Langenbecks Arch Surg (2017) 402:1145–1151
DOI 10.1007/s00423-017-1606-5

REVIEW ARTICLE

Modern diagnosis and treatment of hiatal hernias

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Received: 13 July 2017 / Accepted: 18 July 2017 / Published online: 21 August 2017

Abstract
Purpose Hiatal hernias are a common finding on radiographic or endoscopic studies. Hiatal hernias may become symptomatic or, less frequently, can incarcerate or become a volvulus leading to organ ischemia. This review examines latest evidence on the diagnostic workup and management of hiatal hernias.
Methods A literature review of contemporary and latest studies with highest quality of evidence was completed. This information was examined and compiled in review format.
Results Asymptomatic hiatal and paraesophageal hernias become symptomatic and necessitate repair at a rate of 1% per year. Watchful waiting is appropriate for asymptomatic hernias. Symptomatic hiatal hernias and those with confirmed reflux disease require operative repair with an anti-reflux procedure. Key operative steps include the following: reduction and excision of hernia sac, 3 cm of intraabdominal esophageal length, crural closure with mesh reinforcement, and an anti-reflux procedure. Repairs not amenable to key steps may undergo gastropexy and gastrostomy placement as an alternative procedure.
Conclusions Hiatal hernias are commonly incidental findings. When hernias become symptomatic or have reflux disease, an operative repair is required. A minimally invasive approach is safe and has improved outcomes.

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Keywords Hiatal hernia · Sliding hernia · Paraesophageal hernia · Laparoscopic hernia repair · Giant paraesophageal hernias

Anatomy, etiology, and presentation

The esophageal hiatus describes the space enclosed by the right and left diaphragmatic crura. In this anatomic position, the crural arches are mostly composed of thickened diaphragm muscle overlain with peritoneum and fibroconnective tissue. As the crura weave posteriorly behind the esophagus, they cross immediately anterior to the aorta to form the median arcuate ligament. Moving further posterior, the right crus anchors into the fibers of the anterior longitudinal ligament of the upper three lumbar vertebrae, while the left anchors into this ligament overlying the upper two lumbar vertebrae. Anteriorly, the arch and shoulders of the crura insert into the central tendon of the diaphragm. The diaphragm supports the distal esophagus by suspending it within a complex arrangement of tissue termed the phrenoesophageal ligament that defines its central core. This tissue membrane is a fusion of the endothoracic and transversalis fascia that circumferentially surrounds and supports the esophagus. This tissue and ligament allow for independent movement of the esophagus and diaphragm during respiration and swallowing. This anatomic relationship also maintains the gastroesophageal junction (GEJ) in a position distal to the diaphragmatic hiatus [1].

A hiatal hernia forms when the stomach or abdominal viscera herniate out of the abdominal cavity through the esophageal hiatus and into the thoracic cavity. Many theories have been purposed to explain the etiology of this anatomic finding. One of these postulates that esophageal acid exposure induces mucosal injury and then transmural injury may cause esophageal shortening, thus "pulling" the GEJ above the level of the

hiatus [2]. Comparable physiologic insults include repetitive swallowing "stress," vomiting, abdominal straining, and increased intraabdominal pressure (obesity, multiple pregnancies), all of which can similarly cause weakening of the phrenoesophageal membrane, degeneration of the elastic tissues, widening of the crura, and potential herniation.

Most often, hiatal hernias are discovered incidentally either through radiographic studies, or during an operative procedure. When symptoms occur, they usually manifest as vague and intermittent epigastric and substernal pain or discomfort. Patients may have early satiety, dysphagia, or regurgitation with large hernias. Less commonly, acute incarceration or volvulus may lead to tissue ischemia, resulting in necrosis and signs of systemic sepsis.

Classification

Conventional classifications have defined hiatal hernias as being either sliding or paraesophageal. The contemporary grading system classifies hiatal hernias based on the location of the GEJ in relationship to the pillars of the crura (Table 1). A type I hernia is the classic "sliding" hernia, characterized by the displacement of the GEJ above the diaphragm, while the stomach and gastric fundus remain below the GEJ and in their native intraabdominal location. Type I hernias are the most common and the most difficult to diagnose. The most common clinical consequence of a type I hernia is the associated gastroesophageal reflux disease (GERD) that results from distortion of the normal anatomic characteristics of the GEJ and lower esophageal sphincter (LES).

