Chapter 6
Management of Complicated and Strangulated Hiatal Hernias

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6.1 Classification and Pathophysiology of Hiatal Hernia

6.1.1 Classification

The prevalence of hiatal hernias is estimated to be somewhere between 10 and 50 % in the population, with greater frequency in patients over the age of 50. Many are discovered incidentally by radiologists or gastroenterologists, as symptoms caused by the hernia or gastroesophageal reflux occur in half of patients. The lifetime risk of gastric volvulus or strangulation with ischemia to the stomach is not known precisely, but mortality of emergency surgery in this scenario has historically reported to be greater than 50 % [1].

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The classification system of hiatal hernias is based on the relative positions of the gastroesophageal junction, the stomach, and the esophageal hiatus [2].

- Type I hernias are sliding hiatal hernias, where the gastroesophageal junction migrates freely above the diaphragm due to weakness predominantly in the posterolateral phrenoesophageal attachments. The stomach, however, remains in its normal alignment.
- Type II hernias occur when the gastroesophageal junction remains fixed in its normal anatomic position, but a portion of the fundus herniates through the diaphragmatic hiatus adjacent to the esophagus. The anterior phrenoesophageal attachments are usually disrupted in this case, while the posterolateral attachments may be preserved.
- Type III hernias represent a combination of types I and II, whereby the gastroesophageal junction has migrated above its normal anatomic position, and the fundus and body have herniated through the hiatus, lying cephalad to the intrathoracic gastroesophageal junction.
- Type IV hernias are characterized by the herniation of other intra-abdominal organs, such as the spleen, colon, small bowel, and/or omentum through the esophageal hiatus. It is often an extension of a type III hernia, as the gastroesophageal junction and some or all of the stomach have already herniated through the hiatus as well. These are associated with a very large hiatal defect.

Type I hiatal hernias are, by far, the most common type, representing up to 95 % of all hiatal hernias. Acute presentation of sliding hiatal hernias is exceedingly rare, however, and they tend to be associated with gastroesophageal reflux disease (GERD) and obesity. As there is almost never an indication to address type I hernias on an emergent basis, the focus of this chapter will be on type II–IV hiatal hernias, referred to as paraesophageal hernias (PEH), which comprise the residual 5 % of hiatal hernias. Almost 90 % of PEH are type III, and the least common

is a type II at less than 2 %. The term "giant paraesophageal hernia" typically refers to type III and IV hernias, where greater than 50 % of the stomach is in the chest [3]. With respect to giant paraesophageal hernias, distinguishing between subtypes is more of a theoretical than practical exercise, as the surgical approach and management are rarely affected.

6.1.2 Pathophysiology

The pathophysiology of hiatal hernias is not entirely understood, but widening of the esophageal hiatus and cephalad migration of the gastroesophageal junction are likely related to the following factors: [4]

- Laxity of the phrenoesophageal membrane as a result of decreased elastin and collagen fibers in the context of connective tissue dysfunction or advanced age
- Increased intra-abdominal pressure due to obesity, pregnancy, or possibly repetitive straining (i.e., vomiting, heavy lifting, constipation)
- Esophageal shortening as a consequence of GERD with chronic inflammation and fibrosis

While genetics may play a role to some degree, the above are primarily acquired risk factors. Of note, other diaphragmatic hernias, such as congenital or traumatic hernias, are beyond the scope of this discussion, though some principles of management and surgical repair may overlap. Because the phrenoesophageal membrane and its attachments to the muscular wall of the lower esophagus constitute a key anatomic component of the lower esophageal sphincter (LES), there is a close relationship in the evolution of both hiatal hernias and gastroesophageal reflux. Thus, GERD is a frequent early symptom of hiatal hernia in the initial non-acute presentation and represents an indication for elective repair if proton pump inhibitor therapy proves insufficient.

