



## Surgical Therapy of the Epiphrenic Diverticulum - A Single Center Experience Over 12 Years

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### Abstract

**Background:** Epiphrenic diverticulum is caused by an increase of intraluminal pressure, which leads to an outpouching of the mucosal and submucosal layers, causing symptoms such as dysphagia and heartburn. Aim of this study was the retrospective evaluation of symptoms, quality of life and post-surgical complications among patients with epiphrenic diverticulum receiving surgical treatment.

**Methods:** Twenty three patients diagnosed with esophageal diverticulum were retrospectively included into this study. Main outcome parameters were symptoms, quality of life and post-surgical complications.

**Results:** Preoperative symptoms included dysphagia (83.34%), regurgitation (50%) and heartburn (27.8%). Twenty patients underwent surgery: Fourteen had a diverticulectomy, one received a diverticulopexy, three underwent esophagectomy and two received a single myotomy. An additional myotomy was performed in eight patients. Among patients undergoing surgical treatment, rates of heartburn, regurgitation or dysphagia were decreased. In 7 patients who underwent surgery, post-surgical complications occurred: four patients showed mild complications according to Clavien-Dindo I, one patient suffered from severe complications according to Clavien-Dindo IV a and two patients died (Clavien-Dindo V) due to sepsis and multiorgan failure.

**Conclusion:** Our study suggests, that diverticulectomy (with/without myotomy) might be an effective surgical treatment leading to an improvement of symptoms and quality of life among patients with epiphrenic diverticulum. Still, the operative treatment is accompanied by considerable perioperative morbidity and should only be performed in carefully selected patients in experienced centers. Furthermore, minimally invasive procedures are associated with better post-operative outcomes compared to open procedures.

**Keywords:** Epiphrenic diverticulum; Diverticulum; Esophagus; Minimally invasive surgery; Conservative therapy

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### Introduction

Epiphrenic Diverticula (ED) are outpouchings of the esophageal mucosa and submucosa located in the distal part of the esophagus [1,2]. ED is a rare esophageal pathology, with a prevalence between 0.015% and 2% in radiological studies and an age peak in the 6<sup>th</sup> and 7<sup>th</sup> decade of life [3,4]. ED develop due to a chronic increase of intraesophageal pressure to the esophageal wall, which typically occurs in motility disorders, mechanical obstructions (after antireflux surgery or due to tumors), congenital or acquired tissue weaknesses (e.g. Ehlers-Danlos syndrome), after iatrogenic damage to the esophageal wall caused by myotomies or following tumor enucleations [2,3,5,6].

ED are usually diagnosed and assessed with a combination of endoscopy, esophagram and high-resolution manometry in order to locate the exact position of the diverticulum, determine the size of the diverticulum and look into possible esophageal motility disorders [7].

Patients with small ED are usually asymptomatic or have mild symptoms, and in many cases, diagnosis is an incidental finding [2]. In these patients, follow-up visits or conservative therapy is

advised [1]. Symptomatic patients typically present with dysphagia, regurgitation, thoracic pain, heartburn, weight loss or aspiration [3]. Large diverticula can give compression on neighboring structures, such as lung and heart. The character of the symptoms can vary individually and symptoms depend on the size of the diverticulum and possible underlying motility disorders [2,8-12]. Symptomatic patients have an indication for either conservative or surgical treatment. Conservative treatment consists of balloon dilatation, whereas surgical therapy comprises diverticulectomy, possibly in combination with myotomy or fundoplication, in case a motility disorder is confirmed.

Transthoracic diverticulectomy has been the standard of care for symptomatic ED for a long time. In 1959 however, Effler et al. suggested the combination of diverticulectomy and a long myotomy from the aortic arch down to 1 cm to 2 cm below the cardia, thereby giving consideration to functional obstruction involved in the etiology of ED [13]. This view was supported by Ronald Belsey and other leading surgeons of that time [14]. Later, it became clear, that cardiomyotomy extending down to 1 cm to 2 cm below the cardia could jeopardize functional results by facilitating Gastroesophageal Reflux (GERD) with potential complications like ulceration and stenosis. Therefore, the most popular surgical intervention today consists of diverticulectomy, cardiomyotomy, and fundoplication serving as an antireflux barrier [4]. As an alternative to cardiomyotomy, conservative treatment, including preoperative balloon dilatation of the lower esophageal sphincter, can be performed [15]. This approach offers the advantage of maintaining the esophagogastric anatomy to reduce the incidence of post-interventional reflux disease. As an alternative to diverticulectomy, diverticulopexy should also be considered. By using this method, it is possible to obliterate the diverticulum without excision and opening of the esophagus [9,16].

