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HOW-I-DO-IT ARTICLES

Side-overlap esophagogastric tube (SO-EG) reconstruction after minimally invasive Ivor Lewis esophagectomy or laparoscopic proximal gastrectomy for cancer of the esophagogastric junction

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Abstract

Purpose Both laparoscopic proximal gastrectomy with lower esophagectomy (extended LPG) and minimally invasive Ivor Lewis esophagectomy (MIILE) are acceptable treatments for adenocarcinoma of the esophagogastric junction (AEG), but the optimal reconstruction technique for mediastinal esophagogastrostomy (one that provides adequate reflux prevention) has not been established. We devised a novel side-overlap esophagogastric-tube (SO-EG) reconstruction.

Methods We performed a retrospective review of patient records after LPG or MIILE. In each patient, we created a 3-cm wide gastric tube, overlapping the esophagus by 5 cm. A linear stapler was inserted into the left side of the esophageal stump and the anterior gastric wall along the greater curvature. The entry hole was closed to make a slit-like anastomosis, and the right side of the esophageal wall was fixed to the anterior gastric wall.

Results Ten consecutive patients underwent this procedure between June 2020 and July 2021. Five patients had Siewert type II AEG: 4 with lower thoracic esophageal cancer and 1 with benign lower esophageal stenosis. A total of 3 patients underwent extended LPG, and 7 underwent MIILE. The median operative time was 352 min (range, 221–556 min). The postoperative course was uneventful in 9 patients; a single patient developed pneumonia. Seven patients underwent follow-up endoscopy at 6 months. One patient with anastomotic stenosis and 2 with mild reflux esophagitis were treated conservatively.

Conclusion Our novel SO-EG reconstruction is simple and feasible, with acceptable results for preventing reflux esophagitis. This technique can be performed with either extended LPG or MIILE.

Keywords Esophagectomy · Esophagogastric junction · Gastrectomy · Laparoscopic surgery

Introduction

The incidence of adenocarcinoma of the esophagogastric junction (AEG) has been increasing in both the West and East [1–3]. The rate of lymph node (LN) metastasis in patients with esophagogastric junction (EGJ) tumors has been confirmed by a recent prospective Japanese study, which also demonstrated the optimal extent of LN dissection [4]. Based on these findings, the current surgical strategy for EGJ tumors is generally divided into the following 3 types according to the extent of esophageal and gastric invasion: Ivor Lewis esophagectomy, extended proximal gastrectomy with transhiatal lower esophagectomy, or extended total gastrectomy with transhiatal lower esophagectomy [5].

As in many fields of surgery, minimally invasive techniques have been increasingly applied in patients undergoing gastrointestinal surgery, even when treating AEG. These techniques provide patients with better quality of life and have acceptable oncologic outcomes [6, 7]. Although minimally invasive surgery is a promising approach for AEG resection, performing reconstruction in the narrow mediastinum is technically demanding. Esophagogastrostomy is theoretically the optimal approach, considering its technical simplicity and ability to preserve normal bowel integrity, but it can potentially increase the risk for postoperative reflux esophagitis (RE) because of the negative pressure in the mediastinum. Surgeons have reported using esophagogastrostomy with antireflux anastomosis techniques, such as the

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double-flap technique [8–11], hand-sewn esophagogastrostomy techniques [12, 13], and side overlap with fundoplication by Yamashita (SOFY) [14]. Most of these laparoscopic techniques were developed for intraabdominal anastomosis with a well-preserved abdominal esophagus; there are no standardized techniques devised for AEG surgery. There is a need to establish the optimal reconstructive technique for esophagogastrostomy in the mediastinum — one that provides adequate reflux prevention. We devised a novel intracorporeal side-overlap esophagogastric-tube (SO-EG) reconstruction technique for use after laparoscopic proximal gastrectomy with lower esophagectomy (extended LPG) or minimally invasive Ivor Lewis esophagectomy (MIILE).