6.2 Clinical Manifestations in the Acute Setting

6.2.1 Presentation

6.2.1.1 Gastric Volvulus

The clinical presentation of PEH in the acute setting includes obstruction, bleeding, perforation, or strangulation. Nearly 50 % are thought to be symptomatic (though minor symptoms may be incorrectly attributed to other etiologies), and the literature suggests that the annual risk of developing symptoms in the setting of a known PEH is approximately 14 % [5]. The risk of developing acute symptoms, however, that mandates an emergent operation is likely to be less than 2 % per year. Gastric volvulus with migration of the stomach into the chest is categorized as either mesenteroaxial or organoaxial, based on the axis of rotation of the stomach. Organoaxial rotation is more common (approximately 60 % of cases) and occurs when the stomach rotates horizontally along the long axis, connecting the pylorus and gastroesophageal junction. Strangulation and necrosis occurs in up to 30 % of cases with organoaxial gastric volvulus [6]. Mesenteroaxial refers to vertical rotation along the short axis of the stomach, bisecting the greater and lesser curves of the stomach. Mesenteroaxial rotation is less frequent and less likely to lead to vascular compromise of the stomach. Combined organoaxial and mesenteroaxial rotation is also possible, but occurs in less than 10 % of cases. Borchardt's triad of epigastric pain, retching without vomiting, and inability to pass a nasogastric tube represents the acute clinical manifestation of gastric volvulus that has progressed to complete obstruction. Of note, volvulization of the stomach with organoaxial or mesenteroaxial rotation can be chronic and may be seen on imaging in the absence complete obstruction, strangulation, or perforation, though significant symptoms are usually apparent and risk of

progression to either of these endpoints is presumably higher in these patients.

6.2.1.2 Obstruction

Obstructive symptoms may occur intermittently, usually following oral intake. These symptoms range from nausea, vomiting, dysphagia, heartburn, and regurgitation to severe postprandial pain related to gastric distension and transient ischemia with or without volvulus. At times, the clinical picture can be confused with angina or other cardiopulmonary etiologies given that substernal chest pain radiating to the back, palpitations, and dyspnea are quite common. Respiratory symptoms frequently occur with giant paraesophageal hernias, though repair does not necessarily relieve these symptoms. On average, patients experience a 10–20 % improvement in pulmonary function values [7]. Giant paraesophageal hernias can also cause compression of the inferior pulmonary vein or right atrium, which leads to rhythm disturbances, such as supraventricular tachycardia. This often triggers a full battery of cardiac testing, including cardiac catheterization, all of which usually turn up negative. Patients may also present to the emergency department with a more chronic history of reflux, recurrent aspiration events with pneumonia, early satiety, worsening food intolerance, and weight loss. Only paraesophageal hernias where part (i.e., fundus) or all of the stomach has ascended into the chest are at risk of acute gastric volvulus and subsequent obstruction.

6.2.1.3 Bleeding

Upper gastrointestinal (GI) bleeding in the setting of PEH is almost always a consequence of Cameron's ulcers, which are thought to arise from mechanical friction of the gastric mucosa

in the sliding hernia sac. They are typically described as superficial, linear erosions of the stomach at the level of herniation where the stomach is constricted by the diaphragm. While slow, occult bleeding resulting in iron deficiency (microcytic) anemia has been reported in up to 47 % of patients with giant paraesophageal hernias, acute symptomatic hemorrhage from Cameron's lesions, accompanied by melena or hematemesis, is only seen rarely. Initial treatment of upper GI bleeding from Cameron's ulcers involves acid suppression with intravenous proton pump inhibitors and supportive measures, such as iron supplementation or transfusion if necessary. Definitive management, however, is not amenable to endoscopic interventions and relies on surgical repair of the hernia. Occult bleeding with iron deficiency anemia resolves in 90 % of patients following surgical repair [8].

6.2.1.4 Strangulation

Strangulation represents the most catastrophic endpoint of gastric volvulus within a PEH and is defined by acute vascular compromise of the stomach and possibly other organs. Patients may present in various degrees of extremis, and symptoms tend to escalate from intermittent to constant, severe substernal and epigastric pain. Frequently, obstructive symptoms will exacerbate the clinical picture. Signs of sepsis may also be present with hypotension requiring vasopressors, respiratory distress, and evidence of inadequate end-organ perfusion. Laboratory studies may reveal a lactic acidosis and a leukocytosis, though the elderly septic patient may be leukopenic instead.

6.2.1.5 Perforation

Perforation is a much less common endpoint of acute PEH, but has been described in various case reports where incarceration

of the fundus of the stomach within the hernia sac leads to perforation. Linear tears of the gastric corpus have also been described in the setting of organoaxial volvulus. This complication is more common in the immunosuppressed patient on steroids. Typically, other symptoms of obstruction and strangulation precede perforation, as this represents a downstream finding likely secondary to ischemia. The perforation may be contained within the hernia sac or may extend freely into the peritoneal or pleural cavities. Pleural effusions or fulminant mediastinitis may result, and signs of systemic sepsis, leukocytosis with bandemia, and respiratory failure are to be expected in this scenario.

