Chapter 6
Treatment of Epiphrenic Diverticula

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Abstract The goal of this chapter is to illustrate our approach to patients with epiphrenic diverticula in terms of preoperative evaluation and surgical technique. Two techniques will be presented: a laparoscopic repair and a thoracic approach. Indications for each technique will be discussed, as well as proper patient selection and management.

Keywords Epiphrenic diverticula • Gastroesophageal reflux disease • Laparoscopic antireflux surgery • Esophageal function testing • Laparoscopic repair • Thoracoscopic repair

Esophageal diverticula are categorized by their anatomic location and whether they are pulsion or traction diverticula. The most common anatomic locations are the pharyngoesophageal junction, the mid esophagus, and the epiphrenic region. The distinction between pulsion and traction diverticula relates to the etiology of the diverticulum. Pulsion diverticula occur due to an increase in intraluminal pressure, typically from segmenting contractions of the esophagus, and generally result in false diverticula, consisting of only the mucosal and submucosal layers. Traction diverticula are caused by external traction on the esophageal wall from surrounding inflammation; they usually consist of mucosal, submucosal, and muscular layers of the esophagus and are thus true diverticula [1].

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Epiphrenic diverticula are the rarest type of esophageal diverticula. They are pulsion diverticula and are located in the distal third or 10 cm of the thoracic esophagus, and their occurrence is considered to be secondary to an esophageal motility disorder [2]. Dysfunctional contractions of the esophagus cause increased intraluminal pressure and thereby cause mucosal herniation through weaknesses in the esophageal musculature. Most epiphrenic diverticula are observed in either middle-aged or elderly populations, which is consistent with a gradual weakness in the esophageal wall observed in pulsion diverticula [1].

The majority of epiphrenic diverticula are found incidentally, and less than 40 % of patients with this finding have any symptoms [2]. In patients who are symptomatic, commonly reported symptoms include dysphagia, regurgitation of undigested food, chest pain, heartburn, nocturnal aspiration, aspiration pneumonia, and if severe, weight loss [1]. Because the etiology of the diverticula is an underlying motility disorder, most symptoms such as dysphagia, chest pain, and heartburn are due to the motility disorder and not to the diverticulum itself [1]. This is why the size of the diverticulum does not correlate with the severity of symptoms experienced by the patient. Regurgitation of undigested food, nocturnal aspiration, and aspiration pneumonia, however, are clinical manifestations of the diverticulum [2].

Because of potentially life-threatening complications such as aspiration pneumonia, some have argued that all epiphrenic diverticula should be resected. Most of the current literature, however, suggests that the risks of surgical management outweigh the incidence of these rare complications [3]. Treatment of epiphrenic diverticula is thus usually reserved for severely symptomatic patients. There is additional concern that larger diverticula have an increased, albeit small, risk for malignant transformation of the diverticular mucosa owing to longstanding inflammation [2]. Most reports of concomitant cancer with a diverticulum have involved squamous cell cancer [4].

Where there is more controversy is in finding a consensus as to which patients qualify for surgical intervention. Evaluation includes the severity of the patient's symptoms; dysphagia, regurgitation, and aspiration are considered indications for further clinical assessment. The current diagnostic workup for epiphrenic diverticula includes a combination of barium swallow, upper endoscopy, and possibly esophageal manometry [5]. A barium swallow is performed primarily for anatomic considerations and is generally the first test performed. It not only demonstrates where the diverticulum is located, which has implications in the accessibility of the diverticulum through a laparoscopic or transthoracic approach, but it is also useful in determining the size of the diverticulum. Diverticula that are located more than 10 cm proximal to the gastroesophageal junction or that have wide necks may require a transthoracic approach to dissect the upper portion of the diverticulum from the surrounding mediastinal structures [2].

