



Semi-prone video-assisted thoracoscopy for the treatment of large infracarinal traction diverticula

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Abstract

Background Large middle-third esophageal diverticula are rare. Thoracotomy has been proposed as mainstay of treatment; however, minimally invasive resection through lateral or prone position thoracoscopy has been described.

Methods The technical aspects of the novel semi-prone minimally invasive thoracoscopy (spVATS) in the management of large (> 5 cm) infracarinal traction diverticula are described. Operative outcomes, pre- and postoperative symptoms (Eckardt score) and quality of life (Short-Form 36) are analyzed.

Results Four symptomatic patients underwent spVATS for traction midesophageal diverticula. The median age was 59 years and 75% were males. The median diverticulum size was 7.0 cm (range 5.5–8). The median preoperative Eckardt score was 8.4 (range 5–10), and the overall incidence of respiratory symptoms was 50%. Esophageal manometry was performed in three patients with no evidence of underlying motility disorders. The median operative time was 149 min (range 125–175). No intraoperative complications or open conversions occurred. Postoperative morbidity and mortality were 25% and 0%, respectively. The median hospital length of stay was 7.5 days (range 6–10). The median postoperative follow-up was 22 months (range 5–35). At the last follow-up, there was a significant improvement of patients' symptoms ($p = 0.024$) and quality of life ($p < 0.05$) with complete resolution of respiratory symptoms.

Conclusion In summary, spVATS seems a valuable approach to treat large midesophageal traction diverticula in centers experienced with minimally invasive esophageal surgery. Further studies are needed to validate the advantages and promising outcomes of the spVATS providing more robust evidence on the treatment of this rare clinical entity.

Keywords Semi-prone thoracoscopy · Diverticulectomy · Midesophageal diverticula

Introduction

Midesophageal diverticula are rare clinical entities accounting for less than 30% of esophageal diverticula. The majority of

patients are asymptomatic or have minimal symptoms; however, about one-third of patients present with disabling symptoms [1, 2]. They usually result from traction phenomenon caused by chronic inflammatory mediastinal diseases that cause full-

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thickness esophageal wall protrusion [3]. Thoracotomy has been proposed as mainstay of treatment; however, resection through lateral or prone position thoracoscopy has been described [4–8].

Semi-prone minimally invasive thoracoscopy (spVATS) has been proposed for major thoracic surgery such as minimally invasive esophagectomy as it allows optimal surgical exposure and an expedite conversion in case of necessity [9, 10]. Up to our knowledge, no previous reports are available on the treatment of large (> 5 cm) midesophageal diverticula via spVATS. The purpose of this descriptive case-series is to illustrate the technical aspects and medium-term outcomes of the spVATS in the management of large (> 5 cm) symptomatic infracarinal midesophageal diverticula.

Patients and methods

This is a single-center descriptive study approved by the Institutional Review Board. The collected database at our tertiary care University hospital was reviewed to identify adult patients treated for a large (> 5 cm) symptomatic infracarinal midesophageal diverticula. Patients with epiphrenic diverticula were excluded. No cases were managed via open thoracotomy during the study period.

All patients underwent preoperative upper gastrointestinal endoscopy, barium swallow study, and thoracic CT scan (Fig. 1a, b). Seven days before surgery, patients were allowed to eat a clear liquid diet. An endoscopic evaluation was performed 24 h before surgery and if necessary, endoscopic wash-out was performed to clear the diverticulum from retained undigested debris. Patients' characteristics, operative variables, postoperative complications, hospital stay, and mortality were recorded. In addition, preoperative and postoperative symptoms and patients' quality of life were evaluated using the Eckardt score and Short-Form 36 (SF-36) [11, 12]. The Eckardt score consists of four components including dysphagia, chest

