Surg Endosc
DOI 10.1007/s00464-016-5368-x

Utility of double endoscopic intraluminal operation for esophageal cancer

Makoto Sohda[1] · Hideyuki Saito[1] · Tomonori Yoshida[1] · Yuji Kumakura[1] · Hiroaki Honjyo[1] · Keigo Hara[1] · Daigo Ozawa[1] · Shigemasa Suzuki[1] · Naritaka Tanaka[1] · Makoto Sakai[1] · Tatsuya Miyazaki[1] · Minoru Fukuchi[1] · Hiroyuki Kuwano[1]

Received: 5 August 2016 / Accepted: 21 November 2016

Abstract
Objectives Endoscopic submucosal dissection (ESD) is a more difficult technique for esophageal cancer than for gastric cancer because the working space for esophageal ESD is small. Further, the difficulty level gradually increases depending on the size of the carcinoma. To overcome these difficulties, double endoscopic intraluminal operation (DEILO), which enables the resection of mucosal lesions using two fine endoscopes and monopolar shears, was reported previously. Here, we report the utility of DEILO for esophageal cancer.
Methods A total of 26 esophageal cancer patients (19 men and seven women) with 26 lesions treated using DEILO between 2011 and 2014 at Gunma University Hospital were included. We evaluated the utility and safety of DEILO for early esophageal cancer.
Results For all patients (100%), the DEILO procedure was performed successfully, and *en bloc* resection was achieved. The median operation time, postoperative hospital stay, and the longitudinal dimension of resected specimens were 123 min (range 45–236 min), 5 days, and 32 mm, respectively. Perioperative perforation, pneumothorax, and mediastinal emphysema were not recognized. Only one patient was diagnosed with a postoperative hemorrhage, but the bleeding was successfully treated by bleeding vessel coagulation.
Conclusion DEILO has good utility as a technique of ESD for early esophageal cancers. Additional improvement and advancement of the procedure will increase the indication of DEILO.

Keywords DEILO · Esophageal cancer · ESD

Esophageal cancer is a leading cause of cancer-related deaths worldwide and is frequently characterized by lymph node metastasis throughout the cervical, mediastinal, and abdominal regions. Despite recent improvements in surgical techniques and adjuvant therapies, the prognosis for patients with advanced disease remains poor [1, 2]. However, because of the development of endoscopic methods for diagnosis, the frequency of superficial esophageal carcinoma detection has increased relative to the frequency of esophageal squamous cell carcinoma detection for all stages. Endoscopic submucosal dissection (ESD) was developed as a novel endoscopic treatment. The major advantages of ESD include both an extremely high rate of *en bloc* resection and the possibility of resection for lesions with submucosal fibrosis [3, 4]. The limitation of the circumference disappeared because of technique improvement and stenosis prevention as per the Guidelines for Diagnosis and Treatment of Carcinoma of the Esophagus April 2012 edited by the Japanese Esophageal Society [5]. The current study revealed that the tumor size and whole circumference resection were independent risk factors for stricture following ESD [6]. Therefore, the provision for stricture after ESD is an area for future investigation. The local injection of triamcinolone acetonide [7] and other systemic steroid therapies [8] are frequently used to prevent esophageal strictures following ESD. Regenerative medical technology using tissue-engineered cell sheets and fabricated autologous oral mucosal epithelial cells for

✉ Makoto Sohda
msohda@gunma-u.ac.jp

[1] Department of General Surgical Science, Graduate School of Medicine, Gunma University, 3-39-22, Showa-machi, Maebashi, Gunma 371-8511, Japan

Published online: 07 December 2016

preventing esophageal strictures have recently been reported [9]. Moreover, this technique is safe and is anticipated to prevent esophageal strictures [9].

ESD is a more difficult technique for esophageal cancer than for gastric cancer because the working space for esophageal ESD is small. In addition, the difficulty level gradually increases depending on the size of the carcinoma. To overcome these difficulties, double endoscopic intraluminal operation (DEILO), which enables the resection of mucosal lesions using two fine endoscopes and monopolar shears, was reported by our institute in 2004 [10]. The use of two fine endoscopes allows an easy dissection of lesion in both the esophageal and gastric lumens [11]. Subsequently, Mochiki et al. [11] reported an assessment of the efficacy and safety of DEILO in 31 early gastric cancer patients. In addition, Toyomasu et al. [12] evaluated the long-term outcomes of patients with early gastric cancer whose tumors were resected using DEILO. They reported that the DEILO procedure for early gastric cancer shortens ESD operating time, with efficacy and complication rates comparable with that of the standard procedure [12]. Moreover, for surgeons who are accustomed and prefer a two-handed technique, as in conventional surgery, DEILO is an acceptable method. Fatourou E and Papaziogas B [13] reported DEILO that Mochiki et al. reported is unclear whether surgeons not as familiar with the DEILO approach can achieve a similar short operating time; there is also the risk for a higher complication rate than that reported by Mochiki et al. Here, we report the safety and long-term outcomes of DEILO for the treatment of early esophageal cancer.

Patients and methods

The study subjects were 26 esophageal cancer patients (19 men and seven women) with 26 lesions treated using DEILO between 2011 and 2014 at Gunma University Hospital. Patients with multiple cancers and post-treatment radiation therapy were excluded from this study. The characteristics of the 26 patients are presented in Table 1. The mean age of patients who underwent DEILO was 65 years (range 28–81 years). Of the 26 tumors, 11 were located in the middle thoracic (Mt) esophagus, eight in the middle lower thoracic (Lt) esophagus, four in the abdominal esophagus (Ae), two in the upper thoracic (Ut) esophagus, and one in the cervical esophagus (Ce). From the macroscopic diagnosis, 13 tumors were 0-IIb type, nine were 0-IIc type, and four were 0-IIa type. In addition, 10 tumors (38.4%) had less than 1/3, 12 tumors (46.2%) had greater than 1/3 but less than 2/3, and four tumors (15.4%) had greater than 2/3 of the circumference.

