



Epiphrenic and Mid-Esophageal Diverticula

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Introduction

The esophagus is an organ composed of four layers: mucosa, submucosa, muscularis propria, and adventitia. In the adult, the esophagus measures 35 cm in length and is divided into three segments: cervical, middle, and distal. The *cervical* portion extends from the cricoid cartilage to the thoracic inlet (10–18 cm from the incisors). The *middle* segment extends from the thoracic inlet to the halfway between the tracheal bifurcation and the gastroesophageal junction (19–34 cm from the incisors). The *distal* esophagus is the remaining portion that concludes in the abdomen at the gastroesophageal junction (35–42 cm from the incisors). These anatomical segments become important when classifying esophageal diverticula, as the location dictates the pathophysiology and operative treatment.

A diverticulum is defined as an abnormal sac or outpouching formed at the weak point in the esophagus. A *true* esophageal diverticulum involves all the layers of esophagus; conversely, a *false* esophageal diverticulum does not. The vast majority of esophageal diverticular disease are acquired. Esophageal diverticula can be generally classified by pathophysiology, namely, traction or pulsion type. Pulsion diverticula are the most common form and are secondary to esophageal dysmotility. They are false diverticula because they lack a muscular wall and are usually found in the cervical and distal esophagus. Traction diverticula are rare and almost exclusively occur in the mid-esophagus [1]. These are true diverticula, and as the name suggests they are caused by external forces that pull the esophagus into a conical outpouching.

Esophageal diverticula are also classified by their location. Pharyngoesophageal diverticula, commonly referred to as Zenker's [2] diverticula, are the most common diverticula and are located in the cervical esophagus. They occur at the junction between the cricopharyngeus and inferior constrictor muscles, known as *Killian's*

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triangle. This area between the muscle fibers is an inherent weak point that leads to diverticular formation with increased hypopharyngeal pressure. Epiphrenic diverticula are the second most common diverticula and occur at the distal esophagus. They occur most often in the right posterior wall and occur in a 1:3 ratio to pharyngoesophageal diverticula [3]. Mid-esophageal diverticula are the least common of the esophageal diverticula. Although mid-esophageal diverticula were initially thought to be caused exclusively by external traction in patients with mediastinal fibrosis, lymphadenopathy, or inflammatory conditions such as tuberculosis or histoplasmosis, there is recent increasing evidence that the majority of cases now are caused by esophageal motility disorders [4]. Most cases of congenitally acquired esophageal diverticula occur in the mid-esophagus and are a result of abortive tracheoesophageal fistula or foregut duplications [5].

This chapter focuses on the indications, preoperative preparation, minimally invasive operative technique, and postoperative outcomes for epiphrenic and mid-esophageal diverticula. Pharyngoesophageal diverticula is discussed separately in a different chapter.

Epiphrenic Diverticula

Epiphrenic diverticula (ED) are the second most common esophageal diverticula and in conjunction with mid-esophageal diverticula comprise 10–15% of esophageal diverticula. They were first described by Mondiere in 1833 [6], and overall are rare entities, occurring in 0.015% of the general population based on radiological data [7]. These diverticula occur within the distal 10 cm of the esophagus, and the majority occur on the right posterior wall. They are pulsion diverticula and represent herniation of the mucosa and submucosa through the muscular layers of the esophageal wall as a result of increased intraluminal pressure. On radiograph, these diverticula have a wide neck, rounded contour, and retain contrast during a swallow study. A radiographic study at the University of Pennsylvania found ED in their patient population to have a mean width of 4.4 cm and mean height of 3.7 cm, with a direct correlation of width and preferential filling during a barium swallow study [8]. The size also had significant correlation with development of symptoms.

Pathophysiology

With the advancement in esophageal imaging and motility studies, it is clear that these diverticula are a direct result of functional distal obstruction and dysmotility that increase luminal pressure. 66–75% of patients that develop ED have some form of functional obstruction in the form of achalasia, and the majority have esophageal dysmotility, often as a lack of coordination between the distal esophagus and lower esophageal sphincter (LES) [9]. Manometric studies in patients with ED frequently show the classic features of diffuse esophageal spasm or nonspecific motor disorders. It is inferred that increased motor activity and abnormal lower esophageal sphincter relaxation produce zones of increased intraluminal pressure through

which these outpouchings occur [10, 11]. Multiple ED are found in up to a fourth of these patients [12]. When present, they are either aligned longitudinally or circumferentially along the LES. It is currently unknown whether increasing numbers of diverticula directly correlate with development of symptoms.

