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Laparoscopic Repair of Paraesophageal Hernias

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ABSTRACT

Background and Objectives: Laparoscopy has quickly become the standard surgical approach to repair paraesophageal hernias. Although many centers routinely perform this procedure, relatively high recurrence rates have led many surgeons to question this approach. We sought to evaluate outcomes in our cohort of patients with an emphasis on recurrence rates and symptom improvement and their correlation with true radiologic recurrence seen on contrast imaging.

Methods: We retrospectively identified 126 consecutive patients who underwent laparoscopic repair of a large paraesophageal hernia between 2000 and 2010. Clinical outcomes were reviewed, and data were collected regarding operative details, perioperative and postoperative complications, symptoms, and follow-up imaging. Radiologic evidence of any size hiatal hernia was considered to indicate a recurrence.

Results: There were 95 female and 31 male patients with a mean age (± standard deviation) of 71 ± 14 years. Laparoscopic repair was completed successfully in 120 of 126 patients, with 6 operations converted to open procedures. Crural reinforcement with mesh was performed in 79% of patients, and 11% underwent a Collis gastroplasty. Fundoplications were performed in 90% of patients: Nissen (112), Dor (1), and Toupet (1). Radiographic surveillance, obtained at a mean time interval of 23 months postoperatively, was available in 89 of 126 patients (71%). Radiographic evidence of a recurrence was present in 19 patients (21%). Reoperation was necessary in 6 patients (5%): 5 for symptomatic recurrence (4%) and 1 for dysphagia (1%). The median length of stay was 4 days.

Conclusion: Laparoscopic paraesophageal hernia repair results in an excellent outcome with a short length of stay when performed at an experienced center. Radiologic recurrence is observed relatively frequently with routine surveillance; however, many of these recurrences are small, and few patients require correction of the recurrence. Furthermore, these small recurrent hernias are often asymptomatic and do not seem to be associated with the same risk of severe complications developing as the initial paraesophageal hernia.

Key Words: Hernia, Paraesophageal, Fundaplication, Laparoscopy, Reflux.

INTRODUCTION

Paraesophageal hiatal hernias are relatively uncommon in that they represent approximately only 14% of all hiatal hernias.[1] The most common hiatal hernia is the sliding hiatal hernia (type I), most of which are asymptomatic and do not require repair. In contrast, the importance of the remaining types of hiatal hernias, which all involve a paraesophageal component, lies in their potential for the development of life-threatening complications. As the name implies, the classic paraesophageal hernia (PEH) involves a protrusion of the gastric fundus through the diaphragmatic hiatus with (type III) or without (type II) the herniation of the gastroesophageal (GE) junction into the thorax alongside the thoracic esophagus. The inclusion of any additional abdominal viscera in the chest cavity along with the stomach denotes a type IV hernia. The frequent axial rotation of the stomach as it passes through a relatively stiff diaphragmatic hiatus can produce devastating complications including perforation, strangulation, volvulus, and hemorrhage.[2,3] Therefore most authors advocate early surgical repair, even in patients who are asymptomatic.

Historically, PEHs were repaired by laparotomy or thoracotomy. However, the advent of minimally invasive surgical options for upper abdominal surgery has led to widespread acceptance of the laparoscopic approach to this disease process. When compared with the open ap-

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proach, the advantages of laparoscopy include better visualization allowing for more extensive mobilization of the thoracic esophagus, along with less morbidity, a shorter hospital stay, and faster recovery.[4,5] Despite laparoscopy being a technically demanding operation, several studies were published that showed the feasibility and effectiveness of this procedure.[5–7] Early results were met with skepticism, however, especially when a study by Hashemi et al[8] in 2000 found a 42% incidence of recurrence with the laparoscopic approach compared with 15% with the open approach when routine radiographic follow-up with barium esophagram was used. Several recent studies with varying degrees of postoperative radiologic follow-up have shown more promising results with recurrence rates ranging from 8.6% to 33%.[9–16] A meta-analysis that summarized many of these studies and others determined that when objective radiographic follow-up with barium esophagram was obtained, the "true recurrence rate" was 25%.[17] When compared with a landmark report by Maziak et al[18] that reported a 2% recurrence rate after open hiatal hernia repair, these recurrence rates seem disappointingly high and have led many surgeons to question the durability of the laparoscopic repair.

