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HOW I DO IT

Laparoscopic Treatment of Epiphrenic Diverticula: Preoperative Evaluation and Surgical Technique. How I Do It

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Abstract
Introduction Traditionally, epiphrenic diverticula have been managed through a left thoracotomy. With the advancement of minimally invasive techniques, a laparoscopic approach has gained widespread popularity. Unfortunately, the preoperative evaluation of patients with epiphrenic diverticula, and their surgical management, is still not well characterized.
Discussion The goal of this article is to illustrate our approach to patients with epiphrenic diverticula in terms of preoperative evaluation and surgical technique. The final discussion will focus on the evidence-based rationale for our preoperative assessment and surgical approach.

Keywords Gastroesophageal reflux disease (GERD) · Laparoscopic antireflux surgery (LARS) · Epiphrenic diverticula · Esophageal function testing

Introduction

Epiphrenic diverticula are acquired, false, or pseudo-diverticula that result from herniation of the mucosa and submucosa through the muscular wall of the distal esophagus. They are also called "pulsion" diverticula, as their pathophysiology usually involves the presence of an underlying esophageal motility disorder, which is thought to cause an increased intraluminal pressure against a closed or nonrelaxing lower esophageal sphincter. Epiphrenic diverticula are rare and although their treatment is usually performed in experienced tertiary care centers, inconsistencies in preoperative evaluation or surgical techniques has led to a wide range of reported complications, with leak rates as high as 23%.[1] Evidence has shown that in order to achieve good results, the evaluation of patients with epiphrenic diverticula must begin with a careful preoperative evaluation to correctly localize the diverticulum and identify the underlying esophageal motility disorder usually associated with it (e.g., achalasia, diffuse esophageal spasm, nutcracker esophagus, and hypertensive lower esophageal sphincter). Following these essential steps, a carefully planned operation involving stapling of the diverticulum's neck, contralateral cardiomyotomy extending onto the stomach, and a partial fundoplication should then be performed. The following is a description of our preoperative evaluation, followed by a step-by-step description of our technique with a final discussion of the evidence-based rationale for our preoperative assessment and surgical approach.

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Preoperative Evaluation

All patients with epiphrenic diverticula undergo a preoperative assessment that consists of a symptomatic evaluation that includes a comprehensive 21-point questionnaire, a barium swallow, an upper endoscopy, and ambulatory esophageal manometry. While each test has its individual indication, the

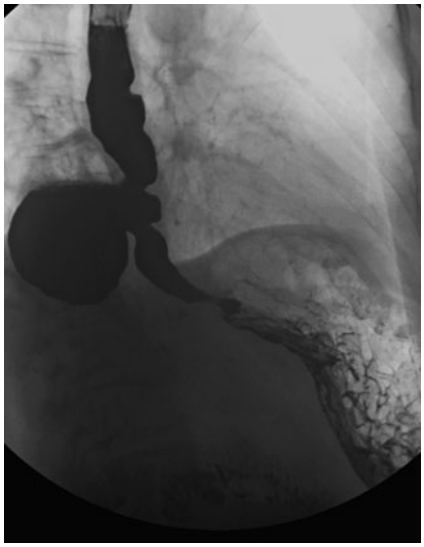

Fig. 1 Barium swallow showing a 6×7 cm epiphrenic diverticulum and a corkscrew esophagus. In this 88-year-old male, the diverticulum was located high in the mediastinum and the barium swallow allowed planning a thoracoscopic resection

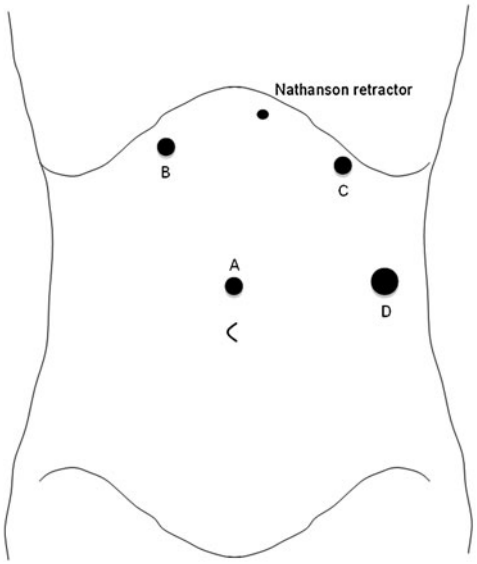

Fig. 3 Position of operative ports and Nathanson retractor

collective data gathered from them best allows for the optimal surgical treatment of these patients.