pain, regurgitation, and weight loss. Each component is assigned a score from 0 to 3 based on the patient's self-reported response, resulting in a total score that can vary from 0 to 12. A symptom score of 0–1 corresponds to clinical stage 0, a score of 2–3 to stage I, a score of 4–6 to stage II, and a score >6 to stage III. Stages 0 and I indicate symptom remission while stages II and III represent treatment failure or symptoms recurrence [13]. Respiratory symptoms and related complications were also recorded. Cough was defined as chronic paroxysmal cough lasting more than 8 weeks [14]. Aspiration pneumonia was defined by the presence of symptoms or signs suggestive of lower respiratory tract infection, including sputum production, and fever with radiological confirmation of a lung infiltrate [15]. A gastrographin swallow study was performed on postoperative day four. If negative, the patient was allowed to restore a semiliquid diet and the chest tube was removed. Patients were scheduled for an office follow-up visit two months after surgery and then every six months after surgery. A barium swallow study and upper gastrointestinal endoscopy were performed every six months after the operation or whenever the patient complained of recurrent symptoms.

Surgical technique

The patient is intubated in the supine position and then turned in the semi-prone position without selective lung intubation. The right arm is positioned on a support device with the forearm flexed to improve abduction of the scapula and enlargement of the intercostal spaces. Pads are placed under the pelvis to avoid abdominal compression. The chest is stabilized on the operative table using bean bag and right side supports to allow 45° rotation in a semi-prone position. The surgeon and assistant are on the right side of the patient. Collapse of the right lung is induced by low-pressure CO₂ insufflation (8 mmHg) and the first 12-mm camera port is inserted in the seventh intercostal space

Fig. 1 a, b Preoperative thoracic computed tomography (a) and barium swallow study (b) show a large infracarinal midesophageal diverticula located on the right lateral aspect of the esophagus

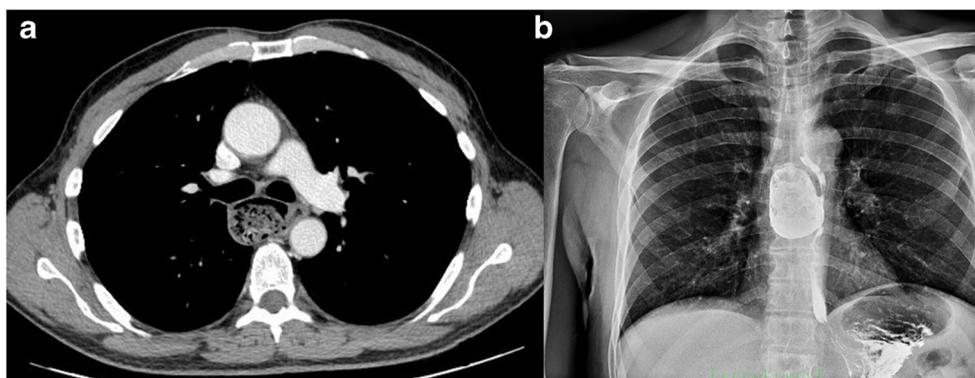




Fig. 2 The chest is stabilized on the operative table using bean bag and right side supports to allow 45° rotation in a semi-prone position. The 12-mm camera port is placed in the seventh intercostal space under the tip of the scapula. Two additional 12-mm ports are placed in the fifth and ninth intercostal space on the posterior axillary line to obtain triangulation

under the tip of the scapula. Two additional 12-mm ports are placed in the 5th and 9th intercostal space on the posterior axillary line to obtain triangulation (Fig. 2). The esophageal diverticulum is identified and the overlying pleura is incised (Fig. 3a, b). The azygos vein and the vagus nerve with its bronchial branches are identified and possibly preserved. The neck of the diverticulum is carefully dissected from the perivisceral adhesions, carina, and right main bronchus with blunt and sharp dissection (Fig. 4). Intraoperative endoscopy is performed with controlled insufflation to precisely identify the diverticular neck (Fig. 5a, b). Diverticulectomy was performed with a linear non-reinforced 60-mm purple stapler (EndoGIA®) under endoscopic guidance to avoid stricture of the esophageal lumen. An additional linear stapler could be used in case of large neck diverticula. Before stapling, the endoscope is retracted to release any possible traction on the suture line. An air-leak test could be performed to rule-