6.2.2 Diagnosis

6.2.2.1 Computed Tomography

Spiral computed tomography (CT) scan is the primary diagnostic tool of choice in the patient that presents to the emergency department with acute symptoms and suspicion of PEH [6]. Abdominal plain films are insufficient to map out the anatomy and plan for the appropriate surgical approach. CT scan clearly shows the anatomy of the esophagus and stomach and allows for a complete assessment of the hernia including (1) percentage of the stomach that has herniated into the chest, (2) whether other organs are contained in the hernia sac, (3) complete or partial obstruction if there is no passage of contrast distally, (4) organoaxial vs. mesenteroaxial gastric volvulus with swirling of the fat of the lesser or greater omentum, (5) ischemia if there is stranding or pneumatosis of the stomach wall, (6) and perforation with free air and fluid. Figure 6.1 shows a CT image of a giant type IV PEH containing small bowel and stomach with organoaxial rotation. Plain films can certainly provide clues with findings such as a retro-cardiac air fluid level on lateral view or an

Fig. 6.1 Axial CT image of a giant type IV paraesophageal hernia

intrathoracic stomach with compressive atelectasis of the lung. The presence of pneumomediastinum or pneumoperitoneum signifies perforation.

6.2.2.2 Upper GI Series

In the stable patient with lower concern for complete obstruction or strangulation, esophagram plus upper GI series with either water-soluble contrast or barium is the first-line diagnostic study and can be a helpful adjunct to CT in further delineating the anatomy of the esophagus and stomach, the position of the gastroesophageal junction, and whether any partial obstruction may exist. A contained perforation may

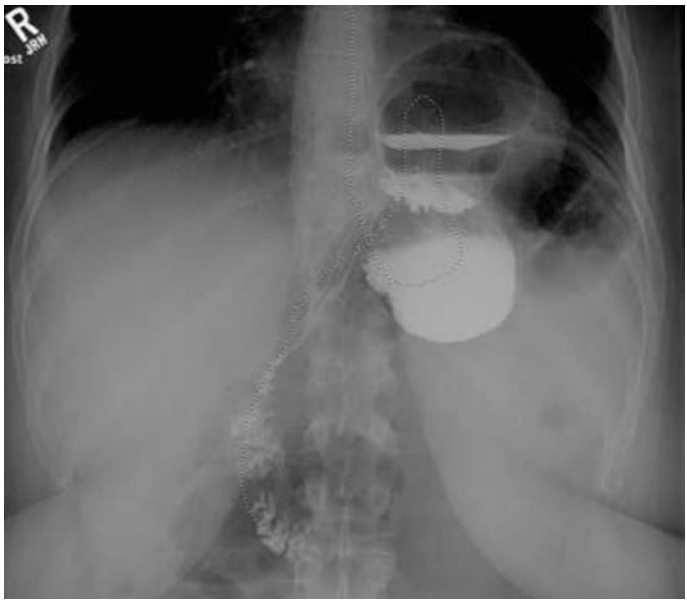

Fig. 6.2 Upper GI series of incarcerated intrathoracic stomach with near-total obstruction

also be identified. Gastric volvulus is best recognized on CT scan, but can also be seen on a barium contrast study. Figure 6.2 demonstrates an incarcerated intrathoracic stomach with near-total obstruction and only minimal passage of contrast to the small bowel, as seen on an upper GI series contrast study. In the patient that presents with systemic sepsis or gastric volvulus with concern for vascular compromise of the stomach, barium studies should be forgone as they simply delay surgical intervention. Moreover, they should be avoided if there is imminent risk of aspiration of contrast material. Lastly, obtaining an esophagram in the acute setting may not

even be an option, as many centers do not have a 24-h on-site radiologist or gastrointestinal fluoroscopy team readily available to perform emergent exams.

6.2.2.3 Manometry and pH Testing

While manometry and pH probe monitoring can also occasionally provide useful information with respect to the degree of symptomatic reflux and motility pattern of the esophagus and stomach, there is absolutely no role for these studies in the acute presentation of PEH. In the elective setting, the function and location of the LES may be more accurately assessed by manometry, and esophageal shortening may be apparent if the distance between the upper and lower esophageal sphincters is less than expected. Evaluation of peristaltic function, combined with data on symptomatic acid reflux, may assist the surgeon in determining what type of anti-reflux procedure to offer the patient prior to an elective repair. However, many surgeons would argue that these tests are of little value even in the elective setting, since the need for an esophageal lengthening procedure or fundoplication in an attempt to restore LES function is usually determined intraoperatively. In addition, both manometry and 24-h pH probe monitoring may be technically impossible to execute in patients with giant paraesophageal hernias.