Patients and methods

Patients

We retrospectively reviewed the medical records of all patients who underwent the SO-EG reconstruction technique after extended LPG or MIILE between June 2020 and July 2021. The length of esophageal invasion in Siewert type II tumors was measured preoperatively using upper gastrointestinal endoscopy and an upper gastrointestinal x-ray series. The tumor stage was classified according to the 8th edition of the TNM staging system of the Union for International Cancer Control [15]. Surgical complications were classified according to the Clavien-Dindo system [16]. The results of endoscopic assessments of esophagitis were recorded using the Los Angeles classification [17].

We also retrospectively reviewed the medical records of all patients who underwent esophagogastric tube reconstruction [18] or double-tract reconstruction as part of radical surgery for AEG between April 2011 and December 2018. This allowed us to assess the short- and mid-term results of our previous reconstructive methods for extended LPG before introduction of the SO-EG technique. Because MIILE was rarely performed at that time, due to the surgeons' preference for the McKeown procedure, we excluded MIILE from this part of the analysis. We analyzed the anastomosis-related complications, postoperative endoscopic assessments of esophagitis, and proton pump inhibitor (PPI) use at 1 year for both groups.

Surgical procedure

We used the SO-EG procedure for laparoscopic transhiatal reconstruction in the lower mediastinum after extended LPG and for thoracoscopic reconstruction in the middle/upper mediastinum after MIILE. The details of laparoscopic gastric tube creation, LN dissection around the celiac axis and along the lower esophagus [18], and thoracoscopic mediastinal dissection [19] have been described elsewhere.

After placing 5 trocars into the abdominal wall (Supplementary Fig. 1a), we laparoscopically mobilized the stomach and created a gastric tube of 3 cm in width after complete dissection of the lesser curvature LNs along the branches of the left gastric artery (Fig. 1). During extended LPG, the center of the phrenic tendon was cut, and each phrenic crus was retracted laterally to obtain a good operative field of view. We performed transhiatal mediastinal LN dissection, preserving the left pleura if possible; we then transected the esophagus with an adequate proximal margin.

When performing MIILE, we created a minilaparotomy incision at the umbilicus to apply seromuscular sutures along the stapled line of the gastric tube, then inserted the tip of the gastric tube into the mediastinum and placed the patient in the semi-prone position. We then placed an additional trocar (Supplementary Fig. 1b) and collapsed the right lung using carbon dioxide insufflation to clear the surgical field. We inserted the thoracoscope through the 12-mm trocar in the ninth intercostal space. We mobilized the thoracic esophagus to the level of the cervicothoracic junction when the upper mediastinal dissection was completed. When upper mediastinal dissection was omitted, we limited mobilization to the caudal side of the arch of the azygous vein. We transected the esophagus in the mid- or upper mediastinum, with an adequate proximal margin; the excess length of the gastric tube was sacrificed before making the anastomosis. The resected specimens were pushed into the abdominal cavity through the hiatus in MIILE procedure.

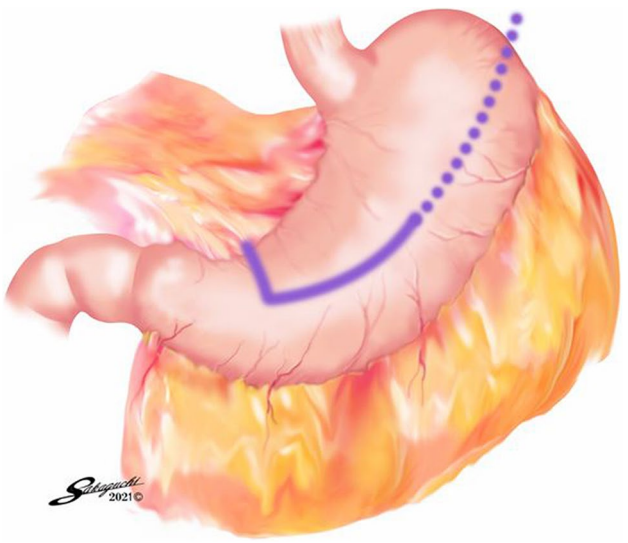

Fig. 1 A 3-cm gastric tube is created laparoscopically. The purple line indicates the transecting line. The dotted line indicates the transecting line for MIILE