Surgical approaches can be either open (e.g. thoracotomy, laparotomy) or minimally invasive using Video Assisted Thoracoscopic Surgery (VATS) or laparoscopic transhiatal surgery [15]. Advantages of minimally-invasive surgery include among others improved patient comfort, shorter hospital stay and faster recovery times [1,17,18].

Since ED is such a rare esophageal disease, only a limited number of studies and case reports on treatment, postoperative outcomes and course of symptoms are available. Aim of this study thus was the retrospective evaluation of symptoms, quality of life and post-surgical complications among patients with epiphrenic diverticulum receiving surgical treatment. Furthermore, we compared different surgical approaches in the treatment of ED.

## Material and Methods

Patients diagnosed with an esophageal diverticulum were retrospectively included into this study. Accordingly, patient and follow-up information were retrospectively gathered from the hospital database "ORBIS" (version 08042702; Agfa HealthCare N.V., Belgium) including demographics, clinical reports on X-ray (esophagogram), esophagogastroduodenoscopy (e.g., Pentax Medical, Japan; Olympus Corporation, Tokyo, Japan) and manometry (if available).

The main outcome parameters were symptoms, quality of life and post-surgical complications. Treatment success was defined as the improvement of symptoms and quality of life after conservative or surgical treatment. In contrary, treatment failure was defined as the presence of refractory symptoms or worsening of symptoms.

Pre- and post-surgical symptoms as well as Health-Related Quality of Life (HRQoL) were evaluated using the Gastrointestinal Quality of Life Index (GIQLI). The GIQLI questionnaire was developed for the assessment of HRQoL of patients with diseases of the digestive system and includes 36 items divided into functional domains (physical, emotional, social, role and cognitive), with a five-point scale 0 to 4 points. Higher total scores reflect a better HRQoL [19]. Postsurgical complications were evaluated based on the Clavien-Dindo classification [20]. Accordingly, complications were classified based on severity into grade I (any deviation from normal postoperative course without the need of an intervention), grade II (pharmacological intervention required), grade III (surgical, endoscopic, or radiological intervention required under IIIa local anesthesia or IIIb general anesthesia), grade IV (life-threatening complications with IVa single organ dysfunction or IVb multiorgan dysfunction) and grade V (death of a patient) [20].

## Results

### Demographics

Twenty-three patients diagnosed with esophageal diverticula that were treated between 2005 and 2019 within the Department of General, Visceral, Cancer and Transplantation Surgery at the University Hospital of Cologne was considered for this study. Median age was 67 years (range: 39 to 85 years). Three patients (2 males, 1 female; median age 70 years) were treated conservatively and twenty patients (15 males, 5 females; median age 66.5 years) received a surgical therapy.

The following comorbidities were reported: Cardiovascular (n=13), pulmonal (n=2), stroke (n=2), Gastroesophageal Reflux Disease (GERD) (n=6), hypothyroidism (n=3), diabetes mellitus (n=3) or esophageal motility disorders (n=14). Eleven of the surgical treated patients previously underwent abdominal surgery, of whom four patients already underwent esophageal surgical procedures including fundoplication (n=3) as well as a combination of fundoplication and cardiomyotomy (n=1). Median follow-up of all patients was 4.15 months (range: 1 to 122.3 months), for conservatively treated patients 11.45 months (range: 1 to 28.3 months), and for patients of the surgical cohort 2.56 months (range: 1 to 122.3 months). Patients' demographics and comorbidities are summarized in Table 1.

### Endoscopic and surgical treatment

Depending on the initial symptoms, preexisting comorbidities, and the results from diagnostic tests, different therapeutic procedures were performed. Three patients underwent conservative treatment, including balloon dilatation, due to multiple severe comorbidities.