Esophageal manometry is used to classify the underlying motility disorder in selected patients. The most commonly identified disorders include a nonspecific esophageal motility disorder, achalasia, diffuse esophageal spasm, nutcracker esophagus, and hypertensive esophagus. Due to the episodic nature of these motility disorders, it is important to note that manometry results might not always be abnormal in these patients [6]. However, given the correlation between epiphrenic diverticula and esophageal dysmotility, normal manometry results should not be used to influence the

surgical management of the diverticulum, but may be useful in determining whether additional surgical considerations are needed [2]. Regardless of manometric findings, myotomy is the primary treatment for diverticula and should be included in any surgical therapy for this disorder. Finally, upper endoscopy is used to evaluate for mucosal lesions within the diverticulum and search for any additional pathology in the upper gastrointestinal tract, such as esophageal and gastric ulcers, Barrett's esophagus, or diffuse esophagitis, which may contribute the patient's presentation [5].

Surgical management of the patient with a diverticulum includes three elements: myotomy, possible diverticulectomy, and possible fundoplication. The goal of the surgery is to address the underlying motility disorder, remove the diverticulum when appropriate, and prevent postoperative gastroesophageal reflux. Historically, a transthoracic approach through a left thoracotomy incision has been the standard of care. This allows optimal visualization and access to the distal esophagus and provides the best exposure for diverticulum resection, oversewing of the esophageal musculature, and myotomy. With advances in minimally invasive operative techniques, laparoscopy has become a reasonable approach for surgical management in most cases and has been shown in numerous clinical studies to be effective in providing symptomatic relief [7]. Regardless of whether treatment is done through an open, thoracoscopic, or laparoscopic approach, morbidity and mortality may be considerable. The most common complication is leakage from the staple line, with other severe complications including sepsis, pneumonia, empyema, and abscess. Leakage may be prevented, as it is strongly associated with the failure to perform a myotomy, which is crucial in addressing the underlying motility disorder and avoiding leaving a high pressure zone distal to the staple line [8].

The advantages of laparoscopic approach include an avoidance of performing surgery through the chest, an easy application of endostapler to resect the diverticulum, and easier performing cardiomyotomy, partial fundoplication, and closure of the diaphragmatic hiatus [9]. However, these advantages may be limited in cases of large-sized diverticulum, long distance between the diverticulum and the hiatus (>8–10 cm), and presenting of dense adhesion between the diverticulum and adjacent mediastinal structures, making dissection, application of the stapler, and approximation of the muscle layers, through the laparoscope, more difficult [10, 11]. In these circumstances, video-assisted thoracoscopic surgery (VATS) may be more suitable as either a single or combined procedures with laparoscopy. In these combined procedures, some authors suggest that a laparoscopic procedure should be performed before VATS to prevent a loss of the air into the dissected pleural space [11, 12].

Technique of Laparoscopic Repair of Epiphrenic Diverticula

The transabdominal approach consists of three parts, diverticulectomy, myotomy, and fundoplication. The myotomy is a crucial portion of the procedure as it will correct the underlying dysmotility disorder that most likely caused of diverticulum. We prefer to perform an anterior partial fundoplication to protect the myotomy and prevent gastric reflux at the same time.

Preparation

The patient is placed in the supine position on a beanbag. Rapid sequence intubation should be performed to minimize gastric distention and risk of aspiration. A Foley catheter is placed for the duration of surgery. Once anesthesia has been induced, the patient is placed in stirrups and reverse Trendelenburg. The surgeon stands between the legs. Alternatively, some surgeons prefer stand at the right side of the patient that is placed supine on the operating table.

Port Placement

The abdomen is insufflated to 14 mmHg, and an 11 mm Optiview trocar is inserted into the abdomen through a 1 cm supraumbilical incision (approximately 1 in. above the umbilicus) under direct visualization. Four working ports are placed, including the supraumbilical port *A* (Fig. 6.1). Ports *B* and *C* are also 11 mm ports. *D* is a 12 mm port that accommodates the stapler. A 5 mm incision is then made immediately left of the xiphoid process for placement of a Nathanson retractor. This retracts the left lobe of the liver to expose the esophageal hiatus. We use a 30° laparoscope for better visualization into the mediastinum.

