

Laparoscopic Repair of a Chronic Iatrogenic Diaphragmatic Hernia

Andrew L. Blount, B.S., Randall O. Craft, M.D., Kristi L. Harold, M.D., and Catherine C. Roberts, M.D.

We report the diagnosis and repair of a chronic, iatrogenic diaphragmatic hernia using minimally-invasive techniques. A 69-year-old man presented with intermittent abdominal and shoulder pain. He had previously undergone laparoscopic Nissen fundoplication in which a grasper-induced puncture injury to the left hemidiaphragm was noted but not repaired. Radiographs and CT imaging diagnosed a left diaphragmatic hernia, with stomach herniated into the left thoracic cavity. This was repaired successfully via an intra-abdominal laparoscopic approach. This case represents the potential importance of repairing post-traumatic diaphragmatic hernia at the time that they occur, as well as a minimally invasive means for their repair.

Introduction

A minimally-invasive approach to the repair of chronic traumatic diaphragmatic hernias has not yet been universally accepted. However, the literature continues to reflect the growing trend towards this alterna-

tive. The use of prosthetic mesh for closing chronic, post-traumatic diaphragmatic hernias is also gaining popularity in concert with the increased application of laparoscopic techniques. In this case report, we describe the successful laparoscopic mesh repair of a chronic, traumatic diaphragmatic hernia caused by a grasper injury from a previous operation.

Citation: Blount AL, Craft RO, Harold KL, Roberts CC. Laparoscopic Repair of a Chronic Iatrogenic Diaphragmatic Hernia. *Radiology Case Reports*. [Online] 2009;4:304.

Copyright: © 2009 The Authors. This is an open-access article distributed under the terms of the Creative Commons Attribution-NonCommercial-NoDerivs 2.5 License, which permits reproduction and distribution, provided the original work is properly cited. Commercial use and derivative works are not permitted.

Abbreviations: CT, computed tomography

Andrew L. Blount, B.S., is at the University of Arizona College of Medicine, Tucson, Arizona, United States of America.

Randall O. Craft, M.D. (Email: craft.randall@mayo.edu), and Kristi L. Harold, M.D. (Email: harold.kristi@mayo.edu), are in the Department of General Surgery, Mayo Clinic, Phoenix, Arizona, United States of America.

Catherine C. Roberts, M.D. (Email: roberts.catherine@mayo.edu), Department of Radiology, Mayo Clinic, Phoenix, Arizona, United States of America.

Published: July 18, 2009

DOI: 10.2484/rcr.v4i3.304

Case Report

A 69-year-old man presented for evaluation of intermittent abdominal bloating associated with left-sided shoulder pain. He denied any other associated symptoms. Physical exam was benign and did not reproduce symptoms. Past surgical history was significant for a laparoscopic Nissen fundoplication performed three years prior for treatment of severe gastric reflux. Of note, the operative report described an iatrogenic grasper-induced puncture injury to the left hemidiaphragm that was not repaired intraoperatively. The patient denied dysphagia

Laparoscopic Repair of a Chronic Iatrogenic Diaphragmatic Hernia

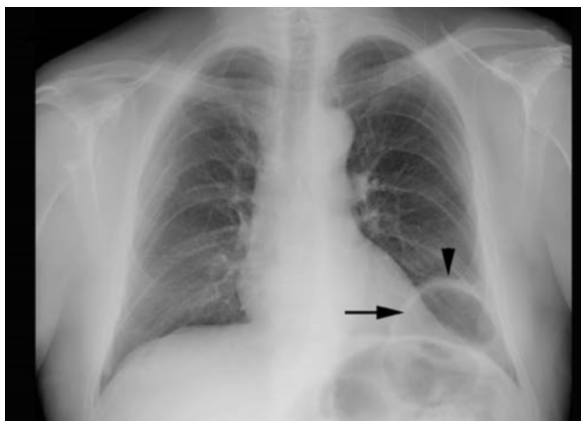


Figure 1. 69-year-old man with chronic diaphragmatic hernia. PA chest radiograph demonstrates a focal air collection (arrow) at the left lung base with adjacent pulmonary atelectasis (arrowheads)

or current gastroesophageal reflux disease (GERD). Chest radiography (Fig. 1) demonstrated an air collection at the left lung base, which was surrounded by a rim of atelectatic lung parenchyma. The left hemidiaphragm had a normal silhouette. The air collection was not definitively contiguous with the stomach.

