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Large hiatal hernia: minimizing early and long-term complications after minimally invasive repair

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Abstract

Paraesophageal Hernia (PEH) is the protrusion of the stomach and/or other abdominal viscera into the mediastinum due to an enlargement of the diaphragmatic hiatus. The treatment of PEH is challenging: On the one hand, watchful waiting carries the risk of developing acute life-threatening complications requiring an emergency operation. On the other hand, elective repair of PEH has non-negligible morbidity and mortality rates, also due to the characteristics of PEH affected patients, who are generally elder and frail. A review of the literature is presented to highlight strategies that can be adopted to minimize early and long-term complications after PEH surgical repair. The laparoscopic approach has been shown to provide reduced hospital stay, postoperative morbidity and mortality, and overall costs compared to traditional open surgery, and it is currently considered the standard approach both to elective and emergency operations. The evidence suggests that strict adherence to surgical principles, such as hernia sac excision, extended mediastinal dissection of the esophagus, and tension-free crural repair with or without mesh are mandatory to achieve optimal surgical outcomes and reduce PEH recurrence rate. Different shapes, materials, and techniques of prosthetic repair and the use of relaxing incisions have been proposed, but long-term data are lacking, and no conclusions can be drawn regarding the ideal method of crural closure. When a short esophagus is recognized despite extensive mediastinal dissection, esophageal lengthening procedures are indicated. Systematic addition of a fundoplication is strongly encouraged, for either treating gastroesophageal reflux or reducing recurrence rate.

Keywords: Hiatal hernia, paraesophageal hiatal hernia, fundoplication, complications



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INTRODUCTION

Hiatal hernia (HH) is the protrusion of an abdominal organ into the mediastinum through the diaphragmatic hiatus.

There are four main types of HH: Type 1 (“sliding”), the most common, is the herniation of the esophago-gastric junction (EGJ) above the diaphragm, leaving the stomach in the abdomen; Type 2 (“pure paraesophageal”) is the thoracic migration of the gastric fundus while the EGJ remains in the correct position; Type 3 (“mixed”) is a combination of both Type 1 and Type 2 components; and, in Type 4 (“giant”) HH, the herniation involves the entire stomach along with other abdominal viscera, including colon, omentum, small bowel, liver and spleen^[1]. Types 2-4 HH are defined as paraesophageal hernias (PEH) and share the same preoperative work-up and surgical treatment^[2].

Clinical manifestations of PEH include obstructive (dysphagia and postprandial fullness) and compressive (respiratory complications and recurrent pneumonia) symptoms, gastroesophageal reflux (GER) (heartburn and regurgitation), and chronic anemia. PEH can also present acutely with complications: bleeding, acute obstruction, and strangulation resulting in gastric necrosis^[3].

The diagnosis is made with upper endoscopy and barium esophagogram, to assess the morphology of HH. Other examinations, such as computed tomography scan and esophageal manometry, could be helpful in treatment planning, but they are not mandatory^[1,4].

INDICATIONS FOR SURGERY

Elective vs. emergent

In contrast to Type 1 sliding HH, which does not require surgical intervention unless in the presence of severe GER, PEH carries the potential for severe acute complications^[5].

In the past, PEH repair was proposed for all surgically fit patients, regardless of symptoms, due to previous studies demonstrating an unacceptably high mortality rate (ranging 29%-56%), associated with acute presentations^[6,7].

A study from Stylopoulos *et al.*^[8] changed this paradigm. The authors performed a Markov Monte Carlo decision analysis to address the optimal treatment strategy for PEH. The input variables considered, obtained from a systematic review of the literature and data of the 1997 Nationwide Inpatient Sample, were: the estimated mortality rate after elective laparoscopic (1.4%, range 0%-5.2%) and emergency (5.4%) PEH repair, the annual probability of developing symptoms progression (13.8% range 8.1%-21.7%), the annual probability of acute presentation requiring emergency surgery of untreated patients (1.1% range 0.7%-1.9%), and the annual probability of HH recurrence after surgical repair (1.9% range 0.3%-5.4%). With these assumptions, the authors estimated that watchful waiting would be the optimal treatment for 83% of PEH patients, as the risk of developing life-threatening complications is only 1.1% per year.

