiograph revealed haziness of the left thoracic cavity with elevation of the diaphragm, without a definite pneumothorax (Figure 1). Focused assessment with sonography for trauma (FAST) was negative and she was taken emergently for computed tomography (CT) imaging.

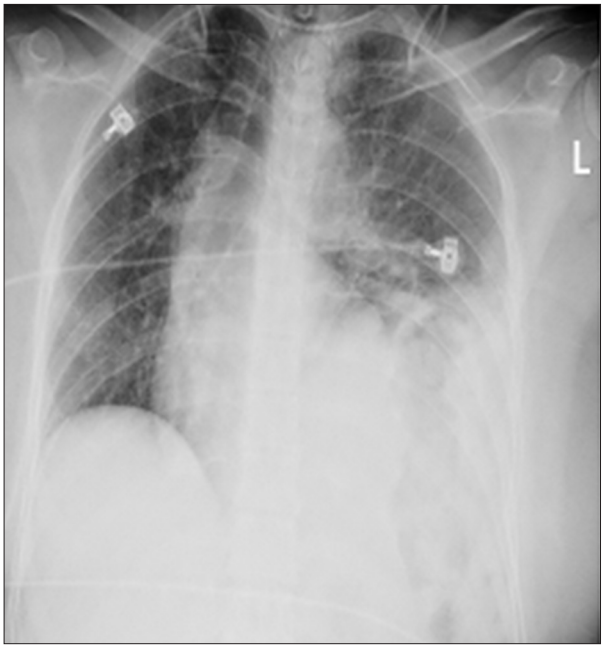

Figure 1. Initial trauma bay chest radiograph. Initial trauma bay chest X-ray with a hazy left thoracic airspace opacity and elevation of the left hemidiaphragm with no definite pneumothorax appreciated.

CT imaging revealed discontinuity of the left hemidiaphragm with intrathoracic herniation of the stomach and colon (Figure 2). The patient suffered several other traumatic injuries, including multiple left-sided rib fractures, left hemothorax, left lower-lobe pulmonary contusion, bilateral grade 2 renal injuries, grade 2 splenic laceration, grade 1 hepatic laceration, left retroperitoneal hematoma, left pelvic fractures, and lumbar transverse process fractures. The patient had a total Injury Severity Score (ISS) of 24, indicating a severe injury burden. The patient was taken emergently to the operating room and underwent an exploratory laparotomy with a midline incision. Upon entering the abdomen, there was minimal hemoperitoneum with a grossly apparent defect of the left diaphragm with transverse colon and stomach intrathoracic herniation (Figures 3, 4). These organs were reduced and lacerations to the liver and spleen were identified and treated via electrocautery, hepatorrhaphy, and splenorrhaphy (Figure 5).

Indexed in: [PMC] [PubMed] [Emerging Sources Citation Index (ESCI)] [Web of Science by Clarivate]