6.2.2.4 Endoscopy

Endoscopic evaluation of the esophagus and stomach should be performed in the operating room prior to any surgical intervention, acute or elective, for PEH. Findings of erosive esophagitis, Barrett's dysplasia, mass, or ulcer disease can guide operative planning, as resection may be indicated rather than simple reduction of the hernia. Viability of the gastric mucosa

and torsion of the stomach is also critical to assess in the case of gastric volvulus and may also guide the surgeon toward resection or not. Endoscopic decompression of the stomach may facilitate further operative management, and nasogastric tube placement may require direct visualization if the tube does not pass easily or if there is uncertainty about the effectiveness of gastric decompression. Endoscopic detorsion of the stomach with percutaneous endoscopic gastrostomy placement in the setting of acute gastric volvulus is rarely feasible, though this approach has been described by some surgeons in cases where most of the stomach is below the diaphragm.

6.3 Indications for Surgical Repair

6.3.1 Elective Indications

As the morbidity and mortality associated with emergent repair of PEH has been historically high, some surgeons insist that all should be repaired on an elective basis regardless of symptoms if the patient is an appropriate surgical candidate. In 1967, Skinner and Belsey published a rate of nearly 30 % of patients who did not undergo operative repair that progressed from only minimal symptoms to death from acute strangulation [1]. The rationale for repair upon diagnosis is also related to the fact that many surgeons believe that paraesophageal hernias tend to enlarge over time and become more and more technically difficult to reduce and repair, and the patient's operative risk will only increase with advancing age, though there is little actual published data describing the natural history of hiatal hernia. Other, more recent data suggests a much lower rate (less than 2 % per patient per year) of asymptomatic patients that go on to develop life-threatening complications of an incarcerated

PEH. In particular, Stylopoulos and colleagues use an extensive mathematical model that incorporates the results of five different studies to estimate the risk of acute complications to be approximately 1.2 % per patient per year [5]. The lifetime risk of acute complications of PEH in a 65-year-old patient is, therefore, predicted to be on the order of 18 %. Thus, repairing an asymptomatic or minimally symptomatic PEH has become increasingly controversial. Morbidity and mortality following emergent or urgent repair has significantly decreased as well over time in the era of laparoscopic reduction, to a range of 5–20 % in more recent studies [9]. As a result, the current recommendation is to follow asymptomatic patients, especially in the absence of a large hernia (greater than 30 % of the stomach above the diaphragm) or evidence organoaxial rotation of the stomach. In the author's experience, giant paraesophageal hernias are very rarely completely asymptomatic, and symptoms may be more insidious and long standing or slow to evolve. They may include postprandial bloating, weight loss, a change in eating habits to small portions, or avoidance of certain foods. If the patient is symptomatic, the guidelines universally support pursuing elective repair at whatever age if the patient is of reasonable surgical risk [10]. Larusson et al. have reported a significant quality of life improvement in elderly patients over the age of 70 who underwent laparoscopic repair [11]. Prophylactic repair is considered acceptable in patients younger than age 65 of low surgical risk based on patient preference, though recommendations for prophylactic repair need to be tempered by the realization that radiographic evidence of recurrent herniation is seen in 40 % of patients within 5 years of surgery in some series [12]. Prophylactic repair in patients over the age of 80 is not recommended. Undeniably, patients that undergo elective repair of giant paraesophageal hernia early upon onset of symptoms have the best outcomes. Mortality following elective repair is less than 1–2 % [13].

6.3.2 Urgent Indications

Estimates of the morbidity and mortality of emergency surgery for acute presentation of complicated PEH vary widely, and therefore, the timing of when to operate is not well defined. The majority of patients that present to the emergency department with acute symptoms of giant paraesophageal hernia can be treated conservatively in the initial phase, as most commonly, their complaints are related to either acute or chronic worsening obstruction secondary to volvulus. These are patients with stable hemodynamics and no signs of systemic sepsis or imminent ischemia or perforation of the stomach. First steps of management rely on nasogastric tube decompression of the stomach, electrolyte repletion, and fluid resuscitation with correction of any base deficit. Many patients will improve with these preliminary measures, and in that case, they may be watched closely and either repaired during the same hospitalization or semi-electively if their condition improves adequately. Even mild to moderate epigastric pain due to low-grade ischemia and partial strangulation may resolve with decompression, since the redundant blood supply to the stomach makes gastric necrosis a rare event. These patients should, however, undergo surgical intervention within days of initial presentation. Bawahab et al. propose a useful algorithm based on their study of 20 patients that were repaired laparoscopically [14]. Their study suggests repeating a contrast study after nasogastric decompression and fluid resuscitation. If the patient remains obstructed, repair is performed urgently. If there is passage of contrast, surgery is delayed to the semi-elective setting. Though only six patients were included in the semi-elective repair group, a study from Kohler et al. also shows that delayed or semi-elective operative management yields better outcomes than emergency surgery as none of the patients in this arm experienced a perioperative complication [15].