Signs, Symptoms, and Diagnosis

Most patients who develop epiphrenic diverticula are asymptomatic. When patients do become symptomatic, the two most common reported symptoms are dysphagia and regurgitation. Dysphagia can occur both in the setting of a hypertensive LES and a normotensive LES [13]. As the diverticulum enlarges and fills with undigested food, regurgitation occurs and worsens. Often these symptoms are easily mistaken for gastroesophageal reflux disease, but a careful history will elicit a taste of bland and not bitter food in the mouth as the regurgitated food never mixes with gastric acid. It is important to realize that the size of the diverticulum, while contributory to regurgitation, is not the most important determinant. It is now recognized that symptoms correlate better with the esophageal dysmotility characteristics than with the size of the diverticulum [14], and it is this distinguishing feature which must be taken into account when deciding upon a robust and long-lasting operative treatment. Pulmonary complications from aspiration occur in 24% to 45% of patients [15]. Ulceration, bleeding, and even perforation have been described. Though ED is correctly classified as a benign disease process, there have been reports of benign (leiomyoma) and malignant (squamous cell carcinoma) neoplasms with ED. [16–19]

The diagnosis of ED is first established by a barium swallow. Most ED are under 5 cm in width, though giant diverticulum can grow in excess of 10 cm. Best imaging results are accomplished with prone RAO oblique and upright swallow views. With a contrast swallow, it is imperative to determine the relationship between the diverticulum and the gastroesophageal junction. It is also possible to identify evidence of esophageal motility disorders and the presence of a hiatal hernia. Further diagnostic testing should proceed after initial imaging because, as stated previously, the diverticulum is the result of a functional obstruction and esophageal dysmotility. Failure to reach a diagnosis of the latter will result in sub-optimal treatment. Esophagoscopy is used to evaluate the esophagus for strictures, masses, erosions, and dysplasia (i.e., Barrett's). Special attention should be focused on the LES, noting the distance from the incisors as well as the muscle tone and possible presence of a hiatal or paraesophageal hernia. The diverticulum size and relation to the gastroesophageal junction can also be assessed directly. The stomach and proximal duodenum are also evaluated. Any abnormal finding should be documented and if necessary biopsied. Manometry and pH studies can be performed but are not required as the anatomic defect can make placement of the probes difficult and may not alter the operative plan. Often it is necessary to place it under endoscopic guidance as the catheter may otherwise coil in the diverticulum. The manometric findings may help determine the length of esophagomyotomy required to relieve the functional obstruction. The LES resting pressure, esophageal body contractile amplitudes, and contractile propagation should be measured. Twenty-four-hour pH study adds little and can be deferred as the decision for a fundoplication often is related to the operative approach.

Indications for Operative Treatment

Once a diagnosis of ED is made, there is debate concerning the indications for operative management. Patients who present with moderate-to-severe symptoms that affect lifestyle should undergo operative treatment. The controversy remains on how to manage those patients with mild symptoms or without symptoms at all. The natural history of asymptomatic ED remains widely unknown, though some reports state that less than 10% of these patients will progress to classic symptoms [20]. Proponents of treating mildly symptomatic or asymptomatic patients by medical means argue that the majority of these patients do not progress to lifestyle-limiting symptoms and the risks of surgery outweigh the benefits. Benacci et al. from the Mayo Clinic [21] reporting a series of 112 patients described the natural history of the condition in a group of 47 asymptomatic individuals who did not undergo surgical therapy. Twenty of these patients were monitored for a median of 4 years and all remained symptom-free. Fifteen additional patients had mild symptoms without surgical intervention, and in none of them did incapacitating symptoms develop during a median follow-up of 11 years. Although only half the patients with asymptomatic or mildly symptomatic disease had long-term follow-up available for review, progressive symptoms or complications did not develop in any of them. Opponents of the conservative approach state that developing symptoms can have devastating consequences. Altorki and colleagues strongly supported surgical intervention in all patients after noting aspiration in 9 of 20 patients, 3 of whom experienced life-threatening complications. Some, such as Debas et al., have argued that the size of the diverticulum guides treatment, using the arbitrary cutoff of >5 cm as an indication for operative treatment. However, as stated by Belsey himself, the size of the pouch correlates poorly with symptom severity, and it is the underlying motility disorder that should be sought after and fixed. An increasing number of asymptomatic patients are being treated surgically if found to have an underlying obstructive or motility disorder, and the results suggest that this is a safe approach with acceptable long-term outcomes.