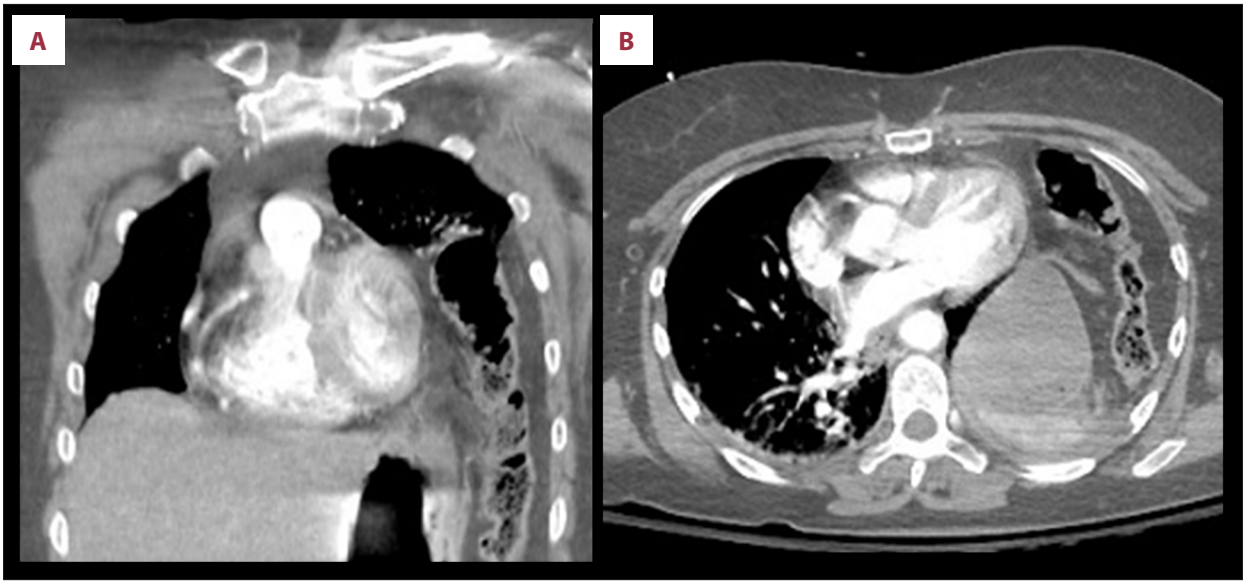

Figure 2. (**A**) CT chest coronal view. CT chest coronal view with left diaphragmatic rupture and intrathoracic herniation of bowel. (**B**) CT chest axial view. CT chest axial view with left diaphragmatic rupture and intrathoracic herniation of bowel.

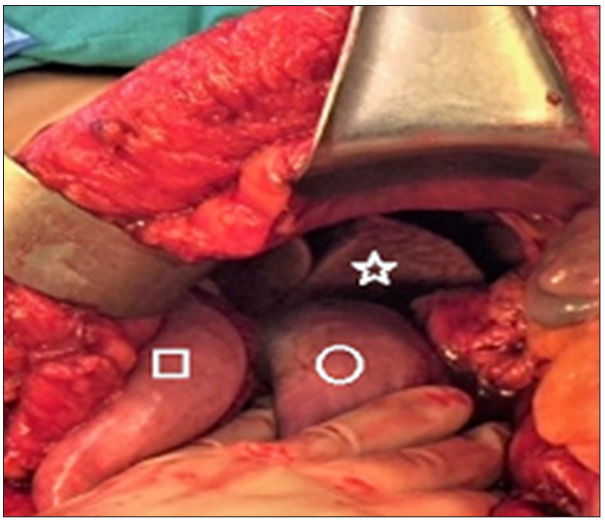

Figure 3. Left diaphragmatic rupture with visceral intrathoracic herniation. Left diaphragmatic defect with herniated stomach and bowel. Square: herniated intrathoracic bowel. Circle: stomach. Star: left lung.

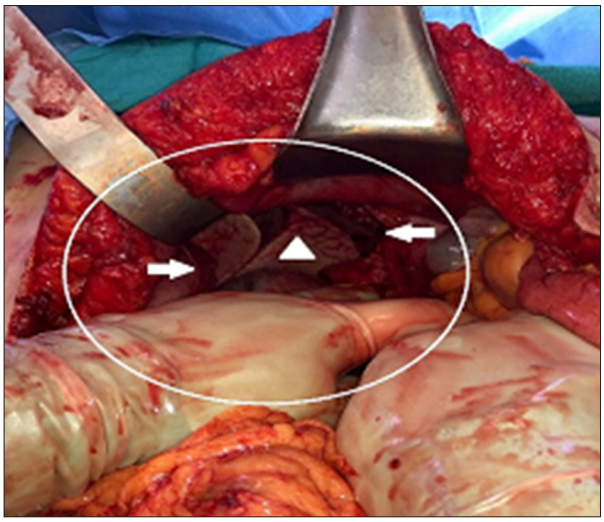

Figure 4. Left diaphragmatic defect. Left diaphragmatic rupture with visualized lung through the defect. Arrows: diaphragmatic defect borders. Arrowhead: left lung.

The diaphragmatic rupture measured 20 cm in length with a curvilinear stellate component extending to the posterior left base, constituting a grade 4 injury. The defect was primarily repaired in 2 layers in an interlocking figure-of-eight and horizontal mattress fashion followed by a reinforced second layer in a running fashion (Figure 6). The left upper quadrant was filled with sterile solution and no air bubbles were appreciated. Two left-sided size 28 French chest tubes were placed and the patient was transferred to the Intensive Care Unit. Her postoperative course was complicated by small pleural effusions, atelectasis, and ileus (Figures 7, 8). The patient eventually recovered and was discharged after a 3-week hospitalization. At 2 weeks follow-up she was doing well.

