



(RESEARCH ARTICLE)



Management of esophageal diverticula through an open surgical approach: A 16 year experience

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GSC Advanced Research and Reviews, 2022, 12(02), 026–037

Publication history: Received on 26 June 2022; revised on 31 July 2022; accepted on 02 August 2022

Article DOI: <https://doi.org/10.30574/gscarr.2022.12.2.0200>

Abstract

Introduction: Esophageal diverticula are rare. There are controversies over the indication for surgery and the optimal surgical approach in these patients. In this study, we target to evaluate the complications and outcomes of 34 surgery candidates with esophageal diverticula undergoing an open approach.

Method: This is a retrospective review of patients with either cervical or thoracic diverticula who underwent surgery by thoracic surgery teams over a 16-year period. The selected surgical approach was postero-lateral thoracotomy for mid-esophageal and epiphrenic diverticula and left side neck incision for cervical esophageal diverticula. Myotomy was performed only in the case of esophageal motility disorders in patients with thoracic diverticula and in all patients with cervical diverticula. The postoperative intermediate-term outcomes were assessed.

Results: Of the 34 patients, 9 patients had cervical diverticula, 13 (38%) had mid-esophageal diverticula and 12 (35%) of those had epiphrenic diverticula. All the patients with epiphrenic and mid-esophageal diverticula underwent postero-lateral thoracotomy, and those with cervical esophageal diverticula underwent cervical approach. 21 patients underwent diverticulectomy and myotomy (61%), and 6 patients underwent diverticulectomy alone (17%). There were a total postoperative (4 patients). None of the patients had in-hospital or 30-day mortality.

Conclusion: Although in this era, minimally invasive approach is the first choice for diverticulectomy; however, we observed that in our study the mortality and leak rates were as low as those of the previous studies. Hence, open approach could be safe and effective if it is performed by surgeons with high degree of expertise.

Keywords: Esophageal diverticula; Esophageal surgery; Diverticulectomy; Esophageal myotomy; Thoracotomy

1. Introduction

Esophageal diverticula are outpouchings emerging from the wall of the esophagus. They are mostly male-dominated and are typically seen in elderly. Approximately, less than 1% of the general population and less than 3% of the population with dysphagia have esophageal diverticulum; hence, they are relatively rare. Zenker diverticulum is the commonest type of all esophageal diverticula, and pulmonary aspiration is the most serious consequence of this type.

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[4] Esophageal diverticulum typically manifests itself as dysphagia; it is, nonetheless, asymptomatic in most cases and would not be diagnosed until the patient becomes symptomatic. [4] Esophageal diverticula can be classified based upon their location, histological findings (false or true), or pathophysiology of formation (traction or pulsion). [1] True diverticula are made up of all 4 layers of esophageal wall, whereas false diverticula merely contain mucosa and submucosa. Pulsion diverticulum typically occurs in view of increased intraluminal pressure, mostly in the setting of esophageal motility disorders. Commonly only mucosal tissue herniation is present (so it is known to be a false diverticulum). In contrast, traction diverticulum occurs as a result of retraction and pulling of the esophageal wall secondary to mediastinal inflammation and scarring such as in tuberculosis and histoplasmosis. Mostly all layers are involved in this process (true diverticulum) [1]. As far as location is concerned, diverticula can be categorized as pharyngeal diverticula, mid-esophageal diverticula, and epiphrenic diverticula. Zenker diverticulum, the most common type of pharyngeal diverticula, is formed in the hypopharynx at the kilian's triangle (a muscular weak point between the cricopharyngeal and thyropharyngeal parts of the inferior pharyngeal constrictor muscle). Impaired upper esophageal sphincter (UES) relaxation and increased pharyngeal pressure were both evident in patients with zenker diverticulum based on manometric studies. [2] Mid-esophageal diverticulum occurs at the bifurcation of trachea and is generally known as traction diverticulum. It usually results from mediastinal inflammatory reactions. Middle esophageal diverticulum was a very common finding in tuberculosis infected patients with involved mediastinal lymph nodes during tuberculosis era [2]. Epiphrenic Diverticulum forms in the distal 10 centimeters of the esophagus in relation to inadequate relaxation of the LES and consequently high intraluminal pressure. This type of diverticula is usually in association with motility disorders. Achalasia and diffuse esophageal spasm are frequently associated with this type of diverticula [2]. Identical to zenker diverticula, epiphrenic diverticula are also considered as a pulsion diverticula; thus, they are both false or pseudo diverticula.