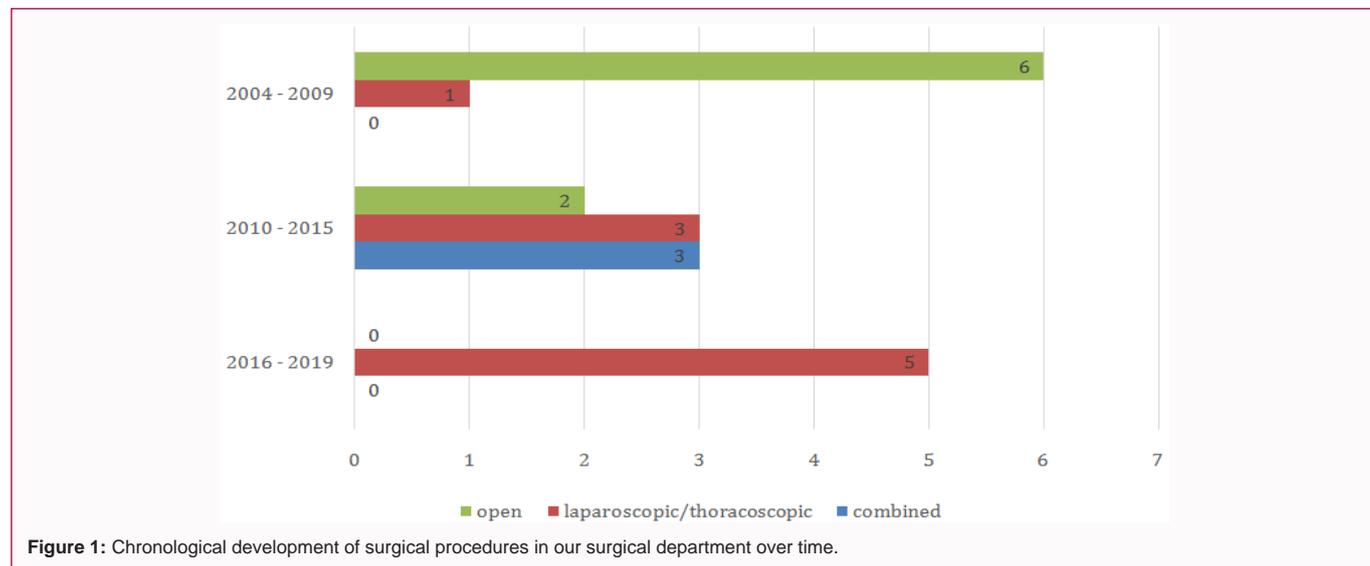
Fourteen patients received surgical therapy with diverticulectomy (seven with additional cardiomyotomy, five with additional balloon dilatation of the lower esophageal sphincter and one with additional cardiomyotomy and balloon dilatation). One patient underwent diverticulopexy and three additional patients had esophagectomy due to either presence of esophageal carcinoma or multiple diverticula and two patients received myotomy with diverticula left in situ (one with additional balloon dilatation). Median duration of surgery was 160 minutes (min: 61 min-max: 393 min) and median hospital stay was 13 days (min: 3-max: 174 days).

In eight cases, a thoracic approach was chosen for surgery while in nine patients, surgery was performed *via* an abdominal approach. In three patients who received esophagectomy, a combination of both thoracic and abdominal approaches.

**Table 1:** Patients' demographics and comorbidities.

Variable	Conservative treatment (n=3)	Surgical treatment (n=20)	Total (n=23)
<b>Demographics</b>			
<b>Gender</b>			
Male	2 (66%)	15 (75%)	17 (74%)
Female	1 (33%)	5 (25%)	6 (26%)
<b>Age</b>			
Median (min - max)	70 (62-85)	66.5 (39-78)	67 (39-85)
BMI kg/m <sup>2</sup>	not reported	25.14 (19.8-36.8)	-
Smoker	1 (33%)	4 (20%)	5 (22%)
<b>Comorbidities</b>			
Cardiovascular	2 (66%)	11 (55%)	13 (57%)
Arterial Hypertension	2 (66%)	11 (55%)	13 (57%)
Stroke	1 (33%)	1 (5%)	2 (8.7%)
Heart Valve Defect	1 (33%)	1 (5%)	2 (8.7%)
Arrhythmia	1 (33%)	1 (5%)	2 (8.7%)
Heart Failure	1 (33%)	2 (10%)	3 (13%)
Coronary Heart Disease	2 (66%)	0	2 (8.7%)
Diabetes mellitus	2 (66%)	1 (5%)	3 (13%)
Hypothyroidism	1 (33%)	2 (10%)	3 (13%)
Pulmonary Diseases	0	2 (10%)	2 (8.7%)
Gastroesophageal Reflux Disease	1 (33%)	5 (25%)	6 (26%)
Esophageal Motility Disorders	2 (14%)	12 (86%)	14 (61%)*
Previous Abdominal Surgery	1 (33%)	11 (50%)	12 (48%)
Previous Esophageal Surgery	0	4 (20%)	4 (17%)