The debate surrounding laparoscopic PEH repair is further complicated by the wide array of surgical techniques currently in use. Several techniques have been advocated in the literature during both the open and laparoscopic eras of hiatal hernia repair, including resection of the sac, adequate mobilization of the thoracic esophagus, fundoplication, gastropexy, and reinforcement of the crura with a prosthetic mesh.[15,19–25] Recent literature would suggest that when these techniques are properly used, the recurrence rates of laparoscopic PEH repair are actually quite comparable with those of the open technique.[26] The technique at our institution has evolved to emphasize complete resection of the hernia sac, extensive thoracic esophageal mobilization, and crural reinforcement as key components in successful repair. Our aim was to examine and discuss the effectiveness and necessity of routinely used operative strategies such as the addition of anterior gastropexy and use of cruroplasty along with mesh reinforcement, as well as analyze operative complications and radiographic recurrence rates and their association with patient symptoms.

METHODS

We performed a retrospective chart review of a cohort of 126 consecutive patients who underwent laparoscopic repair of large PEHs between 2000 and 2010 by 2 experienced laparoscopic surgeons at 3 neighboring teaching hospitals. A large PEH was defined as the presence of at least one third of the stomach in the chest, as seen on computed tomography (CT) scan or barium esophagram. Preoperative evaluation included CT scan with oral contrast in 112 patients (89%), barium esophagram in 85 patients (67%), and upper endoscopy in 99 patients (79%). Upper endoscopy was performed at the time of surgery in all patients. Selected patients also underwent manometry, cardiac stress testing, echocardiography, or other studies as deemed necessary by the attending surgeon or consulting physicians. Case records were retrieved from the institution's medical record database, and information regarding the perioperative course including complications was reviewed and recorded.

Postoperatively, all patients attended a follow-up office visit at 2 to 4 weeks after discharge from the hospital and again at 4 to 6 months for routine follow-up CT scan or barium esophagram. Patients were followed up yearly thereafter with office visits or phone interviews. They were questioned about the frequency and severity of heartburn, dysphagia, regurgitation, retrosternal chest pain, abdominal pain, bloating, shortness of breath, and overall satisfaction. Patients with Barrett esophagus were followed up with annual endoscopies, and patients complaining of persistent dysphagia received a barium esophagram. The length of radiologic follow-up was calculated as the time from the date of surgery to the date of the most recent esophagram or CT scan. CT scans and barium esophagrams were reviewed by an experienced radiologist, and a recurrence was defined as the presence of a hiatal hernia of any size.

Statistical Analysis

Comparisons of patient characteristics and clinical variables were performed by use of the χ^2 test or Fisher exact test where appropriate. $P < .05$ was considered significant.

Surgical Technique

After insufflation with carbon dioxide to a pressure of 10 to 15 mm Hg, we used a 5-port technique with four 5-mm ports and one 12-mm port. We used 30° telescopes as indicated to aid visualization of the operative field. The left lateral segment of the liver was retracted and secured with a stationary positioning device. The patient was then placed in the steep reverse Trendelenburg position to allow the abdominal viscera to fall away from the stomach and esophageal hiatus. The pars flaccida and gastrohepatic ligament were incised to expose the right crux of the diaphragm. Dissection of the hernia sac was begun from

