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The Optimal Approach to Symptomatic Paraesophageal Hernia Repair: Important Technical Considerations

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Abstract While the asymptomatic paraesophageal hernia (PEH) can be observed safely, surgery is indicated for symptomatic hernias. Laparoscopic repair is associated with decreased morbidity and mortality; however, it is associated with a higher rate of radiologic recurrence when compared with the open approach. Though a majority of patients experience good symptomatic relief from laparoscopic repair, strict adherence to good technique is critical to minimize recurrence. The fundamental steps of laparoscopic PEH repair include adequate mediastinal mobilization of the esophagus, tension-free approximation of the diaphragmatic crura, and gastric fundoplication. Collis gastroplasty, mesh reinforcement, use of relaxing incisions, and anterior gastropexy are just a few adjuncts to basic principles that can be utilized and have been widely studied in recent years. In this article, we present a comprehensive review of literature addressing key aspects and controversies regarding the optimal approach to repairing paraesophageal hernias laparoscopically.

Keywords Symptomatic paraesophageal hernia · Recurrent paraesophageal hernia · Hiatal hernia · Collis gastroplasty · Relaxing incision · Shortened esophagus

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Introduction

Henry Bowditch first described the hiatal hernia in 1853 as a "very curious dilation of the esophageal opening [1]." The majority of hiatal hernias are sliding hernias in which the gastroesophageal (GE) junction migrates above the diaphragm (Fig. 1b). Type II–IV hiatal hernias are further classified as paraesophageal hernias (PEHs) and are characterized by herniation of intra-abdominal contents through a defect in the phrenoesophageal membrane (Fig. 1c–e). PEHs account for 5 % of all hiatal hernias [2]. Type II hiatal hernias are the least common and involve herniation of the stomach into the thoracic cavity while the GE junction remains fixed to the preaortic fascia and median arcuate ligament below the diaphragm. Type III PEHs are the most common (90 %) and represent a combination of type I and type II hiatal hernias. Type IV hernias involve herniation of other viscera through the hiatus such as the colon, small intestine, or spleen.

The prevalence of PEHs varies widely ranging from 10–80 % and is higher in patients with advanced age [3]. Pathophysiology is due to stretching of the phrenoesophageal ligament over time due to repetitive motion of the esophagus and a positive pressure gradient between the abdominal and thoracic cavities. Many PEHs are diagnosed based on radiologic or endoscopic studies demonstrating a GE junction or herniated fundus above the diaphragm. Though many PEHs are clinically asymptomatic [4], some patients may experience heartburn, regurgitation, postprandial fullness, chest pain, dysphagia, anemia, or vague discomfort.

Life-threatening symptoms such as obstruction due to volvulus, bleeding, strangulation, and perforation are also possible; however, the incidence of acute symptoms and associated complications is lower than originally suspected. Early studies advocated for early repair in both symptomatic and asymptomatic PEH patients due to high rates of incarceration with