\* A presurgical manometry to identify esophageal motility disorders was only performed in 14 patients



The majority of surgical procedures was performed laparoscopically (n=12). In one patient, surgical strategy was intraoperatively converted from laparoscopy to open surgery. Table 2 illustrates all surgical details of patients within the surgical cohort of this study. Figure 1 summarizes the chronological development of the surgical procedures in our surgical department.

**Symptoms and quality of life**

Pre-operative symptoms included heartburn (n=5), regurgitation

(n=12) and dysphagia (n=16). Some patients also presented with a combination of above-mentioned symptoms. Pretreatment evaluation of quality of life using the GIQLI questionnaire resulted in a median of 97.0 (range: 57-100). Among patients undergoing conservative treatment, complete resolution of symptoms was experienced. Within the surgical group, 80% completed the symptom questionnaire in the short-term follow-up. Among these patients, rates of heartburn, regurgitation, or dysphagia were decreased (n=2,

**Table 2:** Details of patients who underwent surgical treatment for epiphrenic diverticulum.

Patient Number	Endoscopic Balloon Dilatation	Surgical Intervention	Surgical approach	Surgery time (min)
1	no	Esophagectomy	Laparoscopy+Thoracotomy	393
2	no	Esophagectomy	Laparoscopy+Thoracotomy	373
3	yes	Esophagectomy	Laparoscopy+Thoracotomy	295
4	no	Diverticulopexy+Myotomy	Laparoscopy	107
5	no	Diverticulectomy+Myotomy	Laparoscopy	246
6	no	Diverticulectomy	Laparoscopy	227
7	no	Diverticulectomy+Myotomy	Laparoscopy	246
8	no	Diverticulectomy+Myotomy	Laparoscopy	288
9	no	Diverticulectomy+Myotomy	Laparoscopy	164
10	no	Diverticulectomy+Myotomy	Laparoscopy	105
11	yes	Diverticulectomy	Thoracoscopy	149
12	yes	Diverticulectomy	Thoracotomy	95
13	yes	Diverticulectomy+Myotomy	Thoracotomy	160
14	no	Diverticulectomy+Myotomy	Thoracotomy	200
15	yes	Diverticulectomy	Thoracotomy	158
16	yes	Diverticulectomy	Thoracotomy	96
17	yes	Diverticulectomy	Thoracotomy	130
18	no	Diverticulectomy+Myotomy	Thoracotomy	no information
19	no	Myotomy only, Diverticulum left <i>in situ</i>	Laparoscopy	61
20	yes	Myotomy only, Diverticulum left <i>in situ</i>	Laparoscopy	134

**Table 3:** Complications according to Clavien-Dindo classification occurring among included patients.

Grade of complication (Clavien-Dindo)	Number of Patients	Reason	Surgical intervention
No post-surgical complications	13	-	2x Esophagectomy 1x Diverticulopexy 7x Diverticulectomy 2x Diverticulum left, Myotomy only
I	4*	Fever Rib Fracture Diuretics required Urogenital infection	1x Esophagectomy 4x Diverticulectomy
II	0	-	-
IIIa	0	-	-
IIIb	0	-	-
IVa	1	Pneumonia with need of ICU	1x Diverticulectomy
IVb	0	-	-
V	2	Respiratory insufficiency → Death Tachyarrhythmia absoluta+pneumonia → Death	2x Diverticulectomy

\* no further information available for one patient; ICU: Intensive Care Unit

n=1 and n=2, respectively). The GIQLI showed a mean of 129.5 (range: 128-131), which is a mean increase of health-related quality of life of 32.5 points post-surgery.