the right side at the level of the arcuate ligament and carried out circumferentially, proceeding anterior to the esophagus. The gastrosplenic ligament and short gastric vessels were divided to allow continuation of the hernia sac dissection to the posterior fat pad. Several important technical maneuvers were used to minimize damage to key structures and reduce the likelihood of postoperative hernia recurrence. An extensive mobilization of the esophagus circumferentially to the level of the carina was achieved beginning with dissection of the sac. Emphasis was placed on not trying to grab and reduce the intrathoracic stomach back into the abdomen but rather on grasping the hernia sac and dissecting from its surrounding attachments, which allowed the stomach to then gently fall back into the abdomen once the sac had been completely dissected free. Esophageal mobilization was further achieved by placing a Penrose drain around the GE junction to place gentle traction on the esophagus and complete mediastinal mobilization of the esophagus as well as to free it completely from the crura. The crura were then approximated posterior to the esophagus with interrupted No. 0 braided polyester sutures (Covidien, Mansfield, Massachusetts) with an Endo Stitch 10-mm suturing device (Covidien). This technique allowed the esophagus to be pushed anteriorly and could aid in achieving abdominal esophageal length, although often 1 or more anterior crural sutures were also needed to close the defect to avoid placing the crural closure under tension. After crural reapproximation was completed, a biologic (typically Permachol [Covidien] or Allomax [C.R. Bard/Davol, Warwick, Rhode Island]) or polytetrafluoroethylene (Crurasoft; C.R. Bard/Davol) mesh was frequently used. Our choice of whether to use mesh for crural reinforcement did vary throughout the 10-year course of our practice. In the early years, mesh use was reserved for patients in whom tension-free crural closure could not be achieved, or those with attenuated diaphragms. However, because we were early adopters of the mesh-cruroplasty technique, most patients who underwent procedures after 2003 received crural reinforcement with mesh unless otherwise contraindicated. If placed, mesh was secured with a fixation device (AbsorbaTack or ProTack; Covidien) or interrupted sutures using an Endo Stitch suturing device. The location of the GE junction was then evaluated using both endoscopic and laparoscopic visualization. If the GE junction did not lie at least 3 cm caudad to the diaphragmatic hiatus while tension free, then a Collis gastroplasty or wedge fundectomy was performed. After crural reconstruction, a 360° Nissen fundoplication or partial fundoplication was performed depending on the preoperative assessment of esophageal motility in the patient. Anterior diaphragmatic gastropexy was performed selectively in patients with organoaxial volvulus or a large hiatus or elderly patients with significant comorbidities.

Table 1.
Patient Clinical Characteristics and Repair Techniques
(N = 126)

	Mesh (n = 99)	No Mesh (n = 27)	*P* Value
Sex (male/female)	20/79	11/16	.29
Age			
>70 y	52 (53%)	13 (48%)	.687
<70 y	47 (47%)	14 (52%)	
Esophageal lengthening procedure	13 (13%)	0	.299
Fundoplication	88 (89%)	25 (93%)	.575
Nissen	87 (88%)	24 (89%)	
Dor	0	1 (4%)	
Toupet	1 (1%)	0	
Gastropexy	11 (11%)	11 (41%)	.001
Gastrostomy tube	7 (7%)	2 (7%)	.614
Prevalence of comorbidities	47 (47%)	14 (52%)	.687
History of smoking	14 (14%)	5 (19%)	.554
Pulmonary disease	12 (12%)	4 (14%)	.747
Cardiac disease	16 (16%)	5 (19%)	.774
Hypertension	23 (23%)	6 (22%)	.971
Diabetes	9 (9%)	3 (11%)	.719

RESULTS

A total of 126 patients underwent laparoscopic repair of PEH. The median age was 71 years (range, 31–96 years) with a male-to-female preponderance of 1:3.1. PEHs were classified based on preoperative imaging and intraoperative findings as type IV in 37 patients (29%), type III in 75 (60%), and type II in 14 patients (11%). At least one third of the stomach was in the chest in all patients. Of the patients, 116 (92%) underwent elective procedures whereas 10 (8%) were emergency cases that presented with obstruction (5), unrelenting pain (1), hemorrhage (2), septic shock due to perforation (2), and heart failure due to extrinsic compression (1). Patient demographic data and comorbidities are summarized in **Table 1**. Both groups shared similar demographic characteristics and had a similar prevalence of comorbidities. Anterior gastropexy was significantly more common in the nonmesh repair group. The median length of stay was 4 days (range, 3–57 days).