Since then, other studies have demonstrated lower mortality rates associated with PEH repair, both in the elective and in the emergency setting^[9,10]. Even with these new reports, an updated study using the same statistical methodology achieved the same conclusions in terms of mortality^[11]. However, considering cost-effectiveness, a similar study performed by Morrow *et al.*^[12] concluded that elective repair, although more expensive, guarantees superior quality of life compared to watchful waiting. Current guidelines recommend the elective repair of all symptomatic PEH, while in asymptomatic patients the indications to elective surgery must be balanced with the patient's age and comorbidities^[5].

Open vs. minimally invasive approach

The conventional open approach to PEH repair, through a thoracotomy or a laparotomy, was associated with a high rate of morbidity (5.3%-25%) and mortality (0%-3.7%). The main complications described were pneumonia (2.6%, range 2.1%-8.7%) and wound infections (5.8%, range 0.8%-8.7%)^[13]. Since the introduction of the laparoscopic technique to PEH treatment by Cuschieri^[14] in 1992, the minimally invasive approach has spread rapidly. Several population-based studies demonstrated a significant reduction in hospital stay, intensive care unit stay, postoperative morbidity, mortality, and overall costs of laparoscopic PEH repair compared to the conventional open approach^[15,16]. Therefore, laparoscopy is considered the preferred surgical access for PEH repair, including in the emergency setting^[5,17].

More recently, the robotic platform has been proposed for surgical PEH treatment. The evidence regarding robot-assisted repair of PEH consists of small retrospective series of single institutions in their early experience with this technique, and no long-term follow-up is available. These studies described a postoperative morbidity of 15%-23% and a mortality rate of 0%-2.5%, which are comparable with the outcomes of the laparoscopic series reported in the literature^[18-20].

However, no studies specifically assessing the comparison of robot-assisted and laparoscopic approaches to PEH repair have been conducted, and no clear benefits of the robotic approach have been elucidated yet. Therefore, the role of robotics in the surgical management of PEH remains controversial.

SURGICAL PRINCIPLES

The essential technical steps of the procedure consist of complete reduction of HH, hernia sac excision, extensive mediastinal mobilization of the esophagus, and tension-free crural closure.

The first step of the procedure is the abdominal reduction of HH contents by gentle traction of the hernia sac, proceeding gradually with extensive mediastinal mobilization of the esophagus with blunt dissection in order to obtain at least 2-2.5 cm of intra-abdominal esophageal length [Figure 1A and B]^[21].

During hernia sac dissection, caution must be used to prevent injury to the vagal nerves on the anterior and posterior aspect of the esophagus, to the pleura, and to the adjacent vascular structures [Figure 2]^[22].

After complete reduction, sac excision is imperative [Figure 3]. A tension-free closure of the diaphragmatic crura must be achieved with crural approximation with or without mesh [Figure 4A and B]. Additional technical steps, such as fundoplication, esophageal lengthening, gastropexy, and relaxing incisions, have been investigated to improve the results of PEH repair and are discussed below.

The most common intraoperative complication reported is visceral injury (esophageal and gastric perforations), which is reported in up to 11% of cases, followed by vagal nerve injury and pulmonary complications (pneumonia)^[23].

Sudden increases in intra-abdominal pressure in the immediate postoperative period, due to coughing, belching, vomiting, and lifting weights, have been shown to contribute to PEH recurrence^[24]. Therefore, postoperative nausea and vomiting must be treated aggressively^[5].

Routine early upper gastrointestinal series before starting diet is unhelpful in the absence of suspicious clinical signs, as it has been shown that it would change the clinical management of patients in only 0.8% of cases^[25].