The remaining groups are classified as true paraesophageal hernias and encompass types II, III, and IV. These hernias account for approximately 5–15% of all hiatal hernias [3]. The common anatomic defect among this group is herniation of the stomach into the thoracic cavity, due to laxity of the gastrosplenic and gastrocolic ligaments in addition to crural deformation. Due to size and laxity, the concerning clinical sequelae of this herniation include obstruction, volvulus, or ischemia.

A type II hernia results from herniation of the gastric fundus through a localized defect in the phrenoesophageal membrane. In this case, the fundus lies above the crura, while the GEJ remains at or below the diaphragm. Type III hernias have combined elements of types I and II. They are characterized by herniation of the GEJ and gastric fundus through the hiatus, commonly into the left posterior thorax. Type III hernias account for approximately 90% of the true paraesophageal hernias and, as they enlarge, can draw more of the stomach into the left chest. [4]. Type IV hiatal hernias are the result of large phrenoesophageal membrane defects that draw gastric and non-gastric viscera (e.g. colon, small bowel, or spleen) into the hernia sac.

Diagnosis and preoperative assessment

Hiatal hernias are almost never a primary diagnosis. Rather, they are usually discovered after being found on endoscopy, manometry, or other radiographic studies investigating GERD or other upper abdominal complaints. Occasionally, chest pain or dysphagia may prompt an upright chest radiograph that reveals a retrocardiac air-fluid level or a nasogastric tube that coils in the chest and does not proceed inferior to the diaphragm.

Hiatal hernias can be diagnosed by barium swallow, if the axial herniation is greater than 2 cm. Similarly, endoscopy or esophageal manometry can be utilized. Herniation of less than 2 cm generally can only be determined intraoperatively on inspection, and are generally clinically insignificant. Barium swallow is the primary diagnostic modality used to determine the anatomy of the hernia defect. It provides information on the size of the hernia, orientation of the stomach, and location of the GEJ. A sliding hernia is diagnosed by a >2 cm separation between the diaphragmatic hiatus and the rugal folds of the stomach. If the gastric fundus is visualized herniating along the esophagus, the diagnosis of paraesophageal hernia can be made. Video-esophagram carries the additional benefit of examining bolus transit. If the patient presents with signs concerning for obstruction, or if there is a concern for aspiration, an ionic water soluble contrast should be given in place of barium.

Similar diagnostic criteria are required for upper endoscopy. If a greater than 2 cm distance is noted between the squamocolumnar junction and the diaphragmatic impression, a sliding hiatal hernia is present. A paraesophageal hernia can

Table 1 Classification of hiatal hernias

Classification	Nomenclature	Anatomy above diaphragm	Notes
Type I	Sliding	GEJ	GERD is common
Type II	Paraesophageal	Gastric fundus	GEJ remains below diaphragm
Type III	Paraesophageal	Gastric fundus and GEJ	Majority of paraesophageal hernias
Type IV	Paraesophageal	Stomach and other viscera	Large phrenoesophageal defect

GEJ gastroesophageal junction, *GERD* gastroesophageal reflux disease

be appreciated on retroflexed view and usually demonstrates the fundus herniating through the diaphragm adjacent to the endoscope. The unique benefit of endoscopy is the added ability to examine the mucosa for tissue perfusion, esophagitis, Barrett's esophagus, or other lesions, such as Cameron erosions (linear ulceration of mucosal folds at the level of the diaphragmatic impression).

A sliding hiatal hernia can also reliably be detected with high resolution manometry (HRM) with esophageal pressure topography. Using HRM, a hiatal hernia is noted with separation of the crural diaphragm from the LES by a pressure trough. For instances where resources are lacking, a normal motility noted on swallow study can replace catheter-based manometry studies [5]. Erosive esophagitis or Barrett's esophagus noted on endoscopy confirms reflux disease and negates the need for pH testing, with regard to operative planning [5].