There are several diagnostic workups for the patients who are suspected with esophageal diverticulum. Barium swallow is a useful study not only to diagnose but also to determine the location and size of the diverticulum; furthermore, most patients are diagnosed with this diagnostic modality [1, 2]. It is mandatory for all patients to undergo upper digestive endoscopy as soon as the diverticulum is suspected, which can help confirm the presence of the disease and rule out associated disorders such as malignancy. 2 Manometry is also regarded as a gold standard test, determining the associated motor disorder such as achalasia. [1, 2]

A non-operative management is usually considered in asymptomatic patients with diverticula, owing to an insignificant risk of malignancy and associated complications in these patients. Cases with middle esophageal and epiphrenic diverticula are usually in this category. Symptomatic patients should undergo either surgical or endoscopic therapeutic approaches. Patients with pharyngeal diverticulum are more likely to be in this category. In patients with symptomatic epiphrenic diverticula, the application of routine myotomy in addition to diverticulectomy is rather logical owing to the fact that there is a close association between epiphrenic diverticula and the underlying esophageal dysmotility [2, 3]. For patients with zenker diverticulum, cricopharyngeal myotomy is performed with or without a diverticulectomy/diverticulopexy. Leaks and vocal cord paralysis were found to be the most frequent postoperative complications [2].

There are controversies over the indication for surgery, optimal surgical approach and procedure in the treatment of esophageal diverticula. Whether to perform an open or minimally invasive surgery (MIS) in the treatment of esophageal diverticula is still a notable point of contention.

The objective of the present study is to review and evaluate the perioperative and postoperative outcomes of those symptomatic patients with esophageal diverticula who underwent diverticulectomy through an open surgical approach during a period of 16 years.

2. Methods

This study is a retrospective review of the patients with either cervical or thoracic esophageal diverticula who were operated on by Razi and Arya medical centers' thoracic surgery teams over a 16-year period between the years 2002 and 2018. The institutional board of Guilan University approved our study protocol. Informed consents were obtained from all participants of the study.

A complete preoperative evaluation including physical examination and medical history was performed for all surgery candidates. Investigations performed prior to the surgery were: esophageal manometry, barium esophagram, and esophagoscopy. Esophageal motility disorders were also identified prior to the surgery. We tailored the surgical approach based upon the location of the esophageal diverticulum. The approach we used was right or left postero-lateral thoracotomy for mid-esophageal and epiphrenic diverticula, respectively. We also used left side neck incision for

cervical esophageal diverticula. Patients underwent flexible esophagoscopy just before the surgery in an attempt to confirm the location of the diverticulum and assess any other esophageal abnormalities. Patients with lower esophageal or epiphrenic diverticula underwent left thoracotomy since it provided optimal access to distal esophagus as well as gastro-esophageal junction and cardia.

We meticulously dissected away the esophageal diverticula from the enclosing structures down to the neck of the diverticulum via an ultrasonic shears, without allowing perforation into the diverticular lumen. In order not to leave a residual diverticulum behind at the surgery site, all the diverticular neck was exposed. The aforementioned process was facilitated by a myotomy in patients with thoracic diverticula if a motility disorder was confirmed prior to the surgery; nevertheless, in the case of cervical diverticula, myotomy was performed on all patients regardless of presence of a motility disorder. The diverticulum was excised via either a linear endo-GIT 60 stapler (Auto Suture; United States Surgical Corporation, Norwalk, CT) after a 44F to 54F bougie had been placed in the esophagus. We excluded any leakage in the staple-line by a hydro-pneumatic test after the surgery.

Myotomy was performed proximally to the neck of the diverticulum and was extended distally, but the degree of the extension to the distal part varied from patient to patient based upon intraoperative and preoperative findings. In patients with epiphrenic diverticula, myotomy was extended distally along the esophagus across the lower esophageal sphincter onto the stomach, then all the overlying structures encompassing muscle and pleura were reapproximated over the diverticulectomy site. A chest tube was placed in the pleural space in patients who underwent thoracotomy, and a penrose drain was inserted in the operation site in patients who underwent cervical diverticulectomy.