A barium swallow is usually the first test performed to determine the location and size of the diverticulum as it provides a "roadmap" of the esophageal anatomy. The anatomic information gleaned from this test helps in the operative planning because, if the diverticulum is located more than about 10 cm higher than the diaphragm, its resection might be easier accomplished thoracoscopically (Fig. 1). Occasionally, the barium swallow may detect esophageal dysmotility when ambulatory esophageal manometry is normal (Fig. 1).

Ambulatory esophageal manometry is the "golden standard" in the diagnosis of esophageal motility disorders and it always performed to document the underlying esophageal abnormalities that are frequently associated with the diverticulum (Fig. 2). An upper endoscopy is routinely performed to rule out esophagitis, Barrett's esophagus, or peptic ulcers.

Preoperative Considerations

The patient is positioned on the operative table on a beanbag. Pneumatic compression stockings are used as prophylaxis against deep vein thrombosis and preoperative antibiotics are administered prior to skin incision. A rapid sequence induction is always performed to prevent aspiration of particulate matter present inside the diverticulum or inside the esophagus of patients with achalasia. After intubation, a Foley catheter is inserted, the lower extremities are placed in stirrups, and the beanbag is inflated. The abdomen is then prepped and draped and the patient is positioned in steep reverse Trendelenburg.

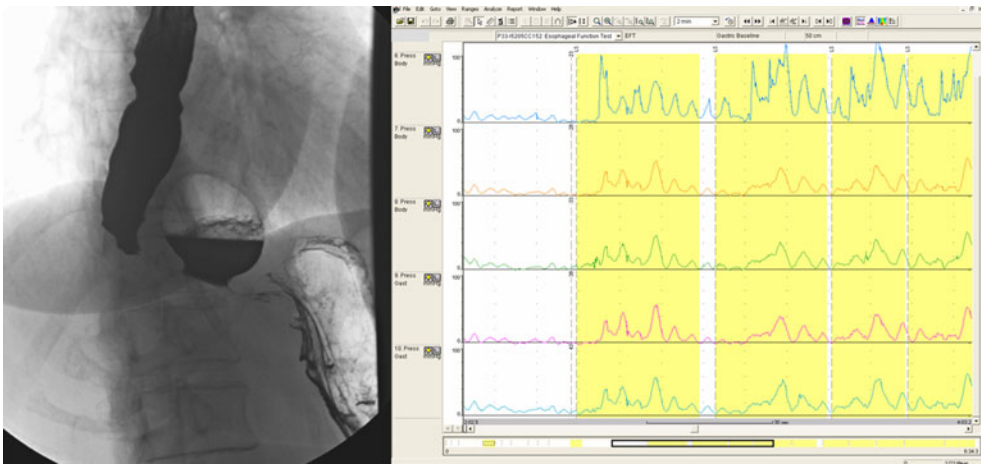

Fig. 2 Ambulatory esophageal manometry (*right panel*) showing high-amplitude, simultaneous, and repetitive contractions, characteristic of diffuse esophageal spasm in a 73-year-old female, in whom an epiphrenic diverticulum was discovered during an upper endoscopy. The barium swallow on the same patient (*left panel*) incorrectly suggested achalasia and shows mild tertiary esophageal contractions and a 5×6 cm epiphrenic diverticulum

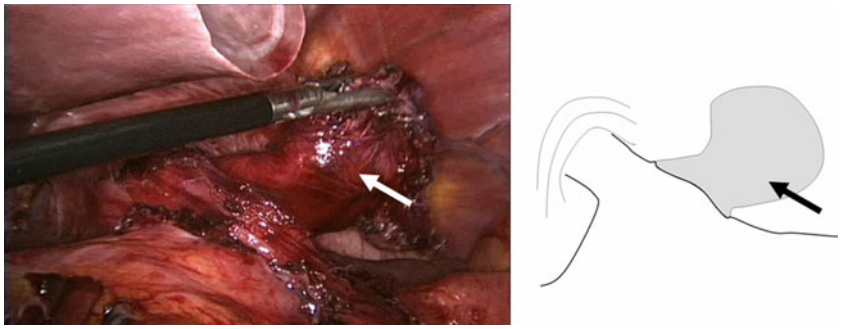

Fig. 4 An epiphrenic diverticulum (*white arrow*, *left panel*) is shown extending below the diaphragm, with the esophageal mucosa and submucosa herniating from the esophageal musculature. The artist's representation (*right panel*) shows the diverticulum (*black arrow*) located at the 2 o'clock position with respect to the body of the esophagus