Operative Technique

The tenets of operative treatment for ED revolve around three points:

1. Direct treatment of the diverticulum, either with diverticulectomy or diverticulopexy.
2. Esophagomyotomy.
3. Anti-reflux procedure, either full or partial esophageal wrapping.

Minimally invasive operative techniques have gained popularity and are rapidly becoming the procedure of choice for most surgeons. Recently, there have been many reports of safe and effective thoracoscopic and laparoscopic results in the literature when performed in high-volume centers by experienced surgeons. Though discussed in this chapter, the main surgical approach used until recently has been a

left thoracotomy. This provides excellent access to the distal esophagus, esophago-gastric junction, and the diverticulum itself. Reported morbidity from an open approach ranges from 6% to 38%, and mortality ranges from 0% to 11% [22].

Thoracoscopic Approach

The standard thoracoscopic approach is through a right video-assisted thoracoscopic surgery (VATS). The right side is chosen as the majority of ED develop from the right side of the esophagus and are adherent to the right pleura or diaphragm, or both. If there are preoperative manometric abnormalities, it is suggested that pneumatic LES dilatation be performed to help overcome the difficulty of performing a myotomy from the right chest [23]. Single-lung ventilation is preferred. The patient is placed in the left lateral decubitus position, and four thoracoscopic ports are used: one for the camera, one for retraction, and two for working instruments (Fig. 46.1). Dissection is begun by taking down the inferior pulmonary ligament and freeing the right lower lobe to the level of the inferior

Fig. 46.1 Port placements for right video-assisted thoracoscopic surgery (VATS). (Source: Sugarbaker et al. [46]. Copyright © The McGraw-Hill Companies, Inc. All rights reserved)

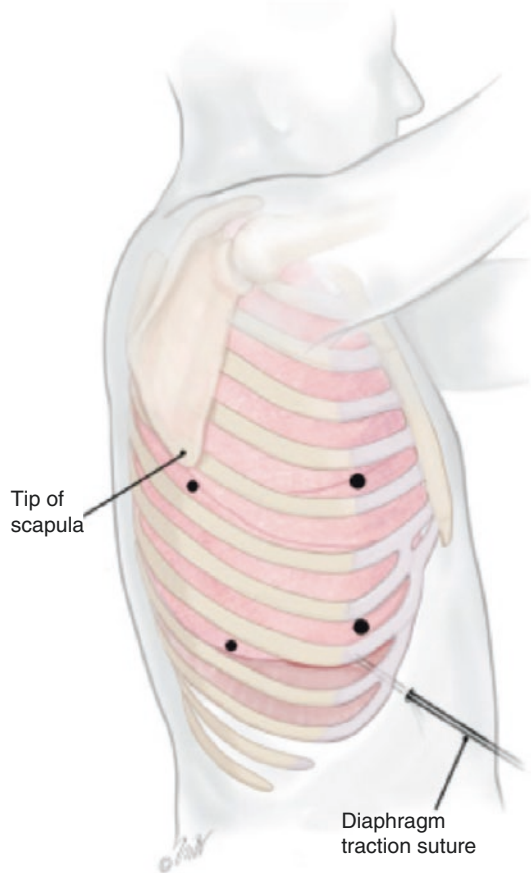
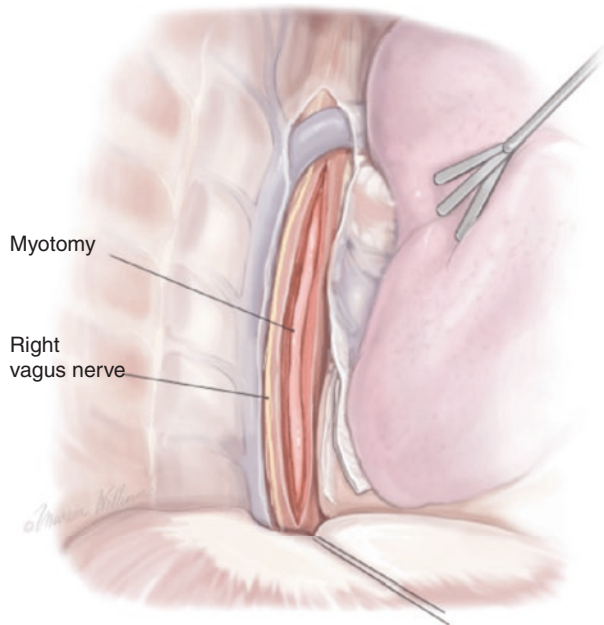


