

# Simple and Reliable Transhiatal Reconstruction after Laparoscopic Proximal Gastrectomy with Lower Esophagectomy for Siewert Type II tumors: y-shaped Overlap Esophagogastric Tube Reconstruction Laparoscopic transhiatal y-shaped esophagogastric tube anastomosis

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# Abstract

**Purpose:** Despite the increasing incidence of adenocarcinoma of the esophagogastric junction, laparoscopic proximal gastrectomy with lower esophagectomy (PGLE) is not widely accepted owing to the lack of standardized reconstruction techniques. In this study, we developed a new reconstruction method named y-shaped overlap esophagogastric tube reconstruction, which reproduces an angle of His and a pseudo-fornix, to be used in laparoscopic transhiatal PGLE. This study aimed to determine the feasibility of this novel reconstruction method.

**Methods:** This retrospective study included the analysis of short- and mid-term surgical outcomes of 30 consecutive patients with Siewert type II esophagogastric junction adenocarcinoma who underwent laparoscopic PGLE with y-shaped overlap esophagogastric tube reconstruction from April 2015 to August 2020. A novel method was used to form a 6-cm pseudo-fornix and an angle of His using the distal esophagus and a long gastric tube.

**Results:** The median operation time was 369 min, and the median blood loss was 28 mL. The median follow-up period after surgery was 37 months. Although two patients experienced postoperative anastomotic leakage, none of the patients developed stenosis. One patient experienced moderate reflux symptoms, whereas four patients developed moderate reflux esophagitis based on the 1-year follow-up endoscopic examination; the condition of all patients could be efficiently controlled with medication.

**Conclusion:** The short- and mid-term surgical outcomes of y-shaped overlap esophagogastric tube reconstruction reflected the feasibility of this simple technique and suggested its potential utility as a reconstruction alternative for Siewert type II tumors.

## Introduction

The incidence of adenocarcinoma of the esophagogastric junction is increasing globally, including in Japan [1]. Proximal gastrectomy (PG) with lower esophagectomy (PGLE) has become acceptable for the treatment of Siewert type II tumors based on abdominal and mediastinal nodal spread patterns in Japan [1-3]. The laparoscopic transhiatal approach for Siewert type II tumors has been reported to provide good visualization of the hiatus and lower mediastinum [4-6]. Circumventing total gastrectomy is associated with many benefits, including vitamin B12 absorption preservation and Castle's intrinsic factor and ghrelin production; however, reflux esophagitis (RE) remains a complication of PG [7-9]. Reconstruction methods to prevent RE after PG with intraabdominal anastomosis for gastric cancer include esophagogastrostomy with double-flap technique (DFT) and double-tract reconstruction [10-12]. However, transhiatal DFT not only involves the use of techniques that are relatively complicated but also needs to be performed in a narrow space within the mediastinum or intrathoracic cavity, which requires precision. In addition, double-tract reconstruction necessitates esophagojejunostomy at a higher thoracic level beyond the diaphragm, where attention should be paid to the tension on anastomosis. Aside from this, two additional anastomotic sites, gastrojejunostomy and jejunojunctionostomy, should be completed. A

recent Japanese nationwide prospective multicenter study on postoperative complications after surgery for esophagogastric junction cancer reported that these approaches promoted extremely high rates of anastomotic leakage (4/21, 19.0%), despite the limited number of patients who underwent transhiatal gastrectomy with minimally invasive surgery [13]. We hypothesized that anastomosis requiring the completion of a difficult technique in a narrow space at a high thoracic level would increase the risk of anastomotic leakage and development of severe intrathoracic empyema. At present, two simple laparoscopic methods using surgical staplers have been utilized to reduce the risk of RE following esophagogastronomy, in patients with proximal gastric cancer [14, 15]. With regard to simple reconstruction after PGLE for Siewert type II adenocarcinomas, a 2014 study by Hosogi et al. had been the first to report on the usefulness of the simple esophagogastric tube reconstruction technique with a stapled pseudo-fornix [5]. By 2015, we had developed a straightforward method for esophagogastric tube anastomosis, which simply reproduces a sufficiently long pseudo-fornix and an angle of His, by fixing the distal esophageal stump obliquely in a “y” shape on the anterior side of the gastric tube during the laparoscopic transhiatal approach for Siewert type II adenocarcinomas. In the present study, we aimed to evaluate the feasibility and safety of this novel method called the y-shaped overlap esophagogastric tube reconstruction, following laparoscopic transhiatal PGLE by examining the short- and mid-term surgical outcomes including anastomosis-related complications.

