Original Article

Minimally invasive therapy for epiphrenic diverticula: Systematic review of literature and report of six cases

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Abstract

INTRODUCTION: Epiphrenic diverticula (ED) are infrequent and conventional surgical treatment entails aggressive open or transthoracic surgery. Minimally invasive treatment has changed the surgical approach but some surgical controversies are not resolved. **OBJECTIVE:** The objective of this study is to describe our experience in minimally invasive treatment of the ED and to perform a systematic review of the current literature in this subject. **MATERIALS AND METHODS:** We reviewed all data from the Hospital de Sant Pau, focusing on patients that underwent minimally invasive treatment for an ED since 1998 to date. Furthermore, we performed a systematic literature review focused on the minimally invasive approach for ED. **RESULTS:** A total of 6 patients have been treated (5 transhiatal and 1 with abdominal and thoracic approach). We found a predominance of males with a median age of 63. The diagnosis was made with an endoscopy, barium swallow and manometry. Half of the manometry results were pathologic. The surgical technique involved a diverticulectomy, myotomy and a Dor partial founduplication. Two patients that presented suture line leakage (SLL) were treated conservatively. No mortality was reported. The systematic review was carried out under the Preferred Reporting Items for Systematic Reviews and Meta-analyses scheme, with a total of 20 studies where 189 patients were found. No comparative or prospective randomised trials were found. Overall morbidity was 24%, with a SLL rate of 12%, hospital stay of 5 days and mortality of 1.5%. After a median follow-up of 42 months, 81.5% of the patients were asymptomatic. **CONCLUSION:** The minimally invasive approach for ED is a safe and feasible procedure.

Key words: Epiphrenic diverticula, oesophageal diverticulum, minimally invasive surgery

Access this article online	
Quick Response Code:	Website: www.journalofmas.com
	DOI: 10.4103/0972-9941.141498

INTRODUCTION

Epiphrenic diverticula (ED) are a rare condition with an unknown incidence.[1,2] There is an estimated prevalence of 0.015% in the United States, 0.77% in Japan and up to 2% in Europe.[3-8] In 1998, Rosati *et al*.,[9] was the first surgeon to perform a minimally invasive transhiatal access for ED on a patient. Most of the authors recommend surgical treatment when a diverticulum becomes symptomatic, disabling or is associated with atypical symptoms such as pulmonary pathology.[10-13]

Now-a-days, there is no consensus on the type of surgical access, the length of the myotomy, or the type of antireflux technique.[1,7,14-21] The conventional surgical procedure that was usually performed consisted in a left thoracotomy, diverticulectomy, myotomy and a Belsey Mark IV procedure; nonetheless, this treatment implicates a non-negligible morbidity rate; reaching up to 20-25% of patients, the most important being suture line leakage (SLL) and mortality up to 5%.[22] These results and access to the hiatal hiatus obtained through a minimally invasive technique have favoured a switch to endoscopic surgery in the last few years. However, the rarity of this procedure makes it difficult to obtain definitive data from a large series about the performance of randomised trials and justifies presenting the outcome of shorter series and analysing the pooled results of different experiences using a systematic methodology. The objective

of this study is to describe our experience with minimally invasive surgical treatment of the ED and to systematically review the current knowledge about treating ED with an endoscopically access.

MATERIALS AND METHODS

Cases Report

We retrospectively reviewed the medical records of patients that underwent minimally invasive access surgery for ED in the database of the Hospital de la Santa Creu i Sant Pau, from 1998 to date. The variables that we analysed were: Pre-operative characteristics (age, gender), pre-operative work-up, type of surgery, post-operative complications, length of hospital stay (LOHS) and follow-up.

Minimally invasive transhiatal approach technique

The abdomen is approached with five trocars located as is conventionally for upper abdominal surgery. We start with the dissection of the gastrohepatic ligament using a harmonic scalpel and continue until we find the right diaphragmatic pillar, with a complete dissection of the phrenoesophageal ligament and the circumference of the gastroesophageal junction. A Pinotti's manoeuvre (section of the hiatus) is performed selectively according to the size of the hiatus. Afterwards, we mobilise the lower oesophagus extensively to identify the diverticulum. Dissection is performed combining blunt, electrocautery or harmonic energy, until the neck of the ED is reached at the submucosal level. Once the diverticulum is released, we expose the diverticular neck and it is severed with a linear stapler. Then, the suture line integrity is confirmed endoscopically and/or by methylene blue. The next step is to proceed with an anterior myotomy of the oesophagus, beginning at the upper level of the neck transection and the myotomy ends 1.5-2 cm caudally into the gastric wall. The last step is a partial Dor fundoplication. We systematically place mediastinal drainage. At 48 h after the procedure, a gastrografin swallow is performed before starting the oral intake.