Fig. 46.2 A long myotomy is performed through a right VATS approach after resection of the epiphrenic diverticulum. (Source: Sugarbaker et al. [46]. Copyright © The McGraw-Hill Companies, Inc. All rights reserved)

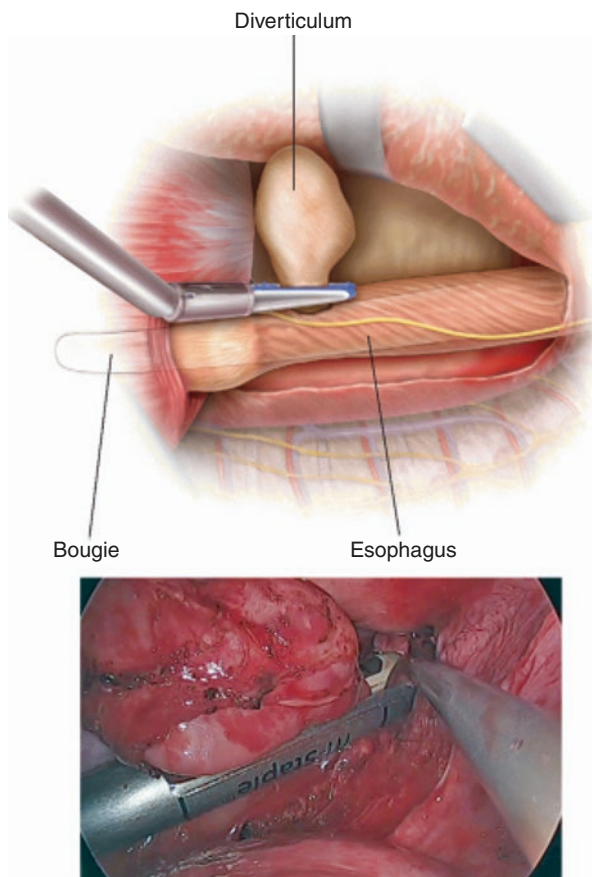


pulmonary vein. Often a single retraction suture in the central tendon of the diaphragm can facilitate exposure of the distal esophagus. A fan retractor is used to retract the lung anteriorly, and division of the azygous vein is sometimes advantageous. The pleura overlying the esophagus is incised, and the right lateral aspect of the esophagus is dissected for a length of approximately 10 cm. Moderate insufflation and transillumination through an esophagoscope facilitate both dissection and resection of the diverticulum. The pouch is grasped with a clamp and gentle traction applied to facilitate identification of the diverticular neck. A myotomy must be performed either on the contralateral or ipsilateral side (Fig. 46.2). The myotomy typically extends proximal to the neck of the diverticulum and distally to an extent that is based on the preoperative and intraoperative findings. If required, the myotomy is extended across the lower esophageal sphincter (LES) and onto the stomach. A bougie or the endoscope can be used to stent the esophagus. The diverticulum is then resected using a reticulating stapler (EndoGIA), making sure that the stapler is oriented parallel to the longitudinal axis of the esophagus (Fig. 46.3). The overlying muscle and pleural layer is approximated over the mucosa staple line.