Prior to creating the anastomosis, we overlapped the esophagus and the gastric tube by a length of 5 cm. We created small holes in the left side of the esophageal stump and the anterior gastric wall along the greater curvature and added some full-thickness sutures to prevent submucosal fork insertion. When using the stapler to create the anastomosis in MIILE, we changed the scope position to the 12-mm trocar in the seventh intercostal space, and inserted the stapler through the trocar in the ninth intercostal space. We inserted the 2 sides of a linear stapler, 45 mm in length (Signia^{TM} Stapling System; Covidien Japan, Tokyo; or Powered Echelon Flex®; Ethicon Endo-Surgery, Tokyo), and completed the first stapling (Fig. 2). The entry holes were hand sutured from both edges using an absorbable barbed suture device (V-Loc^{TM}; Covidien Japan, Tokyo) to make a slit-like anastomosis (never a V-shaped anastomosis) (Fig. 3). The right side of the esophageal wall and the stump of the esophagus were fixed tightly to the anterior gastric wall, around the longitudinal stapled line, using a nonabsorbable barbed suture device (V-Loc^{TM}; Covidien Japan, Tokyo) (Fig. 4) so that the esophagus lay flat against the stomach. Finally, the anastomosis was reinforced by wrapping it with the greater omentum. A soft silicone drain was inserted through the seventh intercostal trocar and advanced to the vicinity of the anastomosis. After completing the anastomosis for the MIILE procedure, the patient was moved to the supine position, and the specimen was retrieved through the umbilicus. In the extended LPG procedure, we placed a left thoracic drain when opening the left pleura. The opened diaphragm was closed, and the elevated gastric tube was sutured to the crura of the diaphragm to prevent hiatal hernia. Short video clips of a transhiatal reconstruction during extended LPG (Supplementary Video 1) and an intrathoracic reconstruction during MIILE (Supplementary Video 2) are available in the supplementary files.

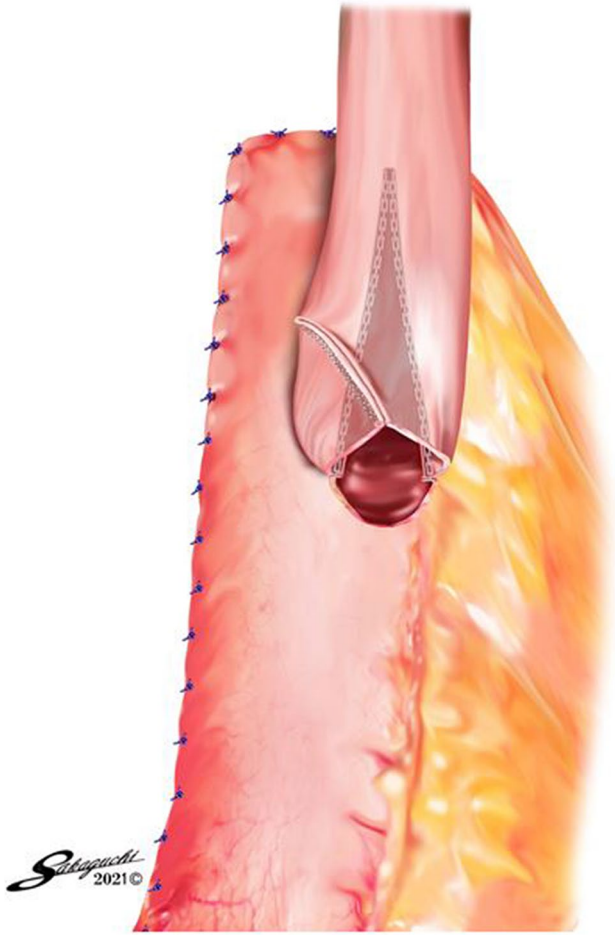

Fig. 2 View after the first stapling. A 45-mm linear stapler is used to create a V-shaped anastomosis comprising the left side of the esophageal wall and the anterior gastric wall along the greater curvature