## Materials And Methods

### Patients

This retrospective study assessed the clinical outcomes of patients who underwent transhiatal reconstruction after laparoscopic PGLE for Siewert type II tumors in the period from April 2015 to August 2020 at Kobe University. The preoperative diagnosis in all patients was based on endoscopy and computed tomography scans. All tumors included in this study were confirmed as Siewert type II adenocarcinomas by preoperative examination. In all patients, preoperative endoscopic marking was performed by placing two clips on the proximal edge of the tumor 1–7 days prior to surgery. At least one surgeon who was qualified to perform laparoscopic gastrectomy according to the Endoscopic Surgical Skill Qualification System in Japan [16] participated in all the surgeries. Exclusion criteria included patients who had previously undergone synchronous surgeries combined with laparoscopic PGLE and who had a history of upper abdominal surgery. In all patients, lymph node dissection and reconstruction in laparoscopic PGLE were performed using the same established method. The Japanese Classification of Gastric Carcinoma (3<sup>rd</sup> English edition) was used for TNM staging [17].

The study was approved by the ethics committee of Kobe University (No. B210278). All patients provided written informed consent for permission on the anonymous use of surgery-related data.

### Surgical procedures

In all patients, laparoscopic PGLE was performed as follows. Under general anesthesia, the patient was placed in the reverse Trendelenburg position with their legs apart. The first 12-mm trocar was inserted through an umbilical incision via the open surgical method, a 10-mm flexible laparoscope (Olympus Optical, Tokyo, Japan) was inserted through the port, and pneumoperitoneum was established. The second 12-mm trocar was inserted from inside the right costal margin, and a 5-mm trocar was inserted from outside the right costal margin. A 5-mm trocar was inserted 20-mm above and to the left of the umbilicus, and the third 12-mm trocar was inserted from the left costal margin. The fourth 12-mm trocar was inserted from the epigastric region. A constant intraabdominal pressure of 10 mmHg was maintained during the procedure.

### *Lymph node dissection*

After lifting the lateral liver segment [18], the dissection of the following lymph nodes was performed based on tumor location, according to the Japanese Gastric Cancer Treatment Guidelines 2020 (5th edition): tumors within the submucosa, 1, 2, 3a, 7, 9, 19, 20, 110, 111, and 112; tumors deeper than the submucosa, 1, 2, 3a, 7, 8a, 9, 11p, 11d, 19, 20, 110, 111, and 112 [19]. In some patients with advanced cancer, lymph nodes in the area around the left renal vein (16a2lat) were laparoscopically sampled.

The operator and the first assistant stood on the patient's right and left sides, respectively, and the camera operator stood between the patient's legs. On the greater curvature, the right gastroepiploic artery was preserved and the left gastroepiploic and short gastric arteries were dissected around the root. On the lesser curvature, the section from the first to the third branch of the right gastric artery was preserved. Before proceeding with mediastinal lymph node dissection, a 40-mm incision was made in the left diagram using a 45-mm stapler device (Signia™ with a Tri-staple, 45-mm camel cartridge; Medtronic, Ireland, Dublin) and a surgical retractor (Endo Retract II™, 10 mm; Medtronic, Ireland, Dublin) was inserted via the epigastric port. The epicardium was lifted using a surgical retractor, and mediastinal lymph node dissection was performed.