Laparoscopic Approach

The laparoscopic approach has also been advocated in an effort to simplify alignment of the stapler and facilitate performance of myotomy and fundoplication [24]. Another reported benefit of this technique includes better visualization of the distal esophagus, which is of particular importance in patients undergoing a myotomy, fundoplication, or both of these [25, 26]. The major disadvantages of the

Fig. 46.3 Epiphrenic diverticulectomy. Note that the angle of the endoscopic stapler must be parallel to the neck of the diverticulum to ensure complete resection of the diverticulum and its neck



laparoscopic approach are seen in cases of diverticula that are large or inflamed with significant adhesions, both of which make adequate transhiatal dissection difficult [27, 28]. The patient is placed on the operating table supine and in reverse Trendelenburg inclination. Lithotomy positioning can be helpful. Pneumoperitoneum is established, and five operating ports are placed in the upper part of the abdomen (Fig. 46.4). The phrenoesophageal membrane is incised, and the dissection is carried up into the mediastinum to mobilize the esophagus. Mediastinal dissection is performed bluntly close to the esophageal wall until the diverticular pouch is reached. Moderate insufflation and transillumination through an endoluminal esophagoscope facilitate dissection of the diverticulum and identification of its neck. The pouch must be thoroughly cleaned of all adhesions. A Heller myotomy is performed. It is extended distally for approximately 2 cm on the gastric side and extended above the diverticulum. The endoscope is kept in the esophageal lumen to stent the esophagus. A reticulating linear endostapler is introduced through the trocar and applied parallel to the esophageal axis. Further stapler application may be necessary to remove the diverticulum. The integrity of the suture line must be

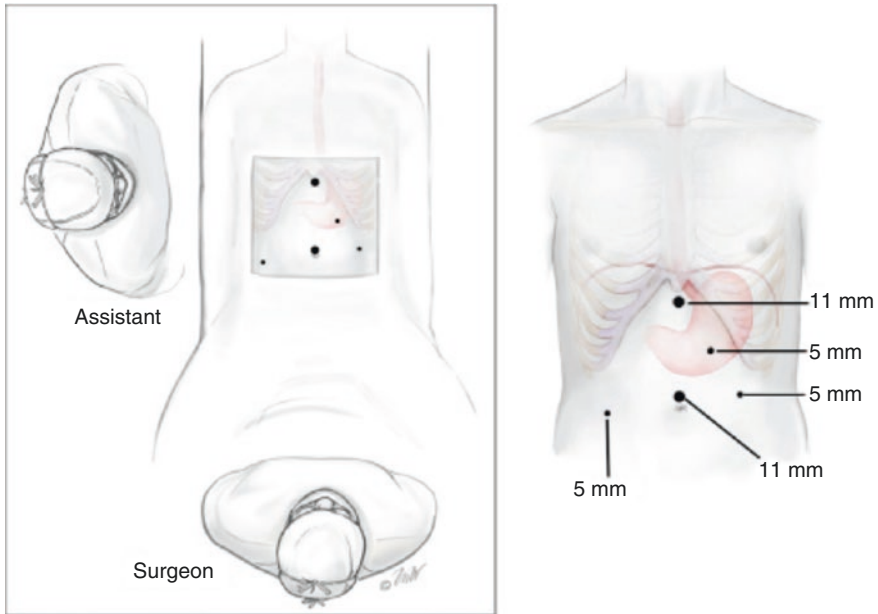


Fig. 46.4 Laparoscopic approach for epiphrenic diverticulum resection, myotomy, and fundoplication. This figure illustrates the surgeon standing in lithotomy position. (Source: Sugarbaker et al. [46]. Copyright © The McGraw-Hill Companies, Inc. All rights reserved)

checked endoscopically. A partial fundoplication is constructed by suturing the anterior fundic wall to the edges of the myotomy. The cranial sutures also attach the fundus to the anterior crus. A posterior hiatoplasty may be performed with interrupted sutures if the hiatal opening is enlarged.

Postoperative Management

A fluoroscopic swallow test is performed using Gastrografin or thin barium prior to oral feeding. This is not only to test for a leak through the staple line but to document no swallow dysfunction or aspiration. If the swallow test is reassuring for no leak, the patient is initiated on a liquid diet. An epidural is often used when a thoracoscopic approach is used to prevent postoperative splinting, and chest tubes are placed intraoperatively and usually removed 48–72 h after surgery. The median hospital stay is 5–7 days [22, 32]. Following a laparoscopic approach, patients can be advanced on a typical Nissen course.