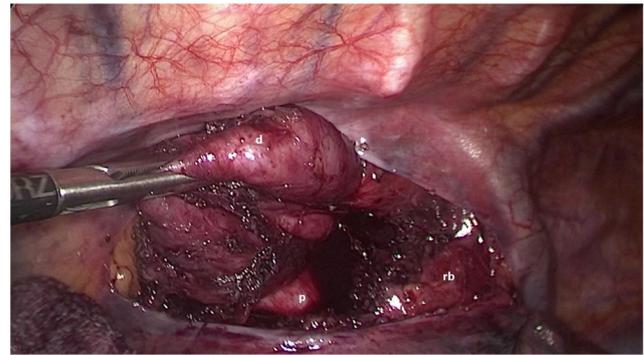


Fig. 4 The diverticula is carefully dissected from the perivisceral adhesions, carina, and right main bronchus (rb); p, pericardium; d, diverticula

out early leak. The overlying mediastinal pleura is closed with an absorbable 3.0 V-Lock running suture (Covidien, Inc., Mansfield, MA ®) (Fig. 6a–d). A chest tube is placed and the specimen is extracted.

Statistical analysis

The Statistical Package for Social Science (SPSS, Version 23, SPSS, Inc., Chicago, IL) was used for data analysis. Quantitative variables were expressed as median and range. Fisher's exact test was performed where appropriate. $p < 0.05$ was considered significant.

Results

Between November 1, 2015, and December 31, 2018, four consecutive patients underwent spVATS for symptomatic infracarinal esophageal diverticula. The demographic and clinical characteristics are shown in Table 1. Three patients were males and the median age was 59 years (range 54–65). All patients underwent preoperative barium swallow study, upper endoscopy, and thoracic

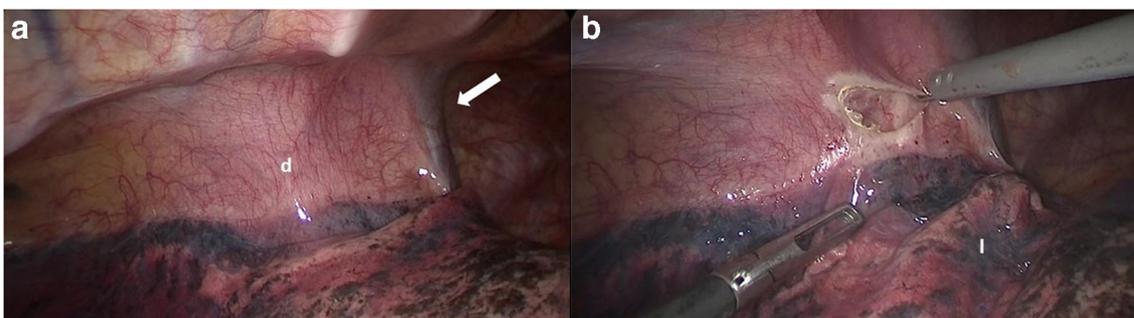


Fig. 3 a, b The midesophageal diverticula is identified under the azygos vein and the overlying pleura is incised; white arrow: azygos vein. d, diverticula; l, lung

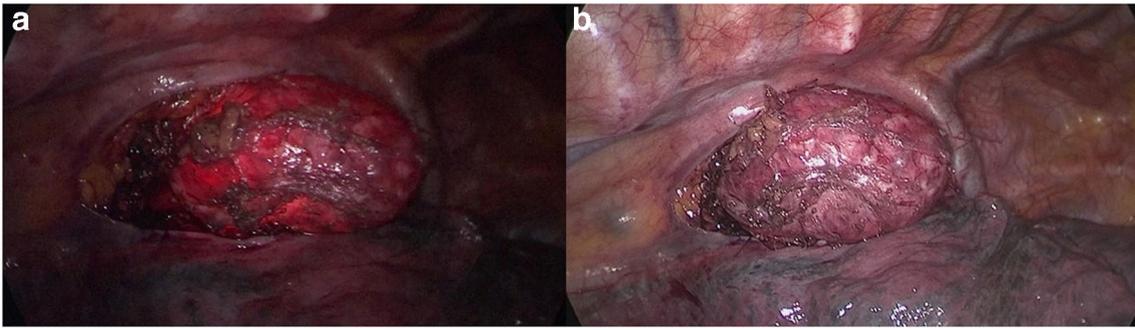


Fig. 5 **a, b** Intraoperative endoscopy with controlled insufflation allows the precise identification of the diverticular neck and to check for the completeness of peri-diverticular adhesiolysis