An enhanced chest CT (Fig. 2) revealed the air



Figure 2A. 69-year-old man with chronic diaphragmatic hernia. Axial enhanced CT image through the lower chest shows a portion of the stomach (arrow) lying within the left thoracic cavity.

collection to represent a portion of stomach that had herniated through a defect in the left hemidiaphragm. There was no recurrence of the hiatal hernia. Normal postoperative changes of Nissen fundoplication were also present.

The patient was subsequently taken to the operating suite for laparoscopic repair of his chronic iatrogenic hernia of the left hemidiaphragm. The abdominal cavity was entered under direct visualization. A five-trocar technique was employed. A liver retractor was used to expose the hiatus. The patient's previous fundoplication appeared intact, and there was no hernia at the hiatus. A portion of the greater curvature of the stomach, as well as a substantial portion of associated fat, had herniated through a small defect in the left diaphragm and into the thoracic cavity (Fig. 3A). The scar around the defect was excised and the hernia contents reduced (Fig. 3B). Intraoperative esophagogastroduodenoscopy was performed after reduction to exclude injury to the stomach. The diaphragmatic defect was measured and found to be approximately 2 x 2cm. A 6 x 6 cm piece of polytetrafluoroethylene (PTFE) Gore DualMesh was fashioned and secured circumferentially with interrupted sutures to the musculature of the diaphragm (Fig. 3C).

A chest radiograph obtained postoperatively (Fig. 4) demonstrated a normal subdiaphragmatic position of the gastric air bubble. Six months postoperatively, the



Figure 2B. 69-year-old man with chronic diaphragmatic hernia. Axial enhanced CT image approximately 3 cm distal to the prior image shows a portion of the stomach (white arrow) streaming through the diaphragmatic defect (arrowheads). Postoperative changes of Nissen fundoplication (black arrow) are partially visualized.

Laparoscopic Repair of a Chronic Iatrogenic Diaphragmatic Hernia

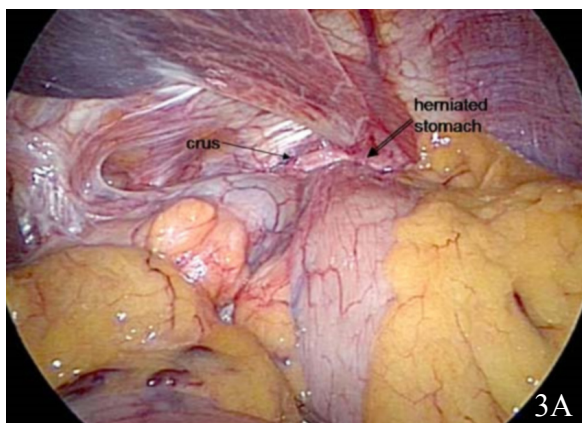


Figure 3A. 69-year-old man with chronic diaphragmatic hernia. Intraoperative photograph of the stomach herniating through the left diaphragmatic defect.

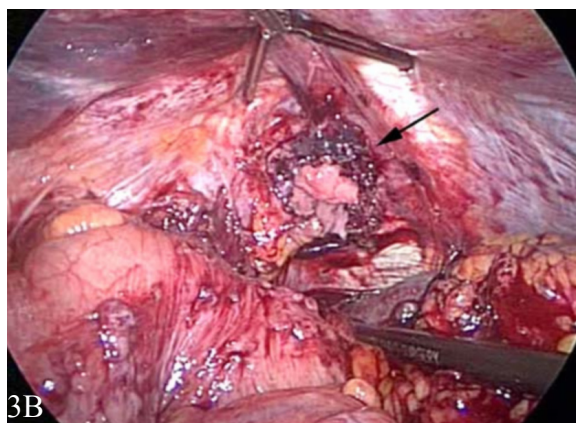


Figure 3B. 69-year-old man with chronic diaphragmatic hernia. Intraoperative photograph showing the diaphragmatic hernia (arrow) after reduction of stomach.