Complications

The University of Pittsburgh reported a series of minimally invasive epiphrenic diverticula resection spanning 15 years. Patients were followed for a median of 20 months, and the median postoperative dysphagia scores were significantly

reduced compared to preoperative scores ($p < 0.001$) [29]. Their overall complication rate was 30%. Major morbidity includes leak from the suture line or myotomy line, mediastinitis, fistula, recurrent laryngeal nerve injury, phrenic nerve injury, recurrence from incomplete myotomy, and development of reflux.

Controversies

There are several areas of controversy in the management of epiphrenic diverticula. The first area revolves around the choice of surgical approach. Macke et al. report that the trend of operative approach at the University of Pittsburgh has favored thoracoscopic treatment between 2003 and 2012, while the laparoscopic approach dominated between 1997 and 2002 [29]. While there are no prospective, randomized trials that compare open, laparoscopic, and thoracoscopic approaches in terms of morbidity and mortality, there are many reports in the literature of comparable results when each approach is studied individually. Hirano et al. looked at 133 patients within 25 articles published between 1995 and 2008 discussing results from laparoscopic or thoracoscopic surgery for epiphrenic diverticula. The laparoscopic approach was used in 84%, the thoracoscopic approach used in 14%, and a combined laparoscopic and thoracoscopic approach used in 2%. Overall mortality was 2%, and overall morbidity was 21%. The breakdown of complications was as follows: leak (15%), dysphagia (3%), pneumonitis (2%), symptomatic reflux (2%), and diverticulum recurrence (1%) [7]. Kilic et al. similarly looked at the operative results of 85 patients published in 10 papers who underwent minimally invasive surgery. Perioperative mortality was 1.2%, and the morbidity ranged from 0% to 45% with leaks comprising 14% [30]. While these numbers were higher than many of the more contemporary reports, many of these small series were early in the surgeons' experience with minimally invasive surgical approaches. These results were also comparable to the outcomes from open procedures reported from a large series in which mortality was 6.1% and morbidity ranged up to 38%. The authors prefer the laparoscopic approach as it gives good access to the diverticulum, allows for better extension of the myotomy distally, allows for a fundoplication, and has better pain control.

The second area which is now largely less debated is the question of performing a diverticulectomy versus a diverticulopexy. There are many reports from previous decades of varying degrees of successful diverticulopexy or imbrication for small diverticula. However, most contemporary surgeons would argue that complete resection is necessary to only prevent recurrence but also to prevent rare transformation into squamous cell carcinoma [31]. The critical step in performing a diverticulectomy is identification, exposure, and resection of the diverticular neck as failure to do so can lead to long-term recurrence. Many surgeons advocate buttressing the resection staple line. Mack and Luketich from the University of Pittsburgh found that omitting the buttressing step led to higher leak rates in an early series [32].

Another topic that has been debated in the literature is routine use of myotomy and the length of the myotomy. Belsy first stated the importance of addressing the underlying etiology leading to epiphrenic diverticular formation, namely,

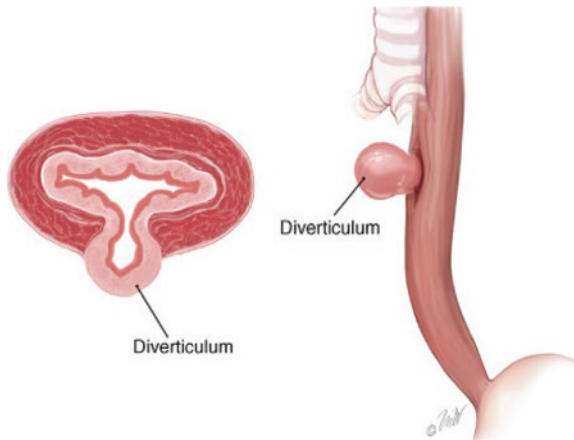
resolving dysmotility and over-pressurization of the esophagus. This has led to many surgeons advocating the routine use of myotomy, even if a motor disorder is not identified preoperatively [33, 34]. The counter argument is that a certain percentage of patients do not have manometric findings of dysmotility and that performing a myotomy routinely is unnecessary. However, accurate placement of the manometer can be difficult in the setting of a diverticulum, and in many cases the esophageal dysmotility can be intermittent and not captured with manometry. The Mayo Clinic reported a series where 60% of patients who were operated on for diverticular treatment had been diagnosed with esophageal dysfunction preoperatively. Varghese et al. at the University of Michigan reported preoperative identification of 82% of patients, and Nehra et al. reported 100% preoperative identification at the University of Southern California. Omitting a myotomy has led to leak and recurrence rates ranging from 10% to 20% [15, 21, 32, 35]. A closely related topic is the length of the myotomy. Streitz and colleagues advocated performing a myotomy only in the area of the motor abnormality while sparing the lower sphincter unless hypertensive [36]. Opponents to this idea state that the risk of complication is too great to omit a myotomy that extends through the lower sphincter and onto the stomach, as there are a percentage of patients with a hypertensive lower esophageal sphincter who are not diagnosed preoperatively. Currently there are no studies to conclusively state a superior myotomy length. The authors support performing a myotomy on all patients who undergo a diverticulectomy as the risk of leak and recurrence due to persistent high intraesophageal pressure remains high.