Discussion

Diagnosing diaphragmatic injuries can be challenging despite a thorough history and physical examination and despite recent advances in imaging. Chest radiographs diagnose diaphragmatic ruptures in as low as 25% of cases, which can lead to a delayed or missed diagnosis. In a single-slice CT study, the sensitivity for left-sided diaphragmatic injuries was 78% and 50%

Indexed in: [PMC] [PubMed] [Emerging Sources Citation Index (ESCI)] [Web of Science by Clarivate]

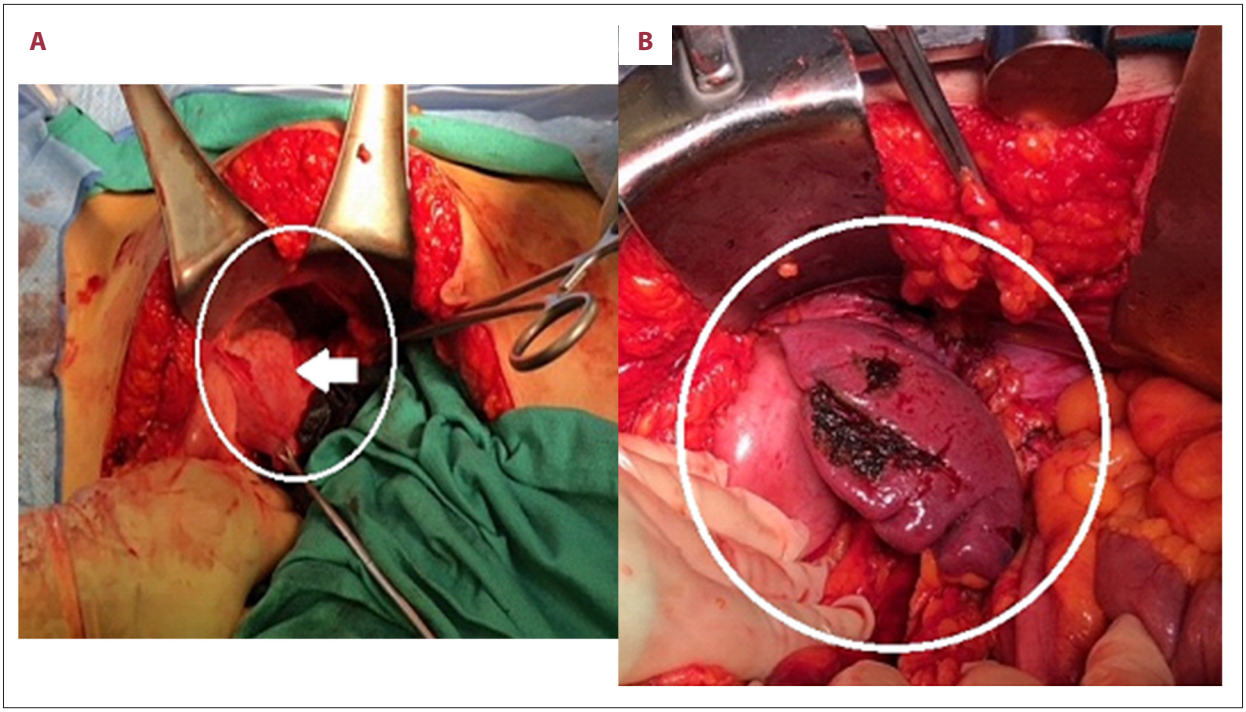

Figure 5. (**A**) Left diaphragmatic injury. Left diaphragmatic rupture with defect appreciated. The borders of the defect are grasped with Babcock clamps. Arrow: visualized left lung through the defect. (**B**) Grade 2 splenic injury. Splenic injury repaired via electrocautery splenorrhaphy.