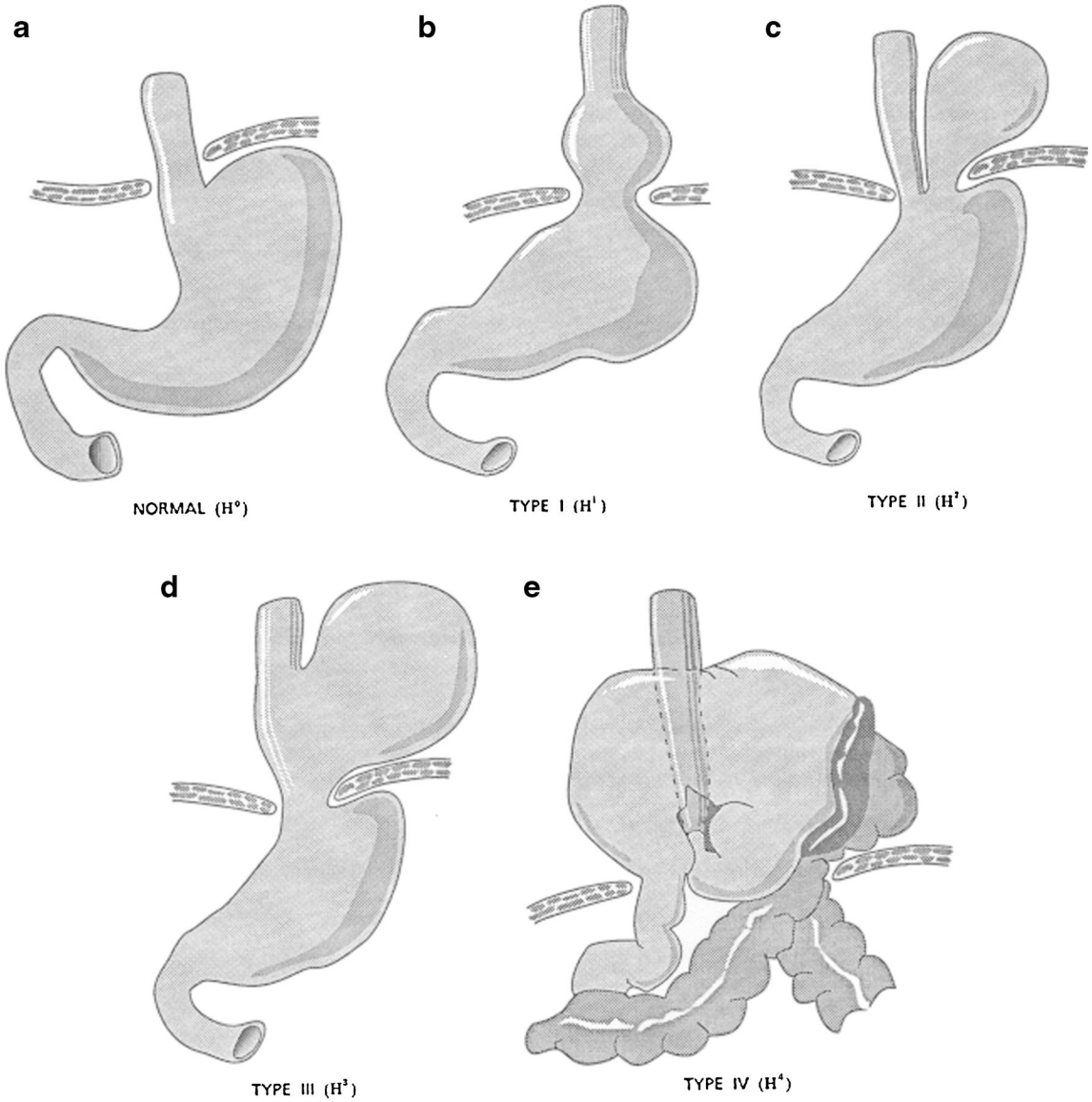

Fig. 1 Artistic rendering of a normal hiatus (**a**) with GE junction and intra-abdominal contents below the diaphragm, type I sliding hiatal hernia (**b**) with migration of the GE junction above the diaphragm, type II hernia (**c**) with herniation of the stomach above the diaphragm, type III hernia (**d**) with passage of both the GE junction and stomach above the diaphragm, and type IV hernia (**e**) with herniation of the entire stomach and colon above the diaphragm

observation and significant morbidity and mortality associated with emergency surgery [5, 6]. A landmark study in 2002 by Stylopoulos et al. demonstrated that in patients greater than age 65 with minimal symptoms, the probability of developing acute symptoms with an asymptomatic PEH is low (1.2 % per year) and that quality of life is improved with watchful waiting rather than with elective hernia repair [7]. Mortality with emergency surgery was also found to be lower at 5 % as opposed to 17 % in the earlier literature. Non-operative management of asymptomatic PEHs is the current standard, though there is a small subset of patients with giant PEHs (preoperative hernia size >75 %) who may benefit from elective repair even with minimal symptoms [8•].

Preoperative Work-Up

Appropriate preoperative work-up of a PEH is critical. Symptoms that should prompt operative intervention include chest or abdominal pain, dysphagia, weight loss, postprandial bloating, chronic anemia, and anorexia. Radiologic and endoscopic studies should be done to augment clinical evaluation and can guide clinical decision-making (Fig. 2). Barium swallow can demonstrate orientation of the hernia, location of the GE junction, and esophageal motility. CT scan is particularly useful in the urgent setting and can be used to determine width of the hiatus, size, and orientation of the PEH, and whether other intra-abdominal organs such as the colon or pancreas have

Fig. 2 Upper GI series (**a**, **b**) and CT chest (**c**, **d**) of a patient with a recurrent paraesophageal hernia. Note that greater than 50 % of the stomach has herniated into the chest and that the esophagus takes a tortuous course, indicating that it may be fixed within the mediastinum

herniated into the mediastinum. Endoscopy allows for evaluation of the esophageal and gastric mucosa for inflammation and ulcers, Barrett's esophagus, and strictures. High-resolution manometry can also provide useful information regarding esophageal motility; however, catheter placement below the LES can be difficult in the presence of a large PEH, and findings may not be accurate with a small PEH (<2 cm) [9].