Finally, the issue of whether a fundoplication should be performed is not settled. Thomas and associates noted no difference in leak rates after myotomy with or without fundoplication (7% versus 8%), but they did report a higher rate of postoperative heartburn when a fundoplication was not performed (16% versus 9%) [37]. In a more recent series by Rossetti and coworkers, a leak rate of 24% was reported after diverticulectomy, myotomy, and complete fundoplication [38]. Most series report a fundoplication when a myotomy is performed either laparoscopically or when the myotomy is carried through the gastroesophageal junction onto the stomach. Moreover, when achalasia is present, most would favor a partial over a full fundoplication. When a thoroscopic approach is taken, reports of not performing a fundoplication, performing a modified Belsey Mark IV, as well as adding a selective laparoscopic fundoplication have been advocated.

Mid-Esophageal Diverticula

Mid-esophageal diverticula are the least common diverticula of the esophagus. They occur between the thoracic inlet up to the distal 10 cm of the esophagus, with the majority of these outpouchings occurring within 4 cm of the carinal level (Fig. 46.5). The true etiology of mid-esophageal diverticula is unknown, but often they are considered the only true diverticula of the esophagus. There were descriptions of these types of diverticula in 1840 by Rokitansky, in 1878 by Zenker, and in 1932 by Kragh [39, 40].

Fig. 46.5 Mid-esophageal diverticulum. Though thought to be exclusively a traction diverticulum, mid-esophageal diverticula can be pulsion type that does not involve all layers of the esophageal wall. (Source: Sugarbaker et al. [46]. Copyright © The McGraw-Hill Companies, Inc. All rights reserved)



Pathophysiology

Traditionally mid-esophageal diverticula have been associated with mediastinal lymph nodes that were pathologically altered secondary to tuberculosis, anthracosis, histoplasmosis, or other granulomatous diseases. These inflamed nodes become adherent to the esophagus, and over time the resultant scarring begins to contract and pulls the affected portion of the esophagus outward as a diverticulum. Those diverticula that arise from this outward traction are appropriately named *traction* diverticula and are true diverticula. Initially these mid-esophageal diverticula were believed to be strictly acquired, but in the early twentieth century, Ribbert began arguing a possible congenital etiology [41]. He postulated that in some patients mid-esophageal diverticula are a direct result of a closed tracheoesophageal fistula or foregut duplication cyst, and there have been reports in the literature to support this theory. Currently in the Western world there has been a steady decline in granulomatous disease of the mediastinum, and one recent review concluded that the most common etiology of these diverticula is an esophageal motor disorder [42]. Evander and associates from the University of Chicago studied a group of ten patients with mid-esophageal or epiphrenic diverticulum, and they found that whether they were traction or pulsion types, all of them had underlying esophageal motility disorders [43]. Consequently, any esophageal diverticulum should be regarded as a pulsion diverticulum until proven otherwise. There are reports of detection of squamous cell carcinoma arising from a mid-esophageal diverticulum, but this is rare [44].

Signs, Symptoms, and Diagnosis

The overwhelming majority of patients are asymptomatic, and most are discovered incidentally on imaging. This is believed to be secondary to the wide-based neck and dependent drainage distally in the esophagus. Symptoms associated with these diverticula include dysphagia, retrosternal pain, regurgitation, hemoptysis, and recurrent pneumonias and mediastinitis secondary to fistulization. Bleeding can

result from erosion of the diverticulum into bronchial or esophageal arterial branches. Fistula formation between the esophagus and trachea can result in a “swallow-cough” phenomenon and recurrent aspiration pneumonias.