### Morbidity and mortality

Postsurgical complications were evaluated according to the Clavien-Dindo classification and summarized in Table 3 [20]. In seven patients, who underwent surgery, post-surgical complications occurred. Four patients showed mild complications according to Clavien-Dindo I, including post-operative fever or urogenital infection. Complications according to Clavien-Dindo IVa were experienced in one patient who suffered from pneumonia with need of intensive care. Two patients died (Clavien-Dindo V) due to sepsis and multiorgan failure based on cardiovascular complications and severe pneumonia.

## Discussion

In this study, our single-center experience on the treatment of epiphrenic diverticula was retrospectively analyzed within a high-volume center for upper gastrointestinal surgery. Overall, twenty-three with ED were identified between 2005 and 2019, twenty patients underwent surgery and three were treated conservatively due to relevant comorbidities. Our findings suggest that postsurgical symptoms were regressive, and quality of life was improved within the short-term follow-up.

In the past, different surgical approaches have been established for the management ED including open, minimally-invasive and robotic-assisted approaches [21-25]. In the majority of patients, diverticulectomy is performed. In our cohort, diverticulectomy

was often combined with myotomy, which is in concordance with the literature reporting both surgical procedures in 84% to 93.3% of patients due to underlying motility disorders [26-28]. Some authors recommend minimally-invasive myotomy *via* thoracoscopy, especially when the neck of ED is located more than 5 cm above the gastroesophageal junction [25]. In contrast, ED directly above the diaphragm might be repaired transhiatally [23]. In contrary to several other studies, we did not combine diverticulectomy (with/without myotomy) with additional fundoplication [16,22,25]. Complete cardiomyotomy and fundoplication is usually performed simultaneously in order to reduce the risk of postoperative development of severe Gastroesophageal Reflux Disease (GERD) due to insufficiency of the lower esophageal sphincter [29]. To overcome this issue, we introduced the concept of preoperative endoscopic balloon dilatation of the Lower Esophageal Sphincter (LES) with subsequent transthoracic diverticulectomy and selective myotomy of the distal esophagus. In this way, the structure of the LES was protected since the post-interventional LES pressure is almost twice as high after cardiomyotomy compared to balloon dilatation [30].

Besides different surgical methods, the patient's morbidity as well as mortality is essential aspects of benign esophageal surgery. A considerable surgery-associated morbidity and mortality was detected in 15% of patients in our study. These post-surgical complications were most likely associated with more invasive, open surgery approaches. Over time, minimally invasive surgery has more and more replaced open procedures. This approach is associated with less perioperative complications, which is also in line with our findings. Tapias et al. reported a postsurgical overall morbidity of 35.5%, with major morbidity in 19.4% of patients (n=6), within their study considering open thoracotomy within 31 patients between 1974 and 2016 [28]. In 2013, Onwugbufo et al. presented a retrospective analysis using the US Nationwide Inpatient Sample database from 2000 to 2009 including 1056 patients with epiphrenic diverticulum who underwent surgery [31]. The authors stated that the postoperative mortality of 1.61% was mostly caused by sepsis. Considering the association between different surgical approaches and the resulting patients' morbidity, Onwugbufo et al. demonstrated that the risk of developing postoperative morbidity was higher in patients receiving thoracotomy compared to laparoscopy (OR: 7.45, 95% CI 1.11-50.18) [31]. These findings correlate with our own experience, as severe complications and mortality only occurred in patients undergoing open surgical approaches. We further observed that complications were reduced in patients undergoing minimally invasive surgery such as laparoscopy or thoracoscopy. Although there are still reports considering open-surgical approaches, minimal-invasive techniques dominate nowadays.

In our study only a few patients reported persistent heartburn, regurgitation, and dysphagia and health-related quality of life was improved. These findings indicate that surgical treatment in patients with ED effectively improves preexisting symptoms and quality of life. This correlates with the data of Tapias et al. who reported an excellent outcome (defined as absence of symptoms) in 75% of patients and Achim et al., who reported increased quality of life after surgery [28].