Table 1 Characteristics of the patients

	n
Male/female	19/7
Age; years (mean ± SD)	65 ± 11.7
Tumor location	
Ce	1
Ut	2
Mt	11
Lt	8
Ae	4
Macroscopic type	
0-IIa	4
0-IIb	13
0-IIc	9
Circumference	
<1/3	10
1/3 ≦ ~ <2/3	12
2/3 ≦	4

DEILO procedure

Kuwano et al. [10] previously reported the DEILO procedure in detail. All treatments were performed with the patient under general anesthesia. Airway management by the insertion of an endotracheal tube assists secure ventilation and may prevent intraoperative aspiration or postoperative pneumonia. The patients were positioned laterally on their left side throughout the operation period. After spraying Lugol's solution onto the mucosa, the mucosal surface surrounding the lesion margin was carefully marked using the Flash knife (DK2618JN15; FUJI FILM Co., Ltd.) with electrocauterization (soft coagulation mode). A submucosal injection using MucoUp® (Johnson & Johnson Co., Ltd.) mixed with epinephrine and indigocarmine was administered to lift the lesion. A circumferential mucosal incision was made around the lesion using a Flash knife.

In addition, submucosal dissection was performed for approximately half of entire dissection. Immediately following the completion of this procedure, DEILO was commenced using a dedicated overtube and separator (TOP Co., Ltd., Tokyo, Japan) (Fig. 1). Two gastrointestinal endoscopes were used for DEILO, which made the procedure more precise than diagnostic endoscopy. The first endoscope was the GIF-Q260 J (Olympus Co., Ltd., Tokyo, Japan), which had an outside diameter of 9.9 mm. The second endoscope was the GIF-XP260 N (Olympus Co., Ltd.), with an outside diameter of 5.0 mm.

The second endoscope was inserted into the esophagus, and the edge of the lesion was slightly elevated using a

Fig. 1 Specific overtube used for double endoscopic intraluminal operation (DEILO) *Upper device*: Separator *Middle and lower devices*: Overtube set. This overtube is useful if the endoscope must pass through an area several times because it protects the mucosa from injury and is necessary to avoid interference of the two endoscopes

grasping forceps. This traction provided a clear view of the cutting plane and dissected tissue (Fig. 2). The resected specimen was then retrieved with the grasping forceps. The important techniques in DEILO for esophageal cancer include controlling the scope and not interfering with another scope movement. It is crucial to determine the position of the first endoscope in the esophagus because esophageal lumen is narrower than that of the stomach. If the tumor is located in the posterior wall, the first endoscope should control the second scope to create enough traction space. If the tumor is located in the anterior wall, the first endoscope should control the second scope in esophageal lumen.

Histological assessment of the resected specimen

The resected specimen was stretched and fixed on a rubber plate using fine needles and then bathed in 10% formalin solution in the operation room. The resectability of the DEILO specimens was carefully evaluated histopathologically in slices cut 2-mm thick, according to the Guidelines for Clinical and Pathological Studies on Carcinoma of the Esophagus, 10th edition [14]. Each slice was microscopically assessed for histological type, depth of invasion, presence or absence of lymphatic or venous invasion, and completeness of the resection.

DEILO limitations

Because the esophageal lumen is narrow, a dedicated overtube and separator were used for the easy operation of DEILO for esophageal cancer. Therefore, as the overtube covered Ce and parts of Ut tumors, those tumors were excluded. Moreover, the cases of stricture at a part of overtube were excluded as a forceful insertion which could lead to esophageal injury. The length of the overtube used in our institution is 205 mm. Most of patients with cervical esophageal cancer were excluded from the study because their tumors were covered by the overtube, although the distance from the incisor to the oral side of the tumor is different for every patient. However, a few cases, in tall patients with cervical esophageal cancers that were located in the neighborhood of the upper thoracic area, can be included because the overtube did not prevent the ESD procedure. In a similar way, a few cases in short patients with upper thoracic cancers that were located in the neighborhood of the cervical area were excluded from this procedure.

Follow-up

All procedures were performed with careful monitoring of the patients' vital signs and oxygenation. Each patient had chest and abdominal X-rays to identify any complications, such as mediastinal emphysema, pneumothorax, or pulmonary atelectasis, after which the patients returned to their hospital rooms. The following day, all patients received a follow-up endoscopic examination to check for the bleeding of the resected ulcer and were permitted water intake. On the second day after treatment, the patients were

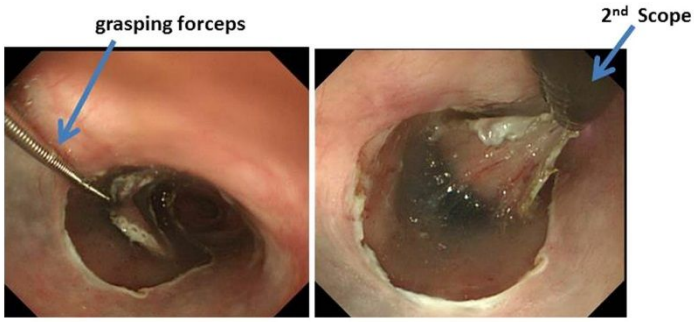

Fig. 2 DEILO procedure *Left*: the edge of the lesion was slightly elevated using a pair of grasping forceps *Right*: this traction provided a clear view of the cutting plane and dissected tissue

Table 2 Operative performance of DEILO

En block resection: *n* (%)	26 (100%)
Median operation time: min (range)	123 (45–236)
Postoperative hospital stay: days (range)	5 (3–24)
Longitudinal dimension of resected specimens(Median):mm (range)	32 (8–60)
Complications: *n* (%)	
Bleeding	1 (3.8%)
Perforation	0 (0%)
Pneumothorax	0 (0%)
Mediastinal emphysema	0 (0%)
Stricture	3 (11.5%)
Recurrence: n (%)	0 (0%)

allowed to resume the consumption of a rice gruel. Antibiotics and a proton pump inhibitor were administered intravenously for the first 2 days. Preventive antibiotics are administered routinely for 2 days to prevent postoperative bacteremia, although obvious perforations were not observed. After discharge from the hospital, an endoscopic examination was performed at fixed intervals, according to pathological examination, or resected circumference.