computed tomography. Esophageal manometry was performed in three patients with no evidence of underlying motility disorders. The diverticulum size ranged from 5.5 to 8 cm (median 7 cm) and the patients' symptoms history ranged from 3 to 6 years (median 5.5 years). The preoperative Eckardt score ranged from 5 to 10 (median 8.4) and the overall prevalence of respiratory symptoms was 50%: 1 patient complained of chronic cough and 1 had both cough and a previous episode of aspiration pneumonia. The operative time ranged from 125 to 175 min (median 149 min). There were no intraoperative complications, the intraoperative blood loss was negligible and none of the patients required postoperative transfusion. No conversion to open thoracotomy was necessary. The overall postoperative morbidity was 25%; one patient developed postoperative pneumonia that was managed with

intravenous antibiotics. A gastrographin swallow study was performed on postoperative day four to check the integrity of the suture line and the completeness of the diverticulectomy (Fig. 7). The postoperative length of hospital stay ranged from 6 to 10 days (median 7.5 days). There was no mortality.

The postoperative follow-up ranged from 5 to 35 months (median 22 months). At the last follow-up and compared with preoperative values, there was an improvement of patients' symptoms according to the Eckardt score (range 0–2; median 1.1). A resolution of pulmonary symptoms was observed in the two patients that complained preoperative cough and aspiration. Assessment of quality of life parameters according to the SF-36 showed an improvement of all included items (Fig. 8).

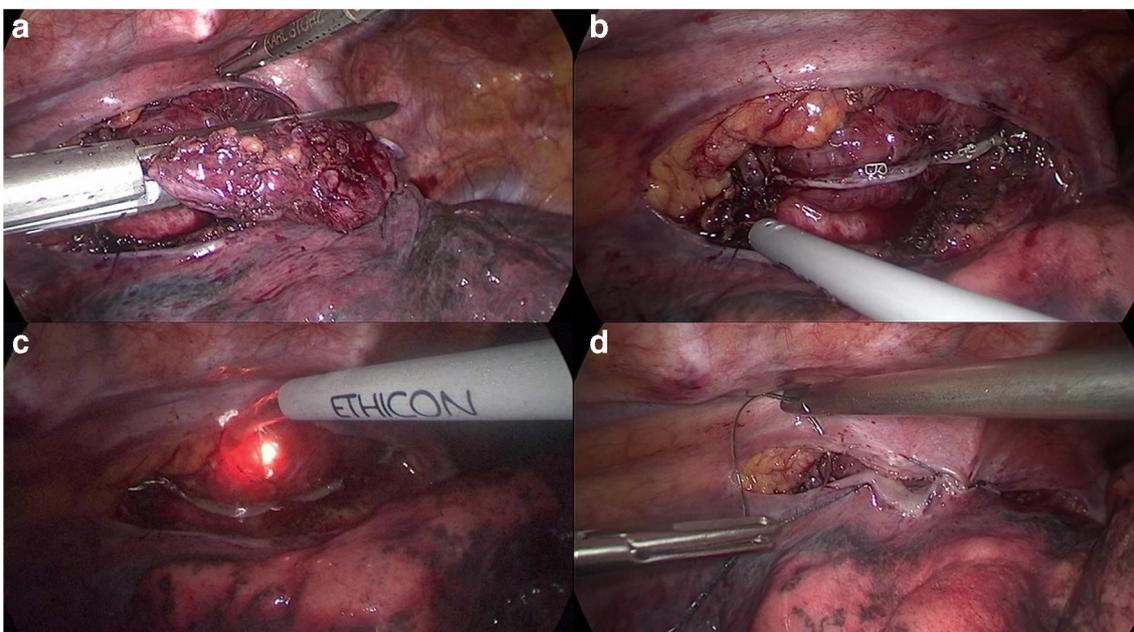


Fig. 6 **a** Diverticulectomy is performed with a linear stapler (EndoGIA®) under endoscopic guidance. **b, c** The suture line is checked and an air-leak test could be performed. **d** The overlying mediastinal pleura is closed with an absorbable 3.0 V-Lock running suture (Covidien, Inc., Mansfield, MA ®)