Table 2.
Perioperative Complications

Complication	No. of Patients
Intraoperative	9 (7%)
Esophageal enterotomy	3
Hepatic artery clipping	1
Pneumothorax	1
Splenic laceration	3
Ventricular laceration	1
Postoperative	12 (10%)
Mediastinal abscess	1
Atrial fibrillation	3
Fascial dehiscence	1
Myocardial infarction	1
Pulmonary embolism	3
Respiratory failure	2
Small bowel obstruction	1
Total	21 (17%)

Laparoscopic repair of a large PEH was completed successfully in 120 of 126 patients. Conversion to open repair was necessary in 6 patients for the following reasons: stomach densely adherent to the heart (2), inability to reduce the hernia sac and its contents (2), gross contamination due to perforation (1), and poor visualization (1). Of the 6 patients requiring open conversion, 3 (50%) were emergency cases. Perioperative complications are summarized in **Table 2**. One patient required urgent re-exploration and median sternotomy for cardiac tamponade found to be due to a small ventricular laceration. There were 2 deaths in the subset of patients who required emergency surgery and open conversion for frank gastric perforation, as well as 1 death in the elective group. The resulting overall morbidity and mortality rates were 17% and 2%, respectively.

Objective follow-up using contrast imaging primarily with CT scan was obtained in 89 patients (71%), with a mean follow-up time of 23 months (range, 1–90 months). Of these patients, 70 were evaluated by CT alone, 8 were evaluated by esophagram alone, and 11 received both an esophagram and a CT scan at some point during follow-up. Among the 11 patients who received both studies, there were no missed recurrences by either CT or esophagram, and estimations of intrathoracic stomach were equivalent between the two modalities. Radiologic evidence of a recurrent hiatal hernia was found in 19 patients (15% overall or 21% in those who underwent contrast imaging). Analysis of recurrent hiatal hernias is presented in **Table 3**. Only 2 of 89 patients (2%) receiving radiographic surveillance showed a large recurrent hernia with intrathoracic stomach ≥50%, with more than half of patients (11 of 19) showing only a small hiatal hernia with <30% of the stomach in the chest. Reoperation was necessary in 6 patients (5%) at a median of 6 months (range, 1–26 months) postoperatively: 5 for symptomatic recurrence (4%) and 1 for dysphagia (1%). The patient with persistent severe dysphagia and weight loss required laparoscopic takedown of the Nissen fundoplication and gastrostomy tube placement and had subsequent resolution of symptoms. The 5 patients with symptomatic recurrence who required reoperation showed no evidence of a second recurrence on repeat imagining postoperatively. Overall recurrence rates were greatly increased in the nonmesh repair group as compared with the mesh group: 7 of 27 patients (26%) versus 11 of 99 patients (11%).

Table 3.
Analysis of Recurrent Hiatal Hernias (19 patients, 21%)[a]

Size of Recurrence as % of Stomach in Chest	Radiologic Recurrence [n (%)]	Time to Recurrence[b] [Median (Range)] (mo)
≤10% (<2 cm)	5 (26)	20 (4–34)
11%–30%	6 (32)	12 (3–36)
31%–50%	6 (32)	13 (1–90)
≥50%	2 (11)	27 (5–49)
Total	19 (21)	13 (1–68)

[a]Recurrent hiatal hernias were present in 21% of all patients undergoing contrast radiography.

[b]Shortest time interval in which hiatal hernia was detected on CT scan.

We analyzed several potential technical factors and comorbidities that may have contributed to recurrence, including the use of an anterior gastropexy, esophageal lengthening procedure, crural reinforcement, smoking history, and morbid obesity (**Table 4**). These comparisons were made only in the patients who had at least 1 form of imaging documenting either the presence or absence of recurrence. We found a markedly increased risk of recurrence in the subset of patients who underwent nonmesh repair as opposed to repair with mesh: 35% versus 18%. We also failed to show evidence that anterior gastropexy reduced the risk of recurrence, with 45% of patients who received an anterior gastropexy showing a radiographic recurrence as opposed to 18% in the group that did not receive gastropexy.