Indications for surgery

Historically, the standard of practice was to repair all hiatal hernias, including those found incidentally, due to concern for gastric incarceration and ischemia [6]. In the early 2000s, this view was challenged by Stylopoulos and colleagues who showed that the annual probability of developing symptoms necessitating emergent repair was only 1% and that watchful waiting is the optimal management strategy in 83% of patients [7]. After this report, expectant management was adopted as a reasonable strategy for patients with a known asymptomatic paraesophageal hernia. The Society for American Gastrointestinal and Endoscopic Surgeons (SAGES) put forth guidelines that strongly recommend *not* repairing type I hernias in the absence of reflux disease and symptoms [5].They do, however, recommend repair of type I hernias with proven reflux disease, since an anti-reflux procedure should be performed with the repair.

For patients with asymptomatic paraesophageal hernias, there is the concern that they may progress to become symptomatic. It has been suggested that the risk of progression to a symptomatic hernia is approximately 14% per year, though the risk of symptoms requiring emergency surgery is no more than 2% per year [7]. This same study noted that elective laparoscopic repair of asymptomatic hernias may even decrease quality-adjusted life expectancy in patients older than 65 years. Taken together, current consensus aligns with the notion that elective repair of asymptomatic paraesophageal hernias should be determined on a case-by-case basis with strong consideration of patient's comorbidities, age, and surgical risk [5].

There is consistent agreement and strong evidence to support hernia repair in all symptomatic patients with paraesophageal hernias. Those with obstructive symptoms and gastric volvulus necessitate urgent repair, as volvulus can progress to strangulation and ischemia of the stomach, which can lead to necrosis and perforation with a resulting high mortality rate [5].

Operation

Hiatal hernias have traditionally been repaired via an open transabdominal or transthoracic approach [8]. In the modern era of minimally invasive surgery, a laparoscopic repair is now favored and has been shown to decrease perioperative morbidity, shorten length of hospitalization, and improve quality of life, when compared to open approach [9, 10]. Advantages of laparoscopy also include improved visualization through the hiatus for dissection and esophageal mobilization. Given this, laparoscopic repair has become the standard approach for hiatal hernia repair, with the rare exception in cases with gastric necrosis, thoracic contamination, or difficulty in performing a laparoscopic Collis gastroplasty [5].

Patient and trocar positioning

Laparoscopic hiatal hernia repair is performed under general anesthesia. The patient is placed in a supine position with pneumatic compression stockings on the legs. If the case will last longer than 4 , a bladder catheter is also generally placed. Most surgeons advocate for both arms to be tucked at the patient's side, though some leave both arms abducted. In addition, surgeons frequently use a split-leg position and stand between the patient's legs.

Access to the abdomen is achieved with either an open or closed technique, based on surgeon preference and the ideal approach for the individual patient. Initial access location is just superior and to the left of the umbilicus. This camera port should be placed high enough to achieve high mediastinal dissection (if required), approximately 15 cm from the xiphoid process. Generally, a 30 or 45^0 laparoscope is used. Four other trocars are placed under direct visualization in the following locations: 7–11 cm to the right of the xiphoid along the costal margin (surgeon's left hand), subxiphoid (liver retractor), 12 cm to the left of the xiphoid along the left costal margin (surgeon's right hand), and 5–6 cm just lateral to the right hand port and along the left costal margin (assistant's port) (Fig. 1). Five-millimeter equipment and cameras can be used for all trocars, except for a 12-mm port for the surgeon's right hand to allow for stapling devices, or passage of a curved needle and suture. After trocar placement, the patient is slowly placed in a steep reverse Trendelenburg position to allow gravitational pull on the abdominal viscera.