Esophagram was performed 48 hours after the operation in order to rule out a leak and make sure that the entire diverticulum had been resected. If free flow of contrast was detected and there was no evidence of leak, the patient was discharged on the 4th or 5th day postoperatively. We collected data on preoperative characteristics, surgical approach, intervention, and postoperative outcomes. The primary outcome was 30-day mortality. Preoperative outcome variables encompassing morbidities, postoperative leaks, and length of hospital stay were also evaluated. Regular follow up visits were arranged and all the symptoms including: dysphagia, heart burn, reflux, cramping, diarrhea and so on were meticulously assessed in the postoperative setting through these visits.

In the last follow up visit for each patient, the intermediate-term functional result of the operation was documented as follows:

- excellent (no symptoms),
- good (mild symptoms, no treatment required),
- fair (symptoms sometimes requiring treatment, eg, occasional antispasmodics for cramping or esophageal dilation for dysphagia), or
- poor (frequent symptoms always requiring treatment, eg, antispasmodics on a daily basis or repeated dilations for dysphagia);

Furthermore, in terms of satisfaction, patients were asked if they were satisfied with the outcome of the surgery and felt better after the surgery.

3. Results

A total of 34 patients underwent surgery due to symptomatic esophageal diverticula. There were 22 men and 12 women. Patients had a mean age of 56 years old. The most frequent presenting symptoms were dysphagia (30; 88%), regurgitation (26; 76%), and chronic aspiraton (25; 73%). Of the 25 patients with thoracic diverticula, in 15 (44%) patients the diverticula were in the right side, and in 10 (29%) were in the left side.

3.1. Symptoms and preoperative work up

Of the 34 patients, 12 patients had epiphrenic diverticula, 13 patients had mid-esophageal diverticula, and 9 patients had cervical diverticula. Three patients were identified to have multiple diverticula. All the patients had undergone upper endoscopy and barium esophagram before the surgery (34; 100%); however, manometry was done for 22 patients. Functional disorders were identified in 18 patients (53%) through manometry or tertiary contractions observed on barium swallow. Patients with achalasia (12 patients; 35%), diffuse esophageal spasm (2 patients; 6%), and hypertensive LES (4 patients; 12%) were the surgery candidates due to esophageal motor disorders.

3.2. Surgical approach and procedure

All the patients with epiphrenic and mid-esophageal diverticula underwent open transthoracic approach 25 (73%), while the remaining 9 (26%) patients who had cervical diverticula underwent cervical approach.

With respect to the procedure, 21 patients (61, 76%) underwent both diverticulectomy and myotomy; hence, it was the most common procedure (61%), whereas diverticulectomy only was performed without myotomy (38, 24%) in 13 patients. Six (17%) of patient have normal manometry. None of the patients underwent fundoplication in this study.

3.3. Complications in the postoperative period

Liquids began on the first postoperative day. On the third postoperative day, soft diet also started. Patients resumed oral intake after we ensured that there was no extravasation in water-soluble contrast examination. If leakage was absent, patients were allowed to initiate a liquid diet and then advanced to a general diet. As of discharge, 26 patients were on a general diet, and the remaining 8 were on soft diet. The median duration of hospital stay was 8 days. There were neither intraoperative and in-hospital death (0%) nor 30-day mortality (0%). Esophageal leak, pleural effusion and deep vein thrombosis were the most common complications after the operation. Of the 4 (12%) postoperative leaks, 2 of them were developed in patients with thoracic diverticula, and 2 were developed in patients with cervical diverticula. All the leaks occurred in patients undergoing diverticulectomy and myotomy. In addition, all the 4 leaks were observed in patients with concomitant motility disorders, which had been confirmed prior to surgery. Of the 2 patients who had developed leak in thoracic diverticula, one required stent placement, while the other one was managed by drain. The remaining 2 leaks, occurring to patients with cervical diverticula, were managed by drain. It should be noted that no reoperation was performed to repair the leaks.

The recurrence of the diverticula occurred in one patient with thoracic diverticulum. It appeared on the contralateral side in mid thoracic area and was documented through Bsand endoscopy. Respiratory complications in this study (eg, PE, acute respiratory failure, pneumothorax, pleural effusion and etc) did not increase the length of hospital stay, and the hospital stay course was uneventful for these patients.

Follow up: Patients were followed for a mean of 28 months.

In the last follow up visit of the 34 patients, functional results were assessed.

- 22 patients (64.7%) were symptom free (excellent result) at the end of the follow up
- 12 patients (35%) experienced mild symptoms, but did not require any treatment (good result),
- None of the patients with mild symptoms required occasional antispasmodics and/or intermittent dilation (fair result)
- None of the patients experienced persistent symptoms and required intermittent regular dilations (poor result)

At the 28th month of follow up, all the 34 patients were satisfied with the result of the surgery with regard to pain and symptom-relief, and none complained about the recurrence of symptoms.