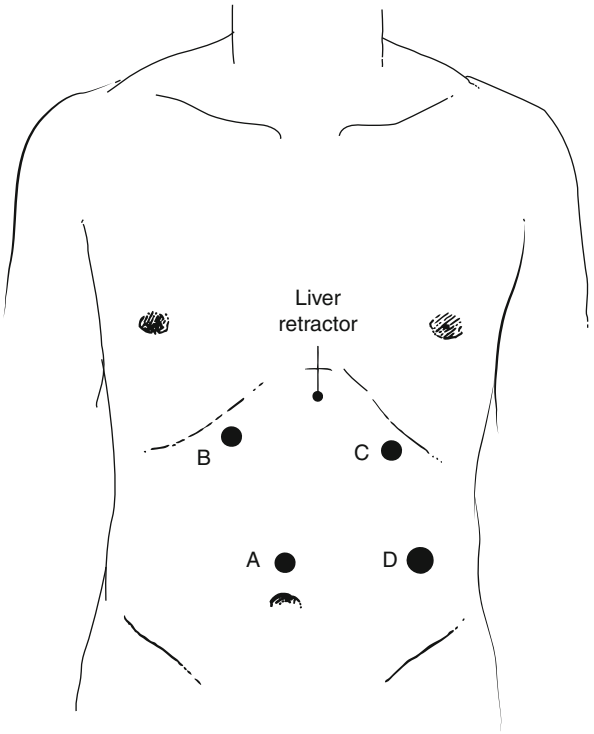

Fig. 6.1 Position of operative ports and liver retractor (Reprinted with permission)

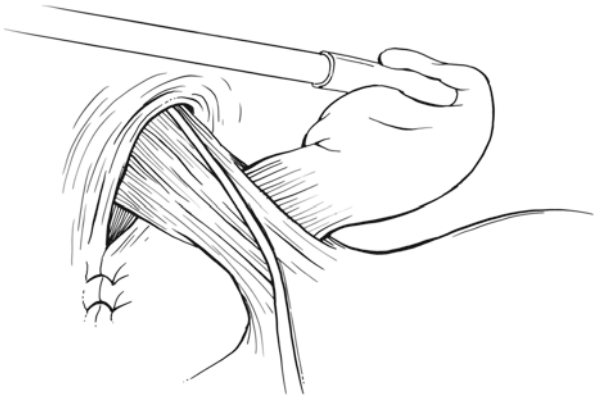

Fig. 6.2 A diverticulum is shown with its neck completely mobilized and its relationship with the anterior vagus nerve demonstrated. The hiatus has been already closed with two interrupted stitches (Reprinted with permission)

Mobilization of the Distal Esophagus

An Allis clamp is inserted through Port *D* near the gastroesophageal junction to lift the gastrohepatic ligament, which is then divided. The esophagus is bluntly dissected from the right crus in order to access the posterior mediastinum. The posterior vagus nerve is identified. A Penrose drain is passed around the esophagus and both vagi, allowing for caudal retraction of the esophagus that will help deliver the diverticulum into the abdomen.

Exposure of the Diverticulum Neck

Once the diverticulum is located, it should be carefully dissected off the dense adhesions to the pleura and the esophageal wall. One must ensure the neck of the diverticulum is adequately isolated. In the case of a large diverticulum, one may need to divide the diaphragm anteriorly (Fig. 6.2). Care should be taken to mobilize the diverticulum neck completely, especially the most cranial portion. Failure to achieve this step may prompt to perform a myotomy and fundoplication transabdominally and then resorting to a thoracoscopic approach to complete the diverticular dissection and perform the final transection.

Stenting

After the diverticulum is dissected free and the neck is isolated, a 54–58 F bougie is inserted into the esophagus. The diverticulum is closed loosely with a grasper to prevent the bougie from entering it. An endoscope may be inserted into the esophagus as an alternative. Endoscopy also provides the option of inspecting and testing the integrity of the staple line after diverticulectomy.