Table 3 Pathological outcome of the patients

	n
Depth of invasion	
Mucosa	24
Submucosa	2
Histological type	
Squamous cell carcinoma	22
Adenocarcinoma	4
Horizontal margin (HM)	
HM0	21
IHM1	2
HMX	3
Vertical margin (VM)	
VM0	26
VM1	0
Residual tumor	
R0	24
R1	2
Infiltrative growth pattern (INF)	
INFα	16
IINFβ	2
INFc	0

Results

The operative performance of DEILO is presented in Table 2. For all patients (100%), the DEILO procedure was performed successfully and *en bloc* resection was achieved. The median operation time for DEILO was 123 min (range 45–236 min), and the median postoperative hospital stay was 5 days (range 3–24 days). The patients were kept in the hospital to observe the safety of the postoperative course, although the reasons varied from case to case. A lot of patients feel vaguely insecure about their postoperative course regarding wound pain, dietary intake, and so on. Wound pain and insufficient dietary intake certainty contributed to increased mean hospitalization in this study. Therefore, for the above-stated reason, the mean postoperative stay was 5 days. The median longitudinal dimension of the resected specimens was 32 mm (range 8–60 mm). With respect to complications, a postoperative hemorrhage was recognized in only one patient with anticoagulants initiated 7 days after the DEILO procedure, but the bleeding was successfully treated by bleeding vessel coagulation. No patients developed perioperative perforation, pneumothorax, or mediastinal emphysema. However, the rate of postoperative stricture was 11.5% (3/26) for all subjects, and all cases of stricture were successfully treated with an endoscopic balloon dilation. Emergency surgery was not required for any patients.

The assessment of pathological outcome is summarized in Table 3. The histopathologic diagnosis revealed that 92.3% (24/26) tumors were mucosal and 7.7% (2/26) tumors were submucosal. Moreover, 84.6% (22/26) tumors were squamous cell carcinoma, and the remnant 15.4% (4/26) tumors were adenocarcinoma. In addition, curative resection was histologically found in 24 lesions (92.3%). Two tumors (7.7%) were diagnosed positive for cancer of the horizontal margin. One case involved a 71-year-old man whose tumor, located in the middle thoracic esophagus, was greater than 1/3 but less than 2/3 of the circumference. Another case involved a 57-year-old man whose tumor, located in the middle thoracic esophagus, was greater than 2/3 of the circumference. On the other hand, DEILO was fortuitously performed in all cases with HMX in 2014. Recurrences have not yet been confirmed. In practice, the average follow-up period in all patients was 2.02 years (range 1.90–2.15). Strict follow-up by endoscopy has been performed every 3 months because the early detection of recurrence and early treatment will save patients' lives. Moreover, computed tomography and ^{18}F-flourodeoxyglucose positron emission tomography have been performed every 6 months to check for recurrence in each patient. There has been no recurrence in tumors (including HMX) cases to date. The vertical margin was negative for all cases in this study.

Discussion

Because of advances in diagnostic modalities, including endoscopy, endoscopic ultrasonography, and narrow band imaging, superficial esophageal squamous cell carcinoma is being increasing detected. ESD is a recently developed procedure allowing accurate submucosal dissection and the *en bloc* resection of these mucosal lesions. Despite technical difficulties, ESD was an effective and relatively safe treatment option for esophageal squamous cell carcinoma [15, 16]. However, technical difficulties still exist in some cases. The tumor location is a crucial factor that affects the completeness of endoscopic treatment. The location of the esophagogastric junction makes endoscopic procedure difficult as the working space is very narrow, and this factor influences the procedure time. DEILO was developed to resolve these technical difficulties, and we reported a DEILO feasibility study in 2004 [10]. The DEILO procedure involves an intraluminal surgery of the esophagus and stomach in which two endoscopes are orally inserted. The advantage of DEILO is that the mucosal layer is easily grasped and lifted using the grasping forceps to cut and visualize the submucosal layer directly [11].

Our data could not show the apparent benefit of DEILO compared with that shown in the previous study on ESD. However, the safety and certainty of submucosal dissection for DEILO were demonstrated with our data. *En bloc* resection was 100% in our study, and we consider this result to demonstrate the utility of DEILO. Mediastinal emphysema, perforation, and bleeding are the primary complications of ESD. Poor visibility can lead to inadequate dissection, resulting in major complications as described above. There were no mediastinal emphysema and perforation cases in this study. These results show that a double-scope operation creates a fine expansion of the submucosal layer. Using double endoscopy, an appropriate amount of tension can be applied to the submucosa to facilitate dissection.

DEILO was a very good method of ESD for some early esophageal cases. In particular, DEILO has a high availability for esophagogastric cancer because ESD with a single scope makes creating a large enough working space of submucosal dissection difficult in such a narrow space. Ota et al. [17] reported the usefulness of clip traction in the early phase of esophageal endoscopic submucosal dissection. In addition, they demonstrated that clip traction shortens the operating time and is safer in esophageal ESD [17]. The most important advantage of DEILO is that it allows the resected specimen to be freely moved so that the assistant can freely operate the second scope. It is possible to achieve a high enough countertraction of the cutting line. Although this technique has many advantages, performing DEILO requires a larger number of staff than that required for performing conventional ESD. Compared with DEILO for early gastric cancer, DEILO for early esophageal cancer has the additional limitation of handling because of the narrow working space. Moreover, one of the problems is the tumor location. Ce and a part of Ut tumors were excluded because those tumors were covered by an overtube.

Our current study first shows the utility of DEILO for early esophageal cancer, although it has some limitations that were mentioned above. DEILO is an advantageous method for patients needing sufficiently high countertraction of the cutting line, although there are some limitations that must be resolved. Also, DEILO is not an apparently difficult method technically as compared to conventional ESD. Moreover, overtubes and separators are sold commercially (TOP Co., Ltd., Tokyo, Japan). These results show the possibility of generalizing DEILO. Centers without significant experience can perform DEILO if staff members are familiar with normal endoscopic operations, as well as the specific devices discussed above. Additional improvement and advancement of the device will increase the indication of DEILO. To our knowledge, this is the first report on the utility of DEILO for esophageal cancer.

Conclusion

In conclusion, the esophageal wall is thin and potentially easy to perforate. The greatest advantage of DEILO for esophageal cancer is the visual confirmation step for accurate and safe targeting by lifting the submucosal layer before cutting. Additional improvement and advancement of the device will increase the indication of DEILO.

Compliance with ethical standards

Disclosures Makoto Sohda, Hideyuki Saito, Tomonori Yoshida, Yuji Kumakura, Hiroaki Honjyo, Keigo Hara, Daigo Ozawa, Shigemasa Suzuki, Naritaka Tanaka, Makoto Sakai, Tatsuya Miyazaki, Minoru Fukuchi, and Hiroyuki Kuwano have no conflicts of interest or financial ties to disclose.