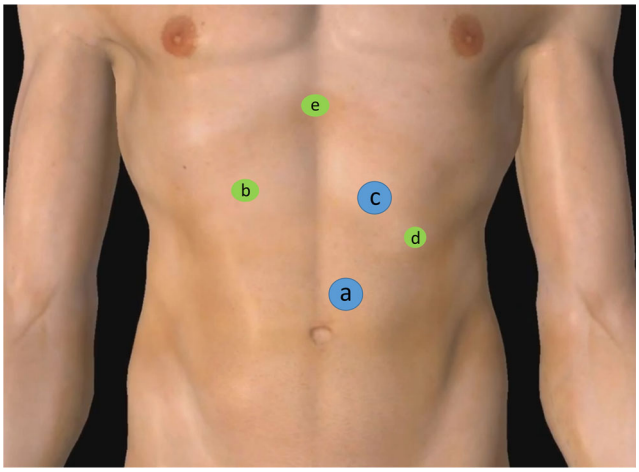

Fig. 1 Trocar positioning. *a* Ten-millimeter camera port just superior and to the left of the umbilicus, 15 cm from the xiphoid. *b* Five-millimeter port for the surgeon's left hand 7–11 cm to the right of the xiphoid along the costal margin. *c* A 12-mm port for the surgeon's right hand 12 cm to the left of the xiphoid along the left costal margin. *d* Five-millimeter assistant port 5 cm distal to surgeon's right hand port along the left costal margin. *e* Subxiphoid liver retractor

Operative technique

Despite different types of hiatal hernias requiring operative repair, the basic tenets of the operation hold true for all repairs. The basic steps of all repairs include the following: reduction of the stomach and hernia sac into an intraabdominal location, excision of the hernia sac, achieving adequate intraabdominal esophageal length by circumferential dissection of the lower esophagus in the mediastinum, and closure of the esophageal hiatus. An anti-reflux procedure is usually also performed, except in instances of surgeon preference or patient instability.

Reduction of hernia sac

After the patient is placed in steep reverse Trendelenburg position, the remaining herniated viscera must be reduced into the abdomen. Once manual reduction has been completed to its fullest extent, we then begin dissecting out the anchoring hernia sac. Surgeon preference dictates starting on the left or the right side of the hiatus. Our preference is to begin our dissection on the left crus, where the hernia sac joints the greater curvature of the stomach. We have found that large hernias tend to draw the right gastric artery and vein up into the hernia sac adjacent to the column of the right crus, exposing these vessels to potential damage if we begin our dissection on the lesser curve side of the stomach.

First, the short gastric vessels on the left are divided. It is our preference to use ultrasonic shears. Next, the peritoneum joining the greater curvature overlying the left crus is incised and dissected circumferentially heading anteriorly across the apex of the crus toward the lesser curvature of the stomach. The gastrohepatic ligament should then be divided. In 10% of cases, an accessory left hepatic vessel may be encountered running in the gastrohepatic ligament. This should be clipped and transected. Dissection then follows to the border of the right crus, and the endothoracic fascia is separated from the transversalis fascia and hernia sac with blunt sweeping motions and ultrasonic ligation of the bridging vessels. The right border of the esophagus should then be exposed, and the posterior and anterior vagus nerves should be identified for preservation. Once the hernia sac is properly reduced into the abdomen, a latex-free drain is wrapped around the GEJ to allow for caudal retraction and further circumferential dissection of the lower esophagus in the mediastinum (Fig. 2).

Hernia sac excision

Once in the correct plane, the hernia sac can easily be separated from the thoracic pleura. Inadvertent tears in the pleura can occur, though these are rarely of physiologic consequence. If noted, the anesthesia team should be informed and, in the case of capnothorax resulting in hypotension or increased airway pressures, one should reduce insufflation to correct these changes. An alternative remedy is to thread a red rubber catheter through the defect into the chest cavity to equalize pressures and to protect against tension physiology. The capnothorax can be evacuated under water through this catheter at the end of the case. A chest tube is rarely required. After the distal esophagus is circumferentially freed from the crura, mediastinal dissection is started.

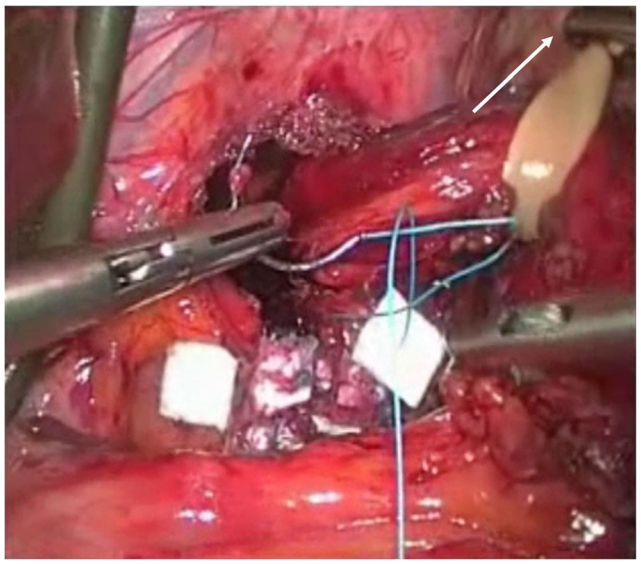

Fig. 2 Caudal retraction of the gastroesophageal junction. A latex-free drain is passed posterior to the esophagus and brought around anteriorly. This drain can then be used for caudal and anterior retraction (*arrow*)