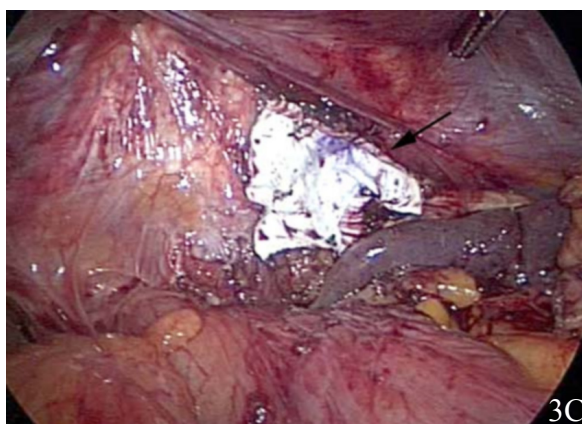


Figure 3C. 69-year-old man with chronic diaphragmatic hernia. Intraoperative photograph of the completed diaphragmatic hernia repair utilizing PTFE mesh (arrow).

patient reported resolution of his left shoulder pain and abdominal bloating.

Discussion

Overview

Diaphragmatic hernias can be classified as either congenital or traumatic. Congenital diaphragmatic hernia (CDH) is a common etiology of newborn respiratory

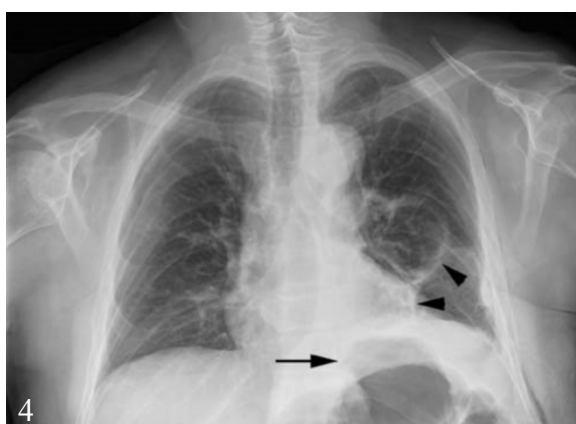


Figure 4. 69-year-old man with chronic diaphragmatic hernia. Postoperative AP chest radiograph demonstrates reduction of the herniated stomach, as seen by a normal location of the gastric air bubble (arrow) below the level of the diaphragm. Atelectatic changes (arrowheads) involve the left lung base.

distress, with a prevalence estimated at 0.25 per 1,000 births [1]; however, it rarely manifests past the newborn period [2]. Daher et al reported a median presentation time of 6 months, with a range of one day to 14 months [3]. Other studies have reported that 5-25% of CDH presents after the neonatal period, but the majority still within childhood [4, 5]. Skari published a meta-analysis reporting that left-sided defects occurred in 81-90% of cases [1]. Alternatively, Daher and colleagues reported

Laparoscopic Repair of a Chronic Iatrogenic Diaphragmatic Hernia

that 56% (10 of 18) of pediatric CHDs were right-sided in their group evaluated between 1990 and 1999. For patients with delayed presentation, gastrointestinal and respiratory symptoms predominate. Kitano et al noted that patients presenting with respiratory symptoms were more likely to have right-sided CDH, while those with gastrointestinal symptoms more commonly had left-sided defects [6].

Traumatic diaphragmatic hernia (TDH) is a common, though often occult, problem. Approximately 1 to 5 percent of hospitalized victims of motor vehicle collisions and 10 to 15 percent of patients with penetrating wounds to the lower chest suffer TDH [7, 8], with most diagnoses attained only after laparotomy for other suspected abdominal lesions [9]. Additionally, TDH accounts for 4 to 20 percent of all wounds due to blunt trauma when diagnosed at the time of trauma-associated thoracotomy or laparotomy [10, 11]. Left-sided TDH is three times more common than right-sided TDH [12], though Voeller et al suggest this number may be skewed by failure of diagnosis due to the presence of the liver [13]. Additionally, an autopsy series revealed an equal incidence of right and left-sided ruptures. Speculation about this infers that right-sided ruptures occur with more violent injuries, thereby causing more deaths before diagnosis occurs [14, 15].