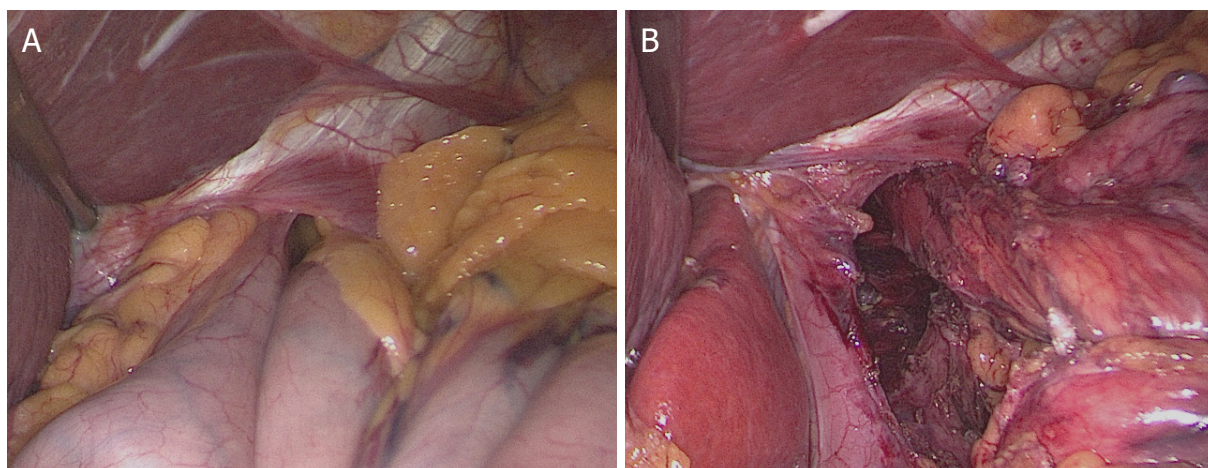


Figure 1. Hernia content reduction: (A) reduction of hiatal hernia contents by gentle traction of the hernia sac; and (B) obtaining at least 2-2.5 cm of intra-abdominal esophageal length

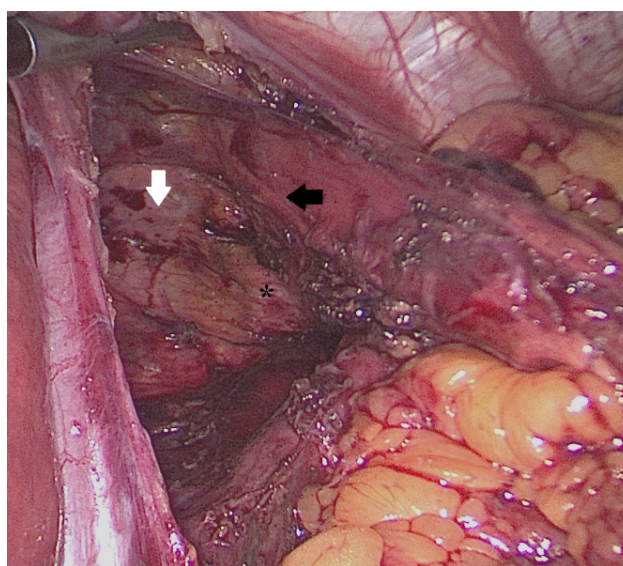


Figure 2. During hernia sac dissection, caution must be used to prevent injury to the vagal nerves on the anterior and posterior aspect of the esophagus, to the pleura, and to the adjacent vascular structures. White arrow, pleura; black arrow, posterior vagus nerve; asterisk, aorta

POSTOPERATIVE COMPLICATIONS

PEH recurrence

A significant rate of recurrences after PEH repair has been reported, although patients are often asymptomatic^[26]. “Radiological” recurrences are described in up to 20%-30% of cases, while only 5% of patients would require surgical revision^[27].

Several technical factors have been investigated in an attempt to reduce the rate of PEH recurrences: PEH sac excision, the method of crural closure, the addition of an esophageal lengthening procedure, and the addition of a gastropexy.

PEH sac excision

To reduce the risk of recurrence, complete excision of the hernia sac should be performed whenever feasible^[28]. This fundamental step of the procedure accomplishes several objectives: first, it represents