Surgical Principals

In the first published report of a hiatal hernia repair, Alfredo Soresi reported that reduction of hernia contents with closure of the diaphragm was the key to the operation [1]. Almost a century later, the basic principles remain the same. The operation begins with dissection and reduction of the hernia sac, which should be excised when possible. Identification of bilateral crura and extensive, circumferential mediastinal dissection to gain intra-abdominal esophageal length of at least 2 cm is critical (Fig. 3b). Care should be taken to avoid injury to the anterior and posterior branches of the vagus nerve during dissection. Crura should be closed in a tension-free fashion (Fig. 3c, d), utilizing mesh and relaxing incisions when necessary. Lastly, the fundus is mobilized to create a complete or partial wrap and re-create an appropriate anti-reflux barrier [10]. While there is a consensus over most of these basic tenants, there are many controversial points that will be discussed in further detail.

Laparoscopic vs. Open Repair

The first report of laparoscopic hiatal hernia repair was published by Cuschieri et al. in 1992 [11]. Even in its initial stages, laparoscopic PEH repair was associated with less morbidity than open repair with significant reduction in blood loss, ICU stay, and ileus [12]. Enthusiasm for a minimally invasive approach was somewhat dampened when Hashemi et al. published a study that demonstrated a 42 % recurrence rate for laparoscopic repair as opposed to 15 % for the open approach [13]. However, it is important to note that many patients with recurrence were clinically asymptomatic and were satisfied with their surgical outcome. More recent studies by the same group have suggested that the difference in recurrence between the two approaches may not be so disparate, although mesh