Diagnosis

Delayed diagnosis of blunt TDH is reported to occur in 20 to 50 percent of patients [16]. Blunt TDH is relatively subtle and often asymptomatic, often not evidenced by external deformity. Additionally, diagnostic methods are invasive and time-consuming, with low sensitivities for routine imaging used in the trauma setting.

Sensitivity of chest radiography for diagnosing acute TDH is reported as 46% for left-sided and 17% for right-sided ruptures [17], with 25-50% of imaging reported as normal in the affected patient [18]. When definitive diagnosis on radiography is possible, it is usually due to visualization of air-containing viscera above the level of the diaphragm. Additional findings include elevation of the hemidiaphragm, mediastinal shift, elevated nasogastric tube tip, discontinuous diaphragm silhouette, pleural effusion, and pulmonary atelectasis. Computed tomography has been utilized for diagnosis with better success, with reported sensitiv-

ity of 78% for left-sided and 50% for right-sided acute ruptures [19]. On CT, findings of diaphragmatic hernia include discontinuity of the diaphragm and herniation of viscera into the hemithorax through a focal region of constriction (a.k.a. "collar sign"). Additional imaging techniques, including fluoroscopy, magnetic resonance imaging and sonography, can be diagnostic but are less commonly utilized to evaluate the integrity of the diaphragm and assess for intrathoracic viscera.

Diagnosis in the acute setting may also be hindered as the diaphragm may maintain an effective barrier until it is weakened by inflammation or progression of an initially occult defect [20]. Diagnostic laparoscopy has been described by Smith et al to both diagnose and repair occult diaphragmatic injuries [21]. Concerns have been raised in the literature for the use of laparoscopy as a diagnostic modality in this setting, citing risk for tension pneumothorax [21], gas embolization, the need for general anesthesia, and additive health care costs [22, 23]. Unfortunately, 60% of blunt ruptures go undiagnosed in the acute period [11], with the attendant morbidity and mortality estimated as high as 40 to 80 percent secondary to herniation and strangulation [24, 25].

The presentation of undiagnosed TDH is nonspecific, most commonly associated with vague respiratory disorders, nonspecific chest pain, and gastrointestinal compromise. Surgical reduction and diaphragmatic repair is critical upon diagnosis [26]. Trans-abdominal and trans-thoracic approaches have both been utilized with success, with a retrospective review by Murray et al showing no difference in outcomes between the two methods [27].

Treatment

A minimally-invasive approach to treating TDH is appealing due to the inherent advantages of avoiding thoracotomy or laparotomy. Frantzides and Carlson described the first laparoscopic repair of an acute injury to the diaphragm from a penetrating abdominal injury in 1994 [28]. Subsequent reports have demonstrated consistent success with laparoscopic repairs of traumatic diaphragmatic injuries. Matthews et al reported a series of 17 patients where laparoscopic repair of traumatically-acquired acute and chronic diaphragmatic hernias was attempted. Laparoscopic repair was successful in 13 of the 17 patients, three of which were repaired with

Laparoscopic Repair of a Chronic Iatrogenic Diaphragmatic Hernia

expanded PTFE mesh. Conversion to an open procedure was necessary in four patients because of reluctance or inability to laparoscopically suture a very long (greater than 10cm) diaphragmatic laceration near vital structures. In two patients, a transverse diaphragmatic laceration was adjacent to the pericardium and anterior to the esophageal hiatus. In the other two, the laceration actually communicated with the esophageal hiatus. They concluded laparoscopic repair was a safe and effective alternative but recommended laparotomy for hernias adjacent to or involving the esophageal hiatus [29].