Systematic Review

Search strategy

This systematic review of literature was performed according to the recommendations published in the consensus document "Preferred Reporting Items for Systematic Reviews and Meta-Analyses."[23] The electronic search was conducted in the PubMed and in the latin-american database using the following terms: "Diverticulectomy," "minimally invasive diverticulectomy," "surgical treatment for ED", "surgical treatment for ED", "laparoscopic diverticulectomy epiphrenic," "epiphrenic diverticulectomy," "oesophageal diverticulum" and "tratamiento laparoscópico de divertículo epifrénico." The search was performed restricting language to English and Spanish.

Inclusion criteria

(a) Clinical studies including minimally invasive transhiatal diverticulectomy, either with laparoscopic access or robotic-assisted, (b) articles that study both techniques (transhiatal and thoracoscopy), in which the transhiatal approach was used in more than 50% of the patients under study and (c) studies which specifically describe the pre-operative characteristics, diagnostic method, surgical technique, complications and follow-up.

Exclusion criteria

We excluded studies using open approaches (thoracotomy) or thoracoscopy in more than 50% of the population. We also ignored all studies that did not fulfil the criteria described.

Data collection

We reviewed the full text of the articles obtained based on the above search strategy. The data collected included the author's name, time of the study, population demographics, pre-operative characteristics, perioperative data and post-operative complications and follow-up.

RESULTS

Case Report

Since 1998 to date, we operated on six patients in our centre. Clinical features of the patients are plotted in Table 1. We performed a transhiatal approach on five patients. On one patient that presented a mid-oesophageal diverticulum and hiatal hernia with gastro-esophageal reflux disease (GERD), we performed a combined technique. Initially, we performed a transabdominal approcah with a hiatal closure and a partial (Toupet) wrap. In a second procedure, a video assisted thoracoscopic resection was performed. Operative time ranged between 180 min and 210 min, with minimal intraoperative bleeding (30-100 ml). Two patients had post-operative SLL, one of them during the first 48 h. In the other case, the patient was readmitted 10 days after an uneventful recovery due to thoracic pain and a minimal leakage was observed. The patient was treated conservatively with diet and antibiotics, evolving uneventfully [Table 1]. Five of the five patients were asymptomatic after a mean follow-up of 62 months (1-180) and one patient developed dysphagia due to a pseudo-diverticulum at the myotomy site.

Literature Review

We found 56 articles related to treatment for ED in PubMed. Only 20 publications met the inclusion criteria. A total of 189 patients were reported, including our 6 cases [Graph 1].

Table 1: Case report patients

Patient	Gender	Age (years)	Diagnostic method	Manometry	Surgical procedure	Complications	LOHS (days)	Follow-up (months)
1	M	67	Barium swallow	Normal	Laparoscopic Toupet fundoplication+toracoscopy with diverticulectomy	No	2	Asymptomatic
2	M	60	Barium swallow	Normal	Diverticulectomy, myotomy and Dor fundoplication	No	5	Asymptomatic
3	F	55	Endoscopy	Hypertensive lower oesophageal sphincter	Diverticulectomy, myotomy and Dor fundoplication	Suture line leakage	53	Oesophageal pseudodivertículum
4	M	65	Barium swallow	Normal	Diverticulectomy, myotomy and Dor fundoplication	Suture line leakage	5	Asymptomatic
5	M	72	Barium swallow	Unspecific motor abnormality	Diverticulectomy, myotomy and Dor fundoplication	No	4	Asymptomatic
6	M	64	Endoscopy + barium swallow	Unspecific motor abnormality	Diverticulectomy, myotomy and Dor fundoplication	No	5	Asymptomatic

