SN Comprehensive Clinical Medicine (2020) 2:2500–2503
https://doi.org/10.1007/s42399-020-00524-5

SURGERY

Traumatic Diaphragmatic Hernia: Safety and Efficacy of a Minimally Invasive Approach: Case Report

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Accepted: 16 September 2020 / Published online: 28 September 2020

Abstract

Missed diagnosis of traumatic diaphragmatic hernia is a known complication of blunt trauma as the diagnosis can be difficult to ascertain acutely. Pre-operative diagnosis is challenging, and to date, there is no consensus on the standard management for this condition. Until recently, open primary repair was the standard of care with few centers attempting laparoscopic repair for select patients. The objective of this study was to evaluate the safety, technical feasibility, and clinical outcomes for minimally invasive repair utilizing the DaVinci Robotic platform for traumatic diaphragmatic hernia repair. Robotic repair was performed on a patient who presented with a large diaphragmatic hernia 9 years after blunt trauma. The procedure was recorded, technique detailed, and clinical outcomes assessed. There were no significant adverse events noted. After 1 year, the patient is doing well with no complaints, no evidence of recurrence and no other complications. Robotic repair of traumatic diaphragmatic hernia effectively achieved reduction of herniated contents, primary defect closure, and broad mesh overlap with good results at 1 year. This approach may provide an innovative minimally invasive option for surgeons and patients.

Keywords Traumatic diaphragmatic hernia · Robotic · Delayed presentation

Introduction

The true prevalence of traumatic diaphragmatic injury (TDI) is difficult to estimate given the often-delayed diagnosis. The reported incidence of diaphragmatic injury after blunt thoracoabdominal trauma is as high as 14% [1, 2]. Left-sided injuries are more common than right [1, 3]. Because the presentation of traumatic diaphragmatic injury continues to be clinically challenging to identify given their occult features, they often present months or even years after a traumatic injury [4]. Missed TDIs can result in devastating consequences, such as incarceration and strangulation of herniated viscus. A retrospective review of 45 patients with diaphragmatic hernias from TDI reported 25% mortality for those who re-presented with symptoms after their initial trauma admission [5].

The standard of care is to repair all traumatic injuries. Thoracoabdominal injuries span five visceral compartments, and therefore, many different approaches to their repair have been described. Additionally, they can be repaired through a thoracic, abdominal, or combined approach. Both thoracoscopic and laparoscopic approaches have been advocated for in both the diagnosis and repair of diaphragmatic ruptures during the acute phase after trauma in select patients. Despite this, few papers reported a minimally invasive repair of missed diaphragmatic rupture. Open approach is preferred in patients presenting in critical condition or requiring emergency surgery for intestinal obstruction [6]. Safety of laparoscopic repair of TDI has been shown but is also technically challenging. Minimally invasive approaches have been shown to be successful in anteriorly or centrally located traumatic diaphragmatic hernia without concurrent severe abdominal or thoracic injury [7, 8]. In this manuscript, we review the presentation of a patient with a blunt left-sided, posterior traumatic diaphragmatic hernia for whom robotic repair was successfully performed with good results after 1 year of follow-up. Informed consent statement was obtained for this study. In accordance with the Northwestern University Institutional Review Board (IRB), this study is exempt from IRB approval.

This article is part of the Topical Collection on *Surgery*

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Patients/Material and Methods

Our patient was a 41-year-old female with a past medical history significant for motor vehicle collision in 2007 from which she suffered multiple broken ribs among other orthopedic injuries on the left side. In 2018, she presented with an upper respiratory infection and persistent cough. She underwent a chest X-ray (CXR) which demonstrated near complete infiltration of the left chest which was treated with antibiotics for a presumed pneumonia. Follow-up CXRs did not show resolution of the infiltrate prompting a CT chest. This CT (Fig. 1) revealed a large left-sided, posterior diaphragmatic hernia. The spleen, stomach, and large bowel were incarcerated within the defect on CT. Given the presentation of a diaphragm which was largely detached posteriorly from the ribs, it was presumed this was from her MVC in 2007 although not previously diagnosed.

Description of Procedure

The patient was intubated with a double-lumen endotracheal tube and positioned in steep reverse Trendelenburg in the right lateral decubitus position with arms out and draped to allow for thoracotomy if necessary given the possibility of extensive adhesions in the chest. Initially, only abdominal ports were placed with plans to add thoracic ports if unable to complete the reduction from an intra-abdominal approach. A 12-mm robotic trocar was placed in the left hemi-abdomen, just lateral to the semilunar line, and an 8-mm robotic camera with a 30-degree angle was inserted into the intra-abdominal cavity. Two additional 8-mm trocars were inserted along the left hemi-abdomen just below the costal margin as well as an assistant port in the sub-xiphoid location to accommodate the AirSeal™ (Fig. 2).