Evaluation and repair of right-sided hernias has further implications due to the lack of exposure beyond the liver. Some authors have suggested that right-sided defects be an indication for thoroscopic diagnosis, as the liver can mask defects that would be apparent on thoracoscopy [30]. However, other authors contend that the liver provides a significant enough obstruction to the surgeon's approach that a right-sided defect be an indication for thoroscopic repair [31, 32].

For congenital diaphragmatic hernia repaired at neonatal age, primary closure is preferred as it avoids mechanical and infectious complications posed by a prosthesis, and has a lower rate of recurrence. Mesh is only used when primary repair is impossible or would create excessive tension that would contraindicate its use. When used, Gore-Tex/Marlex composite patch repair has been associated with the lowest recurrence rate [33]. In adults, both laparoscopic primary and laparoscopic mesh repairs have been described for congenital diaphragmatic hernias [34, 35]. Closures should remain tension-free, thus mandating that large defects generally require a prosthesis to maintain normal respiratory excursion [36].

With traumatic diaphragmatic hernia, the use of mesh versus primary repair has not been firmly established, but the current literature trends toward the use of a prosthesis for an optimal tension-free repair. Both Shah et al and Slim et al have described the need for mesh repair with chronic diaphragmatic hernias. They have observed that over time hernia size increases, the edges sclerose circumferentially, and the hernia becomes fixed. Therefore, an adequate tension-free closure requires the use of prosthetic mesh and non-absorbable sutures [37, 38]. Both agree that, in the acute setting, primary closure of the defect is suitable if a tension-free repair is technically feasible [7, 8, 39-41]. The ideal mesh for repair has been debated. Slim et al describe

the use of polypropylene mesh, noting advantages of excellent tissue ingrowth and strong suture line [38]. However, Frantzides et al, prefer polytetrafluoroethylene (PTFE) mesh for congenital diaphragmatic hernia [42], noting that PTFE has a decreased tendency toward adhesion formation. Further, they cite that PTFE is less likely to erode into the gastrointestinal tract as has been described with polypropylene [43, 44]. Slim et al further defended the use of polypropylene, noting that adhesion formation seems significantly decreased with laparoscopic placement compared with laparotomy [45]. They additionally noted that gastrointestinal erosion was actually observed during hiatal hernia repair [44] and that this complication would be unlikely with prosthetic repair of diaphragmatic trauma as the placement of mesh is away from the digestive tract [38].

Conclusion

Our patient presented with complaints of abdominal pain and left shoulder irritation due to an iatrogenic diaphragmatic hernia acquired during a laparoscopic procedure. This case represents the potential importance of repairing such injuries at the time they occur, even when small, as well as a minimally invasive means for their repair.

Acknowledgment

The authors would like to acknowledge the assistance of Elaine M. Ledoux, R.T. (R)(BD)(CBDT) in the preparation of this manuscript.

References

1. Skari H, Bjornland K, Haugen G, Egeland T, Emblem R. Congenital diaphragmatic hernia: a meta-analysis of mortality factors. *J Pediatr Surg*. 2000;35:1187-97. [PubMed]
2. Szavay PO, Drews K, Fuchs J. Thoracoscopic repair of a right-sided congenital diaphragmatic hernia. *Surg Laparosc Endosc Percutan Tech*. 2005;15:305-7. [PubMed]