Fig. 6.3 The stump of the neck of the diverticulum is shown after its stapled transaction alongside the esophagus (Reprinted with permission)

Fig. 6.4 The defect of the esophageal musculature is closed in one layer with interrupted sutures to imbricate the staple line (Reprinted with permission)

Stapling

After the bougie is inserted past the diverticulum, a 2.5 mm vascular cartridge is inserted into the abdomen and oriented longitudinally to the esophagus. We pull back on the bougie prior to firing the stapler to avoid dragging the stent across the staple line. This minimizes staple line disruption. The bougie is then completely removed (Fig. 6.3).

Esophageal Musculature Closure

The diverticulum is removed from the abdomen in a plastic bag. The muscular layers adjacent to the neck of the diverticulum are closed with interrupted sutures to reinforce the staple line (Fig. 6.4).

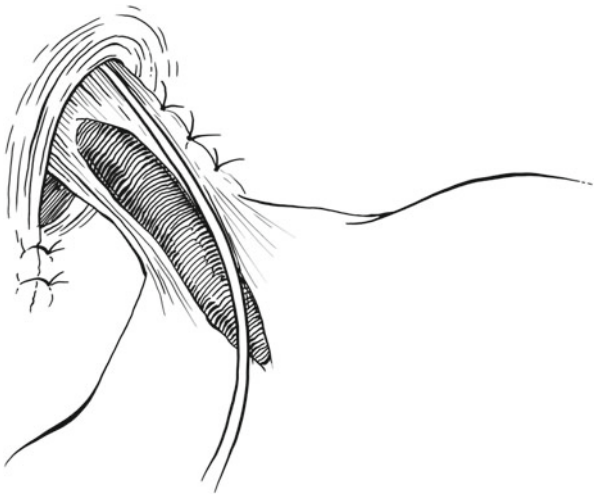

Fig. 6.5 A contralateral myotomy is shown extending onto the body of the esophagus and onto the anterior wall of the stomach. The myotomy is 10 cm long and it is located at the 10 o'clock position (Reprinted with permission)

Myotomy

The myotomy is performed contralateral to the site of the resected diverticulum. It is extended 7 cm cranially proximal to the cranial extent of the diverticulum and 3 cm caudally onto the anterior wall of the stomach until the first branch of the left gastric artery is identified (Fig. 6.5). The anterior vagus nerve is preserved during the myotomy.

Closure of the Esophageal Hiatus

Heavy silk interrupted sutures are used to close the hiatus. To avoid postoperative dysphagia from constriction of the esophageal and prevent a leak at the staple line due to outflow obstruction, the uppermost crural stitch is placed 1 cm posterior to the esophagus. If the diverticulum was large and required anterior splitting of the diaphragm, this is now closed with 0-0 silk interrupted sutures.

Partial Fundoplication

A partial anterior (Dor) fundoplication is preferred and prevents reflux after the myotomy. The short gastric vessels may be divided to enable a tension-free fundoplication. The gastric fundus is then sutured laterally to the apex of the left crus and the left edge of the myotomy. The stomach is folded over the myotomy. It is sutured superiorly along the diaphragmatic hiatus and medially along the right crus with interrupted sutures (Fig. 6.6).

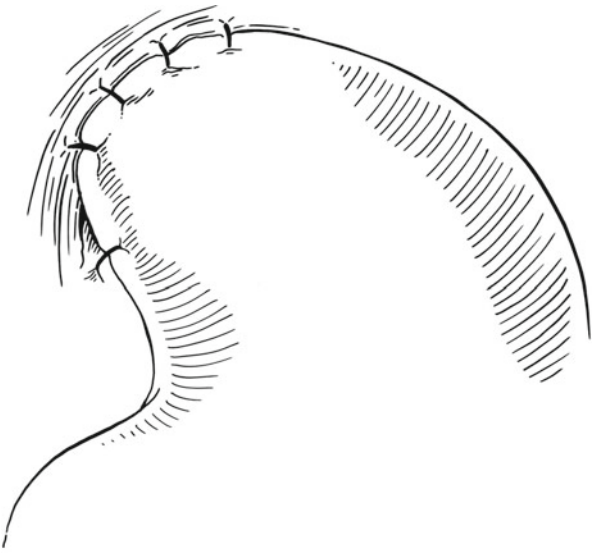

Fig. 6.6 Completed partial anterior fundoplication (Reprinted with permission)

Upon completion of the operation, the Foley catheter is removed while the patient is still in the operating room. The patient is admitted overnight. On postoperative day 1, some surgeons perform a contrast swallow study to evaluate for a possible leak. If no leak is present, the patient is advanced to a soft mechanical diet which he or she will maintain for 1 week postoperatively. The patient will then follow-up in clinic and have dietary restrictions lifted at that time.