6.3.3 Emergent Indications

Emergency surgery for complicated or strangulated PEH is inherently high risk. As mentioned above, mortality was historically reported to be as high as 56%. Early experiences of emergent laparoscopic repair of giant paraesophageal hernia suggested an average mortality rate of 17%. More recently, mortality has been reported to be as low as 5.4% with laparoscopic reduction [5]. The high mortality rates overall, though, are mostly attributable to the patient population that presents with incarcerated PEH (i.e., the elderly and frail), as well as the difficulties of treating mediastinitis. Patients that present with evidence of incarcerated intrathoracic stomach complicated by strangulation or perforation require emergent surgical intervention. Systemic sepsis and lactic acidosis should be treated with intravenous fluids and a nasogastric tube to decompress the stomach since degree of vascular compromise to the stomach may be mitigated with these maneuvers. However, while preoperative decompression and resuscitation is critical, unstable patients presenting in extremis should be taken to the operating room within hours of arrival in the emergency department. Bhayani and colleagues examined the outcomes of 224 patients from the National Surgical Quality Improvement Database who underwent early vs. interval repair following acute presentation [16]. Early repair within 24 h of admission was associated with better outcomes in terms of lower rates of postoperative sepsis and shorter length of hospital stay. Perhaps as a testament to the quality of critical care and nutritional support available in the current era, mortality was not different between early and delayed treatment groups, however. Thus, absolute indications for emergent operation include hemodynamic instability with evidence of gastric necrosis or perforation. The remainder of cases must be taken on an individual basis to determine optimal timing for repair. If there is any suspicion for ischemia, even if

transient, PEH repair should be undertaken during the sentinel hospitalization. We recommend that all paraesophageal hernias presenting in an acute manner be repaired as soon as possible, unless age and comorbidities are prohibitive.

6.4 Surgical Principles and Techniques

6.4.1 Laparoscopic Versus Open

Laparoscopic repair is currently the standard approach in both elective and emergent cases of PEH repair. Many studies now demonstrate that a laparoscopic approach is not only safe but less morbid overall especially in elderly patients. Postoperative respiratory complications, pain, wound infections, and length of hospital stay have all been found to be reduced with laparoscopic repair [17]. Many surgeons also argue that visualization of the hiatus and even into the mediastinum is superior with greater mobilization of the esophagus and less need for esophageal lengthening procedures, though skeptics suggest that pneumoperitoneum may distort the hiatus and perhaps make the intra-abdominal esophagus appear longer. However, the first caveat of laparoscopic paraesophageal hernia repair is that the surgeon must be experienced and comfortable with complex laparoscopy of the foregut, routinely performing anti-reflux and other benign esophageal procedures. The second is that the patient must be able to tolerate pneumoperitoneum for approximately 2–4 h, which is the average duration of this procedure in most hands. Entry into the pleural cavity does occasionally occur during laparoscopic repair when the hernia sac is scarred into the pleural surface and difficult to mobilize. If airway pressures increase, the diaphragm becomes floppy or the patient becomes hypotensive – all signs of a

clinically significant pneumothorax – a pigtail catheter may be placed mid-operation with resolution of symptoms. Typically, the case may proceed laparoscopically, as pneumoperitoneum may still be maintained without respiratory or circulatory compromise. Of note, if there is pleural entry with no clinical consequence during the procedure, pigtail placement is not necessary. Postoperatively, the lung usually re-expands quickly with reabsorption of any residual carbon dioxide.

For surgeons without advanced laparoscopic training, open laparotomy is an acceptable alternative. Efficacy of hernia repair is adequate and has a similar recurrence rate as minimally invasive surgery based on single-center, retrospective comparisons [18]. An open approach is also recommended in the unstable or hypotensive patient that will not tolerate pneumoperitoneum and may have frank gastric necrosis or perforation with gross peritoneal contamination. After the stomach is untwisted and reduced into the abdomen, viability of the stomach must be assessed directly and endoscopically. Small perforations and tears may be repaired primarily in two layers with an omental flap buttress if the stomach is viable. Any necrotic stomach must be resected. If the patient remains unstable from septic shock, requiring vasopressors, performing immediate anastomosis and reconstruction is not advisable. Rather, a damage control strategy should be adopted. The esophagus and stomach may be decompressed using a nasogastric or gastrostomy tube, and reconstruction with esophagojejunostomy or gastrojejunostomy may be performed 24–48 h later. It is nearly impossible to lengthen the esophagus transabdominally and often quite difficult to resect the hernia sac. In such instances, the surgeon needs to reduce the volvulus, ensure viability of the stomach, and try to prevent re-herniation in the short term. This can be done by placing a gastrostomy tube or performing an anterior gastropexy. Repairing the hiatus is not always possible and simply getting the patient out of imminent danger may be the appropriate

endpoint, realizing that a definitive hiatal hernia repair may ultimately be required in the future when the patient can tolerate it. Placement of nonabsorbable mesh to close the hiatus or reinforce hiatal closure in the acute setting should be avoided.