4. Discussion

In this study, our surgical approach was open transthoracic surgery for epiphrenic and midesophageal diverticula.

While the trend for epiphrenic and midesophageal diverticulectomy has recently been in favor of minimal invasive approach, we selected the conventional open surgical approach on account of the fact that all operations were performed over the years between 2002 and 2019 and that the corresponding data were collected retrospectively through these 17 years. This study aimed to demonstrate that in the dearth of thoracoscopy and laparoscopy tools, open approach was still safe for thoracic diverticula. Surprisingly, no mortality occurred in our 34 surgery candidates during their hospital stay or in the 30 postoperative days.

Despite the existing controversies regarding the management of patients with esophageal diverticula, most surgeons reached the consensus that for the symptomatic patients with diverticula, there is an indication for surgery [5, 6], although choosing the appropriate surgical approach for the asymptomatic patients still remains controversial.

Meanwhile, our strategy was to offer surgical approach only to symptomatic patients as well as those asymptomatic patients with large diverticula associated with motor dysfunction. Asymptomatic patients with small diverticula and minimal complaints were just observed until developing symptoms.

There are variations in selecting the procedure for the treatment of esophageal diverticula.

While performing diverticulectomy, it is crucial to fully expose the neck of the diverticulum in order to identify the line of transection. Although failure of the attempt to respect the entire diverticulum may not affect short-term outcomes, it may result in the enlargement of the residual diverticulum and the subsequent recurrence of the symptoms over time. As a routine procedure, we covered the line of the suture in the diverticulectomy site through the re-approximation of the pleura and muscles.

In our study, all patients underwent diverticulectomy, but concomitant myotomy was performed only in the presence of concomitant motor disorders in patients with thoracic diverticula and in all patients with cervical diverticula.

Whether to perform a routine or selective myotomy is highly debatable. Based on previous reports, high leak rates were reported in patients for whom myotomy was not included [7]; thus, many surgeons favor to perform a routine myotomy in patients with esophageal diverticula either in those with or without a concomitant motor disorder. [8-14]

Notwithstanding all the benefits and drawbacks, we tended to approach more selectively and only considered myotomy in individuals with identified concomitant motor disorders before they underwent surgery. This approach is in line with previous studies favoring the aforementioned selective approach [5, 15, 16]. Hence, identifying the presence of a motor disorder through esophagoscopy, esophagram and manometry could be important preoperatively to step up the surgery outcome by selecting the most appropriate approach.

Cardiomyotomy was considered as an ideal method in our study, and it was extended onto the stomach so as to achieve relief of the distal obstruction. It is worth noting that the same method was utilized by other surgeons in previous studies in patients with or without underlying motility disorders [6, 8, 10, 11, 14]; however, due to insufficient data there is still a debate over which myotomy is the choice.

There is an ongoing debate about whether or not to consider the fundoplication during the procedure. Based on Thomas et al.'s study [17], no difference was detected in leak rates in patients on whom myotomy was performed with or without fundoplication; however, the rate of the postoperative heartburn was higher in patients on whom fundoplication was not performed.

With regard to Belsry et al study [8] the rate of postoperative reflux was high in achalasia patients on whom myotomy was performed without fundoplication; however, In our series despite the fact that no fundoplication was performed after cardiomyotomy in patients with distal diverticula, the rate of postoperative heartburn was low (2%). In a recent study, the postoperative leak rate was 24% after diverticulectomy concomitant with myotomy and complete fundoplication [18]; however, the leak rate appeared to be 4% in our study.

Some previous studies advocated for a concomitant antireflux procedure for patients who had undergone esophagomyotomy [8, 19], but we do not normally perform an antireflux procedure in addition to esophagomyotomy once the hiatal hernia is absent. None of our patients had hiatal hernia; hence, no antireflux procedure was carried out. We can accordingly conclude that both myotomy and antireflux procedure should be carried out selectively to minimize the potential complications postoperatively.