Esophageal mobilization

The ultimate goal of esophageal mobilization is to allow the GEJ to remain in the abdominal cavity in a tension-free fashion, with adequate intraabdominal length. We believe that three centimeters of intraabdominal length is the minimum requirement, and proximal mobilization into the mediastinum may be required to achieve this aim. Blunt dissection is carried out in the retroesophageal space, proceeding to the right and anteriorly, but ultrasonic shears may assist in this dissection by controlling the many esophageal perforators. Careful attention should be paid to identifying and preserving both branches of the vagus nerve. If, after high mediastinal dissection, there is still inadequate intraabdominal esophageal length, an esophageal lengthening procedure should be performed. The Collis gastroplasty (or stapled gastroplasty) is used to create a "neo-esophagus," by removing a small portion of the upper gastric fundus, using a laparoscopic linear cutting stapler (Fig. 3). The stapler is deployed through the left subcostal 12 mm port. The fundus resection is carried out with a 40–56 Fr bougie in place.

Closure of the esophageal hiatus

The principle of crural closure is to allow approximation of the crura around the esophagus without constriction. A variety of closure techniques are performed, from interrupted to mattress suturing, addition of pledgets, intracorporeal suturing, or endosuture devices. It is our practice to suture in a simple interrupted fashion with pledgeted, non-absorbable braided polyester 0 sutures, working from posterior to anterior (Fig. 4). We do not use a pledget on the stitch closest to the esophagus to avoid the potential for erosion or irritation of the esophagus by the pledget. The suture should incorporate endoabdominal fascia to minimize tearing of the crural muscle fibers. Ideal crural closure will have the crura just approximating an empty esophagus without constriction or severe angulation. If there is space remaining anterior to the esophagus, further interrupted, non-pledgeted sutures in this position are placed. If the crura are under tension, a number of maneuvers may be performed. First, the pneumoperitoneum can be reduced to 8–10 mmHg to reduce intraabdominal pressure. If decreasing insufflation is inadequate, crural relaxing incisions may be used. Generally, a right-sided relaxing incision is preferred over left-sided incision, as the liver can potentially prevent future diaphragmatic herniation.

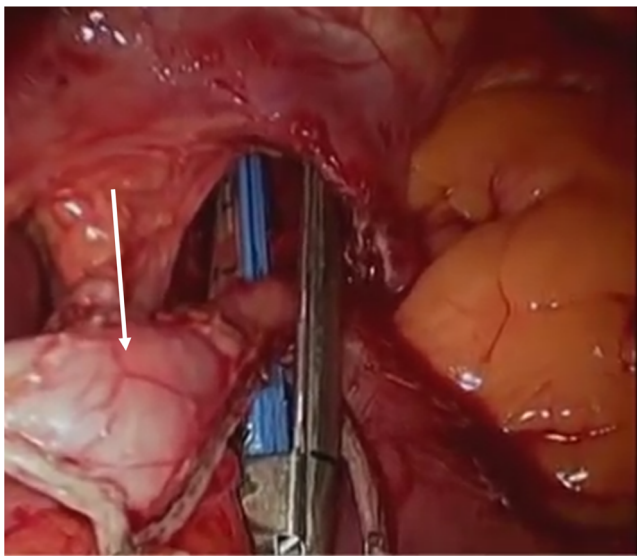

Fig. 3 Stapled gastropexy. A triangular "wedge" of gastric fundus is resected (*arrow*) to create a lengthened "neoesophagus"