References

1. Daly JM, Karnell LH, Menck HR (1996) National Cancer Data Base report on esophageal carcinoma. Cancer 78:1820–1828
2. Wobst A, Audisio RA, Colleoni M, Geraghty JG (1998) Oesophageal cancer treatment: studies, strategies and facts. Ann Oncol 9:951–962
3. Oyama T, Tomori A, Hotta K, Morita S, Kominato K, Tanaka M, Miyata Y (2005) Endoscopic submucosal dissection of early esophageal cancer. Clin Gastroenterol Hepatol 3:67–70
4. Fujishiro M, Yahagi N, Kakushima N, Kodashima S, Muraki Y, Ono S, Yamamichi N, Tateishi A, Shimizu Y, Oka M, Ogura K,

Kawabe T, Ichinose M, Omata M (2006) Endoscopic submucosal dissectionof esophageal squamous cell neoplasms. Clin Gastroenterol Hepatol 4:688–694
5. Kuwano H, Nishimura Y, Oyama T, Kato H, Kitagawa Y, Kusano M, Shimada H, Takiuchi H, Toh Y, Doki Y, Naomoto Y, Matsubara H, Miyazaki T, Muto M, Yanagisawa A (2015) Guidelines for diagnosis and treatment of carcinoma of the esophagus April 2012 edited by the Japan Esophageal Society. Esophagus 12:1–30
6. Funakawa K, Uto H, Sasaki F, Nasu Y, Mawatari S, Arima S, Nakazawa J, Taguchi H, Hashimoto S, Kanmura S, Setoyama H, Numata M, Tsubouchi H, Ido A (2015) Effect of endoscopic submucosal dissection for superficial esophageal neoplasms and risk factors for postoperative stricture. Medicine (Baltimore) 94(1):e373
7. Takahashi H, Arimura Y, Okahara S, Kodaira J, Hokari K, Tsukagoshi H, Shinomura Y, Hosokawa M (2015) A randomized controlled trial of endoscopic steroid injection for prophylaxis of esophageal stenoses after extensive endoscopic submucosal dissection. BMC Gastroenterol 15:1
8. Isomoto H, Yamaguchi N, Nakayama T, Hayashi T, Nishiyama H, Ohnita K, Takeshima F, Shikuwa S, Kohno S, Nakao K (2011) Management of esophageal stricture after complete circular endoscopic submucosal dissection for superficial esophageal squamous cell carcinoma. BMC Gastroenterol 11:46
9. Ohki T, Yamato M, Ota M, Takagi R, Kondo M, Kanai N, Okano T, Yamamoto M (2015) Application of regenerative medical technology using tissue-engineered cell sheets for endoscopic submucosal dissection of esophageal neoplasms. Dig Endosc 27:182–188
10. Kuwano H, Mochiki E, Asao T, Kato H, Shimura T, Tsutsumi S (2004) Double endoscopic intralumenal operation for upper digestive tract diseases: proposal of a novel procedure. Ann Surg 239:22–27
11. Mochiki E, Yanai M, Toyomasu Y, Ogata K, Andoh H, Ohno T, Aihara R, Asao T, Kuwano H (2010) Clinical outcomes of double endoscopic intralumenal surgery for early gastric cancer. Surg Endosc 24:631–636
12. Toyomasu Y, Suzuki M, Yanoma T, Kimura A, Kogure N, Ogata K, Ohno T, Mochiki E, Kuwano H (2016) Outcomes of patients with early gastric cancer who underwent double endoscopic intraluminal surgery. Surg Endosc 30:178–183
13. Fatourou E, Papaziogas B (2010) Double endoscopic intraluminal surgery: superior to ESD for early gastric cancer? Surg Endosc 24:2349–2350
14. Japanese Society for Esophageal Disease (2008) Guidelines for the clinical and pathological studies on carcinoma of the esophagus, 10th edn. Kanehara, Tokyo
15. Fujishiro M, Yahagi N, Kakushima N, Kodashima S, Muraki Y, Ono S, Yamamichi N, Tateishi A, Shimizu Y, Oka M, Ogura K, Kawabe T, Ichinose M, Omata M (2006) Endoscopic submucosal dissection of esophageal squamous cell neoplasms. Clin Gastroenterol Hepatol 4:688–694
16. Ishihara R, Iishi H, Uedo N, Takeuchi Y, Yamamoto S, Yamada T, Masuda E, Higashino K, Kato M, Narahara H, Tatsuta M (2008) Comparison of EMR and endoscopic submucosal dissection for en bloc resection of early esophageal cancers in Japan. Gastrointest Endosc 68:1066–1072
17. Ota M, Nakamura T, Hayashi K, Ohki T, Narumiya K, Sato T, Shirai Y, Kudo K, Yamamoto M (2012) Usefulness of clip traction in the early phase of esophageal endoscopic submucosal dissection. Dig Endosc 24:315–318

Gen Thorac Cardiovasc Surg (2016) 64:763–766
DOI 10.1007/s11748-016-0717-1

ERRATUM

Erratum to: Thoracic and cardiovascular surgery in Japan during 2007

Annual report by the Japanese Association for Thoracic Surgery

Committee for Scientific Affairs[1] · Yuichi Ueda[2] · Yoshitaka Fujii[3] · Hiroyuki Kuwano[4]

Published online: 24 October 2016

Erratum to: Gen Thorac Cardiovasc Surg (2009) 57:488–513
DOI 10.1007/s11748-009-0460-y

The original publication of the article cited above included incorrect values in the following parts: in section (A) Cardiovascular surgery, Table 3 "Thoracic aortic aneurysm", both (1) Dissection and (2) Non-dissection, values in "9. Stent graft*a"; and in section (B) General thoracic surgery (Respiratory surgery), Table 1 "Total entry cases of general thoracic surgery" and Table 20 "10. Lung transplantation". The corrected versions are below.

In Table 2 of section (A) Cardiovascular surgery, the table title "Acquired [total (1) + (2) + (4) + (5) + (6) + (7) + isolated ope. for arrhythmia in (3): 34,907]" should be "Acquired [total (1) + (2) + (4) + (5) + (6) + (7) + isolated ope. for arrhythmia in (3): 35,446]", "(2) Ischemic heart disease [total (A) + (B) + (C): 18,181]" should be "(2) Ischemic heart disease [total (A) + (B) + (C): 18,720]", and "(B) Operation for complications of MI (total 874)" should be "(B) Operation for complications of MI (total 1,413)".

The online version of the original article can be found under doi:10.1007/s11748-009-0460-y.