Operative Technique

Laparoscopic Access and Placement of Trocars

After complete neuromuscular paralysis is achieved, a 1-cm transverse midline incision is made in the skin 1 in. above the umbilicus, the fascia is grasped with a Kocher clamp, a Veress needle is inserted, a water drop test is performed, the abdomen is insufflated to 14 mmHg, and an 11-mm Kii Optical Fixation Trocar ™ (Applied Medical, Rancho Santa Margarita, CA, USA) is inserted into the abdominal cavity under direct visualization. Then three Kii Advanced Fixation Trocars ™ (Applied Medical, Rancho Santa Margarita, CA, USA) are placed, as illustrated in Fig. 3. Port B and C are 11 mm working ports through which the graspers, the laparoscopic Ligasure™ Vessel Sealing System (Valleylab, Boulder, CO), and the suturing instruments are introduced. Port D is a 12-mm port used for manipulation of a laparoscopic atraumatic Allis clamp, the Ligasure™ to take down the short gastric vessels, and the insertion of a laparoscopic stapler. Finally, a 5-mm incision to the left of the xyphoid process is made to insert a Nathanson retractor, which retracts the left lobe of the liver and exposes the diaphragmatic hiatus and the gastroesophageal junction.

Identification and Resection of the Diverticulum

Once all ports are properly positioned, the laparoscopic Allis clamp is applied onto the anterior wall of the stomach to allow lateral traction of the gastroesophageal junction; the gastrohepatic ligament is divided with the Ligasure™ until the right diaphragmatic crus becomes visible; the phrenoesophageal ligament is divided anteriorly, from the apex of the right crus to the apex of the left crus, and the anterior vagus nerve is identified; the esophagus is then bluntly dissected away from the right crus and the posterior vagus nerve is localized. The dissection is continued into the posterior mediastinum, where the diverticulum lies; after the diverticulum is discovered, this is bluntly dissected off the pleura and the esophagus until its neck is clearly isolated (Fig. 4). A bougie (54–58 F) is then placed into the esophagus to stent its lumen and prevent a dangerous stenosis by stapling in excess of the mucosa and submucosa of the diverticulum. The diverticulum's neck is then stapled with a roticulating laparoscopic stapler equipped with a 2.5-mm vascular cartridge and oriented longitudinally to the esophagus (Fig. 5). The bougie is removed and the defect of the esophageal musculature is closed with 2-0 silk interrupted sutures to imbricate the staple line (Fig. 6). Finally, the diverticulum is placed into a bag and retrieved.

Cardiomyotomy and Partial Anterior Fundoplication

A cardiomyotomy is always performed contralateral to the location of the stapled diverticulum; it extends approximately 7 cm cranially onto the esophagus and 3 cm caudally onto the anterior wall of the stomach (Fig. 7). It is performed with a combination of blunt dissection with a laparoscopic Maryland dissector and cautery of the circular fibers with Ligasure™. After the cardiomyotomy is

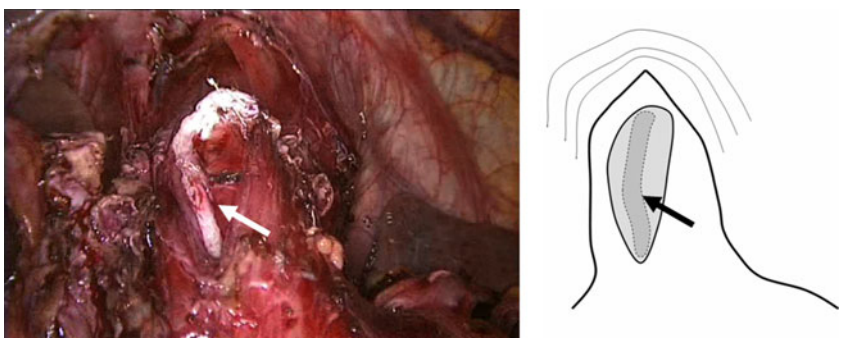

Fig. 5 The stump of the neck of the diverticulum (*white arrow*, *left panel*) is shown after its stapled transaction alongside the esophagus. The artist's representation (*right panel*) shows the longitudinal staple line (*black arrow*) across the esophageal submucosa