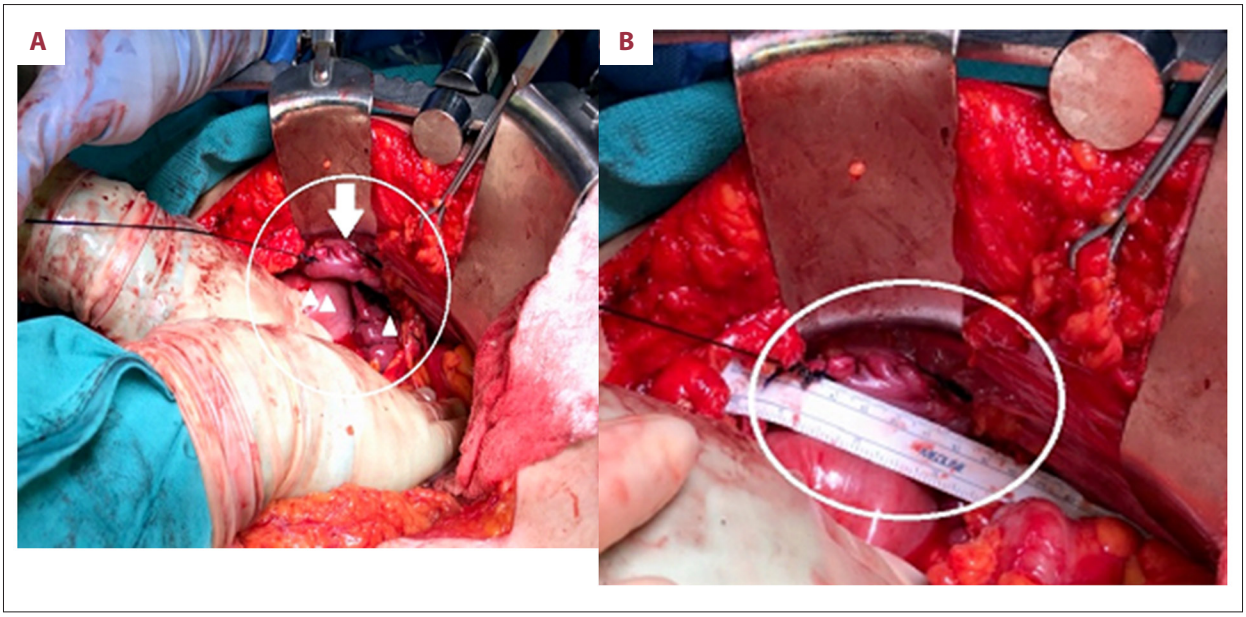

Figure 6. (**A**) Repaired left diaphragmatic injury. Left diaphragmatic defect suture repaired, with visualized spleen and left colon. Arrow: repaired diaphragmatic injury. Arrowhead: spleen. Double arrowhead: colon. (**B**) Measuring the repaired left diaphragmatic rupture. Left diaphragmatic injury after suture repair. The diaphragmatic rupture measured about 15 cm in length, with a curvilinear stellate appearance extending to the posterior left base, which is a grade 4 injury.

for right-sided injuries, but specificity is 100% and 83%, respectively, with a multi-detector CT [4]. In a recent retrospective study analyzing 14 patients diagnosed with diaphragmatic rupture, Corbellini et al. found 57% of patients were diagnosed preoperatively, while the remaining 43% were diagnosed intraoperatively. Investigators found chest radiographs and CT scans

Indexed in: [PMC] [PubMed] [Emerging Sources Citation Index (ESCI)] [Web of Science by Clarivate]