M: Male, F: Female, LOHS: Length of hospital stay

Pre-operative characteristics

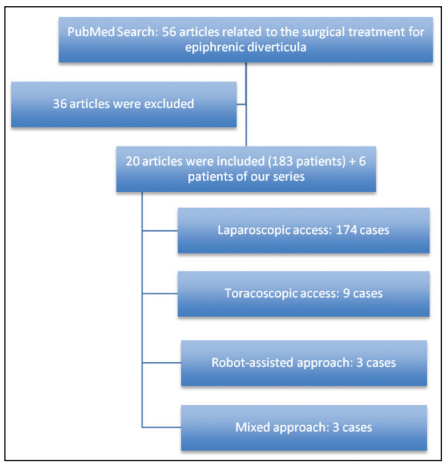
Of the 189 patients, there were 95 men and 94 women, with a mean age of 61 (27-96) and a weighted average of 51.3 months for the duration of symptoms before surgery. The predominant pre-operative symptoms were: Dysphagia followed by regurgitation, chest pain, heartburn, weight loss and less frequent atypical respiratory symptoms. The diagnoses were made by barium swallow, endoscopy and manometry in 90% of the publications [Figure 1]. In addition, some authors included pH monitoring and computed tomography. The average size of the diverticula was 5.5 cm (1.2-11) and was associated with an oesophageal motility disorder in 60% of patients, the most frequent being achalasia, nutcracker oesophagus and non-specific oesophageal motor disorder. The weighted average of the operative time was 120.6 min (106-313), however, this measurement was only reported by 13 authors. The intraoperative bleeding was minimum (30-250 ml) [Table 2].

Diverticulum management

There were 174 laparoscopic transhiatal approaches, 9 cases by thoracoscopy, 3 cases of robot-assisted transhiatal surgery and 3 mixed (abdominal and thoracic approach). 184 diverticulectomies were performed (97.3%) with the use of linear stapler, after which some authors performed suture reinforcement with non-absorbable continuous suture or placement of fibrin in the suture line. Two authors did a diverticulum inversion in a total of five patients [Table 2].

Myotomy

Nearly 90% of the authors performed a myotomy in a total of 170 patients, 61% extended to the stomach between 1 cm and 2 cm, but Soares[17] did the myotomy only in the diverticular neck with a 5.2% leakage rate [Table 2].



Graph 1: Flowchart of the literature review including the patients of our series

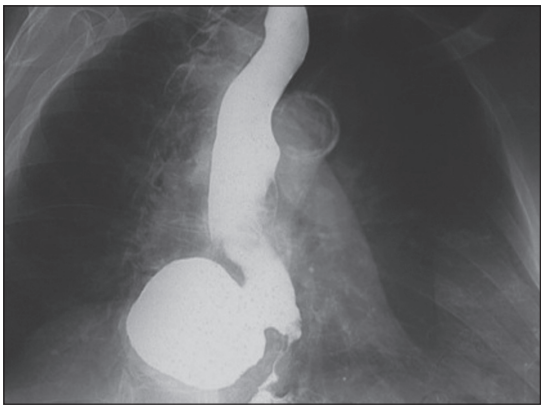


Figure 1: Pre-operative barium swallow of patient number 4

Fundoplication

Of the 92.5% (n = 175) of patients with fundoplication associated with the surgery, 87.5% were partial (Toupet

Table 2: Systematic review of cases with minimally invasive surgical treatment for epiphrenic diverticula