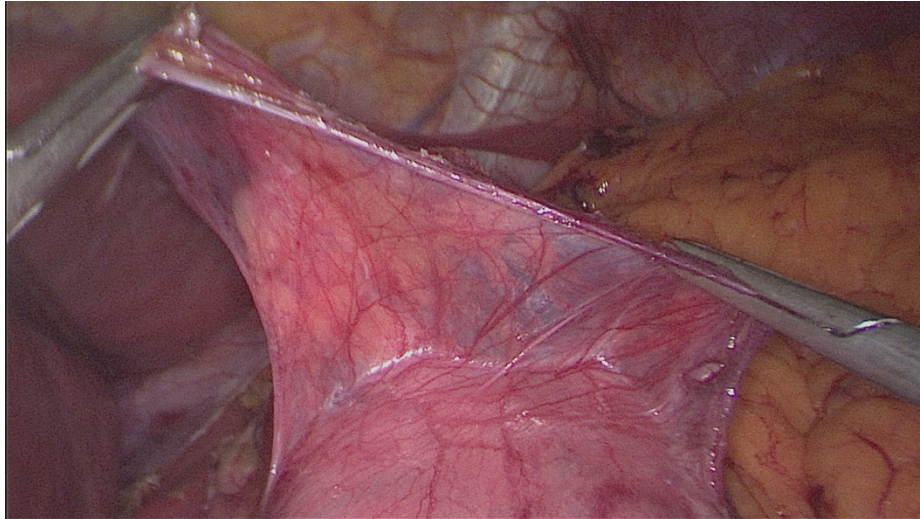


Figure 3. Identification of the hernia sac

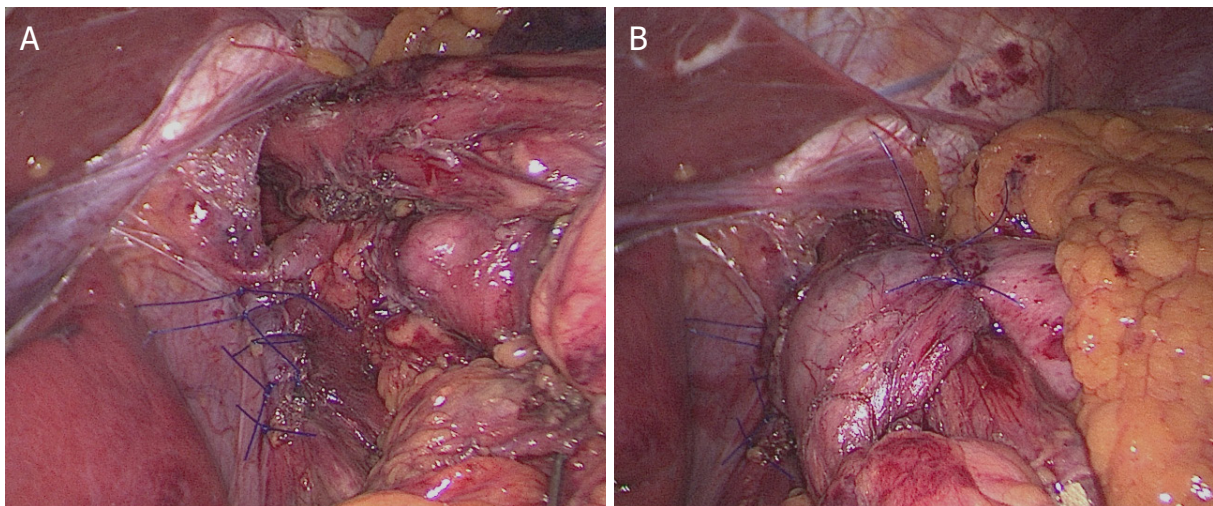


Figure 4. Paraesophageal hernia repair: (A) cruroplasty; and (B) total 360° fundoplication

the correct plane of dissection, avoiding potential injuries to the neural and vascular adjacent structures; second, it reduces the risk of collections in the thoracic cavity; and third, since the hernia sac acts as a lead point that pushes the stomach back in the thoracic cavity, its excision reduces the risk of HH recurrence^[29].

Crural closure: mesh vs. simple cruroplasty

Closure of the diaphragmatic hiatus is mandatory during PEH repair. It can be achieved through several techniques, with primary closure or the use of a mesh. The prosthetic materials can be used as a reinforcement of a primary crural closure or as a “bridge” to close a wide diaphragmatic defect without any attempt to approximate the crural pillars. Moreover, some authors suggest performing crural relaxing incisions to achieve a tension-free crural closure^[30].