Any suspicion should begin with an extensive history focusing on presence of congenital tracheoesophageal fistulas or duplication cysts, previous granulomatous infections of the mediastinum, and previous lung malignancy. The workup should initially consist of chest imaging in the form of a plain X-ray and/or computed tomography (CT). The CT should help identify any mediastinal abnormalities or previous signs of disease. Esophagoscopy should be performed to visualize the diverticulum and look for other esophageal pathology. Esophageal manometry is used to diagnose any dysmotility disorders, and if the patient is having reflux symptoms, a pH study is often helpful to rule out GERD.

Indications for Operative Treatment

Unlike epiphrenic and to some extent upper esophageal diverticula, all mid-esophageal diverticula should be treated surgically. This is mainly to prevent the potentially catastrophic complications of bleeding and recurrent infection. There is no data in the literature that details the natural history of these diverticula or the percentage of patients that develop symptoms over time as this is an exceedingly rare pathologic process.

Operative Technique

The objectives for operative treatment for mid-esophageal diverticula are:

1. Resection of the diverticulum.
2. Resection of any fistula.
3. Treating an underlying esophageal motility disorder.

Thoracoscopic Approach

The optimal strategy is to approach the diverticulum from the right chest as this avoids the heart and aorta obstructing the surgeon’s working field. The patient is placed in left lateral decubitus position, and four ports are used to access the chest in similar placement for a minimally invasive esophagectomy. One port is for the camera, one for a retractor, and two for working ports. Single-lung ventilation is implemented, and the inferior pulmonary ligament is taken down. The mediastinal pleura is dissected to expose the esophagus. There will be likely adhesive disease secondary to chronic inflammation and scarring, and meticulous attention must be used to preserve the anterior and posterior vagi, the phrenic nerve, and the thoracic duct. The azygous vein can be ligated if needed for exposure. Periesophageal dissection is employed for mobilization, and this can be carried to the thoracic inlet if needed in order to rotate the esophagus and display the diverticulum. Care should be taken to preserve as much of the direct arterial and venous branches to the esophagus. The diverticular neck is then exposed and a search for a fistula

should ensue. If there is a fistula, the tract should be ligated and resected. A myotomy is then carried out just proximal to the diverticulum that extends 4–5 cm distal to the diverticulum. A reticulating stapler (EndoGIA) is aligned parallel to the esophagus and fired for resection. It is important to then buttress the staple line with either pleura or an intercostal muscle flap to prevent fistulization. If there is concomitant GERD or lax lower esophageal sphincter, a partial fundoplication may be added.

Endoscopic Approach

Per-oral endoscopic myotomy (POEM) has been recently used to treat mid-esophageal diverticula with short-term success [45]. Patients fast the day before the procedure, and general anesthesia is used. The esophagoscope is introduced and passed into the esophagus. The diverticulum is identified and measured from the incisors. The scope is then passed into the stomach looking for a hiatal hernia or tight lower esophageal sphincter. The scope is then passed back into the diverticulum and all debris is suctioned out. A 2-cm transverse mucosal incision is made approximately 5 cm above the diverticulum with an endoscopic knife, and a submucosal tunnel is created using repeated jet injection of normal saline mixed with methylene blue dye. Then the endoscopic knife is used to perform the myotomy proximal and distal to the diverticulum. The mucosal defect is then closed with metal clips. The scope is then passed down the natural esophageal lumen to confirm easy passage and to look for any esophageal perforation.

Postoperative Management

For patients who undergo thoracoscopic surgery, a fluoroscopic swallow test is performed to assess for esophageal leak or dysfunction. Patients who have no signs of leak or swallowing dysfunction are started on a liquid diet. The chest tubes are usually removed if there is no evidence of a leak. Patients undergoing POEM procedure are kept overnight in the hospital and undergo a contrast swallow study the next day. If there are no signs of leak or perforation, the patient is also started on a liquid diet.

Complications

The main complications that can arise are recurrent diverticulum, fistula formation, esophageal stenosis, recurrent laryngeal and phrenic nerve injury, and esophageal perforation. No long-term results have been reported for minimally invasive mid-esophageal diverticulectomy and myotomy or endoscopic myotomy.

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