Table 4.
Analysis of Factors Potentially Contributing to Risk of Recurrence in All Patients Who Underwent Routine Radiographic Surveillance

	Total Patients (n)	Radiographic Recurrence[a] [n (%)]	*P* Value
Anterior gastropexy			.052
Yes	11	5 (45)	
No	78	14 (18)	
Esophageal lengthening procedure			.0343
Yes	19	2 (22)	
No	70	17 (24)	
Crural reinforcement			.119
Yes	72	13 (18)	
No	17	6 (35)	
Morbid obesity[b]			.67
Yes	11	2 (18)	
No	78	17 (22)	
History of smoking			.274
Yes	19	6 (32)	
No	66	13 (20)	
Pulmonary disease[c]			.739
Yes	16	4 (25)	
No	73	15 (21)	

[a]Detected by CT scan, barium esophagram, or endoscopy.

[b]Body mass index ≥35 kg/m^2.

[c]Defined as preoperative chronic obstructive pulmonary disease, asthma, or interstitial fibrosis.

At a mean clinical follow-up time of 20 months (± 22 months), 51 patients (40%) had complete resolution of symptoms, 30 patients (24%) had only mild operation-related side effects that did not affect their satisfaction with surgery, and the remaining 45 patients (36%) had symptoms that were clinically relevant. There was a significant reduction in the frequency of symptoms after operative intervention, as summarized in **Table 5**. Among the patients in whom a radiologic recurrent hiatal hernia developed, 10 of 19 patients (53%) were asymptomatic; severe symptoms requiring reoperation developed in 5 patients (26%) (nausea and vomiting in 4 patients and chest pain in the fifth patient); and the remaining 4 patients (21%) had only mild complaints of chest discomfort, bloating, and occasional nausea that subsided over time.

Table 5.
Comparison of Long-Term Symptomatic Outcomes in All Patients

	Preoperative Symptoms [n (%)]	Postoperative Symptoms [n (%)]
Epigastric pain	8 (6)	2 (2)
Dysphagia	47 (37)	15 (12)
Dyspnea	40 (32)	12 (10)
Bloating	20 (16)	9 (7)
Reflux	55 (44)	13 (10)
Gastrointestinal bleeding	9 (7)	1 (1)
Vomiting	31 (25)	15 (12)
Chest pain	36 (29)	8 (6)

DISCUSSION

Laparoscopic surgery has been shown to be safe and provide numerous short-term advantages over open surgery for patients with PEH.[4,5,8,22,26] These benefits include an improved quality of life, reduction in morbidity, reduced mortality rate, and shorter postoperative hospital stay.[20,26] As a result, the use of laparoscopic techniques for the treatment of PEH has continued to increase in popularity and is now considered by many surgeons to be the standard of care. However, because the current literature shows highly variable outcomes after laparoscopic repair of large PEHs, especially with regard to radiographic recurrence rates, the role of various techniques used in the repair has undergone considerable scrutiny. The use of anterior gastropexy, esophageal lengthening procedures, and especially crural reinforcement in PEH repair has been the subject of much debate since the first report of laparoscopic PEH repair in 1992.[27] Despite routine use of many of these techniques, the best observed recurrence rate to date is 12.3% when routine long-term radiologic follow-up with contrast imaging is used.[26] We routinely used contrast imaging to assess long-term recurrence rates in our patient population. Although the rate of reoperation was low (5%), a moderately high radiographic recurrence rate of 21% was observed in this study. Variations in technique, especially with regard to the use of mesh, appeared to influence the recurrence rate. We did not identify any preoperative risk factors that contributed to recurrence, such as preoperative pulmonary disease, which has been shown by other authors to increase the risk of recurrence.[15] Although the recurrence rates may appear moderately high in this study, especially when compared with the best reported recurrence rate of 2% for open repair, they were actually comparable with those observed by other

surgeons performing open repair in this decade.[26] Furthermore, most early studies on open PEH repair did not assess long-term radiographic recurrence rates.