Table 1 The demographic and clinical characteristics of the patient population

No.	Age	Sex	BMI (kg/m ²)	ASA score	Diverticular size (cm)	Location	Patophysiology	Surgery	Complications	HLOS (day)
1	54	M	24.6	2	8	Right lateral	Traction	Diverticulectomy	nn	6
2	62	F	23.4	2	6.5	Right lateral	Traction	Diverticulectomy	nn	8
3	65	M	21.9	3	5.5	Postero-lateral	Traction	Diverticulectomy	Pneumonia	10
4	55	M	26.7	2	6	Right lateral	Traction	Diverticulectomy	nn	7

HLOS hospital length of stay

Discussion

The preliminary results of this study show that spVATS is feasible in the management of symptomatic patients with infracarinal midesophageal diverticula. A significant improvement of patients' symptoms and quality of life were observed in the medium-term follow-up.

The treatment of midesophageal diverticulum is debated and no established evidence exists on the best surgical approach. A recent meta-analysis with 511 patients with non-Zenker esophageal diverticulum showed similar outcomes comparing open and the minimally invasive approaches. However, only 53 patients had middle-third esophageal diverticulum and no definitive conclusion could be drawn [3].

Similar to the prone position, the semi-prone thoracoscopy through a single lumen tracheal tube has several advantages. The preservation of two-lung ventilation may result in a decreased parenchymal trauma and reduced morbidity. The improved oxygen delivery, the reduced pulmonary shunt, and the

better ventilation-perfusion match have been described as possible determinants in the reduction of postoperative respiratory complications. In addition, a potential reduction of the ischemia-reperfusion injury and oxidative stress has been argued [16]. From a technical point of view, compared with the left lateral and prone decubitus, the semi-prone position allows an improved surgical ergonomics [9]. The gravitational force allows anterior lung deflation and fluid pooling thus reducing any possible interference with the thoracoscopic camera [6]. Furthermore, the semi-prone position allows an easier access to the endotracheal tube from the anesthesiologist and, if emergency, conversion to an open procedure is required, an expedite conversion by lateral tilting of the operative table is possible [9]. Finally, the semi-prone position allows a more direct exposure of the posterior mediastinal and subcarinal area, that is, be crucial for the identification and section of mediastinal inflammatory adhesions between the subcarinal lymph nodes, main bronchus, and diverticular wall in case of traction diverticula. Therefore, the semi-prone VATS to midesophageal diverticula require a significant experience in the field of minimally invasive esophageal surgery and should be left to referral and dedicated centers.

The adding of a myotomy is a debated argument and to date no robust evidence exist. While some authors propose an extended myotomy in patients with esophageal motility disorders, others do not recommend it because the risk of poor functional results and diverticulization [3, 4]. In the present series, there were no apparent latent motility disorders and the traction physiopathology, supported by intraoperative findings, was presumed in all cases. For these reasons, esophageal myotomy was not performed in an effort to reduce the risk of long-term diverticulization and poor outcomes. The use of intraoperative endoscopy is an additional debated argument because of the supposed high risk of perforation. We believe that the graduated and controlled inflation in the setting of midesophageal traction diverticula permits an easier identification of the diverticular sac from perivisceral inflammatory adhesions, main bronchus, and pericardium. Finally, during stapling, the endoscope could be placed in the esophageal lumen acting as a calibrator to avoid stricture and to check for the completeness of the suture line at the end of the procedure [7].