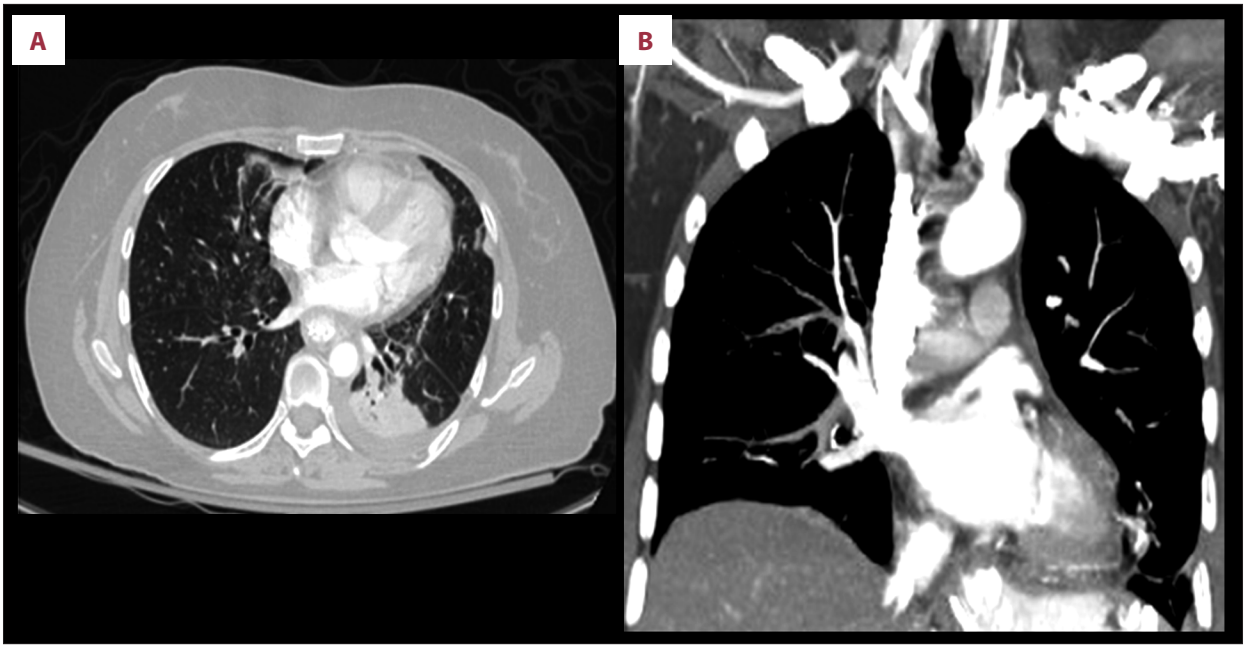

Figure 7. (**A**) Postoperative CT chest axial view. Postoperative day 11 CT chest axial view no longer showing transthoracic organ herniation. Note the resolving right lower-lobe atelectasis. (**B**) Postoperative CT chest coronal view. Postoperative day 11 CT chest coronal view no longer showing transthoracic organ herniation.

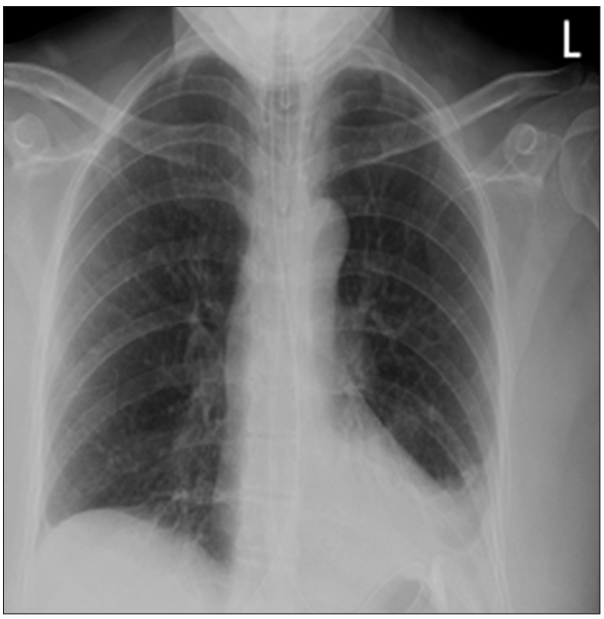

Figure 8. Postoperative chest radiograph Postoperative day 15 chest X-ray. Note the small pleural effusion and complete resolution of the initial haziness seen on the initial trauma bay chest X-ray.

to be diagnostic in 50% and 60% of cases, respectively [7]. When there is a high degree of suspicion despite "negative" diagnostic imaging, the clinician should consider direct visualization by laparoscopy or thoracoscopy, which can exclude or confirm the existence of a diaphragmatic injury. If the patient does not have any signs of intra-abdominal injuries and does not require a laparotomy, video-assisted thoracic surgery (VATS) is an excellent tool for the diagnosis and treatment of diaphragmatic injury [4].