With respect to the surgical approach, the direct comparison between open approach and minimally invasive surgical approach could be a difficult one due to variations in patient population. Based on previous open approach series, morbidity varied from 6% to 33%, with leak rate of 18% [5, 6, 9-12, 14, 15, 20], while in series publishing the results of MIS approaches, a morbidity rate of 7 to 29% and the leak rate of 24% were observed. [16, 18, 21-25] In our study with open approach, a morbidity rate of 50% was observed and appeared to be a bit higher than previous series, nonetheless, no 30-day, perioperative and in hospital mortality occurred and the leak rate of 12% revealed a lower leak rate compared to the previous studies with approach [5, 6, 9-12, 14, 15, 20], as well as those with MIS approach [16, 18, 21-25]. On the whole, no significant difference was observed either in leak rates or in morbidity rates in our study compared to previous studies.

Traditionally, right thoracotomy approach was selected for mid-esophageal diverticula and left thoracotomy was appropriate for the management of epiphrenic diverticula [5, 9-12, 15]. In our study, right posterolateral thoracotomy

was selected for upper and mid-esophageal diverticula and left posterolateral thoracotomy was applied for lower esophageal diverticula and epiphrenic diverticula, they provide better access to diverticulum in distal esophagus allowing resection and mobilization of the diverticulum.

This study has a number of limitations. First, all the patients were managed through an open approach since data collection initiated 12 years ago when MIS was not in vogue. Secondly, as the study was carried out in a retrospective fashion, selection bias is expected. Thirdly, longer follow-up was required to better evaluate the symptom-relief duration and investigate further adverse outcomes that may occur later in postoperative years.



Figure 1 Computed Tomography (CT) scan of the chest with oral contrast shows a huge right side epiphrenic diverticulum



Figure 2 A large epiphrenic diverticulum freeing from the adjacent structures



Figure 3 A huge cervical diverticulum mobilizing from the adjacent structures

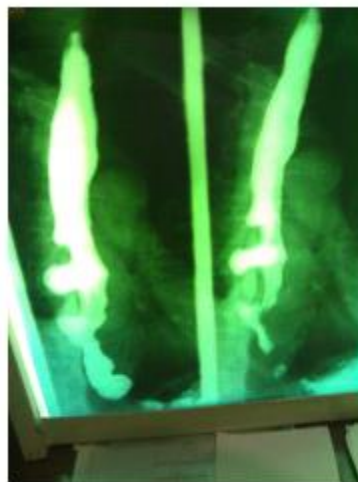


Figure 4 Barium swallow shows a huge left side epiphrenic diverticulum

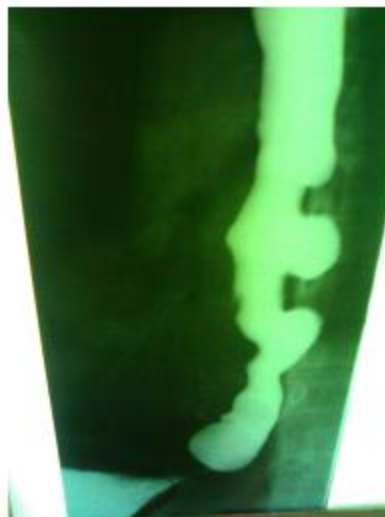


Figure 5 Swallow shows three mid-esophageal diverticula on the left side

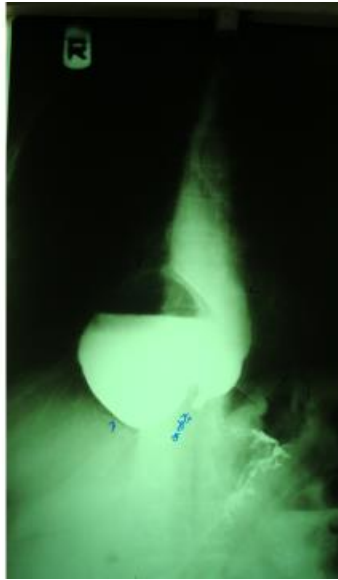


Figure 6 Barium swallow shows a left side cervical esophageal diverticula (zenker diverticulum)



Figure 7 Barium swallow of a patient with huge epiphrenic diverticulum projecting to the right side of the patient



Figure 8 Barium swallow shows a large cervical diverticulum mobilizing from the adjacent structures