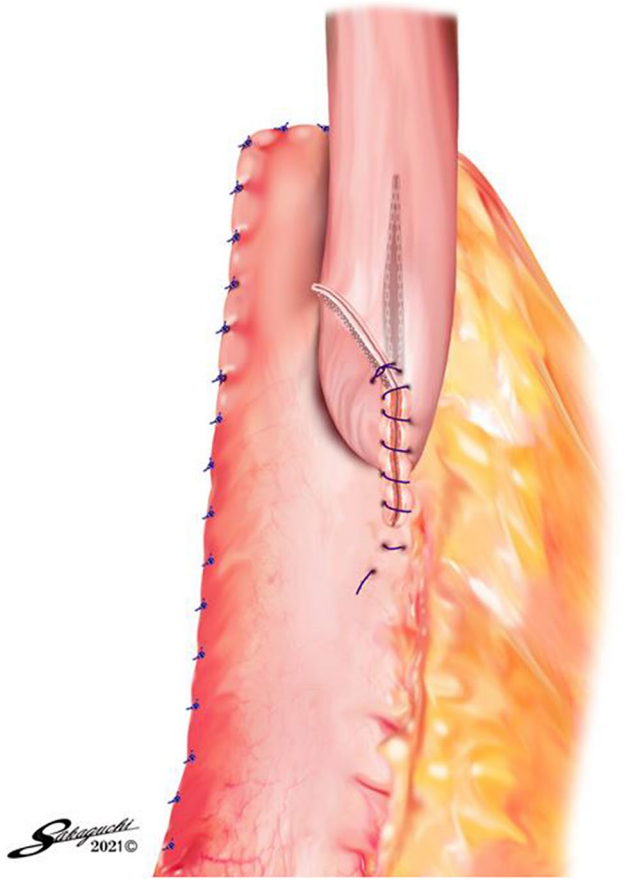

Fig. 3 The entry hole is hand sutured. The direction of suturing creates a slit-like opening

Statistical analysis

The Mann–Whitney *U* test was used to compare continuous variables, and either Fisher's exact test or the chi-squared test was used to compare categorical variables. We used

Fig. 4 Final view of the anastomosis. The right side of the esophageal wall and the stump of the esophagus are fixed tightly to the anterior gastric wall around the longitudinal stapled line, and the esophagus lies flat against the stomach

JMP, version 14.0.0 (SAS Institute, Cary, NC) to perform all statistical analyses. A p value of less than 0.05 was considered statistically significant.

Results

Ten patients underwent this reconstruction technique. We analyzed the short-term surgical outcomes of all 10 patients and the mid-term outcomes of 7 patients who completed 6-month follow-up and underwent postoperative endoscopy at 6 months. The clinicopathologic characteristics are shown in Table 1; the pathologic findings and the short- and mid-term results are shown in Table 2.

Five patients had Siewert type II AEG: 4 with lower thoracic esophageal squamous cell carcinoma and 1 with lower esophageal stenosis due to a benign esophageal ulcer. A total of 3 patients underwent extended LPG, and 7 underwent MIILE. Of the 7 patients who underwent MIILE, 3 had an upper mediastinal LN dissection. Of the 5 patients with Siewert type II tumors, 3 underwent extended LPG. These patients had esophageal invasion of 10 mm, 10 mm, and 20 mm, respectively. The other 2 patients with Siewert type II tumors underwent MIILE: one with esophageal invasion of 20 mm and suspected mid- and upper mediastinal LN metastases, and the other with esophageal invasion of 40 mm. There were no conversions to open surgery. The median operative time was 352 min (range, 221–556 min), and the blood loss was minimal (0–60 g). The esophagogastric-tube anastomosis was performed in the upper ($n = 3$), middle ($n = 4$), and lower ($n = 3$) mediastinum, as indicated. The postoperative course was uneventful in 9 patients; a single patient developed postoperative pneumonia (Clavien-Dindo grade 2), which was treated with antibiotics.

Table 1 Patient characteristics

Patient number	Age (year)	Sex	Histology	Siewert type II tumor	Length of esophageal invasion (mm)	cT[a]	cN[a]	cStage[a]	Neoadjuvant therapy
1	70	M	Adenocarcinoma	Yes	20	3	1	III	None
2	57	M	No malignancy	No	N/A	N/A	N/A	N/A	None
3	66	F	SCC	No	N/A	1a	0	I	None
4	74	M	Adenocarcinoma	Yes	10	3	0	III	None
5	89	M	Adenocarcinoma	Yes	10	2	0	IIB	None
6	90	F	SCC	No	N/A	1b	0	I	None
7	73	M	Adenocarcinoma	Yes	40	3	1	III	None
8	65	M	SCC	No	N/A	2	2	III	None
9	76	M	SCC	No	N/A	3	1	III	NACRT
10	85	F	Adenocarcinoma	Yes	20	3	1	III	None