### *Reconstruction*

The operator and the first assistant stood on the patient's right and left sides, respectively, and the camera operator stood between the patient's legs. During reconstruction, the surgical view of the mediastinum was secured by lifting the epicardium using a surgical retractor. In all patients, intraoperative endoscopic examination was performed to confirm the proximal edge of the tumor by locating the marking clips placed preoperatively and to determine the oral cutting line at least 20 mm away from the clips. The lower esophagus was transected from front to back at least 20 mm proximal to the cutting line using an endoscopic linear stapler (Signia™ with a Tri-staple, 60-mm purple cartridge) from the inside right port of the operator. Next, the entire stomach and regional lymph nodes were removed through a minimally enlarged 40-mm umbilical incision using a retrieval pouch (Endocatch II™; Medtronic, Ireland, Dublin). After examining the physical characteristics of the lesion, such as tumor depth and location, a gastric tube (40–50 mm in width) was created using a linear stapler (Signia™ with

a Tri-staple, 45-mm or 60-mm purple cartridge) under direct vision and a small opening was created 60-mm distal from the top of the gastric tube (Fig. 1a, b). Next, the gastric tube was reinserted into the abdominal cavity and a small hole was laparoscopically created at the dorsal edge of the esophageal stump. A linear stapler (Signia™ with a Tri-staple, 45-mm purple cartridge) was then inserted from the assistant's lower left port, which was parallel to the esophagus and at an angle of 45°–60° with the gastric tube (Fig. 2a), and esophagogastric tube anastomosis was established using a 25–45-mm-long linear stapler by utilizing 45-mm cartridges (Fig. 2b). Of note, full stapling with a 45-mm stapler was routinely performed until July 2017, whereas short stapling, having a length of 25–40 mm, using a 45-mm stapler was routinely performed from December 2017. The esophagogastric tube anastomosis was completed in a y-shaped angle, and a pseudo-His angle was created using the distal esophagus and gastric tube (Fig. 2c). After firing of the linear stapler, the common entry hole was closed using a full-thickness intracorporeal running suture, 25 cm in length, using 3-0 Vicryl™ (Ethicon GmbH, Norderstedt, Germany) (Fig. 2d). Additional suturing in the seromuscular layer was completed using a running suture with 3-0 PDS™, 20 cm in length, and Lapra-Ty™ clips (Ethicon GmbH, Norderstedt, Germany) through the entry hole and both sides of the distal esophagus, to be fixed flatly on the anterior gastric tube (Fig. 2e). A nasogastric tube was not routinely placed into the anastomosis and gastric tube. A soft silicone drain was placed around the anastomotic site through the seventh intercostal trocar under laparoscopic observation via the opened left diaphragm (Fig. 2f), which was closed by utilizing an intracorporeal suture using 2-0 Ethibond (Ethicon). Short video clips of the transhiatal y-shaped overlap esophagogastric tube reconstruction during laparoscopic PGLE can be viewed in the Supplementary Video.

## Operative complications

Data on operative complications and postoperative clinical course were retrospectively retrieved from the database. Postoperative complications included all major and minor complications and were graded according to the Clavien–Dindo classification [20].

## Follow-up protocol

All patients underwent follow-up examination, including regular physical examination and laboratory blood tests, at 3, 6, and 12 months after surgery. The prophylactic proton pump inhibitor (PPI) was recommended at least 12 months after surgery. Postoperative reflux symptoms were evaluated using the modified Visick score at 12 months after surgery [21]. The grade of endoscopic RE was classified and assessed using the Los Angeles classification [22], and the degree of food residue was evaluated according to the residue/gastritis/bile classification [23] based on endoscopy performed at 12 months after surgery.

## Statistical analysis

All statistical analyses were performed using JMP software version 8.0 (SAS Institute, Cary, NC, USA). Continuous variables were presented as medians (range) or [interquartile range], and analyses included

Fisher's exact test and the Mann–Whitney U test. A *P* value of <0.05 was considered to indicate statistical significance.

## Results

Thirty patients underwent laparoscopic transhiatal PGLE with y-shaped overlap esophagogastric tube reconstruction (Table 1). All patients underwent curative R0 resection. Out of these 30 patients, 11 with cStage II/III cancer underwent preoperative chemotherapy and 3 underwent additional lymphadenectomy of the left renal vein area (16a2lat) with curative intent.