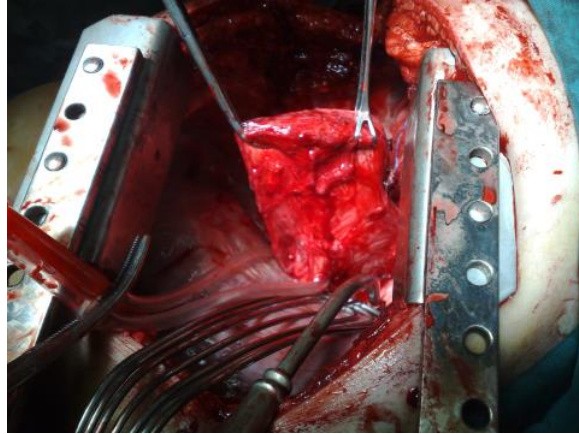


Figure 9 A large epiphrenic diverticulum freeing from the adjacent structures

Table 1 Perioperative Characteristics of the patients

Characteristic	N (%)
Symptoms prior to surgery	
Dysphagia	30 (88)
Regurgitation	26 (76)
Heartburn	12 (35)
Massive hemoptesis	1 (2)
Respiratory symptoms	25 (73)
Weight loss	18 (52)
Characteristics of the diverticula	
Location	
Epiphrenic	12 (35)
Midesophageal	13 (38)
Cervical	9 (26)
Both	-
Size (cm), Median (range)	-
Multiple diverticula	3 (8)
Preoperative work-up	
Barium esophagram	34(100)
Upper endoscopy	34(100)
Manometry attempted	21 (61)
Associated functional disorders	
Achalasia	12 (35)
Hypertensive LES	4 (12)
Diffuse esophageal spasm	2 (6)

Surgical Approach	
Thoracotomy	25 (73)
Cervical	9 (26)
procedures	
Diverticulectomy only	13 (38, 34%)
Diverticulectomy/myotomy	21 (61, 76%)

Table 2 Perioperative Morbidity and Mortality

Mortality (30-days)	0 (0%)
Mortality (in-hospital)	0 (0)
Morbidity	17 (50)
Esophageal leak	4 (12)
Respiratory	
Acute respiratory failure	1 (3)
Pulmonary embolism	2 (6)
Emphyema	2 (6)
Effusion requiring drainage	4 (12)
Pneumonia	3 (9)
Pneumothorax	4 (12)
Atelectasis	5 (15)
Cardiovascular	
Myocardial Infarction	3 (9)
Congestive heart failure	2 (6)
Deep venous thrombosis	4 (12)
Cerebrovascular accident	1 (3)
Other	
Acute renal failure	1 (3)
Follow-up result	
Excellent	22 (64.7)
Good	12 (35)
Fair	0 (0)
Poor	0 (0)

5. Conclusion

In this study we targeted to manage asymptomatic or minimally symptomatic patients conservatively. If incapacitating symptoms were present, diverticulectomy with or without myotomy is highly recommended. In the dearth of minimal invasive surgical tools, an open approach is also safe and effective if it is performed by experienced surgeons. Although minimal invasive surgery is currently the first choice, we should determine the optimal surgical approach as well as the procedures on the basis of individuals' clinical circumstances after a thorough preoperative evaluation.

Compliance with ethical standards

Acknowledgments

We thank all the staff members from Thoracic General Surgery department of Razi Hospital, that greatly assisted the present research. In addition, we express special thanks to the patients who consented to participate in this study. This study did not receive any specific grant from funding agencies.

Disclosure of conflict of interest

The authors declare no conflict of interest for this article regarding the consent and application of this paper. All the authors participated in the interpretation and analysis of the data, revised the manuscript, read and approved the final version

Statement of ethical approval

The study protocol has been approved by Ethics Committee of Guilan University of Medical Sciences and was registered by Razi University Hospital. Animal studies was not applicable.

The approval was obtained from deputy of Inflammatory Lung Diseases Research Center, Department of Internal Medicine, Razi Hospital, School of Medicine, Guilan University of Medical sciences.

Statement of informed consent

Written informed consent was obtained from all the study participants.