6.4.2 Transthoracic Versus Transabdominal Approach

Some surgeons advocate that all giant paraesophageal hernias with greater than 50% of stomach in the chest should be approached via left thoracotomy. Moreover, mobilization of the esophagus may be more extensive with good visualization of the hiatus, and a tension-free repair can be potentially more easily achieved. However, there are cases reported where the stomach could not be completely reduced from the chest, and the patient required subsequent laparotomy to untwist a gastric volvulus [19]. Thus, in the instance of emergency surgery for the strangulated or perforated stomach, laparotomy is likely to be superior to thoracotomy. Opening the pleura and allowing potential contamination of this space predisposes to serious respiratory complications, including pneumonia and empyema.

In general, however, given the high morbidity and pain associated with a transthoracic approach with a thoracostomy tube, most surgeons believe that the Belsey-Collis procedure has become obsolete, except in specific circumstances where prior transabdominal repairs have already failed or there is a history of other major abdominal surgery. Though technically challenging, advanced minimally invasive foregut surgeons have demonstrated that even the total intrathoracic stomach may be reduced laparoscopically with success and adequate esophageal length. Esophageal shortening due to chronic reflux, inflammation, and fibrosis is not common, but does need to be addressed with a Collis gastroplasty procedure, as this is a risk factor for

recurrence. In cases where there have been multiple previous attempts and recurrences, the authors favor a left thoracoabdominal incision for maximal exposure. Equivalent outcomes between transthoracic and transabdominal repair have been shown in terms of recurrence, though no randomized trial comparing the two has been published to date [20]. The authors are not aware of any minimally invasive thoracic approaches to PEH repair that are routinely practiced or well described in the literature at this time.

6.4.3 Hernia Sac Excision Versus Simple Reduction

The fundamental tenets of PEH repair to prevent recurrence, regardless of approach, include (1) tension-free reduction of the hernia with at least 2–3 cm of intra-abdominal esophageal length, (2) complete excision of the hernia sac, and (3) closure of the hiatus [21]. Dissection of the hernia sac off of the crura and mediastinum is a key component of successfully being able to reduce the stomach into its normal configuration in the abdomen when performing either a laparoscopic or open repair. In addition, the planes of dissection are often easier to visualize, especially laparoscopically, and injury to the wall of the esophagus, left gastric vessels, and vagus nerves may be more consistently avoided. In large, long-standing hernias where the sac may be completely fused with surrounding structures, at least partial excision of the sac is recommended to allow for more complete reduction of the hernia and possible performance of a wrap. Leaving a portion of the hernia sac attached to the lesser curve often reduces blood loss, but the hernia sac should be completely dissected from the greater curve, fundus and gastroesophageal junction in order to be certain that normal anatomy has been restored. Failure to excise any of the hernia sac is associated with a higher early recurrence rate. In 1998, Edye

et al. reported a 20% recurrence rate within 8 weeks without excision of the hernia sac [22].

6.4.4 Primary Repair Versus Mesh Repair

Recurrence rates following PEH repair with primary closure of the hiatus have been quoted to be as high as 42% in studies where patients have been followed over the long term [12]. Many of the recurrences are small, asymptomatic, and less than 5 cm in size, however. Hence, it is important to discriminate between the radiographic and clinically significant recurrence rates. Figure 6.3 demonstrates our preferred technique of primary hiatal closure using double-pledgeted sutures. In order to reduce the recurrence rate, many surgeons have used mesh reinforcement of the crural closure, especially if there is any degree of tension or the hiatal defect is large (greater than 5 cm). Of note, the normal hiatus is, on average, 2.4 cm in size [23]. Three techniques have been described that incorporate mesh into the crural closure: (1) reinforcement technique where the crura are approximated primarily and the mesh is placed in an onlay fashion to reinforce the repair using stitches to the crura to keep the mesh in place while fibrosis occurs (Fig. 6.4); (2) bridging technique where mesh is interposed between the crura and is sewn to each crus, so as to eliminate tension altogether: and (3) a keyhole technique where a hole is cut in the mesh so that it can be placed almost circumferentially around the esophagus [24]. In addition to the deciding which of these techniques is appropriate, the surgeon must also decide which type of mesh to use: absorbable/biologic, polypropylene, or polytetrafluoroethylene (PTFE).