The reasons for anatomic failure of PEH repair are numerous. Experience with inguinal and abdominal wall hernias has taught us that tension-free reapproximation is a key tenet to successful repair. The diaphragm is a thin dynamic structure that is constantly in a state of motion and therefore continually places the edges of the repair under tension. Furthermore, a large hiatal defect often makes tension-free reapproximation of the crura impossible. Patients with PEHs are frequently in their seventh, eighth, or even ninth decade of life at the time of repair, and the natural physiological degeneration of muscular tissues that occurs at this age only serves to compound the problem. There are continual repeated stresses on the diaphragm produced by coughing, the Valsalva maneuver, and even breathing. In elderly patients these stresses often result in tearing and disruption of an already attenuated diaphragm.

Because of the high rates of recurrence typically associated with laparoscopic repair, some authors have called for a return to the thoracic approach or open abdominal approach because of the lower recurrence rates reported for these procedures.[8,28] However, because the fundamental risk factors for hernia recurrence as previously discussed (attenuated diaphragm in the elderly, large hiatal defect, dynamic nature of the diaphragm) are unchanged by the approach, we tend to question the validity of this argument. The principal advantages to open repair are improved esophageal mobilization and identification of the GE junction, as well as increased adhesion formation. Our approach to laparoscopic PEH repair is described herein and emphasizes the same principles that are fundamental to successful open repair, including complete excision of the hernia sac, adequate mobilization of the esophagus to achieve 2 to 3 cm of intra-abdominal esophagus, and tension-free repair. In our experience the laparoscopic approach is often better suited to achieve these ends. One might argue that extensive esophageal mobilization is actually easier to achieve in the laparoscopic approach because the use of a camera allows for viewing angles deep in the mediastinum that cannot be achieved in the open abdominal approach. Endoscopy is routinely used at our center to accurately assess the location of the GE junction because chronic herniation often distorts the architecture of the stomach, making identification of this structure difficult. When the GE junction cannot be adequately mobilized to lie sufficiently below the GE junction, a foreshortened esophagus as a result of chronic herniation and fibrosis is often thought to be responsible. A recent meta-analysis of the current literature reported that esophageal lengthening procedures may have a protective benefit on recurrence by reducing the amount of tension placed on the crural repair.[17] In addition, Luketich and colleagues[15] documented a recurrence rate of only 15.7% and partially attributed their success to the high prevalence of esophageal lengthening procedures (86%) used in their series. However, the indications for these procedures remain controversial, and some surgeons do not advocate their use because these procedures can also result in additional morbidity and significantly longer operative times. Although we did not find a protective benefit with the use of Collis gastroplasty in this study, the relatively low number of patients (10%) who underwent this procedure contributed to low power to detect a statistically significant difference between groups. Although Collis gastroplasty was not performed frequently in this series, we believe that esophageal lengthening occasionally may be necessary to achieve a tension-free repair and therefore may be a critical technique in preventing recurrence.

We also failed to find a protective benefit of anterior gastropexy, which other authors have shown to be beneficial in preventing recurrence, especially in the setting of nonmesh repair.[5] We hypothesized that the addition of anterior gastropexy to standard mesh repair would result in a lower rate of recurrence in high-risk elderly patients and patients with multiple comorbidities. Recurrence rates in our study were actually much higher in the group that underwent anterior gastropexy (45% vs 18%). This is likely attributable to selection bias because only the sickest and highest-risk patients typically with larger hiatal defects received this procedure. In addition, anterior gastropexy was usually performed in conjunction with a gastrostomy tube in these high-risk patients. Surgical gastrostomy use has decreased greatly over the past 2 decades largely in part because it has been supplanted by percutaneous endoscopic gastrostomy, which is easy to perform and readily available. This mindset may not be prudent in this group of patients, especially in light of the fact that PEH patients are more frequently elderly and debilitated. Surgical gastrostomy tubes placed at the time of PEH repair can diminish gastric, though not oropharyngeal, aspiration and facilitate early enteric feeding in patients already prone to dysphagia. In fact, dysphagia was the most common postoperative complication in our patient population. More randomized controlled studies are needed to further clarify the role of gastrostomy tubes in PEH repair and to identify exactly which patients will definitively benefit from gastrostomy tubes at the time of surgery. These questions are the subject of an ongoing study at our institution.