The short- and mid-term surgical outcomes of the study cohort are presented in Table 2. The median operation duration was 369 [327–467] min, and the median blood loss was 28 [0–100] mL. No intraoperative complications or conversion to open surgery were observed. During the immediate postoperative period, grade II atelectasis or pleural effusion was observed in seven cases (23%). None of the patients with atelectasis and/or pleural effusion required any treatment after intraoperative routine placement of a left chest drain among the recent consecutive 20 cases. Grade II/III anastomotic leakage was observed in two patients (6.7%), out of which grade III was successfully treated with reoperation. These two patients suffered anastomotic leakage and were discharged at 78 and 112 days after surgery, respectively. Stenosis during the early and late postoperative periods was not observed in any of the patients, and there was no intraoperative mortality. The median duration of hospital stay was 18 [15–23] days. One patient (3%) developed postoperative reflux symptoms with a Visick score of III, and four patients (13%) were found to have developed Los Angeles grade C RE at the 1-year follow-up endoscopic evaluation; the condition of all five patients could be efficiently controlled by temporarily providing an antacid in addition to their routine proton pump inhibitor. No Grade 2 or higher residual food according to residue/gastritis/bile classification [23] was observed at the 1-year follow-up endoscopic evaluation with conventional instructions regarding fasting before the examination. Fig. 3a shows typical endoscopic findings of a patient evaluated 1 year after PGLE with y-shaped overlap esophagogastric tube reconstruction. The reproduction of the pseudo-fornix and His angle could be observed (Fig. 3b, c). Representative upper gastrointestinal series obtained 5 days after surgery, which was not routinely performed in all patients, showed no reflux of the contrast agent into the esophagus by pooling in the pseudo-fornix with the patient in the Trendelenburg position (Fig. 3d). Seven patients underwent adjuvant chemotherapy.

Regarding long-term outcomes, two patients had para-aortic lymph node recurrence, and remnant gastric cancer was observed in one patient. During the median follow-up period of 37 [18–47] months, cancer-related deaths were not observed, whereas four postoperative deaths were recorded owing to other causes, including pneumonia (*n* = 1), septic shock due to viral infection (*n* = 1), and unknown cause (*n* = 2).

Table 3 shows the mid-term nutritional results after surgery. Postoperative body mass index declined from 23.3 kg/m<sup>2</sup> in the preoperative period to 20.4 kg/m<sup>2</sup> and 20.0 kg/m<sup>2</sup> at 6 and 12 months after

surgery, respectively. Other parameters, including the hemoglobin count and levels of serum albumin and total protein, were maintained relatively well at 6 and 12 months after surgery.

Table 4 shows the comparison of surgical outcomes between the patients who underwent the overlap method with a stapling length of  $>35$  mm and those who underwent the same procedure with a stapling length of  $\leq 35$  mm. Albeit the absence of significant differences in the evaluated parameters, using a stapling length of  $\leq 35$  mm was associated with fewer RE symptoms and better nutritional status compared with the use of a stapling length of  $>35$  mm.

## Discussion

This study assessed the short- and mid-term surgical outcomes of patients with Siewert type II tumors. It also demonstrated that PGLE with a novel y-shaped overlap esophagogastric tube reconstruction technique enabled the completion of anastomosis in an easy and secure manner using a laparoscopic overlap method performed at a high thoracic level inside the narrow space of the mediastinum. Our experience illustrates the potential utility of this novel reconstruction method for the laparoscopic transhiatal approach in patients with Siewert type II tumors.

PGLE with lymph node dissection is an oncologically adequate treatment for Siewert type II adenocarcinoma with an esophageal invasion of 2.1–4.0 cm [3] and the proximal margin is recommended to be  $>2.0$  cm [24]. Therefore, in patients with Siewert type II adenocarcinoma and an esophageal invasion of 2.1–4.0 cm who are undergoing the transhiatal approach, lower esophagus should be resected at a minimum of 4.1–6.0 cm from the esophagogastric junction and the reconstruction should be completed at a high thoracic level in the mediastinum. Considering these technical difficulties associated with reconstruction that are encountered during the transhiatal approach, the Ivor Lewis or McKeown approaches for esophagectomy may be considered in patients with Siewert type II tumors. However, as described above, these approaches would be excessively invasive compared with laparoscopic PGLE for Siewert type II tumors with an esophageal invasion of  $\leq 4.0$  cm. Despite concerns regarding the increased risk of RE associated with reconstruction at a lower thoracic level compared with that performed at a higher thoracic level, the incidence of RE after lower mediastinal reconstruction using our technique was comparable to that reported in patients who underwent Ivor Lewis esophagectomy [25].