In the early laparoscopic series, simple primary cruroplasty was associated with an unacceptably high rate of recurrences at medium follow-up, described in up to 42% of patients^[31].

In light of the good results achieved with the introduction of prosthetic materials in inguinal and ventral repair surgery, the use of meshes has been proposed also in PEH repair. There is a wide array of configurations, materials (including synthetic non-absorbable, absorbable, or biologic matrices), and methods of fixation of the mesh (anterior, posterior, or circumferential, with staples, tacks, sutures, or glue)^[32-36].

Several studies showed a reduced recurrence rate with the use of synthetic meshes. For instance, Frantzides *et al.*^[37] performed in 2002 a randomized controlled trial (RCT) of patients undergoing laparoscopic PEH repair with simple (36 patients) *vs.* reinforced polytetrafluoroethylene (PTFE) cruroplasty (36 patients). The recurrence rate, verified with barium contrast studies, was significantly higher in the simple cruroplasty group compared with the PTFE group (22% *vs.* 0%, $P < 0.006$).

Disadvantages related to the use of synthetic materials include the risk of mesh adhesion, erosion of the esophageal wall, and extensive fibrosis resulting in the onset of troublesome dysphagia^[38].

Biological and absorbable meshes have been proposed to overcome the downsides of synthetic meshes. Oelschlager *et al.*^[39] performed a multicenter RCT to test the efficacy of crural reinforcement with a biological mesh derived from porcine small intestinal submucosa (51 patients) compared to primary crural closure (57 patients). The authors published in 2006 the phase 1 results of the trial, showing a significant reduction in radiological PEH recurrences compared to primary repair (9% *vs.* 24%) at six-month follow-up. However, a longer follow-up of the same study showed a high rate of recurrences, with no significant differences between the two groups (59% in the mesh group *vs.* 54% in the primary repair group)^[40].

The short-term results of biological meshes were also confirmed in a systematic review and meta-analysis performed by Antoniou *et al.*^[41] including five studies comparing simple suture *vs.* biologic mesh cruroplasty. However, no long-term data were available for analysis.

Watson *et al.*^[42] performed a multicenter RCT in 2015 with the aim of comparing three methods of PEH repair: primary suture (43 patients), absorbable mesh (41 patients), and non-absorbable mesh (42 patients) cruroplasty. A combined radiological and endoscopic assessment of recurrences was performed at 12-month follow-up, and no significant difference was found among the three groups. These results were also confirmed at five-year follow-up^[43].

Several meta-analyses described a significant reduction in the recurrence rate at medium-term follow-up, including a lower risk of surgical revision, with the use of prosthetic materials, but the quality of analyzed data was poor and therefore the results are of limited level of evidence^[44,45]. For instance, Tam *et al.*^[46] performed in 2016 a systematic review and meta-analysis of studies assessing the comparison between primary repair and the use of synthetic mesh. They reviewed 13 publications including RCTs and observational studies. The overall recurrence rate was found to be 24% (91/382) for the suture group compared to 13% (46/354) for the mesh group. However, follow-up was significantly shorter, with only half of the patients available for follow-up in the mesh group, therefore recurrences could be underestimated. The authors concluded that the available evidence is of low quality and high risk of bias and does not allow drawing definitive conclusions.

Furthermore, more recent series comparing primary *vs.* mesh reinforced cruroplasty have shown similar outcomes in terms of recurrences at long-term follow-up^[47,48]. For instance, Koetje *et al.*^[49] reported the comparison between primary repair (127 patients) and mesh reinforced (62 patients) cruroplasty with a follow-up of 40 months. The overall rate of radiological recurrence was similar between the two groups (25.8% mesh *vs.* 23.6% no mesh), with similar reoperation and symptomatic recurrence rates.

To date, there is no high-level objective evidence recommending the use of meshes in PEH surgical treatment, nor demonstrating the superiority of a specific technique over another. The ideal mesh does not exist, and the choice of the technique largely depends on the surgeon's preferences^[50,51]. Current guidelines admit that no recommendations can be made regarding the use of mesh in PEH repair^[5].