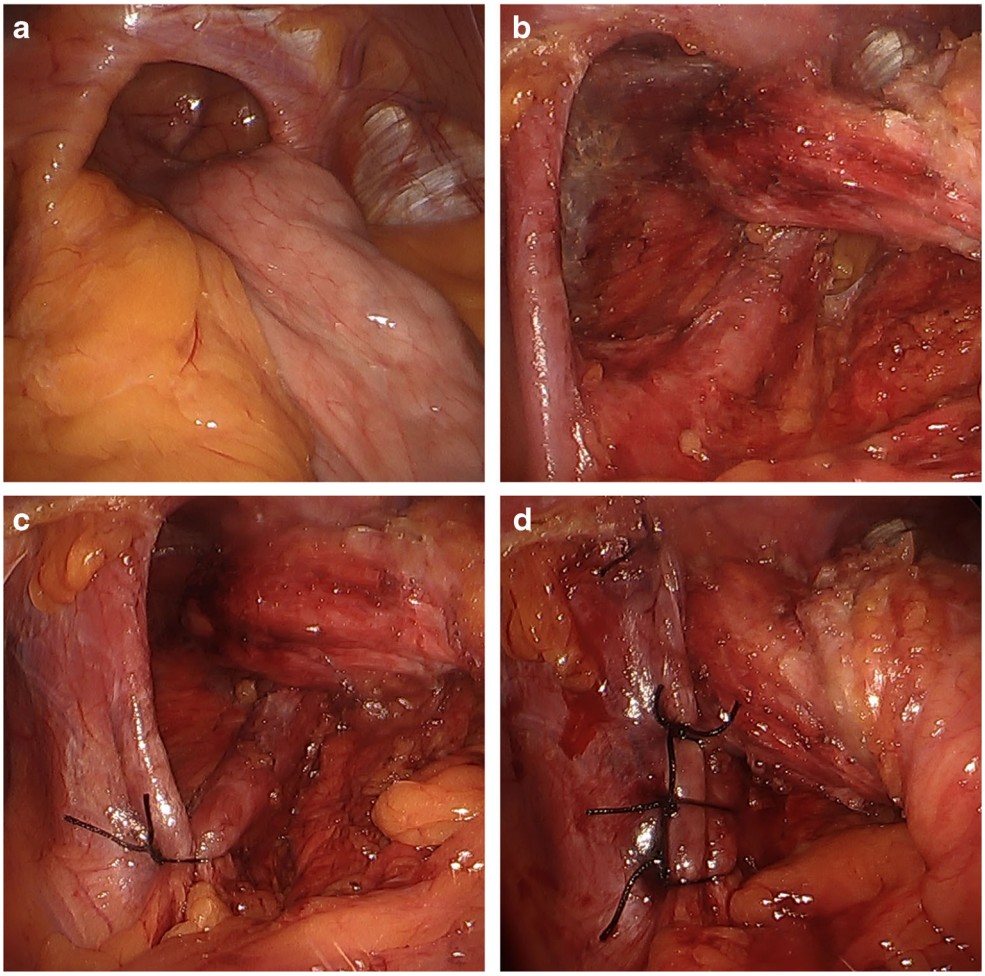

Fig. 3 Intraoperative photos of a paraesophageal hernia (**a**) during laparoscopic repair. Adequate esophageal length (**b**) and tension-free crural approximation (**c**, **d**) are demonstrated

crural reinforcement and Collis gastroplasty were utilized more liberally for the laparoscopic group [14]. Median operative time, length of stay, and perioperative complications were also lower in the laparoscopic group.

The numerous benefits of laparoscopy have made it the most commonly utilized approach for PEH repair in the USA. In the analysis of a large ACS NSQIP database, our group found that 78.4 % of PEHs were performed by the laparoscopic transabdominal approach, while 19.2 % were performed open and 2.4 % were performed via the open transthoracic approach [15]. We also found that laparoscopic PEH repair is associated with a 95 % reduction in 30-day mortality and fewer blood transfusions and pulmonary complications [16]. In addition, analysis of data from our own institution has demonstrated that laparoscopic repair results in a durable improvement of quality of life when compared to baseline preoperative symptoms [17•].

Thoracoscopic vs. Transabdominal Approach

Another topic of contention has been whether the abdominal or the thoracic approach offers superior outcomes. While the transthoracic approach offers better visualization of the esophagus and the ability to obtain increased intra-abdominal esophageal length, there is higher morbidity and mortality using the open thoracic approach when compared with a laparoscopic abdominal approach [18•]. Although thoracoscopic PEH repair and Belsey Mark fundoplication can be performed safely and effectively [19], the laparoscopic transabdominal approach is most commonly performed in the USA. Video-assisted thoracoscopic surgical (VATS) repair of PEHs does play a role in some situations such as failed previous surgery, hiatal hernias fixed in the chest, and when combined with other esophageal pathology [20].

More recently, a combined VATS/laparoscopic approach for giant PEH repair has been described with promising results [21]. Many critics of laparoscopic repair state that the presence of pneumoperitoneum distorts the diaphragm resulting in a false perception of esophageal length. A combined VATS approach allows for better mobilization of the esophagus and ability to dissect the hernia sac. In addition, the increase in intra-abdominal esophageal length virtually eliminates the need for Collis gastroplasty.

The Short Esophagus

While preoperative work-up can predict the presence of a foreshortened esophagus, only intraoperative assessment demonstrating intra-abdominal length less than 2–3 cm is truly accurate. A large type III PEH, Barrett's esophagus, and stricture are just a few of the known risk factors for the development of a shortened esophagus [22]. Pathophysiology is due to chronic inflammation and scarring of the esophagus from long-term reflux. While adequate esophageal length can be obtained by extensive mediastinal dissection in many cases [23], occasionally Collis gastroplasty may be necessary. Collis gastroplasty has been described as an effective approach with low rates of PEH recurrence, improved quality of life, and a symptom resolution profile similar to PEH repair without gastroplasty with less chest/epigastric pain and gas bloat [24, 25]. While there are many reported techniques for performing a Collis gastroplasty, our standard approach is to perform a linear stapled wedge gastrectomy of the fundus over a 54 Fr bougie followed by a wrap in most cases. Collis gastroplasty is not without its complications. The neoesophagus created by the gastroplasty does not exhibit the normal peristaltic activity of the esophagus and can lead to dysphagia. Persistent parietal cells can also lead to recurrent heartburn and esophagitis. In addition, the presence of a staple line can lead to leak rates of 1–3 % even in high volume, experienced centers [26]. Vagotomy has also been described as an alternative to Collis gastroplasty for gaining intra-abdominal esophageal length, but it has not been widely adopted [27].