✉ Committee for Scientific Affairs
survey-adm@umin.net

[1] Tokyo, Japan

[2] Department of Cardiac Surgery, Nagoya University Graduate School of Medicine, Nagoya, Japan

[3] Oncology, Immunology and Surgery, Nagoya City University Graduate School of Medical Sciences, Nagoya, Japan

[4] Department of General Surgical Science (Surgery 1), Gunma University, Graduate School of Medicine, Maebashi, Japan

(A) Cardiovascular Surgery

Table 3 Thoracic aortic aneurysm (total; 10,081)
(1) Dissection (total; 4,549)

Stanford type	Acute						Chronic						Concomitant operation					Redo		
	A			B			A			B										
Replaced site	Cases	30-day mortality	Hospital mortality	Cases	30-day mortality	Hospital mortality	Cases	30-day mortality	Hospital mortality	Cases	30-day mortality	Hospital mortality	AVP	AVR	MVP	MVR	CABG	Cases	30-day mortality	Hospital mortality
1. Ascending Ao.	1,768	155 (8.8)	193 (10.9)	4	0	0	184	3 (1.6)	9 (4.9)	4	0	0	192	74	5	6	86	41	3 (7.3)	3 (7.3)
2. Aortic root	171	27	32	0	0	0	55	3	3	6	0	0	33	99	3	3	35	27	4	4
3. Ascending Ao. + arch	894	107 (12.0)	130 (14.5)	17	2 (11.8)	2 (11.8)	243	8 (3.3)	13 (5.3)	56	2 (3.6)	4 (7.1)	59	30	4	3	66	60	10 (16.7)	11 (18.3)
4. Arch + descending Ao.	62	4 (6.5)	4 (6.5)	17	3 (17.6)	5 (29.4)	27	4 (14.8)	5 (18.5)	103	16 (15.5)	19 (18.4)	2	4	0	0	3	20	2 (10.0)	4 (20.0)
5. Aortic root + Asc. Ao. + arch	60	14 (23.3)	17 (28.3)	1	1 (100.0)	1 (100.0)	21	0	1 (4.8)	4	0	1 (25.0)	4	39	2	0	13	11	1 (9.1)	3 (27.3)
6. Descending Ao.	10	2	3	39	6	6	49	6	8	244	5	11	0	1	0	0	5	26	3	3
7. Thoracoabdominal Ao.	6	1 (16.7)	1 (16.7)	9	3 (33.3)	4 (44.4)	37	3 (8.1)	5 (13.5)	149	15 (10.1)	19 (12.8)	0	0	0	0	0	24	1 (4.2)	2 (8.3)
8. Extra-anatomical bypass	5	2 (40.0)	2 (40.0)	23	2 (8.7)	3 (13.0)	1	0	0	16	0	0	0	0	0	0	0	0	0	0
9. Stent graft*[a]	40	2 (5.0)	2 (5.0)	35	2 (5.7)	3 (8.6)	33	2 (6.1)	4 (12.1)	156	4 (2.6)	5 (3.2)	0	1	0	0	4	39	1 (2.6)	2 (5.1)
1) Transluminal*[b]	12	0	0	28	1 (3.6)	2 (7.1)	15	0	1 (6.7)	127	1 (0.8)	1 (0.8)	0	0	0	0	0	26	0	0
2) Open stent																				
a) With total arch*[c]	26	2 (7.7)	2 (7.7)	5	0	0	17	2 (11.8)	3 (17.6)	17	2 (11.8)	3 (17.6)	0	1	0	0	4	12	1 (8.3)	2 (16.7)
b) Without total arch*[d]	2	0	0	2	1 (50.0)	1 (50.0)	1	0	0	12	1 (8.3)	1 (8.3)	0	0	0	0	0	1	0	0
Total	3,016	314 (10.4)	384 (12.7)	145	19 (13.1)	24 (16.6)	650	29 (4.5)	48 (7.4)	738	42 (5.7)	59 (8.0)	290	248	14	12	212	248	25 (10.1)	32 (12.9)

Values in parenthesis represent mortality %

AVP aortic valve repair, *AVR* aortic valve replacement, *MVP* mitral valve repair, *MVR* mitral valve replacement

Acute, within 2 weeks from the onset

*a = *b + *c + *d

Table 3 continued

(2) Nondissection (total; 5,532)

Replaced site	Unruptured			Ruptured			Concomitant operation					Redo			CPB (–)		
	Cases	30-day mortality	Hospital mortality	Cases	30-day mortality	Hospital mortality	AVP	AVR	MVP	MVR	CABG	Cases	30-day mortality	Hospital mortality	Cases	30-day mortality	Hospital mortality
1. Ascending Ao.	818	20 (2.4)	22 (2.7)	37	3 (8.1)	5 (13.5)	63	527	30	26	105	60	8 (13.3)	11 (18.3)	4	0	0
2. Aortic root	641	17	26	19	2	4	95	409	33	9	85	71	5	7	1	0	0
3. Ascending Ao. + arch	1,646	63 (3.8)	102 (6.2)	214	47 (22.0)	58 (27.1)	14	94	10	10	319	71	7 (9.9)	11 (15.5)	4	0	0
4. Arch + descending Ao.	196	11 (5.6)	18 (9.2)	50	11 (22.0)	15 (30.0)	0	5	0	1	17	21	3 (14.3)	4 (19.0)	1	0	0
5. Aortic root + Asc. Ao. + arch	96	6 (6.3)	7 (7.3)	1	0	0	1	51	7	1	9	10	4 (40.0)	4 (40.0)	1	1 (100.0)	1 (100.0)
6. Descending Ao.	509	20 (3.9)	30 (5.9)	141	27 (19.1)	33 (23.4)	0	2	0	0	14	37	6 (16.2)	8 (21.6)	9	1 (11.1)	1 (11.1)
7. Thoracoabdominal Ao.	369	24	38	67	14	18	0	2	0	0	4	24	3	6	4	0	0
8. Extra-anatomical bypass	15	1 (6.7)	2 (13.3)	4	1 (25.0)	1 (25.0)	0	1	0	0	0	2	1 (50.0)	1 (50.0)	0	0	0
9. Stent graft*[a]	607	14 (2.3)	21 (3.5)	102	17 (16.7)	23 (22.5)	0	5	0	0	18	37	3 (8.1)	3 (8.1)	195	7 (3.6)	10 (5.1)
1) Transluminal*[b]	467	9 (1.9)	13 (2.8)	80	12 (15.0)	17 (21.3)	0	0	0	0	2	32	3 (9.4)	3 (9.4)	195	7 (3.6)	10 (5.1)
2) Open stent																	
a) With total arch*[c]	96	4 (4.2)	6 (6.3)	16	5 (31.3)	6 (37.5)	0	5	0	0	11	3	0	0	0	0	0
b) Without total arch*[d]	39	1 (2.6)	2 (5.1)	5	0	0	0	0	0	0	5	2	0	0	0	0	0
Unspecified	5			1											1		
Total	4,897	176 (3.6)	266 (5.4)	635	122 (19.2)	157 (24.7)	173	1,096	80	47	571	333	40 (12.0)	55 (16.5)	220	9 (4.1)	12 (5.5)