In blunt trauma, a high-energy force is required for the diaphragm to rupture, which can lead to other severe or life-threatening injuries [6]. In an epidemiologic study aimed to identify vehicular and crash factors associated with diaphragmatic injuries, Ryb et al. found they are associated with lateral crashes and higher changes in velocities (ΔV of >40 km/h). In addition, they found that patients with diaphragm ruptures were more likely to have head, chest, and abdominal injuries compared to patients without this injury. They determined that these other injuries were the main cause of mortality rather than the diaphragm injury [8]. Therefore, this pathology serves as a marker for severe trauma and, when diagnosed, the clinician should expect and investigate for other injuries [6].

The American Association for the Surgery of Trauma (AAST) Organ Injury Scaling Committee proposed a classification system for diaphragmatic injury: Grade 1 Contusion; Grade 2 Laceration <2 cm; Grade 3 Laceration 2–10 cm; Grade 4 Laceration >10 cm or with tissue loss <25 cm^2; and Grade 5 Laceration with tissue loss >25 cm^2 [4]. According to this classification system, our patient suffered a grade 4 diaphragmatic injury.

In a retrospective study based on records of 354 307 blunt trauma victims treated between 1998 and 2013 collected by

Indexed in: [PMC] [PubMed] [Emerging Sources Citation Index (ESCI)] [Web of Science by Clarivate]

the Israeli National Trauma Registry, Mahamid et al. found an incidence rate of 0.065% (231 patients) for blunt traumatic diaphragmatic injury, in with motor vehicle collisions accounted for most (84.4%) cases. Associated spleen, liver, and/or lung injuries were found in over 30% of cases, with an overall mortality rate of 26.8% [3].

Fair et al. examined 833 309 cases in the National Trauma Data Bank in 2012 and found 3873 (0.46%) patients with traumatic diaphragmatic injuries, most (67%) of which were penetrating mechanism, followed by blunt mechanism (33%). Patients with blunt injuries had a higher ISS (33±14 *vs.* 24±15, p<0.001) and a higher mortality rate (19.8% *vs.* 8.8%, p<0.001). Blunt compared to penetrating injury patients were more likely to have injuries to the thoracic aorta (2.9% *vs.* 0.5%, p<0.001), lung (48.7% *vs.* 28.1%, p<0.001), bladder (5.9% *vs.*7%, p<0.001), and spleen (44.8% *vs.* 29.1%, p<0.001) [2].

This injury happens too infrequently to undertake randomized controlled trials to develop level-one evidence. Most of the data published are case reports, surgeon experience, and retrospective analyses of hospital-specific outcomes dealing with diaphragmatic injuries. More research is needed to provide surgeons with evidence-based standardized methods for dealing with this rare pathology to ensure optimal patient outcomes.

Historically, the treatment of diaphragmatic rupture from a blunt mechanism includes an abdominal approach via a laparotomy, which allows the surgeon to also treat the commonly associated intra-abdominal injuries simultaneously with the diaphragm [4]. In a retrospective study analyzing 15 consecutive diaphragmatic rupture cases, Porojan et al. found laparotomy to be the preferred surgical approach, with 100% of the cases repaired primarily. Of the 8 diaphragmatic injuries caused by blunt mechanism, investigators found these to have larger tears with an abdominal viscera herniation rate of 75%. Their mortality rate was 20% and deaths were attributed to the associated severe traumatic injuries [9].

In a multicenter review, Ties et al. analyzed 454 patients with diaphragmatic injuries and found the majority were repaired via laparotomy; however, minimally invasive laparoscopic repairs are being used more frequently [10]. In a recent meta-analysis evaluating the most commonly used approach to treat diaphragmatic ruptures, Silva et al. analyzed 68 studies, which included 2023 patients. They found the abdominal approach via laparotomy or laparoscopy to be the most frequently used approach (75%) in the acute setting. However, in the chronic setting, the thorax via thoracotomy or thoracoscopy was the most common (69%). The most common postoperative complications were pulmonary-related, including pneumonia, atelectasis, and empyema (82, 38, and 29 cases), which agrees with our case. There were only 9 cases of dehiscence; however, studies were not separated according to the approach or length of time for follow-up. The initial approach utilized is very important, as revealed by Lim et al., who analyzed outcomes of 38 patients with blunt traumatic diaphragmatic rupture. Of the 38 patients, 22 (57.9%) underwent laparotomy and 16 (42.1%) underwent thoracotomy for their initial surgical approach. They found the rate of additional exploration was higher in patients who initially underwent thoracotomy compared to laparotomy (56.2% *vs.* 9.1%, p=0.003). They found that the additional exploration entailed a significantly longer operation time (330 min *vs.* 237.5 min, p=0.012), and a significantly higher morbidity rate (72.7% *vs.* 22.2%, p=0.008) [6]. Their study suggests that laparotomy is the optimal initial surgical approach in most cases, but current research is lacking comparative studies with minimally invasive approaches such as laparoscopy and VATS.