After entrance into the abdomen, the defect was identified in the posterior left diaphragm (Fig. 3). Upon entry, as shown in the figure, it was clear that the colon, omentum, and spleen were all within the chest. During reduction of the hernia contents, the stomach was also identified and brought out of the chest. All intra-abdominal contents were returned back into the abdomen safely. Electrocautery was used to take down any adhesions to the diaphragm and free up the hernia edges circumferentially. The defect measured 5 cm by 7 cm and was left posterior-lateral. The defect was closed using 0-Ticron interrupted mattress sutures. Bard Felt was cut into 1 cm × 2 cm rectangles and used as suture pledgets in this step (Fig. 4). Before the defect was completely closed, a 7 French round channel drain was placed into the thoracic cavity to help evacuate fluid and allow for lung re-expansion into the left chest postoperatively. The most posterior aspect of the defect was closed to the ribs as there was no remnant diaphragm. This was accomplished with 3 separate interrupted sutures pulled through the abdominal wall fascia using stab incisions and tied externally.

A 15 cm × 20-cm dual-sided Bard mesh with Echo positioning system was chosen to cover and reinforce the defect closure. In order to accommodate this size mesh, the left lobe

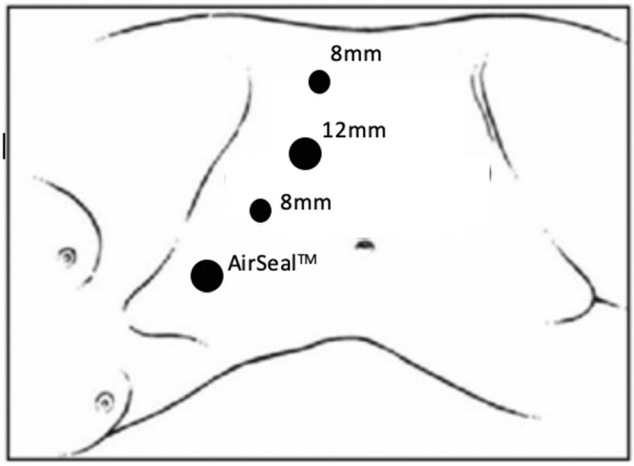

Fig. 2 Laparoscopic port placement. Image shows the placement of robotic ports

Fig. 1 Imaging at presentation. (**a**) Patient's chest X-ray (CXR) showing consolidation in the left lower lobe, (**b**) coronal and (**c**) sagittal CT showing loops of small bowel herniated into the chest from a left posterior diaphragmatic hernia. Circles highlighting defect with herniation of intra-abdominal contents

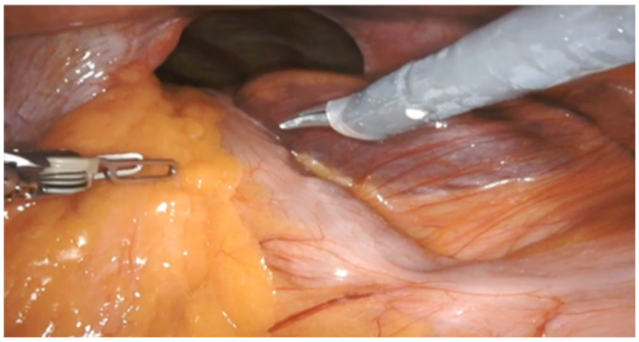

Fig. 3 Intraoperative image depicting left posterior diaphragmatic hernia with bowel and spleen herniated into the chest cavity

of the liver was mobilized medially, taking back the attachments to the level of the midline. The descending colon at the splenic flexure was also mobilized down and out of the way to accommodate the mesh as well. The mesh was brought into the abdominal cavity via the 12-mm port and centered on the most posterior aspect of the defect and the location of greatest tension. The mesh was then secured to the diaphragm and the abdominal wall circumferentially using 2-0 V-Loc absorbable suture. The central portion of the mesh was fixated up to the diaphragm closure to create the three-dimensional shape in the mesh necessary to span the mobile diaphragm and left abdominal wall (Fig. 5).

Results

Postoperative chest X-ray taken on POD 1 showed a well-positioned drain with full inflation of the left lung and trace amount of fluid in the left chest (Fig. 6). The drain was removed on POD 2 and the patient was discharged the same day. The patient was seen in follow-up 2 weeks postoperatively and reported she was ambulating well, tolerating a diet, had no shortness of breath, and no signs or symptoms of infection. She was again seen at 6 months later and is now 1 year postoperative. There is no evidence of recurrence, and the patient reported no activity restrictions.