Author	Patients (*n*)	Mean duration of symptoms (months)	Prevalence (%) and type of motor disorder	Approach/ access	Number and length of the myotomy (cm)	Type of fundoplication	Mean length of hospital stay (days)	Complications	Mean follow-up (months)
Myers and Dempsey[24]	3	13.3 (4-24)	100 (incomplete LES relaxation)	3 lap	3 (1-2 cm to the stomach)	1 Dor and 1 hiatal closure	3.6 (2-7)	1 auricular fibrillation	20
Klaus *et al.*[14]	10	18-62	NR	10 lap	7	9 (4 Nissen, 5 Toupet)	5.5 (1-29)	2 (1 SLL, 1 empyema)	26.4 (2-48)
Fraiji Jr *et al.*[19]	6	134 (24-240)	100 (achalasia)	6 lap	6 (EGU)	6 (5 Dor, 1 Toupet)	4 (1-8)	2 (ileus, pneumonia y empyema)	9.3 (1-17)
Matthews *et al.*[25]	5	12	60	4 lap y 1 toracoscopy	5	4 Toupet	2.7 (2-4)	0	16.2 (3-36)
Del Genio *et al.*[18]	13	115 (8-255)	100	13 lap	13 (2 cm to the stomach)	13 Nissen-Rossetti	13.9 (7-25)	3 (SLL)	58 (3-96)
Fernando *et al.*[26]	20	36 (3-240)	90 (achalasia, unspecific and GERD)	10 lap, 7 vats, mixed 3	16 (1-2 cm to the stomach)	14 (12 Toupet, 2 Collis)	5 (1-61)	9 (4 SLL)	15 (1-70)
Tedesco *et al.*[16]	7	60 (5-360)	85.7	7 lap	7	7 Dor	3±1	1 (para-oesophageal hernia and 1 SLL)	60
Valentini *et al.*[27]	1	120	100 (unspecific)	1 lap	1 (1.5 cm to the stomach)	1 Toupet	4	1 (acute recurrence)	10
Palanivelu *et al.*[28]	5	NR	40 (achalasia)	5 lap	2	3 (2 Toupet, 1 Nissen)	8 (3-20)	1 (SLL)	54 (6-96)
Silecchia *et al.*[29]	1	3	100 (unspecific)	1 lap	1 (3 cm to the stomach)	1 Dor	2	1 (SLL)	3
Elola-Olaso *et al.*[30]	2	NR	50 (hiatal hernia)	2 robot	0	2 (1 Nissen y 1 Toupet)	NR	1 (SLL)	NR
Melman *et al.*[7]	13	NR	84.6	13 lap	13	12 (10 Toupet, 2 Dor)	2.8±0.4	2 (atelectasis, SLL)	13.6±3.0 (3-36)
Ruiz[31]	1	12	100 (nutcracker oesophagus)	1 lap	1 (2 cm to the stomach)	1 Toupet	NR	0	NR
Hoshino *et al.*[32]	1	NR	100 (achalasia)	1 lap	1	1 Dor	4	0	24
Soares *et al.*[17]	19	NR	77	19 lap	16 (only diverticular neck)	17 (16 Toupet and 1 Nissen)	3 (2-12)	5 (2 pleural effusions, 1 SLL, 1 bleeding, 1 Ritcher hernia)	34 (1-134)
Rosati *et al.*[1]	20	36 (6-240)	60 normal, 25 abnormal	20 lap	20 (9 cm in total)	20 (16 Dor and 4 Toupet)	7 (4-13)	6 (1 SLL, 4 pneumothorax, 1 gastric perforation)	52 (1-141)
Fumagalli *et al.*[33]	30	NR	NR	30 lap	30 (1, 5 cm to the stomach)	30 (22 Dor and 8 Toupet)	6.5 (3-14)	2 (1 SLL and 1 hemoperitoneum)	52 (2-144)
Zaninotto *et al.*[34]	24	30	63 (unspecific, achalasia, nutcracker esophagus)	17 lap, 7 mixted	21 (2 cm to the stomach)	24 (19 Dor, 5 Toupet)	NR	6 (4 SLL)	96
Pernazza *et al.*[35]	1	NR	0	1 robot	0	1 Dor	8	0	1
Olarte *et al.*[36]	1	36	100 (hypotonic LES, para-oesophageal hernia)	1 lap	1	1 Toupet	1	0	12
Sant Pau	6	60	60 (hypertensive LES, 1 achalasia)	5 lap y 1 toracoscopy	6 (1, 5-2 cm to the stomach)	6 (5 Dor and 1 Toupet)	12.3 (2-56)	2 (SLL)	62 (1-180)

NR: Not reported, LES: Lower oesophageal sphincter, GERD: Gastro-oesophageal reflux disease, Lap: Laparoscopy, robot: Robot assisted, mixed: Abdominal and thoracic approach, EGU: Oesophagogastric unction, SLL: Suture line leakage

42.5% and Dor 45%) followed by Nissen 11.5% and 1.1% with Collis technique. Rosati *et al*.[1] prefer the Dor fundoplication for with GERD patients and Toupet for those without; and Klaus[14] favours Nissen for those with normal motility and Toupet for abnormal ones. Tedesco[16] is in favour of the Dor fundoplication for all patients while Fernando[26] only for patients with a history of GERD, hiatal hernia, or wide hiatal dissection. Palanivelu[28] uses Nissen fundoplication on patients with GERD and/or hiatal hernia, Toupet technique for those with achalasia and Dor for everyone else [Table 2].

Post-operative features

The average LOHS was 5.1 days (1-56). There were 6 conversions to open surgery because of firm adhesions (2 cases) and diverticula in the mid oesophagus (4 cases). The morbidity was 24% with a leakage rate of 11.7%. Other complications included acute recurrence, empyema, paraoesophageal hernia, Ritcher hernia, pneumothorax, atelectasis, pleural effusion and bleeding. 14 patients had to undergo further surgeries (8%), 75% of which due to suture dehiscence. The mortality rate was 1.5% (one strangulated hernia, one suture line leak and one more for acute myocardial infarction). The weighted average for the post-operative follow-up was 42.4 months (1-96 months) in which 81.5% of patients were reported as asymptomatic, 13.4% presented mild symptoms treated medically and only 5% had severe symptoms that required invasive treatment or conservative medical treatment with poor results. The reported recurrence average is 2.2% [Table 2].