References

- [1] Achkar E. Esophageal diverticula. *Gastroenterol Hepatol (N Y)*. 2011;4 (10): 691-3
- [2] Herbella FA, Patti MG. Modern pathophysiology and treatment of esophageal diverticula. *Langenbecks Arch Surg*. 2012;397 (1): 29-35
- [3] D'Journo XB, Ferraro P, Martin J et-al. Lower oesophageal sphincter dysfunction is part of the functional abnormality in epiphrenic diverticulum. *Br J Surg*. 2009;96 (8): 892-900.
- [4] Ferreira LE, Simmons DT, Baron TH (2008) Zenker's diverticula: pathophysiology, clinical presentation, and flexible endoscopic management. *Dis Esophagus* 21(1): 1-8
- [5] 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: 585-7.
- [6] Altorki NK, Sunagawa M, Skinner DB. Thoracic esophageal diverticula. Why is operation necessary? *J Thorac Cardiovasc Surg*. 1993; 105: 260-4.
- [7] Allen TH, Clagett OT. Changing concepts in the surgical treatment of pulsion diverticula of the lower esophagus. *J Thorac Cardiovasc Surg*. 1965; 50: 455-62.
- [8] Belsey R. Functional disease of the esophagus. *J Thorac Cardiovasc Surg* 1966;52:164-88.
- [9] Benacci JC, Deschamps C, Trastek VF, Allen MS, Daly RC, Pairolero PC. Epiphrenic diverticulum: results of surgical treatment. *Ann Thorac Surg*. 1993; 55: 1109-14.
- [10] Varghese TK Jr, Marshall B, Chang AC, Pickens A, Lau CL, Orringer MB. Surgical treatment of epiphrenic diverticula: a 30-year experience. *Ann Thorac Surg*. 2007; 84: 1801-9.
- [11] Nehra D, Lord RV, DeMeester TR, et al. Physiologic basis for the treatment of epiphrenic diverticulum. *Ann Surg*. 2002; 235: 346-54.
- [12] D'Journo XB, Ferraro P, Martin J, Chen LQ, Duranceau A. Lower oesophageal sphincter dysfunction is part of the functional abnormality in epiphrenic diverticulum. *Br J Surg*. 2009; 96: 892-900.
- [13] Reznik SI, Rice TW, Murthy SC, Mason DP, AppersonHansen C, Blackstone EH. Assessment of a pathophysiologydirected treatment for symptomatic epiphrenic diverticulum. *Dis Esophagus*. 2007; 20: 320-7.

- [14] Fekete F, Vonns C. Surgical management of esophageal thoracic diverticula. *Hepatogastroenterology*. 1992; 39: 97–9.
- [15] Castrucci G, Porziella V, Granone PL, Picciocchi A. Tailored surgery for esophageal body diverticula. *Eur J Cardiothorac Surg*. 1998; 14: 380–7.
- [16] Klaus A, Hinder RA, Swain J, Achem SR. Management of epiphrenic diverticula. *J Gastrointest Surg*. 2003; 7: 906–11.
- [17] Thomas ML, Anthony AA, Fosh BG, Finch JG, Maddern GJ. Oesophageal diverticula. *Br J Surg*. 2001; 88:629–42.
- [18] Rossetti G, Fei L, del Genio G, et al. Epiphrenic diverticula mini-invasive surgery: a challenge for expert surgeons— personal experience and review of the literature. *Scand J Surg*. 2013; 102:129–35.
- [19] Little AG, Soriano A, Ferguson MK, Winans CS, Skinner DB. Surgical treatment of achalasia: results with esophagomyotomy and Belsey repair. *Ann Thorac Surg*. 1988; 45: 489-94.
- [20] Hudspeth DA, Thorne MT, Conroy R, Pennell TC. Management of epiphrenic esophageal diverticula. A fifteen-year experience. *Am Surg*. 1993; 59: 40-2?
- [21] Soares RV, Montenovolo M, Pellegrini CA, Oelschlager BK. Laparoscopy as the initial approach for epiphrenic diverticula. *Surg Endosc*. 2011; 25: 3740–6.
- [22] Melman L, Quinlan J, Robertson B, et al. Esophageal manometric characteristics and outcomes for laparoscopic esophageal diverticulectomy, myotomy, and partial fundoplication for epiphrenic diverticula. *Surg Endosc*. 2009; 23: 1337–41.
- [23] Tedesco P, Fisichella PM, Way LW, Patti MG. Cause and treatment of epiphrenic diverticula. *Am J Surg*. 2005; 190: 891–4?
- [24] Peracchia A, Bonavina L, Rosati R, et al. Thoracoscopic resection of epiphrenic diverticula. In: Peters J, DeMeester TR (eds). *Minimally invasive surgery of the foregut*. St. Louis, MO: QMP Inc. 1994; 110–6.
- [25] Van der Peet DL, Klinkenberg-Knol EC, Berends FJ, Cuesta MA. Epiphrenic diverticula: minimal invasive approach and repair in five patients. *Dis Esophagus* 2001; 14: 60–2.