In Japan, standard reconstruction methods for laparoscopic intraabdominal anastomosis after PG have not been established; however, the DFT with valvuloplasty, which prevents the occurrence of severe RE after PG, has been widely performed in laparoscopic cases [10, 11]. However, the DFT requires a complicated suturing technique and is associated with a nonnegligible incidence of stenosis (4.7%–5.5%) [10, 11]. In a recent study, Omori et al. described a modified DFT, which comprised triangular linear-stapled esophagogastrostomy and a hand-sutured flap closure for laparoscopic transhiatal PGLE for Siewert type II adenocarcinoma [26]; this technique exhibited excellent outcomes with no incidence of leakage or stenosis in 31 patients. Despite the low rate of postoperative gastroesophageal reflux

symptoms based on low Visick scores, the incidence of grade B or higher RE was 10.5%, indicating that RE after reconstruction for Siewert type II adenocarcinoma cannot be completely prevented even with the DFT, which should provide a strong anti-reflux mechanism.

We predicted that increased pressure on the anastomotic site originating from the intrathoracic negative pressure and frequent compression by the heart beat in the mediastinum might contribute to a high incidence of anastomosis-related complications of laparoscopic transhiatal PGLE with esophagogastrostomy such as leakage, stenosis, and RE. The novel anti-reflux method described herein has two main components. First, creating a sufficiently long pseudo-fornix using a gastric tube would reduce the reflux of gastric contents into the esophagus with the patient in the supine position through the effect of gravity on the pseudo-fornix and gastric contents. Moreover, we expected that placing a long pseudo-fornix at a high thoracic level in the dorsal thoracic cavity would reduce excessive pressure from being exerted on the anastomotic site. Second, the distal esophageal stump was fixed obliquely in a y shape on the anterior side of the gastric tube, with the aim of creating a sharp angle between the distal esophagus and gastric tube similar to the His angle. We recommend the use of a stapler in the 25–35-mm range with the new y-shaped overlap esophagogastric tube reconstruction technique (Fig. 2b), for overlapping the esophagus and stomach with a length of 20–30 mm, except during anastomosis, to flatten the distal esophagus by the intragastric pressure in the pseudo-fornix, similar to the technique described for intraabdominal esophagogastrostomy [27].

Hosogi et al. reported the usefulness of esophagogastric tube (35-mm width) reconstruction technique with the stapled pseudo-fornix [5]. Using this technique, the pseudo-fornix with a length of approximately 30-mm was created by stapling the distal esophagus and the top of gastric tube using a 45-mm no-knife stapler and cutting staple row with a length of 15-mm for the anastomotic lumen. In our opinion, this very short overlap anastomosis with a length of 15-mm to ensure a pseudo-fornix length of 30 mm may cause high incidence rates of Grade III or higher anastomotic stenosis (16.7%) [5, 28]. Between 2013 April and 2015 March, we experienced four cases requiring esophagogastric tube reconstruction during laparoscopic PGLE for Siewert type II adenocarcinomas, wherein a straight overlap technique was used with a very short pseudo-fornix (length of 20 mm) by stapling the entry hole at the distal site 5-cm from the apex of gastric tube, with a 30-mm stapler. Although no postoperative leakage and stenosis had occurred in these series, a high rate of severe RE with Los Angeles grade C and D had been observed in two cases (data not shown). Thereafter, we developed the y-shaped overlap esophagogastric tube reconstruction technique that would allow a simple transhiatal esophagogastric tube reconstruction after laparoscopic PGLE, which expectedly lowers leakage, stenosis, and RE rates. Our technique can reproduce a longer pseudo-fornix with a length of around 60-mm by fixing the distal esophageal stump obliquely in a y shape on the anterior side of the gastric tube. As mentioned above, although the short overlap anastomosis with the use of a stapler in the 25–35-mm range is recommended for our y-shaped overlap esophagogastric tube reconstruction to prevent RE, we had never experienced anastomotic stenosis requiring any treatment. Recently, Hosogi et al. reported their experience with the first 10 patients who underwent surgery for the new esophagogastric tube (30-mm width) reconstruction technique during laparoscopic side overlap esophagogastrostomy using a gastric tube for laparoscopic transhiatal