Literature suggests, that epiphrenic diverticulum is highly associated with esophageal motility disorders, such as achalasia [6]. In our study, 60.87% of patients were identified with an esophageal motility disorder. However, it is important to consider that manometry was not performed in all included patients as manometry was not implemented as standard assessment for epiphrenic

diverticulum until a later date. Nevertheless, based on our findings, it may be assumed that indeed there is an important correlation between esophageal motility disorders and epiphrenic diverticula. A possible explanation is the increased pressure on the esophageal wall due to functional obstruction of the lower esophageal sphincter, eventually leading to outpouching of the esophageal mucosa and submucosa. Accordingly, it is reasonable to look further into motility disorders after confirmation of epiphrenic diverticulum using high-resolution manometry.

Our study has some limitations that need to be considered, including the retrospective study design and the low sample size due to the general rarity of epiphrenic diverticula. Therefore, results should be interpreted carefully. Furthermore, the median follow-up time of 4.15 months was relatively short compared to other studies, meaning that conclusions on long-term results cannot be drawn. The short follow-up duration can be explained by the fact that patients were mostly only referred to our department for surgery, and further follow-up occurred elsewhere. However, still seven patients were observed for at least 33.3 months.

In addition, as mentioned before, not all patients received manometry during the initial diagnostic assessment, possibly leading to an underestimation of the association between esophageal motility disorders and epiphrenic diverticulum. For future investigations, a consequent diagnostic work-up including high-resolution manometry is highly recommended.

## Conclusion

Our study suggests that, in case of surgery, diverticulectomy (with or without myotomy) is an effective treatment resulting in an improvement of symptoms and quality of life in patients with an ED. Furthermore, we showed that minimally invasive abdominal approaches were associated with better post-operative outcomes in comparison to open procedures. Still, postoperative complications can also in patient undergoing minimally invasive procedures. We therefore recommend surgical treatment in experienced centers offering minimally invasive surgery in the treatment of epiphrenic diverticula in order to prevent occurrence of major complications associated with a high morbidity and mortality.

## References

1. Kilic A, Schuchert MJ, Awais O, Luketich JD, Landreneau RJ. Surgical management of epiphrenic diverticula in the minimally invasive era. *JLSL*. 2009;13(2):160-4.
2. Bennett B, Akhondi H. Epiphrenic diverticula. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2022.
3. Thomas ML, Anthony AA, Fosh BG, Finch JG, Maddern GJ. Oesophageal diverticula. *Br J Surg*. 2001;88(5):629-42.
4. Soares R, Herbella FA, Prachand VN, Ferguson MK, Patti MG. Epiphrenic diverticulum of the esophagus. From pathophysiology to treatment. *J Gastrointest Surg*. 2010;14(12):2009-15.
5. Smith CD. Esophageal strictures and diverticula. *Surg Clin North Am*. 2015;95(3):669-81.
6. Fisichella PM, Jalilvand A, Dobrowolsky A. Achalasia and epiphrenic diverticulum. *World J Surg*. 2015;39(7):1614-9.
7. Minneman JA, Wright AS. Epiphrenic diverticula: Diagnosis and management. In: Patti MG, Di Corpo M, Schlottmann F, editors. *Foregut surgery: Achalasia, gastroesophageal reflux disease and obesity*. Cham: Springer International Publishing; 2020;61-8.