SCC, squamous cell carcinoma; *M*, male; *F*, female; *N/A*, not applicable; *NACRT*, neoadjuvant chemoradiotherapy

[a]Determined by the 8th edition of the AJCC/UICC TNM classification

Table 2 Short-term and mid-term results

Patient number	Operative time (min)	Blood loss (g)	Procedure	UMD	Anastomotic site	pT[a]	pN[a]	pStage[a]	Postoperative complications (grade)	Endoscopic findings	Prophylactic use of PPI
1	447	Minimal	MIILE	Yes	Upper mediastinum	3	0	IIB	None	None	Yes
2	266	Minimal	MIILE	No	Middle mediastinum	N/A	N/A	N/A	None	LA Grade A	Yes
3	359	30	MIILE	No	Middle mediastinum	Tis	0	0	None	None	Yes
4	308	Minimal	Extended LPG	No	Lower mediastinum	3	3	IVA	None	None	No
5	221	Minimal	Extended LPG	No	Lower mediastinum	2	0	IC	None	LA Grade B	No
6	344	Minimal	MIILE	No	Middle mediastinum	1b	0	IB	None	None	No
7	489	60	MIILE	No	Middle mediastinum	3	3	IVA	None	Anastomotic stenosis	Yes
8	556	Minimal	MIILE	Yes	Upper mediastinum	1b	3	IVA	None	N/A	Yes
9	553	30	MIILE	Yes	Upper mediastinum	0[b]	0[b]	N/A	Pneumonia (2)	N/A	Yes
10	262	Minimal	Extended LPG	No	Lower mediastinum	3	2	IVA	None	N/A	Yes

UMD, upper mediastinal dissection; *POD*, postoperative day; *PPI*, proton pump inhibitor; *N/A*, not applicable; *Tis*, tumor in situ; *MIILE*, minimally invasive Ivor Lewis esophagectomy; *LPG*, laparoscopic proximal gastrectomy; *LA*, Los Angeles classification

[a]Determined by the 8th edition of the AJCC/UICC TNM classification

[b]Pathologic complete response

The use of PPI was recommended until 6 months postoperatively, but 3 of 7 patients discontinued the medication voluntarily before that time. At follow-up endoscopy 6 months after surgery ($n = 7$), a single patient with anastomotic stenosis was treated with balloon dilation, and 2 patients with mild RE were treated with medication (1 with Los Angeles grade A and prophylactic use of PPI; 1 with Los Angeles grade B without prophylactic use of PPI). Figure 5 shows a typical endoscopic finding of a flattened esophagus without RE, showing the slit-like stoma as seen from the esophagus (Fig. 5a) and the reproduced esophagogastric flap valve as seen from the stomach (Fig. 5b).

The short- and mid-term results of extended LPG using our previous reconstructive methods are shown in Table 3. A total of 24 patients underwent esophagogastric tube reconstruction [18], and 12 underwent double-tract reconstruction. Postoperative follow-up endoscopy at 1 year was performed in 30 patients (83%). All symptoms were medically controlled, but RE was observed more often in the patients who underwent esophagogastric tube reconstruction than in those who underwent either double-tract reconstruction or SO-EG reconstruction (Los Angeles grade C or D: 17%, 8%, and 0%, respectively).

Discussion

This report describes a novel technique: intracorporeal SO-EG reconstruction in the deep mediastinum. This technique is "so-easy" to perform with a linear stapler and has the advantage of a good operative view in the narrow mediastinum. Transhiatal anastomosis can be completed safely after extended LPG, and middle/upper mediastinal anastomosis can be completed safely after MIILE. This technique could be a good option for patients with AEG, especially for those with Siewert type II tumors.