Perhaps the most heated area of debate regarding PEH repair surrounds the routine use of crural reinforcement with pros-

thetic mesh. This question was first tested in a randomized trial by Frantzides et al[29] in 2002 and was again examined by Granderath et al[30] in 2005, both of whom reported that the hernia recurrence rate could be significantly reduced when polytetrafluoroethylene mesh was used to reinforce the crural closure. Although these results were favorable, many surgeons were skeptical about the use of synthetic meshes because they could increase the rate of mesh-related complications such as prosthetic migration, esophageal perforation, and dysphagia. Therefore a renewed vigor for the use of prosthetic mesh was prompted by a third prospective randomized trial (by Oelschlager et al[20] in 2006) that provided strong evidence that the risk of hiatal hernia recurrence could be reduced without the risk of mesh-related complications by using a biologic acellular porcine collagen mesh. Although the incidence of postoperative dysphagia was higher in the study by Granderath et al, there were no significant mesh-related complications. Although the risk of mesh-related complications is real, reports are limited to a handful of cases,[31] and their incidence is probably overestimated. We did not observe any early or late mesh-related complications in our study. There was, however, a complication related to fixation of the mesh using a laparoscopic tacking device in a patient, in whom cardiac tamponade developed as a result of a ventricular laceration. Though rare, cardiac tamponade is a well-described complication of mesh-reinforced hiatal hernia repair, usually attributed to a tack, staple, or suture that perforates the heart after passing through the diaphragm.[32,33] Despite all the evidence in favor of crural reinforcement, the largest study to date with long-term follow-up (median, 77 months) boasted a recurrence rate of only 15% without the routine use of mesh.[15] However, the study was not specifically designed to compare recurrence rates between mesh and nonmesh groups, and with only 16% of patients receiving mesh (high-risk patients at that), it lacked the power to show the superiority of a nonmesh repair. Some surgeons have argued that had they used mesh routinely, even lower recurrence rates could have been achieved. Currently, we exclusively use biologic mesh in all repairs. The exact impact of biologic or synthetic mesh on recurrence rates has yet to be fully elucidated. However, it is worth noting that in our experience, repair of a recurrence was much easier when biologic mesh was used initially. This was because although the biologic matrix rapidly degrades, the remodeled diaphragm is stronger and thicker than when the tissue heals naturally.

In our study, we did show a protective benefit of crural reinforcement with a reduction in recurrence rates from 35% to 18%. However, several confounding factors were present, which deserve discussion. Perhaps one of the reasons that we showed such a disparity in recurrence rates between the mesh group and the nonmesh group could be attributed to lead-time bias. A recent study showed that freedom from recurrence decreases over time when patients were followed up with serial barium esophagrams.[26] Most of the patients in our study who underwent nonmesh repair did so in the earlier period of our practice. Although the shift was somewhat gradual, by 2004, we began to highly favor mesh repair; therefore the mean length of follow-up in the nonmesh group was greater than that in the mesh group (30 months vs 22 months). In addition, only 27 patients (21%) underwent cruroplasty without mesh, and therefore the small sample size in the nonmesh group could be contributing to a type I error. This study appears to confirm the fact that although radiographic recurrence rates are relatively high, these can be substantially reduced by using prosthetic mesh.

With regard to symptomatic outcomes, for many years, outcomes were assessed on the basis of symptom resolution. This standard of successful repair may seem inadequate given the fact that PEH repair is recommended to prevent the devastating consequences of an intrathoracic stomach, including obstruction, volvulus, necrosis, and perforation, rather than because of symptoms.[2,3,18,34] In fact, many of these patients are often asymptomatic or have symptoms that are clinically insignificant. This has led many surgeons to advocate a routine protocol of radiographic surveillance when assessing the different variables that may contribute to hernia recurrence.[8,15,16,19–21,25,26] In our series of 126 patients, we observed an overall decrease in postoperative symptoms as compared with preoperative symptoms with nearly complete resolution of both gastrointestinal reflux and dysphagia symptoms.