8. Zaninotto G, Portale G, Costantini M, Merigliano S, Guirroli E, Rizzetto C, et al. Long-term outcome of operated and unoperated epiphrenic diverticula. *J Gastrointest Surg.* 2008;12(9):1485-90.
9. Altorki NK, Sunagawa M, Skinner DB. Thoracic esophageal diverticula. *J Thorac Cardiovasc Surg.* 1993;105(2):260-4.
10. Benacci JC, Deschamps C, Trastek VF, Allen MS, Daly RC, Pairolero PC. Epiphrenic diverticulum: Results of surgical treatment. *Ann Thorac Surg.* 1993;55(5):1109-13; discussion 1114.
11. Castrucci G, Porziella V, Granone PL, Piccicocchi A. Tailored surgery for esophageal body diverticula. *Eur J Cardiothorac Surg.* 1998;14(4):380-7.
12. Streitz JM Jr, Glick ME, Ellis FH Jr. Selective use of myotomy for treatment of epiphrenic diverticula. Manometric and clinical analysis. *Arch Surg.* 1992;127(5):585-7; discussion 587-8.
13. Effler DB, Barr D, Groves LK. Epiphrenic diverticulum of the esophagus: Surgical treatment. *AMA Arch Surg.* 1959;79(3):459-67.
14. Belsey R. Functional disease of the esophagus. *J Thorac Cardiovasc Surg.* 1966;52(2):164-88.
15. Rosati R, Fumagalli U, Bona S, Bonavina L, Peracchia A. Diverticulectomy, myotomy, and fundoplication through laparoscopy: A new option to treat epiphrenic esophageal diverticula? *Ann Surg.* 1998;227(2):174-8.
16. Nehra D, Lord RV, DeMeester TR, Theisen J, Peters JH, Crookes PF, et al. Physiologic basis for the treatment of epiphrenic diverticulum. *Ann Surg.* 2002;235(3):346-54.
17. Brandeis AE, Singhal S, Lee TH, Mittal SK. Surgical management of epiphrenic diverticulum: A single-center experience and brief review of literature. *Am J Surg.* 2018;216(2):280-5.
18. Mohiuddin K, Swanson SJ. Maximizing the benefit of minimally invasive surgery. *J Surg Oncol.* 2013;108(5):315-9.
19. Eypasch E, Williams JI, Wood-Dauphinee S, Ure BM, Schmülling C, Neugebauer E, et al. Gastrointestinal quality of life index: Development, validation and application of a new instrument. *Br J Surg.* 1995;82(2):216-22.
20. Clavien PA, Barkun J, De Oliveira ML, Vauthey JN, Dindo D, Schulick RD, et al. The Clavien-Dindo classification of surgical complications: Five-year experience. *Ann Surg.* 2009;250(2):187-96.
21. Balci B, Kilinc G, Calik B, Akbulut G. Robotic-assisted transthoracic esophageal diverticulectomy. *JLS.* 2018;22(2):e2018.00002.
22. Andolfi C, Wiesel O, Fisichella PM. Surgical treatment of epiphrenic diverticulum: Technique and controversies. *J Laparoendosc Adv Surg Tech A.* 2016;26(11):905-10.
23. Soo WT, Ling JSW, Chuah JS, Siow SL. Epiphrenic oesophageal diverticulum managed *via* laparoscopic transhiatal approach. *Med J Malaysia.* 2019;74(3):243-5.
24. Zaninotto G, Parise P, Salvador R, Costantini M, Zanatta L, Rella A, et al. Laparoscopic repair of epiphrenic diverticulum. *Semin Thorac Cardiovasc Surg.* 2012;24(3):218-22.
25. Achim V, Aye RW, Farivar AS, Vallières E, Louie BE. A combined thoracoscopic and laparoscopic approach for high epiphrenic diverticula and the importance of complete myotomy. *Surg Endosc.* 2017;31(2):788-94.
26. Andrási L, Paszt A, Simonka Z, Ábrahám S, Rosztóczy A, Lázár G. Laparoscopic surgery for epiphrenic esophageal diverticulum. *JLS.* 2018;22(2):e2017.00093.
27. Caso R, Chang H, Marshall MB. Evolving options in management of minimally invasive diverticular disease: A single surgeon's experience and review of the literature. *J Laparoendosc Adv Surg Tech A.* 2019;29(6):780-4.
28. Tapias LF, Morse CR, Mathisen DJ, Gaissert HA, Wright CD. Surgical management of esophageal epiphrenic diverticula: A transthoracic approach over four decades. *Ann Thorac Surg.* 2017;104(4):1123-30.
29. Richards WO, Torquati A, Holzman MD, Khaitan L, Byrne D, Lutfi R, et al. Heller myotomy versus heller myotomy with Dor fundoplication for achalasia. *Ann Surg.* 2004;240(3):405-15.
30. Campos GM, Vittinghoff E, Rabl C, Takata M, Gadenstätter M, Lin F, et al. Endoscopic and surgical treatments for achalasia: A systematic review and meta-analysis. *Ann Surg.* 2009;249(1):45-57.
31. Onwugbuor MT, Obirize AC, Ortega G, Allen D, Cornwell EE, Fullum TM. Surgical management of esophageal diverticulum: A review of the Nationwide Inpatient Sample database. *J Surg Res.* 2013;184(1):120-5.