Values in parenthesis represent mortality %

AVP aortic valve repair, *AVR* aortic valve replacement, *MVP* mitral valve repair, *MVR* mitral valve replacement

*a = *b + *c + *d

(B) General Thoracic Surgery

Table 1 Total entry cases of general thoracic surgery during 2007

	Cases	%
Benign pulmonary tumor	648	1.2
Primary lung cancer	26,092	46.7
Other primary malignant pulmonary tumor	255	0.5
Metastatic pulmonary tumor	5,047	9.0
Tracheal tumor	139	0.2
Mesothelioma	431	0.8
Chest wall tumor	628	1.1
Mediastinal tumor	3,731	6.7
Thymectomy for MG without thymoma	309	0.6
Inflammatory pulmonary disease	3,021	5.4
Empyema	1,425	2.6
Bullous disease excluding pneumothorax	681	1.2
Pneumothorax	11,982	21.5
Chest wall deformity	337	0.6
Diaphragmatic hernia including traumatic	113	0.2
Chest trauma excluding diaphragmatic hernia	346	0.6
Lung transplantation	9	0.0
Others	628	1.1
Total	55,822	100.0

Table 20

	Cases	30-day mortality	Hospital mortality
10. Lung transplantation	9	1 (11.1)	1 (11.1)
Single lung	6	0 (0.0)	0 (0.0)
Bilateral	3	1 (33.3)	1 (33.3)
Living donor	9	0 (0.0)	0 (0.0)

Values in parenthesis represent mortality %

Watanabe *et al. Surgical Case Reports* (2016) 2:127
DOI 10.1186/s40792-016-0256-0

Surgical Case Reports

CASE REPORT Open Access

Resection of an esophageal schwannoma with thoracoscopic surgery: a case report

Takayoshi Watanabe[1], Tatsuya Miyazaki[1*], Hideyuki Saito[1], Tomonori Yoshida[1], Yuji Kumakura[1], Hiroaki Honjyo[1], Takehiko Yokobori[2], Makoto Sakai[1], Makoto Sohda[1] and Hiroyuki Kuwano[1]

Abstract

Background: Esophageal schwannomas are rare primary submucosal esophageal tumors. We herein report a case of an esophageal schwannoma that was difficult to diagnose.

Case presentation: A 39-year-old woman presented with chief complaints of difficulty swallowing and epigastric pain. Enhanced computed tomography of her chest revealed a tumor mass at the upper thoracic esophagus with internal heterogeneity. 18-Fluorodeoxyglucose positron emission tomography/computed tomography showed a hypermetabolic appearance matching the tumor mass; the accumulation had a maximum standardized uptake value of 5.5. We performed endoscopic ultrasound-guided fine-needle aspiration biopsy under general anesthesia, but the small specimens obtained prevented a definitive diagnosis. Thoracoscopic esophagectomy was performed due to the large size of the tumor, suspicion of its malignant potential, and the patient's symptoms. Histopathological examination revealed spindle-shaped cells in a fasciculated and disarrayed architecture in the proper muscle layer. Immunohistochemical studies showed S100 protein positivity and the absence of CD34 and c-kit. We diagnosed the tumor as a benign schwannoma.

Conclusions: We herein report a relatively rare case of schwannoma of the esophagus that was diagnosed with difficulty.

Keywords: Esophageal schwannoma, EUS-FNA, FDG-PET CT, S-100, Thoracoscopic surgery

Background

The incidence of benign primary tumors of the esophagus is low. The most common histological type is leiomyoma; the incidence of schwannoma among benign tumors is low [1–5]. Esophageal schwannomas are difficult to definitively diagnose by biopsy because they are located in the submucosal tissue.

18-Fluorodeoxyglucose positron emission tomography (FDG-PET) has been used to detect metabolism of glucose by tumors. High FDG uptake is generally found in malignant tumors; it is also found in inflammation. Although they are benign tumors, schwannomas reportedly show a hypermetabolic appearance on FDG-PET [6–8]. We previously reported the utility of FDG-PET for diagnosis of schwannoma of the stomach [9].

In general, surgical resection of esophageal submucosal tumors is dependent upon the tumor size, malignant potential, and patient's symptomatic state. Although the final diagnosis must be obtained surgically, as in the present case, minimally invasive thoracoscopic surgery is considered to be an appropriate technique for esophageal submucosal tumors.

Case presentation

A 39-year-old woman presented for evaluation of difficulty swallowing and epigastric pain. Her medical and familial histories were unremarkable. Upper gastrointestinal endoscopy showed a smooth elevated lesion located 19 to 24 cm from the incisor teeth (Fig. 1). Endoscopic ultrasonography showed a large tumor mass of low echogenicity in the esophageal wall. The tumor mass originated in the muscle layer, and we performed a boring biopsy of the tumor mass. However, we were unable to obtain a tissue specimen from the tumor.

* Correspondence: tatsuyamiyazaki@gunma-u.ac.jp
[1]Department of General Surgical Science, Gunma University Graduate School of Medicine, 3-39-22 Showa-machi, Maebashi, Gunma 371-8511, Japan
Full list of author information is available at the end of the article

Fig. 1 Endoscopic findings. This endoscopic photograph demonstrates the submucosal tumor of the esophagus. It occupied the most of the esophageal lumen

A chest enhanced computed tomography (CT) scan revealed a tumor mass (39 × 28 × 56 mm) at the upper thoracic esophagus with internal heterogeneity. No metastasis to the lymph nodes or other organs was seen on the CT scan (Fig. 2a). FDG-PET CT showed a hypermetabolic appearance matching the tumor mass. The maximum standardized uptake value (max SUV) was 5.5 (Fig. 2b).

Magnetic resonance imaging of the chest revealed that the boundary of the tumor was clear and smooth. The mass exhibited isointensity or low intensity compared with the muscles on T1-weighted images and high intensity on T2-weighted images. There was no invasion into the surrounding tissue.