"Short esophagus" and esophageal lengthening

The entity of the "short esophagus" (SE) is debated. SE is defined as less than 2-2.5 cm of intra-abdominal esophageal length after extensive mediastinal dissection^[52]. The estimated incidence of the SE is reported to be 1.9%-20% and is thought to be caused by fibrosis and scarring of chronic severe GER insult^[4]. Some authors question the real existence of SE, claiming the presence of "apparent" SE: a normal-length esophagus that is folded into the chest and appears to be short before extensive mediastinal mobilization^[53]. The use of routine intraoperative endoscopy during PEH repair is suggested to detect SE^[54].

When a "real" SE is recognized intraoperatively, esophageal lengthening procedures, such as Collis-Nissen fundoplication, are indicated^[55]. The current technique consists of a totally laparoscopic gastropasty, performed with a circular stapler, to create a trans-gastric window, through which a linear stapler is introduced to create the "neo-esophagus"^[56]. The results of this procedure, performed with the laparoscopic approach, are similar to those reported with the open technique, with a recurrence rate of 25-13%^[4].

However, Collis-Nissen fundoplication is a challenging procedure, with a reported morbidity rate of 19%-36%, including atelectasis, pneumonia, pneumothorax, and pleural effusion^[57]. Moreover, it carries a higher risk of leak compared to fundoplication alone (2.7% vs. 0.6%)^[58].

Anterior gastropexy

Anterior gastropexy was first described by Boerema in 1969, but it was abandoned due to a reported excessively high risk of recurrence, which occurred in 60% of patients^[59,60]. With the recognition of the importance of the fundamental technical steps of the procedure, such as sac dissection and excision, that were not performed at the time of the original Boerema procedure, this technique has been modified and proposed again. To date, there are limited data regarding the role of anterior gastropexy, in particular without associated procedures such as mesh cruroplasty or fundoplication, in PEH surgical treatment [Table 1]. Only Daigle *et al.*^[68] performed a multicenter study of 101 PEH repair with anterior gastropexy without fundoplication, showing an acceptable recurrence rate of 16.8% at 12-month follow-up and avoiding complications of mesh positioning and anti-reflux procedures. However, 29.7% of patients experienced some degree of postoperative GER.

More recently, several authors have described the use of this procedure in the acute setting or in high-risk patients^[68,70]. In these situations, the procedure was considered attractive because it does not require long operative times or advanced technical skills even with the minimally invasive approach, and does not affect the possibility to perform subsequent elective PEH repair.

For instance, Yates *et al.*^[69] reported the results of 11 high operative risk patients presented with acute gastric volvulus and treated with laparoscopic anterior gastropexy. There were no intraoperative complications, but two patients required reintervention. The authors concluded that laparoscopic anterior gastropexy could be considered a valid surgical alternative for frail patients.

Gastroesophageal reflux

The systematic or tailored addition of a fundoplication during PEH repair is a matter of debate.

Table 1. Outcomes of laparoscopic gastropexy in paraesophageal hernia treatment

| Authors | Year | n | GP (n) | Associated procedures (n) | Recurrences (%) | Mortality (%) | Follow-up (months) | Notes |
|--|------|-------|--------|--|-----------------------------------|---------------|--------------------|--|
| Agwunobi <i>et al.</i> ^[61] | 1998 | 13 HR | 13 | | 14.4% symptomatic | 7.7 | 10 | 15.4% conversions |
| Hawasli <i>et al.</i> ^[62] | 1998 | 27 | 25 | MC = 25 | 0% | 0 | 1-56 | 22.2% reflux |
| Van der Peet <i>et al.</i> ^[63] | 2000 | 19 | 19 | SC = 17 MC = 2 FP = 15 | 15.8% radiological | 0 | 24 | 15.8% conversions 75% reflux esophagitis without FP |
| Ponsky <i>et al.</i> ^[64] | 2003 | 28 | 28 | FP = 28 | 0% radiological | 0 | 12 | |
| Diaz <i>et al.</i> ^[65] | 2003 | 116 | 48 | SC = 110 MC = 6 FP = 114 EL = 6 | 32% radiological | 1.7 | 30 | 4.3% major complications |
| Horstmann <i>et al.</i> ^[66] | 2004 | 16 | 16 | MC = 16 FP = 16 | 0% radiological | 0 | 14 | 6.25% conversions 31% pleural injury |
| Poncet <i>et al.</i> ^[67] | 2010 | 89 | 77 | MC = 89 FP = 89 | 15.7% radiological | 0 | 57.5 | 4.4% conversions 7.8% morbidity |
| Daigle <i>et al.</i> ^[68] | 2015 | 101 | 101 | SC = 94 | 16.8% endoscopic/ radiological | 0 | 10.9 | 22% morbidity 29.7% reflux |
| Yates <i>et al.</i> ^[69] | 2015 | 11 HR | 10 | TG = 11 | 0% symptomatic | N/A | 3 | 2 readmissions 2 TG dislocations |
| Higashi <i>et al.</i> ^[70] | 2017 | 8 HR | 100 | | 0% symptomatic | 0% | 48 | |