There are concerns regarding long-term erosion of mesh into the wall of the esophagus or stomach, which can result in a rare but extremely challenging situation for the surgeon. Removing the mesh and performing a reconstruction is a major undertaking and represents a life-threatening scenario

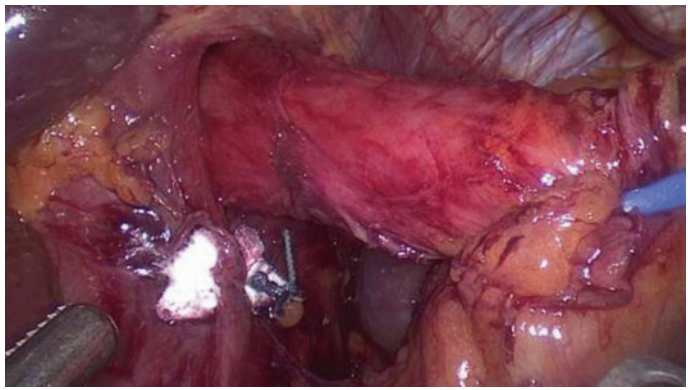

Fig. 6.3 Primary closure of hiatus, reinforced with a double-pledgeted suture

for the patient. An esophagectomy may be ultimately required after the mesh and affected tissues are removed to control sepsis. Due to this possibility we believe that synthetic mesh should be avoided in patients under age 50. Newer biologic mesh onlays made of porcine submucosa or acellular human dermis, on the other hand, are usually resistant to infection and become incorporated into native tissues over time without excessive scar formation. Multiple reports claim that mesh reinforcement of hiatal closure significantly reduces the recurrence rate. Furthermore, a randomized controlled trial conducted with biologic mesh initially supported these claims, with no reported complications related to mesh. However, a 5-year follow-up of these patients showed similar rates of recurrence whether mesh was used or not, and hence the value of biologic mesh as pertains to long-term recurrence rate is questionable [25]. At this time, while short-term data does support the use of mesh, longer-term data does not. Furthermore,

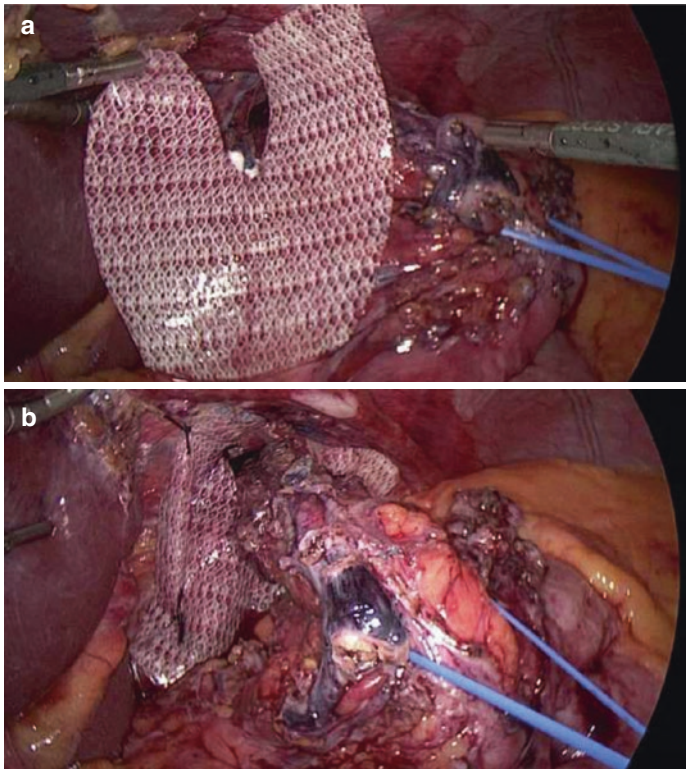

Fig. 6.4 The use of synthetic mesh to reinforce the hiatus. (**a**) U-shaped Mesh prior to fixation. (**b**) Mesh after fixation

in the setting of emergent repair of PEH for strangulation or perforation where there is any concern for contamination of the mediastinum or peritoneal cavity, mesh is generally to be avoided. The use of a biologic mesh may be acceptable, however, if necessary to help salvage a difficult hiatal closure.