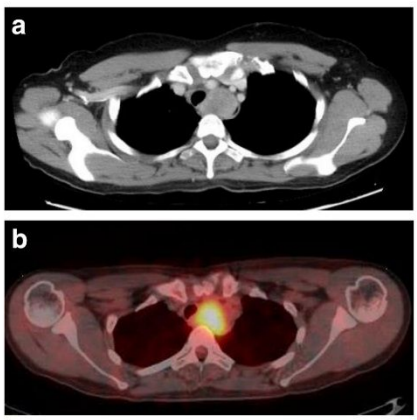

Fig. 2 CT and FDG-PET CT findings. **a** Computed tomography revealed a large isodense mass of the esophageal wall in the upper mediastinal space. **b** Accumulation of fluorodeoxyglucose is demonstrated in the upper thoracic esophagus

We performed endoscopic ultrasound-guided fine-needle aspiration biopsy (EUS-FNAB) with the patient under general anesthesia. Because the specimen was small, we were unable to establish a definitive diagnosis. We suspected an esophageal schwannoma, leiomyoma, or gastrointestinal stromal tumor (GIST).

The patient underwent surgery because of her difficulty swallowing and our suspicion of malignant potential. We performed thoracoscopic surgery with the patient under general anesthesia and single-lung ventilation.

First, we attempted enucleation of the tumor. However, the mass was larger than 5 cm, and enucleation was difficult without creating an extensive defect of the esophageal wall. Therefore, subtotal esophagectomy was performed with thoracoscopic assistance.

The resected specimen measured 55 × 45 × 24 mm. The cut surface was solid milky white (Fig. 3a). Histopathological examination revealed spindle-shaped cells in a fasciculated and disarrayed architecture in the proper muscle layer. Immunohistochemical studies showed S100 protein expression and the absence of CD34 and c-kit protein expression. Nuclear division was inconspicuous, and the MIB-1 labeling index was <10 %. Finally, we diagnosed the tumor as a benign schwannoma. The patient's postoperative course was uneventful, and she had no evidence of recurrence at the time of this writing.

Conclusions

Benign primary tumors of the esophagus account for less than 1 % of all esophageal tumors [1]. The most common benign submucosal esophageal tumor is leiomyoma. According to previous reports, leiomyoma accounts for more than half of all benign esophageal tumors [1, 2]. Benign submucosal esophageal tumors also include lipomas, granular cell tumors, and schwannomas. A GIST is an esophageal submucosal tumor with malignant potential.

A few cases of primary esophageal schwannomas have been reported [3, 4]. Gastrointestinal schwannomas account for 0.4 to 1.0 % of all submucosal tumors of the gastrointestinal tract. Most occur in the stomach; the development of a schwannoma in the esophagus is uncommon [4].

The definitive diagnosis of an esophageal submucosal tumor should be made before tumor excision to avoid unnecessary surgery. However, the preoperative pathological diagnosis of a submucosal tumor is unclear in some cases. As in the present case, an adequate specimen is difficult to obtain during biopsy of a submucosal tumor, even if a boring biopsy is performed. This is because the

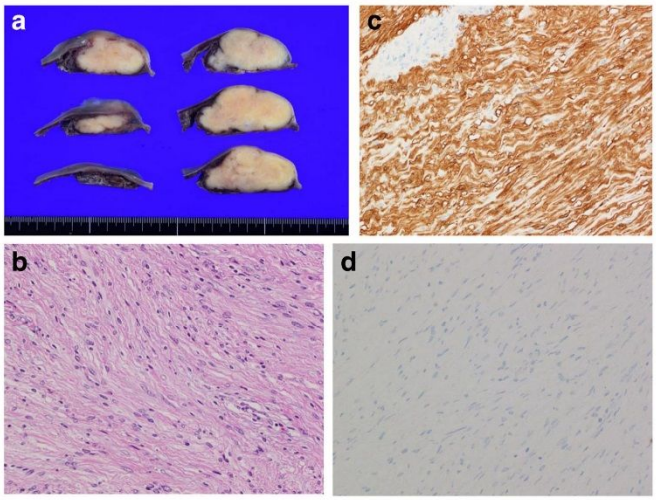

Fig. 3 Representative photomicrographs of tissue sections. **a** Massive white tumor mass in the submucosal layer. **b** High-power photomicrograph of the tumor shows spindle-shaped cells in a fasciculated and disarrayed architecture (hematoxylin–eosin, ×400). **c** S-100 was detected in the cytoplasm of the tumor cells (×100). **d** C-kit was not detected in the tumor cells (×100).

surface of the submucosal tumor is often covered with normal epithelium. EUS-FNAB is now commonly performed to diagnose submucosal tumors. This technique obtains more adequate specimens than does biopsy with upper gastrointestinal endoscopy. Rong et al. [5] reported that the diagnostic accuracy of EUS-FNAB for submucosal tumors was 85.2 % [5]. However, as in our case, EUS-FNAB does not always allow for a definitive pathological diagnosis. We are unsure of the reason for the lack of an adequate specimen in our case. However, a puncture at an acute angle was required to reach the deep portion of the esophageal wall. EUS-FNAB might have been a potentially dangerous procedure in our case because the aortic artery and trachea are located behind the esophagus in the mediastinal space. This may have contributed to the difficulty obtaining the EUS-FNAB specimen in our case. We proposed that the patient undergo EUS-FNAB a third time, but she refused.

Because the preoperative pathological diagnosis was not clear in our case, we performed subtotal thoracoscopic esophagectomy to both treat the patient's symptoms and possibly diagnose a malignancy. Even if the tumor mass had been a malignancy such as a GIST, the operation would have been curative because we performed subtotal esophagectomy.

Although the final diagnosis in this case was a benign schwannoma, FDG-PET showed a hypermetabolic appearance, suggesting malignant potential. Schwannomas are benign tumors, but a hypermetabolic appearance on FDG-PET has been reported. Schwannomas originate from nerve cells that express glucose transporter type 3 [7], and FDG uptake is considered to be increased for this reason. Beaulieu et al. [7] reported that there was no correlation between FDG uptake and the proliferation rate (Ki-67 index). The authors stated that even if the max SUV is >6.0, a benign schwannoma cannot be excluded. Our case does not conflict with their report in that our benign schwannoma showed a max SUV of 5.5 and MIB-1 labeling index of 10 %. Therefore, FDG-PET could not reveal whether the hypermetabolic appearance indicated a benign or malignant tumor. Otherwise, the findings can be meaningful for a diagnosis of schwannoma.