Technique of Thoracic Repair

Preparation

The patient undergoes general anesthesia and a double-lumen endotracheal tube is inserted. Perioperative antibiotics are administered, and venous thromboembolic prophylactic measures are instituted, including lower extremity pneumatic compression devices and subcutaneous heparin. The patient may be placed in either the right (left side up) or left (right side up) lateral decubitus position, depending on the location and orientation of the diverticulum. Most often, pulsion diverticula present to the right side, and so a right thoracic approach is generally favored. Others may prefer a left-sided approach, especially for diverticula that present to the left. The choice is only moderately important, as circumferential dissection of the esophagus is often needed to both treat the diverticulum and perform a subsequent myotomy away from the site of diverticulectomy. The ipsilateral lung is deflated.

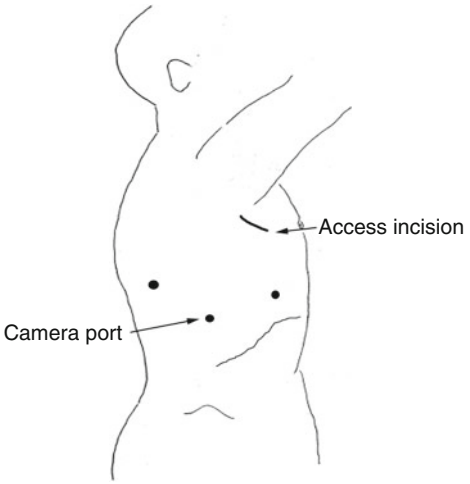

Fig. 6.7 Port placement for thoracoscopic esophageal diverticulectomy and myotomy

Port Placement

The surgeon may stand facing the patient's back or chest, according to personal preference. This chapter describes an approach used when the surgeon stands at the patient's back. Access is gained through a 5 mm camera port low in the chest in the posterior axillary line, two working ports anterior and posterior to the camera port, and a 3 cm non-rib spreading access incision placed anterolaterally in the 4th interspace. Ports are positioned with the goal of having the target in line with the camera and between the two working ports (Fig. 6.7). The pleural cavity may be insufflated initially with warm, humidified carbon dioxide at a pressure of 8 mmHg to facilitate lung deflation. A suture may be placed through the central tendon of the diaphragm and brought out through the lower anterior chest wall to improve visualization.

Esophageal Mobilization

The site of the diverticulum is identified. The mediastinal pleura overlying the diverticulum and the adjacent esophagus is incised. The esophagus is mobilized with a sealing device (EnSeal™ or Ligasure™), hook-electrocautery, or scissors. Mobilization should be sufficient to permit exposure of the neck of the diverticulum. In addition, exposure of the wall of the esophagus 90–180° circumferentially from the diverticulum and from proximal to the neck of the diverticulum to the gastroesophageal conjunction is necessary to perform the myotomy. Care should be taken to avoid injury to the vagus nerves, which should be clearly identified. A Penrose drain may be used to encircle the adjacent esophagus to facilitate retraction and mobilization.

Dissection of the Diverticulum

The diverticulum is bluntly and sharply dissected free from the surrounding structures. It is important to dissect the investing connective tissue from the diverticulum, revealing its origin from between the split fibers of the esophageal circular and longitudinal smooth muscle layers.

Stenting the Esophagus

After the diverticulum is sufficiently dissected, an assessment is made as to whether resection of the diverticulum is needed. Small, wide-mouthed diverticula may be left in situ, eliminating a risk of perforation or suture line breakdown. In most patients, however, diverticulectomy is appropriate. A 48–50 Fr bougie is passed to prevent excess mucosa from being excised during the diverticulectomy. Care must be taken to prevent bougie entry into the diverticulum, which could result in inadvertent perforation. Alternatively, an endoscope may be used to stent the esophagus while the diverticulectomy is performed.