A better alternative that we prefer to employ for difficult crural closure is the use of relaxing incisions. It is safe to make a longitudinal incision in the right crus to allow the medial portion to slide centrally and then be primarily sutured to the left crus. One can then patch the defect in the right crural muscle with a small piece of absorbable mesh or even leave the defect open, as it is almost always covered by the caudate lobe of the liver. Others have described making a relaxing incision in the left crus in a similar fashion.

6.4.5 Gastropexy Versus Wrap

Traditionally, an anti-reflux procedure is performed concomitantly with PEH repair as a method to anchor the stomach in the abdomen and also to reconstruct the lower esophageal sphincter mechanism as a barrier to reflux. The rationale is that following full dissection and mobilization of the gastroesophageal junction, lower esophagus, and hiatal attachments, the geometry of the lower esophageal sphincter has been significantly disrupted and is thus rendered incompetent. The rate of postoperative reflux has been reported to be as high as 65 % following PEH repair without fundoplication, though most argue that symptomatic reflux is far less common, and can be managed with medical therapy if it persists [26]. Because many of the patients who require PEH repair are elderly and have impaired esophageal motility a full 360° fundoplication may predispose to postoperative dysphagia. Hence many surgeons advocate for at least a partial 270° wrap, such a Toupet or Dor fundoplication, particularly if there is a significant history of GERD in order to minimize dysphagia. Although many surgeons believe fundoplication adds bulk and gastropexy to the hiatal hernia repair, the impact of re-herniation after fundoplication has not been examined in a robust fashion in any published data to the authors' knowledge.

In the case of the elderly patient or patient that requires a complex or emergent operation for acute presentation of PEH, a fundoplication is even more difficult to justify. It can prolong the operation significantly, which may be of critical importance in unstable patients with multiple or severe comorbidities. Two retrospective case-controlled studies demonstrate minimal benefit to performing fundoplication routinely as a part of paraesophageal hernia repair [27, 28]. Thus, gastropexy or gastrostomy is preferred under these circumstances. Although recurrence rates associated with gastropexy are high, it can be lifesaving. If gastropexy alone is performed without hiatal closure and sac excision, recurrence is reported to be 23 % at 3 months [29]. Gastropexy involves fixation of the greater curve of the stomach to the diaphragm and abdominal wall in the left upper quadrant anterior to the spleen after all of the short gastric vessels are divided. The goal should be restoration of the normal anatomic position of the stomach without tension. In order to successfully fix the stomach in the abdomen, adequate intra-abdominal esophageal length of 2–3 cm is still required even in the absence of fundoplication (Fig. 6.5).

The major causes of re-herniation are related to increased intra-abdominal pressure postoperatively, lack of tension-free closure of the hiatus, incomplete dissection and removal of the hernia sac, and inadequate intra-abdominal esophageal length. The addition of a Collis gastroplasty to lengthen the esophagus is recommended when the esophagus appears foreshortened. Lower recurrence rates have been published when concomitant gastroplasty is performed. However, there is a non-trivial risk of leak from the gastroplasty staple-line, which is estimated at 3 % [30]. One must also be cognizant of the risk of ischemic stricture when Collis gastroplasty is performed in an unstable patient.

In the scenario of emergent or urgent surgery in the elderly or debilitated patient, if there is concern for sufficient intra-abdominal esophageal length even after extensive mediastinal dissection of the esophagus, placement of a gastrostomy tube

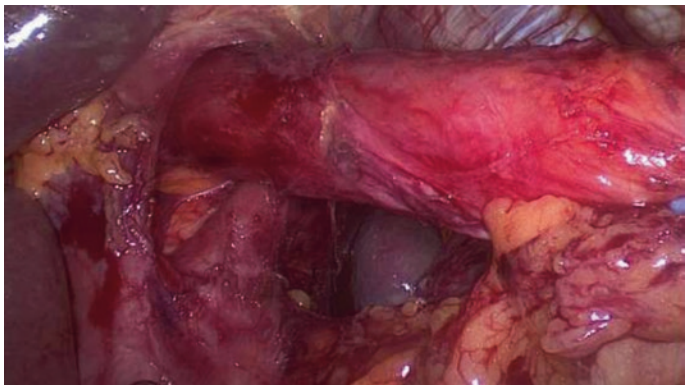

Fig. 6.5 Obtaining adequate intra-abdominal esophageal length

should be considered. The benefits of gastrostomy tube placement include enteral access and decompression of the stomach postoperatively, which can be useful especially if the vagus nerves are damaged or divided inadvertently and delayed gastric emptying becomes an issue.

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