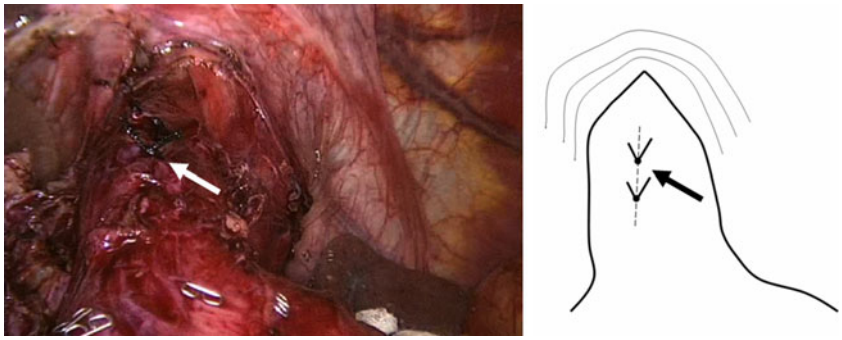

Fig. 6 The defect of the esophageal musculature is closed with interrupted sutures to imbricate the staple line (*white arrow*, *left panel*). The artist's representation (*right panel*) shows these sutures and the imbricated staple line (*black arrow*)

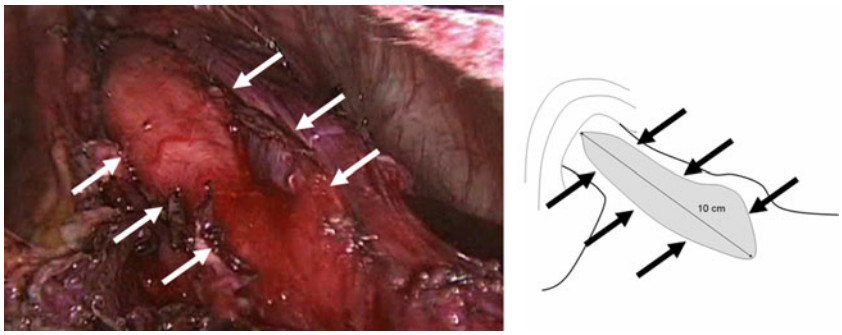

Fig. 7 A contralateral cardiomyotomy (*white arrows*, *left panel*) is shown extending onto the body of the esophagus and onto the anterior wall of the stomach. The artist's representation (*right panel*) shows the cardiomyotomy with the underlying esophageal submucosa (*black arrows*). The cardiomyotomy is 10 cm long and it is located at the 10 o'clock position with respect to the body of the esophagus

completed, the hiatus is always closed with few intracorporeally tied, interrupted #0 silk sutures. Then, the short gastric vessels are divided with the Ligasure™ and a partial anterior fundoplication is performed. This is fashioned by suturing the gastric fundus to the apex of the left crus and the left edge of the myotomy, folding the stomach over the myotomy, and suturing the gastric fundus along the right crus (Fig. 8). Although an upper endoscopy is seldom performed to assess the adequacy of the cardiomyotomy or the integrity of the staple line, we routinely perform it in difficult cases when a perforation is suspected. In these situations, the mucosa is submerged under saline during gentle insufflation to check for a perforation.

Conclusion of the Operation

At the end of the operation, the Nathanson retractor and all trocars are removed under direct visualization and the fascia of the optical port and the 12-mm incision are closed with a figure-of-eight 2-0 absorbable suture. The Foley catheter is removed in the operating room.

Postoperative Care

Postoperatively, all patients are admitted overnight in the surgical floor. They are started on a soft mechanical diet the morning of postoperative day 1, after a Gastrografin™ followed by a barium swallow have ruled out a leak. They are asked to keep this dietary regimen for the first 2 weeks postoperatively after which they are instructed to advance their diet to more solid foods.

Discussion

Inconsistencies in the preoperative evaluation and the variation in surgical techniques have led to a wide range