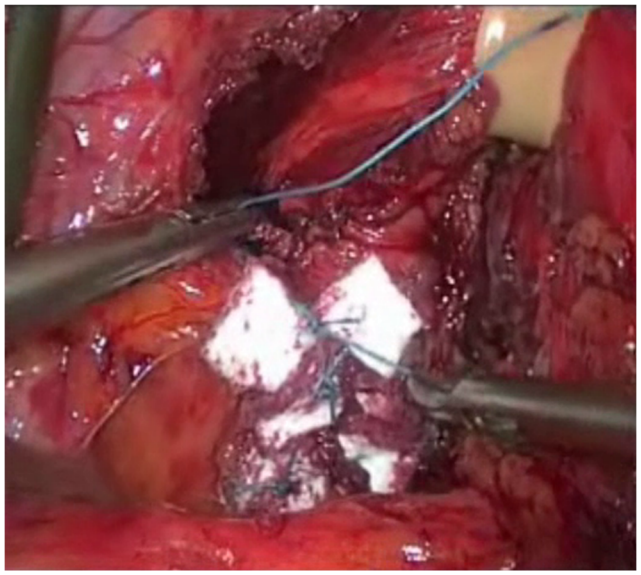

Fig. 4 Hiatal closure. Pledgeted, non-absorbable braded polyester 0 sutures are used in an interrupted fashion from posterior to anterior for crural closure

Primary suture closure of the hiatus has historically been deemed the optimal repair, but follow-up data has suggested significant recurrence rates [11]. Two randomized trials have shown significant reductions in short-term hernia recurrence after mesh reinforcement of crural closure [12, 13]. Despite proven benefit in short-term analysis, a multi-center study established that long-term recurrence rates were similar with either mesh reinforcement or primary repair [14]. With the potential morbidity of early recurrence, we recommended mesh reinforcement of the crural closure [5]. Since synthetic mesh contact with the esophagus risks esophageal irritation and erosion, it is our practice to use composite coated synthetic mesh for crural reinforcement. We do not recommend using mesh as a bridged repair, as this has been shown to be inferior to primary closure with mesh reinforcement [15, 16].

Anti-reflux procedure

Even with a lack of preoperative GERD, fundoplication assists in preventing hernia recurrence by "bulking" the GEJ and buttressing the repair after extensive hiatal dissection that could potentiate reflux disease. There is no definitive data to address the effect of fundoplication after hiatal hernia surgery or its role in preventing recurrence. One small study demonstrated no recurrence in patients with or without fundoplication. Further, the fundoplication group experienced notable dysphagia, while the non-fundoplication group experienced reflux esophagitis [17]. We routinely preform a circumferential (Nissen) fundoplication after all hiatal hernia repairs, unless there is evidence for preexisting esophageal dysmotility (Fig. 5). In this case, a partial fundoplication is indicated.

Surgeons may also be presented with a case that does not allow completion of a paraesophageal repair because of clinically instability, extremes of age, or poor surgical candidacy. For all of the above cases, gastropexy (without excision of the hernia sac) is an alternative "bailout" option. The basic maneuver is to reduce the maximum amount of herniated viscera into the abdomen. Lowering insufflation pressure to 8–10 mmHg may assist this maneuver. A gastropexy may be performed by suturing the superior margin of the greater curvature to the left crus and continuing inferiorly along the curvature, suturing to the anterior abdominal wall, toward the umbilicus. Consideration should be given to placing a gastrostomy tube proximal to the antrum to allow for further security of the gastropexy, to allow gastric venting, or to provide nutrition in critically ill patients or those unable to tolerate oral intake (Fig. 6).

Giant Paraesophageal hernias and high-risk patients

Giant paraesophageal hernias (GPEH) have varying definitions in the literature, but these have become a rare discussion of interest for surgeons. Most reports define a GPEH as a hernia with at least one third of the stomach herniated into the thoracic cavity. These hernias may be asymptomatic, cause chronic low-grade symptoms, or present acutely with signs and symptoms concerning for visceral ischemia or perforation. Though watchful waiting in asymptomatic hernias is a reasonable approach, emergency surgery is associated with increased morbidity and mortality, when compared to an elective repair, especially in the elderly [18, 19]. The major difficulty in surgically managing the GPEH that requires deviation from the above techniques occurs when the hernia is unable to be fully reduced.