As treatment for Siewert type II AEG, esophagectomy or proximal gastrectomy is sufficient when the extent of gastric invasion is less than 30 mm because the risk for nodal involvement along the greater curvature or antrum is low [4, 20]. Laparoscopic transhiatal lower mediastinal LN dissection can be safely performed and has the advantage of a magnified view on laparoscopy [21], but reconstruction in the narrow mediastinum is technically difficult. The available techniques for transhiatal reconstruction include esophagogastrostomy with antireflux anastomosis [8–14], double-tract reconstruction [22], and the Merendino procedure with jejunal interposition [23]. When there is a greater extent of esophageal involvement, appropriate techniques include subtotal esophagectomy and proximal gastrectomy with reconstruction, using either intrathoracic (Ivor Lewis) or cervical esophagogastrostomy (McKeown). Double-tract reconstruction is preferred for transhiatal reconstruction

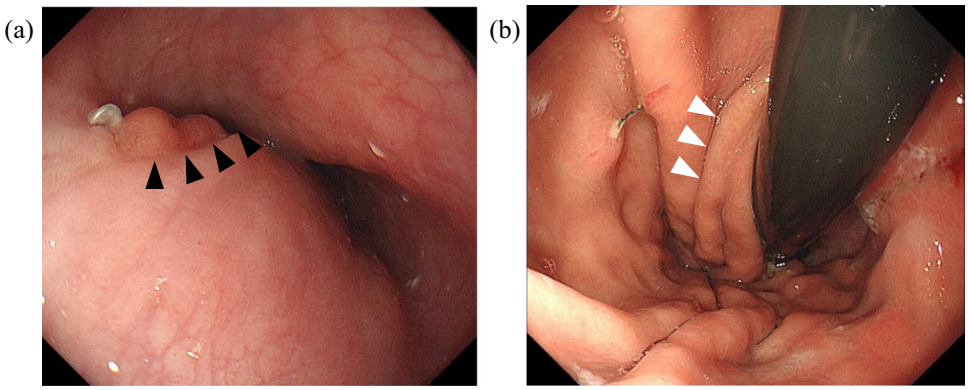

Fig. 5 Postoperative endoscopy. **a** View from the esophagus shows a flattened esophagus without reflux esophagitis and a slit-like stoma (arrowheads); **b** View from the stomach shows a mucosal fold similar to that created by an esophagogastric flap valve (white arrowheads)

Table 3 Short-term and mid-term results of extended LPG with previous reconstructive methods

	Esophagogastric tube (Ref 18)	Double tract	*P*
Number of patients	24	12	
Age, year, median (range)	75 (56–84)	78 (59–86)	0.37
Sex, *n* (male/female)	20/4	11/1	0.65
Operative time, min, median (range)	327 (207–487)	313 (170–550)	0.44
Blood loss, g, median (range)	minimal (0–202)	minimal (0–300)	0.49
Anastomotic leakage, *n* (%)			
Grade 2	0 (0)	1 (8.3)	0.33
≥ Grade 3	3 (12.5)	0 (0)	0.54
Anastomotic stricture, *n* (%)			
≥ Grade 3	4 (16.7)	0 (0)	0.29
Endoscopy follow-up[a], *n* (%)	21 (87.5)	9 (75.0)	0.38
Endoscopic findings, none/LA-A/B/C/D, *n*	9/3/5/0/4	7/0/1/1/0	0.18
PPI use at 1 year, *n* (%)	23 (95.8)	9 (75.0)	0.10

LPG, laparoscopic proximal gastrectomy; *LA*, Los Angeles classification, *PPI*, Proton pump inhibitor

[a]Patients who underwent postoperative endoscopy at 1 year

because of its low rate of RE [23]. This procedure is also easy for laparoscopic surgeons to pick up, because it is technically similar to laparoscopic total gastrectomy with gastrojejunostomy. However, 3 different anastomoses must be completed, and mobilization of the Roux limb to the higher mediastinum is sometimes difficult in patients with a great deal of adipose tissue. Esophagogastrostomy after proximal gastrectomy is the simplest and most convenient physiologic reconstruction method. However, the rate of RE is high without proper reflux prevention, especially in the mediastinum with its negative thoracic pressure; this greatly impairs postoperative quality of life. There is a need to determine the optimal reconstructive techniques for esophagogastrostomy that will reliably prevent RE.