DISCUSSION

ED occurs in the distal oesophagus and only 15-20% is symptomatic. Benacci *et al*.[37] reported that patients with asymptomatic or mild symptoms do not require surgical treatment because 100% of their series showed no symptomatic progression; conversely, authors like Altorki *et al*.[38] are in favour of surgical treatment on all patients to prevent respiratory complications. Currently, minimally invasive surgery has presented excellent results in these situations with a symptomatic improvement of 85-100%, suture leakage rate of 8-23%, 8-10% of pulmonary complications and a mortality of 0-7%.[3,17] It appears that the advantages of the minimally invasive approach include: Easy access, improved visualization, proper stapling line, possibility of myotomy and antireflux technique, along with the possibility of treating any complication during the surgery. In addition, there is a shorter hospital stay and minimal analgesia requirements. The disadvantages that have been described are: The difficulty of dissection for large diverticula or diverticula that are located in the mid oesophagus and the rupture of the pleura with subsequent pneumothorax;[4] Pernazza, *et al*.[35] states that these disadvantages can be avoided with the use of the Da Vinci Surgical System robot with the stereoscopic endoscope, articulation of instruments and 3D vision. The use and length of the myotomy is controversial. The literature describes an increased leakage and recurrence rate when myotomy is not performed concomitantly.[39] Myotomy was proposed, originally by Efler in 1959 and Belsey in 1966,[40] and its utility was confirmed by Nehra *et al.*[41] in 2002 since he observed the existence of a motility disorders in 71% of patients when performing a stationary manometry, which increased to 100% when using an ambulatory 24 h manometry on patients with ED. From the surgical point of view, the myotomy is performed on the contralateral wall of the diverticulum, covering the complete length of the diverticular neck. In a Mayo Clinic study with 21 patients, a high incidence of leakage and recurrence (24% and 19% respectively) was shown when performing the diverticulectomy without myotomy, compared with an associated myotomy (0% for both).[21] The incidence of GERD after a myotomy can reach approximately 50%, hence a fundoplication is preferred for all patients with myotomy.[21] The controversy is related to the type of fundoplication, to avoid a hyperpressive lower esophageal sphincter (LES) that may favour staple line leakage. Nehra *et al*.[41] propose to perform Nissen fundoplication on patients with normal esophageal motility and Toupet on abnormal cases. Del Genio *et al*.[18] performed Nissen-Rossetti fundoplication with an incidence of leakage of 23% and therefore recommend a transoperative manometry to verify the LES pressure. In Japan, the Dor fundoplication is recommended because it is easier to perform and can potentially prevent the formation of a pseudodiverticulum or leakage if an intraoperative oesophageal mucosa perforation occurs.[42] Regarding the complications rate, Rosati *et al*.,[1] associated the risk of SLL with the size of the diverticulum (more than 9 cm) and Zaninotto *et al*.,[34] with the use of more than one stapling shot.

In our experience, we prefer to perform the diverticulectomy, a long myotomy extended to the gastric wall and an anterior Dor partial fundoplication because we believe that oesophageal motor disorder is the cause of diverticula, just as Nehra *et al.* reported[41] The Dor fundoplication not only prevents post-operative gastroesophageal reflux, but also protects the myotomy. Despite these considerations, it is noteworthy that two of our patients had a SLL and were treated conservatively. One of these patients was diagnosed with a pseudodiverticulum 1 year after surgery with normal manometry; which could be explained by intense fibrosis, fundoplication failure, or incomplete myotomy.

CONCLUSION

Minimally invasive surgery for the treatment of ED is reliable with satisfactory results similar to those reported in the

literature with the standard technique. It is difficult to perform prospective randomised studies due to the rarity of the disease; however, we consider that the minimally invasive surgery is the technique of choice for the surgical treatment of the ED.

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Cite this article as: Gonzalez-Calatayud M, Targarona EM, Balague C, Rodriguez-Luppi C, Martin AB, Trias M. Minimally invasive therapy for epiphrenic diverticula: Systematic review of literature and report of six cases. J Min Access Surg 2014;10:169-74.

Date of submission: 19/08/2013, **Date of acceptance:** 29/10/2013

Source of Support: Nil, **Conflict of Interest**: None declared.