Laparoscopic Repair of a Chronic Iatrogenic Diaphragmatic Hernia

3. Daher P, Zeidan S, Azar E, Khoury M, Melki I, Mikhael R. Right congenital diaphragmatic hernia a well-known pathology? *Pediatr Surg Int.* 2003;19:293-5. [PubMed]
4. Newman BM, Afshani E, Karp MP, Jewett TC Jr., Cooney DR. Presentation of congenital diaphragmatic hernia past the neonatal period. *Arch Surg.* 1986;121:813-6. [PubMed]
5. Osebold WR, Soper RT. Congenital posterolateral diaphragmatic hernia past infancy. *Am J Surg.* 1976;131:748-54. [PubMed]
6. Kitano Y, Lally KP, Lally PA. Late-presenting congenital diaphragmatic hernia. *J Pediatr Surg.* 2005;40:1839-43. [PubMed]
7. Johnson CD. Blunt injuries of the diaphragm. *Br J Surg.* 1988;75:226-30. [PubMed]
8. Meyers BF, McCabe CJ. Traumatic diaphragmatic hernia. Occult marker of serious injury. *Ann Surg.* 1993;218:783-90. [PubMed]
9. Kuhn R, Schubert D, St Wolff, Marusch F, Lippert H, Pross M. Repair of diaphragmatic rupture by laparoscopic implantation of a polytetrafluoroethylene patch. *Surg Endosc.* 2002;16:1495. [PubMed]
10. Root H. Injuries to the diaphragm. In: Moore E, Mattox K, Feliciano D (eds). *Trauma.* Norwalk, CT: Appleton and Lange; 1991:427.
11. Shah R, Sabanathan S, Mearns AJ, Choudhury AK. Traumatic rupture of diaphragm. *Ann Thorac Surg.* 1995;60:1444-9. [PubMed]
12. Patselas TN, Gallagher EG. The diagnostic dilemma of diaphragm injury. *Am Surg.* 2002;68:633-9. [PubMed]
13. Voeller GR, Reisser JR, Fabian TC, Kudsk K, Mangiante EC. Blunt diaphragm injuries. A five-year experience. *Am Surg.* 1990;56:28-31. [PubMed]
14. Reber PU, Schmied B, Seiler CA, Baer HU, Patel AG, Buchler MW. Missed diaphragmatic injuries and their long-term sequelae. *J Trauma.* 1998;44:183-8. [PubMed]
15. Welsford M. Diaphragmatic injuries. *Emedicine* (from WebMD). (2007) Available at: <http://www.emedicine.com/emerg/topic136.htm> Accessed March 15, 2008
16. de la Rocha AG, Creel RJ, Mulligan GW, Burns CM. Diaphragmatic rupture due to blunt abdominal trauma. *Surg Gynecol Obstet.* 1982;154:175-80. [PubMed]
17. Gelman R, Mirvis SE, Gens D. Diaphragmatic rupture due to blunt trauma: sensitivity of plain chest radiographs. *AJR Am J Roentgenol.* 1991;156:51-7. [PubMed]
18. Shea L, Graham AD, Fletcher JC, Watkins GM. Diaphragmatic injury: a method for early diagnosis. *J Trauma.* 1982;22:539-43. [PubMed]
19. Killeen KL, Mirvis SE, Shanmuganathan K. Helical CT of diaphragmatic rupture caused by blunt trauma. *AJR Am J Roentgenol.* 1999;173:1611-6. [PubMed]
20. Sirbu H, Busch T, Spillner J, Schachtrupp A, Autschbach R. Late bilateral diaphragmatic rupture: challenging diagnostic and surgical repair. *Hernia.* 2005;9:90-2. [PubMed]
21. Smith RS, Fry WR, Morabito DJ, Koehler RH, Organ CH, Jr. Therapeutic laparoscopy in trauma. *Am J Surg.* 1995;170:632-6; discussion 636-7. [PubMed]
22. Leppäniemi A, Haapiainen R. Occult diaphragmatic injuries caused by stab wounds. *J Trauma.* 2003;55:646-50. [PubMed]
23. Leppäniemi A, Haapiainen R. Diagnostic laparoscopy in abdominal stab wounds: a prospective, randomized study. *J Trauma.* 2003;55:636-45. [PubMed]
24. Gourin A, Garzon AA. Diagnostic problems in traumatic diaphragmatic hernia. *J Trauma.* 1974;14:20-31. [PubMed]
25. Hegarty MM, Bryer JV, Angorn IB, Baker LW.