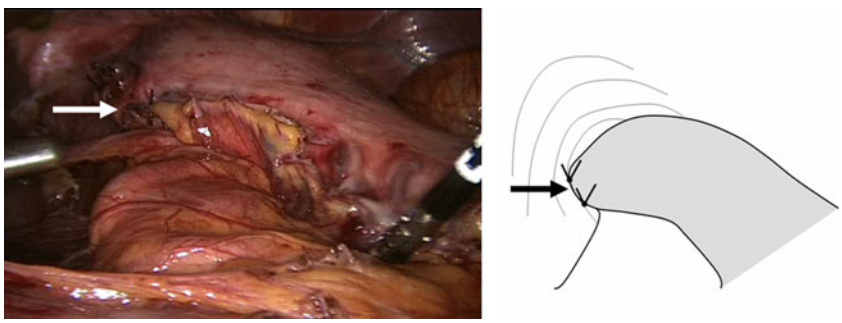

Fig. 8 Completed partial anterior fundoplication is shown (*white arrow*, *left panel*). The artist's representation (*right panel*) shows the fundoplication (*black arrow*) fashioned by folding the gastric fundus over the myotomy and suturing it along the right crus

of outcomes for patients with epiphrenic diverticula. Leak rates have been reported up to 21% in open series[2–6] and up to 23% in laparoscopic reports.[1,7–10] Similarly, mortality rates in open and laparoscopic series have been reported up to 9% and 7%, respectively.[1,4]

Our standard preoperative assessment aims to confirm the location and size of the diverticulum and document the esophageal motility disorder usually associated with the diverticulum. The rationale of our evaluation is supported by studies showing a large percentage of underlying motility disorders in patients with epiphrenic diverticula. This high incidence of esophageal dysmotility has been reported uniformly by several authors ranging from 75% to 100%,[2,5,6,9–13] and has led to believe that a cause–effect relationship exists between esophageal motility disorders and the development of epiphrenic diverticula. This has important implications as it supports our policy to perform in all symptomatic patients a routine cardiomyotomy even in those few cases in which the intermittent nature of the motility disorder precludes the identification of the dysmotility preoperatively.

The laparoscopic approach is our approach of choice in most cases, except in those with a large diverticulum that is located very high in the posterior medistinum; for these patients, a transthoracic resection may be easier to perform. Our choice is based on the observation that, when compared to the thoracoscopic approach, the laparoscopic techniques allow: (a) an easy resection of the diverticulum; (b) a straightforward closure of the diaphragmatic hiatus; (c) a superior exposure of the anterior wall of the stomach and the fundus of the stomach, which facilitates the distal extension of the cardiomyotomy and the performance of a partial anterior fundoplication; (d) the avoidance of a double-lumen endotracheal tube, let alone single lung ventilation during the operation; and (e) the avoidance of an uncomfortable chest tube postoperatively. Several studies have provided a solid argument for this approach. Kilic et al., Soares et al., and Thomas et al. in their reviews of literature showed that a laparoscopic approach to epiphrenic diverticula offered reduced operative mortality, decreased length of stay, and similar symptom relief compared with open surgery in the hands of experienced laparoscopic surgeons.[14–16] The results of those studies also demonstrated that the laparoscopic approach showed "potential benefits without compromising effectiveness and safety"[16] and that it "should be the approach of choice in most cases".[15]

Our surgical technique is based on the routine resection of the diverticulum and addresses at the same time any associated esophageal motor disorder diagnosed preoperatively. Our strategy is based on the almost unanimous consensus that these diverticula are caused by an underlying motility disorder, which, if left untreated, may cause persistent or recurrent symptoms or a potential disruption of a staple line. In fact, symptoms may not be exclusively attributable to the diverticulum alone and a leak may occur when high intraesophageal pressures from the unrelieved distal obstruction caused by the motor disorder persistently stress the staple line. Further supporting this approach, a comparison of published results has shown higher leak rates and higher incidence of recurrent and persistent symptoms following diverticulectomy without a cardiomyotomy.[16] Similarly, leaks have been associated with a mortality of 35% following simple diverticulectomy compared to 15% in those who also had a cardiomyotomy.[16]

Finally, it is our preference to add a partial anterior fundoplication, which has the dual goal to reduce postoperative gastroesophageal reflux and to cover both the myotomy and the imbricated staple line of the stump of the diverticulum's neck. Evidence has shown that the incidence of acid reflux symptoms appears significantly less when a partial fundoplication is added.[16]

Conclusions

Our surgical strategy takes into consideration the current evidence, which supports the laparoscopic approach as a safe and effective treatment for patients with epiphrenic diverticula in most cases, and which does not favor a diverticulectomy without a cardiomyotomy, while it emphasizes the need of accurate preoperative imaging and esophageal motility assessment. When performed in institutions with extensive experience in laparoscopic esophageal procedures, this approach and surgical strategy can achieve excellent outcomes with minimal morbidity and short hospital stay. Numerous studies have strengthened these arguments and have provided the evidence-based justification for our preoperative evaluation and standard surgical management.

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