There is no consensus regarding the surgical treatment of esophageal submucosal tumors. Although the stomach and esophagus differ, the clinical practice guidelines for GIST in Japan declare that surgery is indicated for gastric submucosal tumors larger than 5.0 cm [10]. In our department, we first perform boring biopsy or EUS-FNAB to obtain a histopathological diagnosis of the submucosal tumor. If the submucosal tumor is malignant, such as a GIST, we usually perform a surgical operation. When the histopathological diagnosis is a benign lesion or is unclear, as in the present case, we perform one of the several approaches. If the tumor is

small or asymptomatic, we usually perform simple follow-up of the patient. When the tumor is large, increasing in size, or symptomatic, we consider invasive treatment with curative intent.

We usually first try endoscopic treatment for small tumors originating in the submucosal layer. We then attempt enucleation by a thoracoscopic approach because it is less invasive. If the defect of the esophageal wall is expected to be large upon intraoperative examination or the mass has malignant potential, we perform an extended operation based on the individual patient. In this case, we considered open subtotal esophagectomy when the tumor was diagnosed as malignancy or it was difficult to resect it safely and radically.

Thoracoscopic surgery is becoming common [8]. In our department, we believe that thoracoscopic surgery is a good technique for the treatment of benign tumors because it is less invasive and clinically appropriate, especially for benign esophageal tumors. Compared with conventional operations, thoracoscopic esophagectomy for esophageal submucosal tumors is reportedly associated with fewer postoperative complications such as pneumonia and allows for earlier ambulation [11–13]. We selected the thoracoscopic approach to improve our patient's quality of life and performed subtotal esophagectomy with curative intent.

In conclusion, we have reported a relatively rare case of an esophageal schwannoma. The diagnosis was difficult because we could not obtain an adequately sized specimen by boring biopsy and EUS-FNAB. The thoracoscopic approach is a good treatment option for large submucosal tumors of the esophagus.

Abbreviations
CT: Computed tomography; EUS-FNAB: Endoscopic ultrasound-guided fine-needle aspiration biopsy; FDG-PET: 18-Fluorodeoxyglucose positron emission tomography; GIST: Gastrointestinal stromal tumor; max SUV: Maximum standardized uptake value

Funding
This work was supported in part by the following grants and foundation: Grants-in-Aid for Scientific Research from the Japan Society for the Promotion of Science (JSPS): grant numbers 26461938, 26461969, 15K20902, and 15K10129.

Authors' contributions
TW was the first author and wrote the report. MS performed the operation and managed all data. TM, HS, and MS assisted with the operation. HK and TM performed the pathological diagnosis. All authors read and approved the final manuscript.

Competing interests
The authors declare that they have no competing interests.

Consent for publication
The patient provided consent to publish this case report.

Ethics approval and consent to participate
Not applicable.

Author details
[1]Department of General Surgical Science, Gunma University Graduate School of Medicine, 3-39-22 Showa-machi, Maebashi, Gunma 371-8511, Japan. [2]Department of Molecular Pharmacology and Oncology, Gunma University Graduate School of Medicine, 3-39-22 Showa-machi, Maebashi, Gunma 371-8511, Japan.

Received: 7 June 2016 Accepted: 2 November 2016
Published online: 07 November 2016

References

1. Choong CK, Meyers BF. Benign esophageal tumors: introduction, incidence, classification, and clinical features. Semin Thorac Cardiovasc Surg. 2003;15:3–8.
2. Seremetis MG, Lyons WS, DeGuzman VC, Peabody Jr JW. Leiomyomata of the esophagus. An analysis of 838 cases. Cancer. 1976;38:2166–77.
3. Shelat VG, Li K, Naik S, Ng CY, Rao N, Rao J, et al. Abdominal schwannomas: case report with literature review. Int Surg. 2013;98:214–8.
4. Kitada M, Matsuda Y, Hayashi S, Ishibashi K, Oikawa K, Miyokawa N. Esophageal schwannoma: a case report. World J Surg Oncol. 2013;11:253.
5. Rong L, Kida M, Yamauchi H, Okuwaki K, Miyazawa S, Iwai T, et al. Factors affecting the diagnostic accuracy of endoscopic ultrasonography-guided fine-needle aspiration (EUS-FNA) for upper gastrointestinal submucosal or extraluminal solid mass lesions. Dig Endosc. 2012;24:358–63.
6. Matsuki A, Kosugi S, Kanda T, Komukai S, Ohashi M, Umezu H, et al. Schwannoma of the esophagus: a case exhibiting high 18F-fluorodeoxyglucose uptake in positron emission tomography imaging. Dis Esophagus. 2009;22:E6–10.
7. Beaulieu S, Rubin B, Djang D, Conrad E, Turcotte E, Eary JF. Positron emission tomography of schwannomas: emphasizing its potential in preoperative planning. AJR Am J Roentgenol. 2004;182:971–4.
8. Toyama E, Nagai Y, Baba Y, Yoshida N, Hayashi N, Miyanari N, et al. A case of thoracoscopically resected benign esophageal schwannoma with high uptake on FDG-PET. Esophagus. 2008;5:167–70.
9. Ohno T, Ogata K, Kogure N, Ando H, Aihara R, Mochiki E, et al. Gastric schwannomas show an obviously increased fluorodeoxyglucose uptake in positron emission tomography: report of two cases. Surg Today. 2011;41:1133–7.
10. Nishida T, Hirota S, Yanagisawa A, Sugino Y, Minami M, Yamamura Y, Otani Y, Shimada Y, Takahashi F, Kubota T. Clinical practice guidelines for gastrointestinal stromal tumor (GIST) in Japan: English version. Int J Clin Oncol. 2008;13(5):416–30.
11. von Rahden BH, Stein HJ, Feussner H, Siewert JR. Enucleation of submucosal tumors of esophagus: minimally invasive versus open approach. Surg Endosc. 2004;18:924–30.
12. Shin S, Choi YS, Shim YM, Kim HK, Kim K, Kim J. Enucleation of esophageal submucosal tumors: a single institution's experience. Ann Thorac Surg. 2014;97(2):454–9.
13. Kent M, d'Amato T, Nordman C, Schuchert M, Landreneau R, Alvelo-Rivera M, Luketich J. Minimally invasive resection of benign esophageal tumors. Scand J Thorac Cardiovasc Surg. 2007;113:176–81.