Laparoscopic Repair of a Chronic Iatrogenic Diaphragmatic Hernia

- Delayed presentation of traumatic diaphragmatic hernia. *Ann Surg.* 1978;188:229-33. [PubMed]
26. Crandall M, Popowich D, Shapiro M, West M. Posttraumatic hernias: historical overview and review of the literature. *Am Surg.* 2007;73:845-50. [PubMed]
27. Murray JA, Weng J, Velmahos GC, Demetriades D. Abdominal approach to chronic diaphragmatic hernias: is it safe? *Am Surg.* 2004;70:897-900. [PubMed]
28. Frantzides CT, Carlson MA. Laparoscopic repair of a penetrating injury to the diaphragm: a case report. *J Laparoendosc Surg.* 1994;4:153-6. [PubMed]
29. Matthews BD, Bui H, Harold KL, et al. Laparoscopic repair of traumatic diaphragmatic injuries. *Surg Endosc.* 2003;17:254-8. [PubMed]
30. Feliciano DV, Cruse PA, Mattox KL, et al. Delayed diagnosis of injuries to the diaphragm after penetrating wounds. *J Trauma.* 1988; 28:1135-44. [PubMed]
31. Lindsey I, Woods SD, Nottle PD. Laparoscopic management of blunt diaphragmatic injury. *Aust N Z J Surg.* 1997;67:619-21. [PubMed]
32. Martin I, O'Rourke N, Gotley D, Smithers M. Laparoscopy in the management of diaphragmatic rupture due to blunt trauma. *Aust N Z J Surg.* 1998;68:584-6. [PubMed]
33. Riehle KJ, Magnuson DK, Waldhausen JH. Low recurrence rate after Gore-Tex/Marlex composite patch repair for posterolateral congenital diaphragmatic hernia. *J Pediatr Surg.* 2007;42:1841-4. [PubMed]
34. Lee KF, Chung DP, Leong HT. Laparoscopic repair of Morgagni's hernia with percutaneous placement of suture. *J Laparoendosc Adv Surg Tech A.* 2002;12:65-8. [PubMed]
35. Settembre A, Cucurullo D, Pisaniello D, Capasso P, Miranda L, Corcione F. Laparoscopic repair of congenital diaphragmatic hernia with prosthesis: A case report. *Hernia.* 2003;7:52-4. [PubMed]
36. Craigie RJ, Mullassery D, Kenny SE. Laparoscopic repair of late presenting congenital diaphragmatic hernia. *Hernia.* 2007;11:79-82. [PubMed]
37. Shah S, Matthews BD, Sing RF, Heniford BT. Laparoscopic repair of a chronic diaphragmatic hernia. *Surg Laparosc Endosc Percutan Tech.* 2000;10:182-6. [PubMed]
38. Slim K, Bousquet J, Chipponi J. Laparoscopic repair of missed blunt diaphragmatic rupture using a prosthesis. *Surg Endosc.* 1998;12:1358-60. [PubMed]
39. Gunning KA, Moont M, Sugrue M. Laparoscopic repair of penetrating intra-abdominal injuries. *Br J Surg.* 1995;82:920. [PubMed]
40. Koehler RH, Smith RS. Thoracoscopic repair of missed diaphragmatic injury in penetrating trauma: Case report. *J Trauma.* 1994;36:424-7. [PubMed]
41. Kurata K, Kubota K, Oosawa H, Eda N, Ishihara T. Thoracoscopic repair of traumatic diaphragmatic rupture. A case report. *Surg Endosc.* 1996;10:850-1. [PubMed]
42. Frantzides CT, Carlson MA, Pappas C, Gatsoulis N. Laparoscopic repair of a congenital diaphragmatic hernia in an adult. *J Laparoendosc Adv Surg Tech A.* 2000;10:287-90. [PubMed]
43. Carlson MA, Condon RE, Ludwig KA, Schulte WJ. Management of intrathoracic stomach with polypropylene mesh prosthesis reinforced transabdominal hiatus hernia repair. *J Am Coll Surg.* 1998;187:227-30. [PubMed]
44. Schneider R, Herrington JL, Jr., Granda AM. Marlex mesh in repair of a diaphragmatic defect later eroding into the distal esophagus and stomach. *Am Surg.* 1979;45:337-9. [PubMed]
45. Fitzgibbons RJ, Jr., Salerno GM, Filipi CJ, Hunter WJ, Watson P. A laparoscopic intraperitoneal onlay mesh technique for the repair of an indirect inguinal hernia. *Ann Surg.* 1994;219:144-56. [PubMed]