It is crucial to take into consideration the mechanisms of gastroesophageal reflux and the physiologic antireflux barriers, including the lower esophageal sphincter (LES) and other anatomic factors such as the angle of His, crural diaphragm, and phrenoesophageal ligaments [24]. The LES is a tonically contracted segment of the distal esophagus, with normal resting pressure ranging from 10 to 30 mm Hg relative to intragastric pressure. The pressure is maintained through neurogenic and myogenic mechanisms. Anatomically, the LES lies within the hiatus created by the right crus of the diaphragm and is anchored by the phrenoesophageal ligaments. The oblique entrance of the esophagus into the stomach creates a sharp angle on the greater curve of the EGJ — this is called the angle of His, and it creates a flap-valve effect contributing to EGJ competence. Hill et al. [25] describe their gastroesophageal flap valve, seen endoscopically from the stomach, as a prominent fold of tissue along the lesser curvature, tightly grasping the shaft of the endoscope. A normal appearance of this flap valve is reportedly a predictor of the absence of RE [25]. After radical surgery for AEG, the lower esophagus and the surrounding anatomic structures are lost. Surgeons should try to reproduce the LES and the angle of His during esophagogastrostomy, incorporating an effective antireflux procedure.

The double-flap antireflux technique involves creating an esophagogastric anastomosis to which a fundoplication (based on valvuloplasty) is added. Reflux is prevented by using the intragastric pressure to flatten the lower end of the esophagus into a vulvate shape. This technique has favorable outcomes, including for morbidity and nutritional status [8]. Hand-sewn suturing for esophagogastrostomy achieves a soft and flexible anastomosis that will function as a one-way check valve [8, 9], and it reproduces the LES after valvuloplasty and recreates the angle of His with a pseudofornix on the dorsal side of the esophagus. The SOFY method is also a convenient side-overlap esophagogastrostomy technique for use after LPG. It uses a linear stapler [14] and has a low rate of RE or stenosis. Our technique employs the theoretical basis of antireflux mechanisms: overlap the esophagus and the stomach around a 5-cm, close the entry hole by making a slit-like anastomosis, and tightly suture the opposite side of the esophageal wall to the anterior wall of the stomach. These steps result in a flat anastomosis, with posterior pressure and a shutter mechanism provided by the remnant stomach. In all these laparoscopic techniques, including other hand-sewn esophagogastrostomies [12, 13], the theoretical basis is to reproduce the LES by making a flat or valvate anastomosis and to reproduce the angle of His using the posterior pressure of the overlapped remnant stomach on the dorsal side of the esophagus.

It is important to remember that the majority of the laparoscopic techniques for esophagogastrostomy were developed for intraabdominal anastomosis using a well-preserved abdominal esophagus. Some of these techniques are too complicated to complete in the narrow mediastinum [8–10, 12, 13], and bringing the wide stomach into the mediastinum would be difficult [8–14]. There are no standardized techniques devised specifically for AEG surgery. To simplify the double-flap method and thereby complete transhiatal anastomosis more easily, Omori et al. [11] devised the tri double-flap hybrid method, a technique for valvuloplastic esophagogastrostomy that uses a triangular linear-stapled esophagogastrostomy and a hand-sutured flap closure. This technique is designed for patients with Siewert II AEG and has a low rate of postoperative RE. We previously reported using esophagogastric tube reconstruction after extended LPG, creating a pseudofornix with a no-knife linear stapler to prevent postoperative RE [18]. We designed this technique for patients with Siewert II AEG and have performed it mainly in high-risk patients for whom esophagojejunostomy is better avoided. This is a simple procedure, but RE is not completely prevented at mid-term follow-up (Table 3). We realized that further modification of this technique was required, adhering more strictly to antireflux principles.

In our novel SO-EG reconstruction, the theory of reflux prevention is similar to that of the SOFY method [14]. First, the entry hole after the first stapling should be closed in a direction that will create a slit-like anastomosis, taking care not to open the anastomosis into a V-shape. Second, the right side of the esophageal wall should be sutured to the anterior wall of the gastric tube as tightly as possible so that the distal esophagus becomes flattened. The slit-like anastomosis reproduces the angle of His; this is seen endoscopically with flap-valve formation (Fig. 5b). The flattened esophagus reproduces the LES, resulting in a vulvate anastomosis with good posterior shuttering (Fig. 5a). Our surgical techniques for reflux prevention are similar to the SOFY method but have the advantage of a narrow gastric tube. Our procedure could be used for a transhiatal anastomosis in the deep mediastinum or for an intrathoracic anastomosis; we believe that it could be widely used as treatment for AEG.