Perhaps the most notable finding in our study was that more than half of the patients with a radiologic PEH (58%) were asymptomatic. This is actually in keeping with the findings of other authors.[9,15] No consensus has been reached as to what should be done about these patients. There is a relative black hole in the literature concerning how to correctly manage patients with asymptomatic recurrences, and the natural history of this disease process is unknown. We did not observe any sequelae in our patients with asymptomatic recurrences at a mean follow-up time of 23 months. It is possible that the follow-up time was not long enough to detect an adverse event related to symptomatic recurrence; however, there have been no other series to date that have documented complications similar to those seen on initial PEH presentation, such as volvulus or strangulation, in patients with an asymptom-

atic anatomic recurrence. In fact, White et al[31] concluded in a study with symptomatic follow-up for up to a mean of 11 years that most anatomic recurrences after PEH repair were minimally symptomatic and followed a benign course in the long term. This is particularly interesting because the recurrence rate after laparoscopic PEH repair loses its impact if there are no relevant long-term consequences other than mild symptoms.

The necessity of a fundoplication procedure during PEH repair is not clearly elucidated in the literature. Recent studies have shown that postoperative dysphagia is much more common in patients who have undergone a concomitant fundoplication procedure although reflux is more common in those who have not.[35,36] In most cases, however, reflux is easily controllable with medication. Dysphagia was present in 15% of our patients postoperatively, and it was so severe in 1 patient that takedown of the fundoplication was required. Fundoplication was performed in 90% of patients. Fundoplication was not performed in patients with clear evidence of esophageal dysmotility noted on manometry or barium esophagram or in patients who had anatomy that prohibited the construction of a loose fundoplication. Endoscopy was routinely used to evaluate the tightness of the fundoplication in patients who we suspected might have dysphagia. Despite these additional efforts, dysphagia was the most common postoperative complaint. Although we do not advocate abandonment of a concomitant fundoplication procedure altogether at this time, it is possible that more intensive preoperative screening may minimize the need for reoperation because of dysphagia.

There were several limitations to this study. Because of attrition of patients during follow-up, only 71% of patients received postoperative imaging, and therefore only an estimation of the true recurrence rate is possible. Another acknowledged limitation is the small sample size with a relatively short-term follow-up period, particularly in the mesh repair group. Some surgeons may call into question our use of CT scans to routinely screen for anatomic recurrence as opposed to barium esophagrams; however, we found CT to be a highly sensitive test for the detection of hiatal hernia, with no missed recurrences.

In conclusion, several advancements in the treatment of PEH have been made in the past decade as a result of our work and the work of other surgeons. First, laparoscopic repair of large PEHs has emerged as the dominant and superior technique when compared with open repair. Second, the technique has evolved to include careful awareness of a combination of factors rather than individual variables, most importantly complete excision of the hernia sac, extensive mobilization of the esophagus, use of esophageal lengthening procedures when needed, and crural reinforcement. Meticulous attention to these factors reduces hernia recurrence. Third, although the rate of anatomic recurrence is high when routine radiologic surveillance is used, most of these recurrences are small and may not carry the same risk of catastrophic sequelae observed in primary PEHs. However, several key questions remain that need to be addressed in subsequent studies over the next 10 years. Namely, is biologic mesh truly superior to prosthetic mesh, and if so, does the type of biologic mesh used matter? Should gastrostomy tubes be used more liberally in elderly debilitated patients or patients with multiple comorbidities? Can fundoplication be omitted in select patients to minimize reoperations and postoperative symptoms, and how do we select these patients? As surgeons, we continually strive for perfection, and we look forward to new studies over the course of the next decade that may answer these questions and others that still remain.

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