Diverticulectomy

An endostapler is positioned at the base of the diverticulum and parallel to the esophagus (Fig. 6.8). Care should be taken to gently retract the diverticulum during stapler firing but not to pull it too tightly. More than one firing of the stapler may be used in sequence; care should be taken to ensure that they are in line with each other. The specimen is retrieved through the access port. The continuity of the mucosa should be assessed by direct inspection thoracoscopically and endoscopically during air insufflation.

Muscle Approximation

The muscular layers over the mucosa are approximated with running or interrupted absorbable suture. This reinforces the staple line and helps prevent contamination of the pleural space should a small leak from the stable line occurs.

Myotomy

The esophagus is rotated 90–180° away from the site of the diverticulectomy. Dilute epinephrine may be injected submucosally along the line of the planned myotomy to hydrodissect the plane and to constrict the submucosal plexus of vessels that may

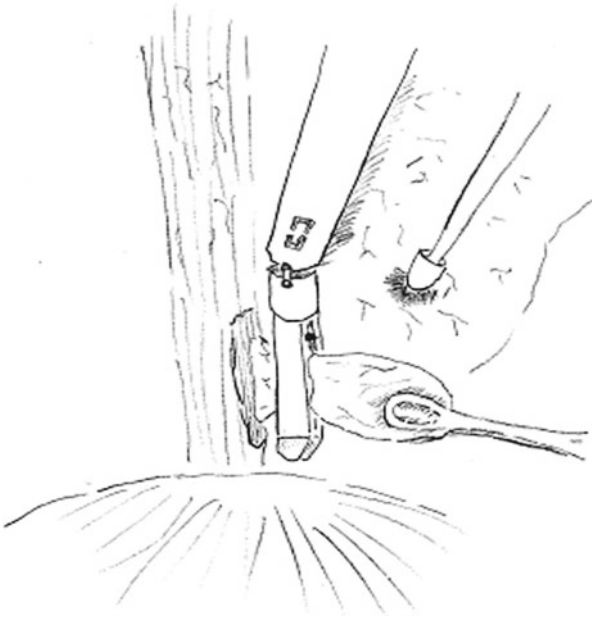

Fig. 6.8 Placement of the endostapling device for thoracoscopic diverticulectomy (Note: The stapler is place through the access incision. The dark area at the base of the diverticulum represents the cut muscle. There is a push retracting the lung anteriorly)

otherwise cause annoying bleeding. The myotomy is performed using hook-electrocautery, scissors, or EnSeal, extending from proximal to the diverticulum origin and extending inferiorly. For very distal diverticula, the myotomy should extend through the lower esophageal sphincter. Leaving the hiatus intact provides sufficient antireflux effect, making a fundoplication unnecessary. For most diverticula, especially those without a defined abnormality on manometry such as achalasia, diffuse spasm, or nutcracker esophagus, the myotomy can end just at the lower esophageal sphincter. Endoscopic insufflation is performed again to ensure that no mucosal injury has occurred.

A pleural drainage tube is placed. A nasogastric tube is not required. A contrast swallow study is performed the following day if there is concern about possible mucosal injury or leak. In the absence of such concerns, a clear liquid diet is started on the first postoperative day and gradually advanced to a soft diet over 7 days.