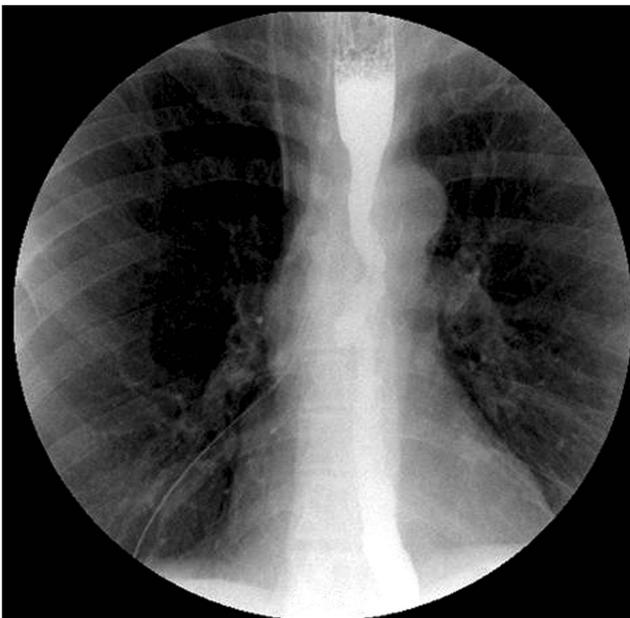
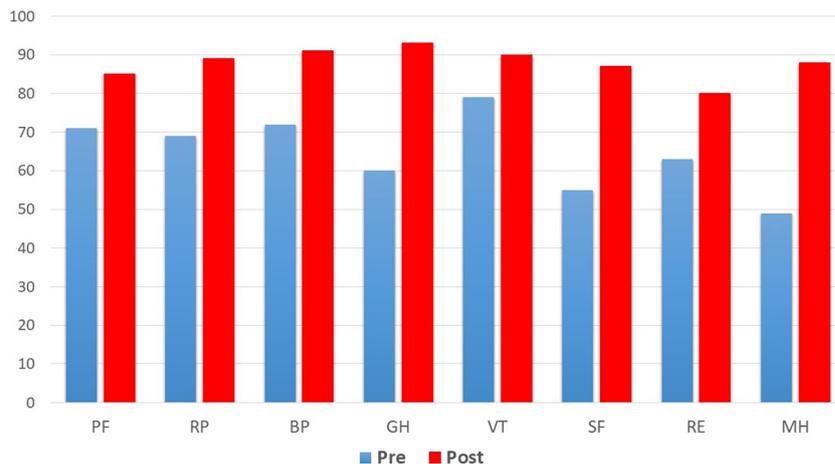


Fig. 7 A gastrographin swallow study was performed on postoperative day four to check the integrity of the suture line and the completeness of the diverticulectomy

Fig. 8 Preoperative and postoperative quality of life according to the 36-item Short-Form Health Survey Health questionnaire. FC, functional capacity; PA, physical aspect; BP, bodily pain; GH, general health; VT, vitality; SF, social function; RE, role emotional; MH, mental health



To the best of our knowledge, this is the first report that describes the technique, medium-term outcomes, and quality of life of the spVATS in the management of infracarinal midesophageal diverticula. Principal limitations of the study are the retrospective designs, the narrow patient population, and the limited follow-up. However, because of the rarity of the disease, it is difficult to obtain a significant number of patients in single-center studies. Further multicenter studies are needed to validate the advantages and promising outcomes of the technique providing more robust evidence on this rare clinical entity.

Conclusion

In summary, spVATS seems a valuable option to treat large midesophageal infracarinal diverticula in centers experienced with minimally invasive esophageal surgery. Intraoperative endoscopy is useful for the identification of the diverticular sac from perivisceral adhesions and to check for the completeness of the suture line. Further multicenter studies are needed to validate the advantages of this approach in the management of large symptomatic infracarinal midesophageal diverticula.

Authors' contributions The manuscript was conceived and designed by Aiolfi, Micheletto, Jonghi-Lavarini, and Bona. The literature was acquired and reviewed by Aiolfi, Tringali, and Bonitta. The manuscript was drafted by Aiolfi and Bona and critically revised by Micheletto and Campanelli. Final approval for publication of this manuscript has been given by all authors.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Human and animal rights All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964

Helsinki declaration and its later amendments or comparable ethical standards;

Informed consent Informed consent was obtained from all individual participants included in the study.

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