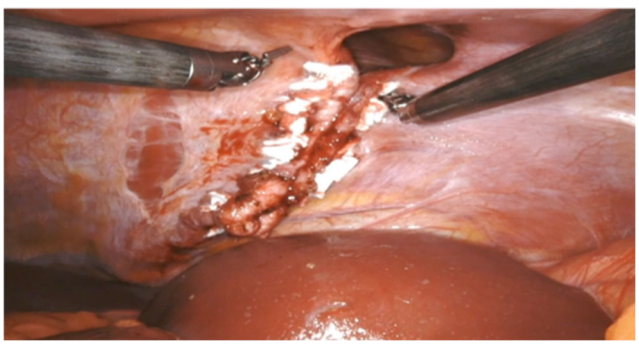

Fig. 4 Primary repair of the defect with pledgeted suture repair

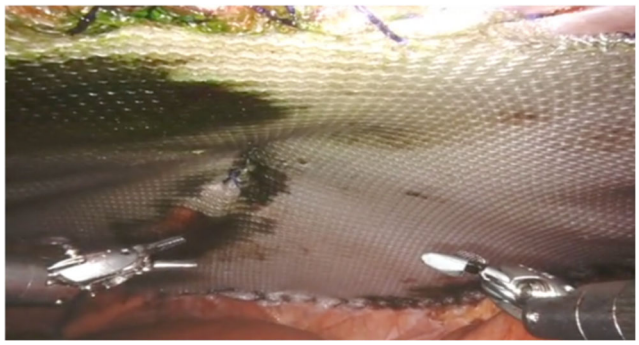

Fig. 5 Final image of the repair of the repaired defect with mesh reinforcement

Discussion

Surgical repair of diaphragmatic hernias was first described as an open technique both via thoracotomy or laparotomy [9, 10]. Since then, laparoscopic and thoracoscopic techniques have been described; however, the incidence of conversion to an open procedure is as high as 23.5%, [2, 11] and the utilization of laparoscopic and thoracoscopic approaches also remains low [12]. The largest review to date reported that of 454 patients with TDI between 1996 and 2011 showed that less than 2% of repairs were performed laparoscopically [12]. Although drivers of this low laparoscopic uptake towards TDI repair has not been studied, technical difficulties include poor visualization, inability to fixate the mesh on the diaphragm using tackers and technical challenges related to intracorporal suturing. The use of a robot allows for optimized three-dimensional visualization and added suturing dexterity due to the technical superiority of instruments with multiple degrees of freedom. This allows for suturing the mesh onto the diaphragm for improved mesh fixation. Robotic repair of TDI also has advantages over open surgery in that it results in

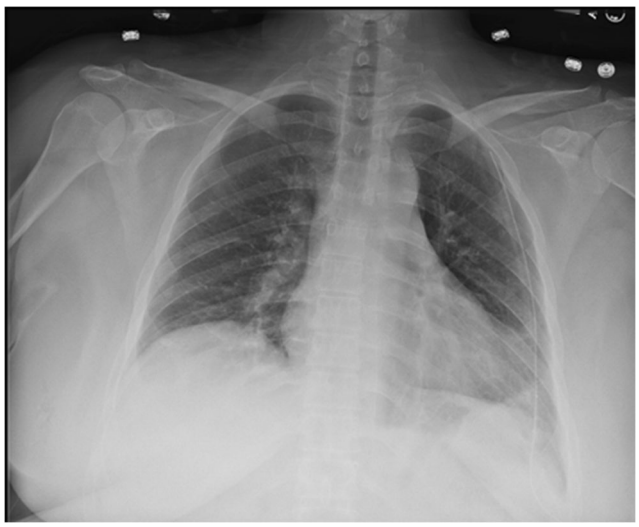

Fig. 6 Chest X-ray taken on postoperative day 1 showing fully inflated lungs bilaterally with no sign of recurrence

minimal manipulation and incisions promoting early recovery.

In the case presented, the robotic transabdominal approach proved to be a useful platform by which a traumatic left-sided diaphragmatic rupture can be repaired. It resulted in a very short length of stay and minimal pain without sacrificing any long-term durability of the repair. Robotic repair, which mirrors the technical advantages of open surgery while providing a minimally invasive approach, allows for primary closure of the defect with mesh reinforcement and is a reproducible and teachable operation. Further study with more patients and long-term follow-up beyond 1 year is needed, but this procedure reproduced all the steps of the open technique and could provide additional options for surgeons tasked with repairing these difficult and rare hernias.

Compliance with Ethical Standards

Conflict of Interest Dr. Ott and Dr. Odell declare that they have no conflict of interest. Dr. Stulberg reports personal fees from Intuitive Surgical Inc., outside the submitted work.

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