Outcomes

The results of laparoscopic and thoracoscopic operations for epiphrenic diverticula are summarized in Tables 6.1 and 6.2. Importantly and similarly improved symptoms are evident after both laparoscopic and VATS approaches. The incidence of complications is low. Mortality rates range from 0 to 10 %, which are comparable to those of open approaches. Morbidity rates appear to be similar between the groups, ranging from 0 to 33 %. At present, there are no studies that evaluate these

Table 6.1 Results of VATS for the treatment of esophageal diverticula

Authors (year)	*N*	Side	Procedures	Months of follow-up (median)	Mortality (*N*)	Complications (*N*) (%)	Good outcome[a] (%)
Peracchia et al. (1994) [13]	8	Right	Diverticulectomy = 3 (converted to open surgery = 2) Diverticulectomy with preoperative pneumatic dilatation = 5	–	0	Overall = 0	83
van de Peet et al (2001) [14]	5	Right	Diverticulectomy = 3 (converted to laparoscopy = 1) Diverticulectomy with myotomy = 2	–	0	Overall = 1 (20) Leak with abscess and sepsis = 1	–
Champion (2003) [15]	3	Left	Diverticulectomy = 2 Myotomy = unknown Fundoplication = unknown	–	0	Overall -	–
Matthews et al. (2003) [16]	1	Right	Diverticulectomy with myotomy = 1	16	0	Overall = 0	–
Fernando et al. (2005) [11]	9	Right	Diverticulectomy = 2 Diverticulectomy with myotomy = 4 Diverticulectomy, myotomy with fundoplication = 2 (combined with laparoscopy) Other = 1	15 (median)	0	Overall Leak = 2	–

[a]*Good outcome* significant improvement or resolution of symptoms, *N* number of patients

Table 6.2 Results of laparoscopic approaches for the treatment of esophageal diverticula

Authors (year)	*N*	Procedures	Months of follow-up (mean/median)	Mortality *N* (%)	Complications *N* (%)	Good outcome[a] (%)
Klaus et al. (2003) [17]	10	Diverticulectomy with myotomy = 6 Diverticulectomy = 4	26.4 (mean)	0	Overall = 2(20) Empyema = 1 Leak = 1	–
Fraiji et al. (2003) [18]	6	Diverticulectomy, myotomy with fundoplication = 6	9.3 (mean)	0	Overall = 2 (33) Empyema = 1 Ileus = 1	100
Del Genio et al. (2004) [19]	13	Diverticulectomy, myotomy with fundoplication = 13	58 (mean)	1 (8)	Overall = 4 (30) Leak = 3 Myocardial infarction = 1	100
Tedesco et al. (2005) [20]	7	Diverticulectomy, myotomy with fundoplication = 7	60 (median)	0	Overall = 1 (14) Leak with paraesophageal hernia = 1	100
Fernando et al. (2005) [11]	10	Diverticulectomy, myotomy with fundoplication = 10	15 (median)	1 (10)	Overall - Leak = 2	–
Zaninotto et al. (2008) [11]	17	Diverticulectomy, myotomy with fundoplication = 14 Diverticulectomy with fundoplication = 3	53 (median)	0	Overall -	–
Melman et al. (2009) [8]	13	Diverticulectomy, myotomy with fundoplication = 13	13.6 (mean)	0	Overall = 2 (15) Atelectasis = 1 Leak = 1	85
Rosati et al. (2011) [10]	20	Diverticulectomy, myotomy with fundoplication = 20	52 (median)	0	Overall = 1 (5) Leak = 1	100
Soares et al. (2011) [21]	18	Diverticulectomy, myotomy with fundoplication = 16 Diverticulectomy with excision of leiomyoma = 1 Diverticulectomy, myotomy with fundoplication with Roux en Y Gastric bypass = 1	45 (median)	1 (5.6)	Overall = 5 (28) Intra-abdominal bleeding = 1 Leak = 1 Pleural effusion = 2 Port site hernia = 1	86

Note: [a]*Good outcome* significant improvement or resolution of symptoms, *N* number of patients

two approaches simultaneously. Comparing outcomes for them is difficult because of the limited number of cases, the variety of surgical techniques used and outcome measurements in each report, and differences in patient selection for each operation.

Conclusion

Epiphrenic diverticulum is a rare disease that is commonly associated with motility disorders. Treatment of the underlying motility disorders must be included in the management of epiphrenic diverticula to prevent potential postoperative complications and recurrences. Laparoscopic and VATS approaches are useful for the treatment of epiphrenic diverticula. The surgical techniques for them are described. Good outcomes can be achieved when performing this procedure in appropriately selected patients and by experienced surgical teams.

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