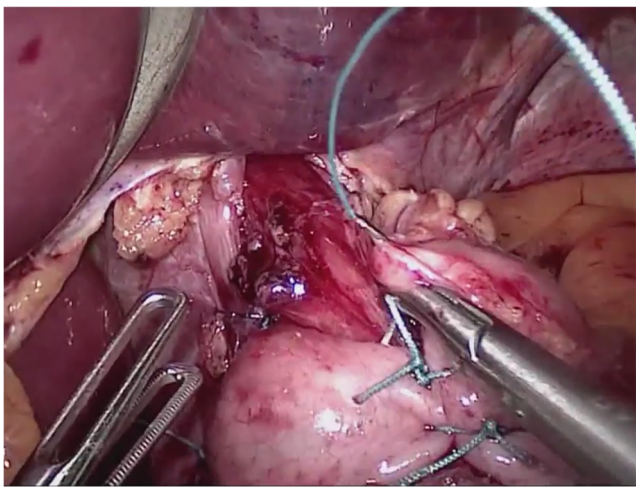

Fig. 5 Fundoplication procedure. A 360^0 fundoplication (Nissen) is completed after crural closure

Postoperative management

Adequate nutritional intake is necessary for recovery. Edema of the GEJ and fundoplication can commonly cause early postoperative dysphagia. We institute a slow, stepwise advancement from liquid to solid diet over 4–6 weeks as dysphagia improves.

Early fundoplication or hernia disruption is a rare but unfortunate event attributed to sudden increases in intraabdominal pressure from retching, vomiting, coughing, or straining [20]. To prevent such occurrences, we institute strict anti-emetic and anti-tussive regimens in the early

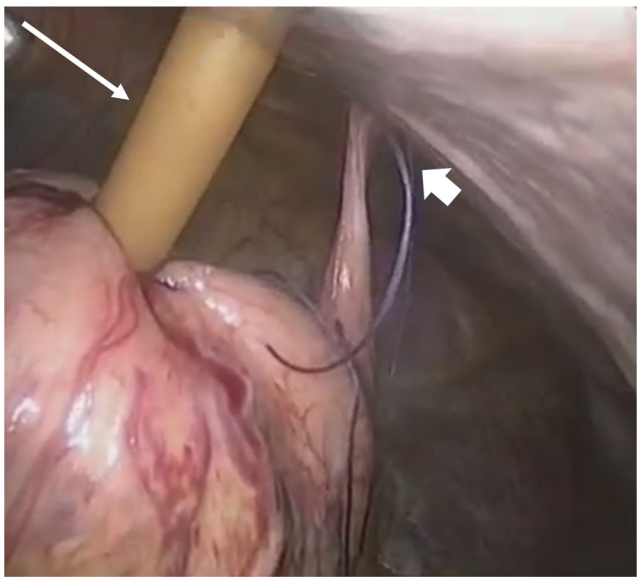

Fig. 6 Gastrostomy and gastropexy. A gastrostomy tube (*arrow*) is placed in the gastric body, and gastropexy suturing (*arrowhead*) is used to anchor the stomach in the abdomen to the abdominal wall

postoperative period and require adherence to activity restriction until clinical follow-up.

Hernia recurrence in the early postoperative period after repair of small hernias is rare, and routine postoperative radiologic studies are likely to find only small and asymptomatic recurrences. We do not recommend routine radiographic follow-up of repairs [5].

Our patients have a clinic visit scheduled 4 weeks after surgery. At this time, the wounds are checked for appropriate healing, and a subjective assessment of symptoms and swallowing ability is performed. Asymptomatic patients who are recovering appropriately do not routinely have long-term follow-up, but this remains at the surgeon's discretion. At this point, we release them from activity restrictions and institute a full diet.

Author's contributions Steve R Siegal MD—conception and design, acquisition of data, analysis and interpretation of data, drafting of manuscript, and critical revision of manuscript; James P Dolan MD, MCR—conception and design, acquisition of data, analysis and interpretation of data, drafting of manuscript, and critical revision of manuscript; John G Hunter MD—conception and design, acquisition of data, analysis and interpretation of data, drafting of manuscript, and critical revision of manuscript.

Compliance with ethical standards

Funding This manuscript received no funding.

Conflicts of interest The authors declare that they have no conflicts of interest.

Research involving human participants This article does not contain any studies with human participants or animal participants performed by any of the authors.

Informed consent Informed consent was not necessary for this study.

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