In our small patient cohort, extended LPG with transhiatal reconstruction was safe for tumors with esophageal invasion up to 20 mm ($n = 3$), as treatment for Siewert type II tumors. For tumors with a greater degree of esophageal invasion ($n = 2$), we preferred MIILE with its safer intrathoracic anastomosis. We think that patients with esophageal invasion up to 20 mm are good candidates for transhiatal reconstruction using our procedure. We acknowledge that MIILE has a significant limitation: the proximal margin cannot be evaluated by specimen retrieval before making the anastomosis. However, MIILE has the advantage of a long gastric tube and easier securing of the proximal margin compared with the transhiatal approach. For higher tumors in which the proximal margin should be examined intraoperatively, the McKeown procedure with transcervical confirmation should be selected.

We use a technical adjustment to complete our procedure during MIILE, where the elevated gastric tube and the esophageal stump are flipped in the semi-prone position. The elevated gastric tube should be rotated 90° counterclockwise, and small holes should be made on the anterior gastric wall along the greater curvature and the left side of the esophageal stump (Supplementary Video 2). Understanding the 3-dimensional relations of these structures is crucial.

Our procedure has the following advantages. First, the use of a gastric tube confers reduced gastroesophageal reflux compared with using the wide remnant stomach [26], possibly because of less acid secretion, faster gastric emptying, and less influence of negative thoracic pressure. Second, our procedure can be widely used not only in the in the lower mediastinum after extended LPG, but also in the middle/upper mediastinum after MIILE for tumors with longer esophageal invasion. This versatility comes from creation of a narrow gastric tube, similar to that prepared in the McKeown procedure. Third, our procedure is technically simple with a linear stapler. Hand suturing is required only for closure of the entry hole and fixation of the esophageal wall to the stomach. Anastomotic procedures that use linear staplers reportedly have favorable outcomes, with fewer

strictures and less reflux than with hand-sewn or circular-stapled anastomoses [27]. Although surgeons must still keep in mind the risk for RE after MIILE and esophagogastrostomy using a linear stapler (Los Angeles grade C/D: 14%, 9% [28]), our novel procedure might be selected to prevent RE after MIILE.

Our study has several limitations. First, the number of patients is very small, and long-term outcomes are not yet available to show the advantages of our new technique compared with the current standard procedures. Second, it has not been clarified whether a 5-cm overlap for fundoplication is adequate to completely prevent reflux. Fundoplication with a longer overlap might be better, although we must overcome some anatomical restrictions to achieve this. Third, the small volume of food that can be retained in a 3-cm gastric tube might affect long-term nutritional outcomes. Fourth, our follow-up data are limited to endoscopic findings. Antireflux function was not verified by 24-h impedance pH monitoring or questionnaires; more data are needed to confirm our results.

Conclusion

Our novel SO-EG reconstruction after extended LPG or MIILE is simple and feasible, with acceptable short-term and mid-term outcomes showing RE prevention. Larger studies are required to confirm the advantages of this technique, but it could represent a procedure of choice for patients with AEG.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s00423-021-02377-5.

Availability of data and materials The data that support the findings of this study are available from the corresponding author upon request.

Code availability Not applicable

Author contribution Study conception and design: HH and SK. Acquisition of data: HH and MS. Analysis and interpretation of data: HH and SK. Drafting of manuscript: HH. Critical revision of manuscript: DY, RO, YH, MS, YS, and SK.

Declarations

Ethics approval This study was conducted in accordance with the tenets of the Declaration of Helsinki and approved by the ethics committee of Japanese Red Cross Osaka Hospital (IRB J-0264).

Consent to participate The requirement to obtain individual patient consent was waived by the ethics committee of Japanese Red Cross Osaka Hospital, given the retrospective nature of the case series.

Consent for publication All authors have provided consent for the article to be published in the Langenbeck's Archives of Surgery.

Conflict of interest The authors declare no competing interests.

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