In cases of delayed diagnosis, an alternative transthoracic approach may offer some benefit because intra-abdominal adhesions and inflammation may lead to a more difficult repair via an abdominal approach [4]. In a recent retrospective analysis of 40 patients with a delayed diagnosis of traumatic diaphragmatic rupture, Zhao et al. found 38 (95%) patients were successfully repaired with a thoracotomy approach, with a recurrence rate of 2.6% at 2-yearsfollow-up, which was repaired with a polypropylene mesh to decrease the tension via a thoracotomy approach [12]. However, as pointed out by Furak et al., multiple approaches can be utilized for chronic traumatic diaphragmatic rupture, including transthoracic, transabdominal, thoracoabdominal, or minimally invasive thoracoscopy, and the choice mainly depends on surgeon experience [4].

The general principles for repairing an acute diaphragmatic rupture include reducing the herniated organs and forming a watertight closure of the diaphragm with placement of a chest tube into the associated hemithorax. There are no randomized controlled trials to recommend specific suture material or repair methods, but it is generally agreed upon that smaller defects can be repaired with a simple running suture or interrupted figure-of-eight or horizontal mattress sutures. Some authors advocate a two-layer closure for defects greater than 2 cm, with an inner layer of interlocking horizontal mattress sutures followed by reinforcement with a running non-absorbable suture. Larger defects, (AAST grades 4–5) may require securing the diaphragm to the ribs or the use of a prosthetic mesh in order to achieve a tension-free repair [4,13,14]. In our case, the herniated colon and stomach seemed to be healthy and without perforation. We were able to successfully achieve a reduction with a watertight tension-free repair utilizing the two-layer closure. However, if the bowel is compromised with signs of gross contamination, the patient may require long-term antibiotics, an extensive washout, and possible bowel resection and colostomy, as reported by Corbellini et al. In their

Indexed in: [PMC] [PubMed] [Emerging Sources Citation Index (ESCI)] [Web of Science by Clarivate]

retrospective study analyzing 14 patients with diaphragmatic rupture, they report a case with diaphragmatic rupture and bowel perforation which required a transverse colon resection and colostomy in addition to the standard reduction and primary repair. The authors reported 3 patients (27%) with postoperative pulmonary-related complications, which were successfully treated conservatively, as in our case [7].

With an incidence as low as 0.5% it is easy to appreciate the difficulty in making the correct diagnosis, as most clinicians will have minimal experience with this pathology. According to Reber et al., the rate of initially missed diaphragmatic ruptures or injuries can be as high as 60%. They found patients with missed diaphragmatic injuries had a mortality rate of 10% and morbidity rate of 30%, with latent signs of obstruction of herniated viscera. The clinician must have a high index of suspicion to correctly diagnose and manage this pathology in a timely fashion in order to avoid long-term morbidity and mortality [15].

Recognizing that the current literature is lacking evidence-based management algorithms for diaphragmatic injuries, in 2018 the Eastern Association for the Surgery of Trauma (EAST) sought to formulate a practice management guideline for diaphragm injuries using the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) methodology. A total of 56 articles were used to formulate the recommendations, with most of the studies being retrospective case series. Unfortunately, the overall quality of the evidence was low and only conditional recommendations could be made, including use of abdominal versus thoracic approach for acute diaphragm injuries, and laparoscopy (with the appropriate skill set and resources) versus open approach for isolated injuries [16]. More research is needed to provide surgeons with evidence-based standardized methods for dealing with this rare pathology to ensure optimal patient outcomes.