Mesh Reinforcement

Mesh reinforcement of cruroplasty has been reported to decrease recurrence after laparoscopic PEH repair. A prospective randomized control trial in 2002 demonstrated that laparoscopic repair of large PEHs with polytetrafluoroethylene (PTFE) patch reinforced cruroplasty resulted in no recurrences at a mean follow-up of 1 year compared to a 22 % recurrence rate in patients with primary cruroplasty [28]. Advocates for the use of synthetic non-absorbable mesh cite the benefit of low recurrence rates. However, concerns for erosion, stricture, and dysphagia due to the presence of a foreign body are problematic. While the incidence of erosion and extensive fibrosis is less than 1 % in some studies, the real incidence is likely underreported as many studies do not include these complications in their analyses [29].

Biologic mesh is an alternative to synthetic prostheses that adds reinforcement to primary crural repair while decreasing complications from the presence of a permanent synthetic foreign body. A multi-center prospective randomized control trial of bioprosthetic mesh consisting of small intestine submucosa (SIS) during laparoscopic PEH repair demonstrated promising results at 6-month follow-up, with a recurrence rate of 9 % in the mesh reinforced group vs. 24 % in the primary closure group [30]. At 5-year follow-up, however, recurrence rates (~50 %) and quality of life indicators were similar in both the SIS mesh-reinforced and primary repair groups. There were no strictures, erosions, or reports of dysphagia in the SIS mesh group at long-term follow-up [31].

Further investigation into biocomposite absorbable mesh is currently being undertaken as a bridge between the two previously mentioned types of mesh. Preliminary reports from several groups have shown that a unique polyglycolic acid:trimethylene carbonate absorbable polymer (Gore Bio-A) decreases recurrence with low rates of complications [32, 33]. The tissue matrix acts a scaffold that stimulates collagen in-growth, and within a span 6 months, the mesh is replaced with native connective tissue [34].

Choice of mesh is only one of the many controversies in mesh reinforcement during laparoscopic PEH repair. Indications for mesh use vary widely among surgeons with size of PEH, presence of a previous recurrence, and patient comorbidities playing a significant role. Mesh positioning is also an important consideration, though most experts would agree that mesh used in a bridging fashion when primary cruroplasty is not possible leads to increased recurrence and long-term complications [18•]. Different methods of mesh fixation using sutures, staples, tacks, or fibrin glue have also been described. A 2006 survey of SAGES members revealed that suture fixation, on-lay positioning, and non-circumferential position around the esophagus were the most common technical principals utilized [35].

Relaxing Incisions

In the event that the diaphragmatic crura cannot be approximated primarily without tension, a relaxing incision may be necessary. While axial tension can be more easily recognized intraoperatively as a shortened intra-abdominal esophagus, radial tension along the diaphragm is more subjective varying on the tactile and visual perceptions of individual surgeons. A recent study utilized a novel device to measure hiatal tension intraoperatively found that while tension correlates with increased hiatal width, the shape of the hernia defect also affects tension [36]. A relaxing incision was applied in a subgroup of patients demonstrating a 46 % reduction in tension after the maneuver. Incidentally, pleurotomy was also found to reduce tension but not as significantly.

Greene et al. recently published outcomes from a series of 15 patients undergoing laparoscopic PEH repair who required relaxing incisions, 13 with right-sided incisions, 1 with a left-sided incision, and 1 with bilateral incisions [37•]. All patients experienced good symptomatic relief at 4 months, though one

patient had an asymptomatic elevated left hemidiaphragm, and another patient had a small radiographic recurrence.

Relaxing incisions are typically performed on the right side unless excessive scarring or close proximity to the inferior vena cava (IVC) is prohibitive in which case a left-sided incision is performed. A right-sided relaxing incision is made by incising the diaphragm between the right crus and IVC and carrying this full thickness into the right pleural space. Caution must be taken to avoid the anterior crural vein and the thoracic duct near the aortic hiatus. A left-sided incision is performed in a similar fashion between the left crus and the left seventh rib taking care not to injure the left-sided phrenic nerve. Crura should be approximated with pledgeted sutures, and the diaphragmatic defects should be closed with a synthetic patch. Reinforcement of the crural closure with absorbable mesh is also recommended. In cases where a unilateral relaxing incision is not sufficient, bilateral relaxing incisions can be performed.