HR: high risk patients; GP: gastropexy; MC: mesh cruroplasty; SC: simple cruroplasty; FP: fundoplication; EL: esophageal lengthening; TG: tube gastrostomy

The rationale for adding a fundoplication is twofold: treating preoperative GER symptoms and preventing the postoperative onset of GER. GER is a frequent clinical manifestation of PEH because the herniation through the diaphragmatic hiatus determines a functional incompetence of the lower esophageal sphincter (LES), favoring the reflux of the gastric contents. GER can also occur “*de novo*” postoperatively due to altered functional anatomy of the GEJ caused by extensive mediastinal dissection. Furthermore, fundoplication is thought to anchor the cardia below the diaphragm, contributing to the reduction in the rate of recurrences^[50]. For these reasons, some authors advocate the routine addition of a fundoplication to restore the functional competence of the LES^[71].

Other authors sustain the selective addition of fundoplication during PEH repair depending on the presence of preoperative GER or altered esophageal motility at esophageal manometry. They believe that the intra-abdominal reduction of PEH restores the normal anatomy of the EGJ, therefore no other anti-reflux operations, with the consequent risk of dysphagia, are needed^[72].

However, the LES competence can be difficult to assess preoperatively, because esophageal manometry can be unreliable in the presence of PEH^[73]. Furthermore, the incidence of dysphagia following fundoplication is minimal in experienced hands^[74].

Müller-Stich *et al.*^[75] performed a RCT comparing mesh-augmented hiatoplasty with or without the addition of a fundoplication. At 12-month follow-up, the fundoplication group had a significantly lower incidence of GER symptoms than hiatoplasty alone, and the subjective results were confirmed by objective upper endoscopy findings. Interestingly, the incidence of gas bloat and dysphagia did not differ between the two groups, leading the authors to favor the systematic addition of an anti-reflux procedure.

In addition, Furnée *et al.*^[76] performed a comparative study of patients who underwent PEH repair with or without fundoplication. Of the 20 patients who did not receive fundoplication, new onset of esophagitis occurred in 28%, and pathological acid exposure was demonstrated in 39%. In the fundoplication group, 8.7% of patients experienced dysphagia. The authors concluded that, since the rate of postoperative side effects of fundoplication is low, while objective evidence of postoperatively *de novo* onset of GER occurred frequently, the addition of a fundoplication should be recommended during PEH repair.

To date, there is no consensus on the type of wrap and on the fixation of the fundoplication to the esophagus or the diaphragmatic pillars^[28]. In a systematic review of the literature, including 24 studies, Andolfi *et al.*^[77] concluded that the preferred approach should be a total fundoplication when the esophageal motility is normal.

CONCLUSION

The current review of the literature shows that the controversies regarding the optimal repair of paraesophageal hernia, including the best technique for crural closure, the addition of a fundoplication, and of esophageal lengthening procedures, remain unresolved. The wide heterogeneity of techniques and materials, together with the low incidence of PEH, makes it difficult to investigate the specific role of the single technical factors concurring in PEH repair.

DECLARATIONS

Authors' contributions

Made substantial contributions to conception and design of the study and performed data analysis and interpretation: Uglicione E, Rebecchi F

Performed data acquisition, as well as provided administrative, technical, and material support: Seno E, Morino M

Availability of data and materials

Not applicable.

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Conflicts of interest

All authors declared that there are no conflicts of interest.

Ethical approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

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