Conclusions

We present a rare case of a large diaphragmatic rupture with transthoracic gastric and colon herniation that was successfully repaired primarily, along with an extensive literature review to examine and improve our understanding of this clinical entity and management of diaphragmatic rupture. This case highlights the importance of diaphragmatic rupture and its associated intra-abdominal injuries when treating trauma patients. With missed diaphragmatic injuries leading to a potential morbidity rate of 30% and mortality rate as high as 10%, the clinician must have a high index of suspicion to correctly diagnose and manage this pathology in a timely fashion in order to avoid long-term morbidity and mortality. We are in agreement with the Eastern Association for the Surgery of Trauma (EAST) that more research is needed to provide surgeons with evidence-based standardized methods for dealing with this rare pathology to ensure optimal patient outcomes.

Conflicts of interests

None.

References:

1. Mahmoud AF, Raeia MME, Elmakarem MAA: Rupture diaphragm: Early diagnosis and management. Journal of the Egyptian Society of Cardio-Thoracic Surgery, 2017; 25(2): 163–70
2. Fair KA, Gordon NT, Barbosa RR et al: Traumatic diaphragmatic injury in the American College of Surgeons National Trauma Data Bank: A new examination of a rare diagnosis. Am J Surg, 2015; 209(5): 864–68
3. Mahamid A, Peleg K, Givon A et al: Blunt traumatic diaphragmatic injury: A diagnostic enigma with potential surgical pitfalls. Am J Emerg Med, 2017; 35(2): 214–17
4. Furák J, Athanassiadi K: Diaphragm and transdiaphragmatic injuries. J Thorac Dis, 2019; 11(Suppl. 2): S152–57
5. Akar E, Kaya H: Traumatic rupture of the diaphragm: A 22-patient experience. Biomedical Research, 2017; 28(20): 8706–10
6. Lim KH, Park J: Blunt traumatic diaphragmatic rupture: Single-center experience with 38 patients. Medicine (Baltimore), 2018; 97(41): e12849
7. Corbellini C, Costa S, Canini T et al: Diaphragmatic rupture: A single-institution experience and literature review. Ulus Travma Acil Cerrahi Derg, 2017; 23(5): 421–26
8. Ryb GE, Dischinger PC, Ho S: Causation and outcomes of diaphragmatic injuries in vehicular crashes. J Trauma Acute Care Surg, 2013; 74(3): 835–38
9. Porojan VA, David OI, Coman IS et al: Traumatic diaphragmatic lesions – considerations over a series of 15 consecutive cases. Chirurgia (Bucur), 2019; 114(1): 73–82
10. Ties JS, Peschman JR, Moreno A et al: Evolution in the management of traumatic diaphragmatic injuries: A multicenter review. J Trauma Acute Care Surg, 2014; 76(4): 1024–28
11. Silva GP, Cataneo DC, Cataneo AJM: Thoracotomy compared to laparotomy in the traumatic diaphragmatic hernia. Systematic review and proportional methanalysis. Acta Cir Bras, 2018; 33(1): 49–66
12. Zhao L, Han Z, Liu H et al: Delayed traumatic diaphragmatic rupture: Diagnosis and surgical treatment. J Thorac Dis, 2019; 11(7): 2774–77
13. Mulholland, MW, Lillemoe KD, Doherty GM et al: Greenfield's surgery: Scientific principles and practice. In: Wisner DH, Galante JM, Dolich MO, Hoyt DB (eds.), Abdominal Trauma 5th ed. Philadelphia: Lippincott Williams & Wilkins, 2011; 392
14. Iadicola D, Branca M, Lupo M et al: Double traumatic diaphragmatic injury: A case report. Int J Surg Case Rep, 2019; 61: 82–85
15. Reber PU, Schmied B, Seiler CA et al: Missed diaphragmatic injuries and their long-term sequelae. J Trauma, 1998; 44(1): 183–88
16. Mcdonald AA, Robinson BRH, Alarcon L et al: Evaluation and management of traumatic diaphragmatic injuries: A Practice Management Guideline from the Eastern Association for the Surgery of Trauma. J Trauma Acute Care Surg, 2018; 85(1): 198–207

Indexed in: [PMC] [PubMed] [Emerging Sources Citation Index (ESCI)] [Web of Science by Clarivate]