Anterior Gastropexy

The addition of anterior gastropexy to other basic principals in the repair of large PEHs has demonstrated a low symptomatic and radiologic recurrence at early follow-up [38]. In theory, gastropexy prevents complete herniation of the stomach into the mediastinum even when crural closure becomes disrupted though this benefit has not been widely demonstrated in the literature. In high-risk patients, gastropexy can be performed without hiatal repair but is associated with a high rate of recurrence [18•].

Gastropexy is performed by tacking the anterior stomach to the abdominal wall with absorbable or non-absorbable sutures that are passed with a transfascial suture passed and secured extracorporeally. A gastrostomy tube can also be placed which can act as a gastropexy with the added benefit of gastric decompression and enteral access for patients postoperatively.

Risk Factors for Recurrence After PEH Repair

There is no consistent standardized definition for recurrence after PEH repair. We have previously suggested that recurrence be defined radiographically on barium contrast study as >2 cm vertical extension of gastric mucosa above the wrap [39]. It is important to note that while the rate of radiologic recurrence is high, up to 57 % in some series [40•], many patients remain clinically asymptomatic.

Risk factors for recurrence have not been clearly identified. Technical factors that play a role include reduction of the hernia, mobilization of the esophagus to gain at least 2 cm of intra-abdominal length, tension-free closure of the hiatus, and completion of an anti-reflux procedure. In addition, size of the hernia as well as patient characteristics such as age, elevated body mass index (BMI), and pulmonary disease has also been cited as possible risk factors for recurrence [40•, 41, 42].

We attempted to identify risk factors for recurrence in a prospective study of elective type III PEHs repaired laparoscopically at our institution [17•]. We found a radiologic recurrence in 27 % of patients at 1 year postoperatively. There was no statistical difference in quality of life scores for patients with recurrent vs. non-recurrent hernias. Preoperative clinical factors such as age, gender, preoperative BMI, smoking status, or comorbidities (diabetes or pulmonary disease) were not statistically significant predictors of recurrence. Although there were no statistically significant preoperative radiologic findings that were predictive of recurrence, patients with herniation of most of their stomach (gastric body or more) and a vertical hernia size greater than 5.5 cm on preoperative UGI tended to experience a higher rate of recurrence.

Role of Obesity

Obesity poses an increased risk for gastrointestinal reflux disease (GERD) and hiatal hernia due to an elevated intra-abdominal pressure. Approximately one third of morbidly obese patients may have a hiatal hernia regardless of symptoms [43]. While most have a sliding type of hiatal hernia, almost 5 % will have moderate to large PEHs. Obesity has traditionally been associated with a high failure rate for primary anti-reflux procedures [44]. However, this trend toward high recurrence after PEH repair in morbidly obese patients has not been confirmed in large retrospective reviews [16]. Nonetheless, many surgeons will encourage weight loss prior to laparoscopic PEH repair or offer a concurrent bariatric procedure, either Roux-en-y gastric bypass (RYGB) or sleeve gastrectomy. In theory, bariatric surgery reduces the risk of recurrence while the patient benefits from reduction of comorbidities that occur with weight loss surgery. PEH repair with laparoscopic RYGB and sleeve gastrectomy have both been described in small retrospective reviews [45–47]. Results demonstrate effective therapy for PEH symptoms and weight loss though longer term follow-up and larger cohorts are needed.

Conclusions

Laparoscopic paraesophageal hernia repair is a technically challenging operation with an approximately 50 % rate of radiologic recurrence. While following basic principles of PEH repair and utilizing techniques to decrease axial or longitudinal tension and reinforcing crural repair may help

decrease rates of recurrence, many controversies persist. Patient factors for recurrence are also not well understood. Despite the lack of evidence that increased weight is associated with recurrence, bariatric surgery does also play a role in PEH repair. Further studies must be done to further optimize laparoscopic repair of symptomatic PEHs.

Compliance With Ethical Standard

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

Human and Animal Right Statement This study does not include any studies with humans or animals performed by any of the authors.

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