PGLE and Ivor Lewis esophagectomy, which applied the mechanism of RE prevention that used the side overlap with fundoplication via the Yamashita method [28]. Although this procedure is expected to prevent RE simply using the side overlap technique with a gastric tube, its utility and safety with regards to Siewert type II tumors remain unclear because this case series included the short-term outcomes of laparoscopic transhiatal PGLE for only 3 of the 10 patients. Our approach, which uses a gastric tube (40–50-mm width) instead of a wide remnant stomach, closely resembles the method described by Hosogi et al. Utilizing a gastric tube is associated with several benefits. First, compared with the method using a wide remnant stomach, laparoscopic transhiatal PGLE using a gastric tube may reduce the incidence of RE owing to faster gastric emptying, less acid secretion, and less effect of negative intrathoracic pressure [28]. Endoscopic findings of Grade 2 or higher residual food, which had not been observed in the current case series despite a previous study on esophagogastrostomy with 21.8% patients exhibiting the same, might have reduced the rate of esophagogastric reflux [29]. Second, reconstruction using a gastric tube allows for tension-free anastomosis at a high thoracic level in the narrow mediastinum. Double-tract reconstruction after laparoscopic transhiatal PGLE prevents the occurrence of RE (<5%) [30] and is thus widely used in Japan [31]; however, the gastric tube can be easily elevated with less tension in higher intrathoracic sites compared with the reconstruction method using jejunum, especially in obese patients. In the current case series, three patients (10%) with a body mass index of >29 kg/m<sup>2</sup> were successfully treated without complications.

Third, by utilizing a gastric tube, the McKeown or Ivor Lewis approaches for esophagectomy can be easily revised in patients who may require upper and middle mediastinal lymph node dissection caused by unexpected esophageal tumor invasion beyond 4 cm based on intraoperative pathological findings [3]. Notwithstanding the potential advantages of utilizing a gastric tube over a wide remnant stomach, concern remains regarding the blood supply to the narrow gastric tube following the dissection of the gastric wall during anastomosis. We believe that our novel technique secures sufficient blood supply to the anastomotic site and the gastric tube because of the placement of the anastomotic site at a sufficient distance from the top of the gastric tube.

Evidence is lacking regarding the differences in the nutritional status of patients after esophagogastrostomy using a gastric tube vs. a wide remnant stomach. However, a recent nationwide study in Japan investigated the quality of life of patients with esophagogastric junction cancer following gastrectomy [31]. The authors reported that there were no notable differences in postoperative body mass index between the esophagogastrostomy and double-tract reconstruction groups following PG or between the total gastrectomy and PG groups. In agreement with that study, the postoperative body weight loss in patients at 6 and 12 months after surgery was low in the current study. Therefore, effective postoperative nutritional support is essential to maintain the postoperative body weight after gastrectomy for Siewert type II tumors, regardless of the procedure and reconstruction method. By contrast, our analyses indicated that the nutritional status, based on the hemoglobin count and levels of serum albumin and total protein, was maintained relatively well in patients at 6 and 12 months after surgery in comparison with the results of previous studies on reconstruction after PG [26, 29].

The y-shaped esophagogastric anastomosis, which reproduces a pseudo-fornix and an angle of His, is a simple technique that creates an overlap anastomosis. Reconstruction using a gastric tube with a simple anti-reflux mechanism having a good surgical view will reduce the incidence of anastomotic leakage and stenosis. In the present study, four surgeons with varying surgical experience participated in the operations. Despite the long operative duration needed in some cases depending on the surgeons' experience, each of them successfully completed the procedure, illustrating that this novel technique requires a basic level of technical skill and ensures complete laparoscopic total gastrectomy with esophagejejunostomy using the overlap method.

The limitations of this study should be acknowledged. First, this was a single-center study with a small cohort. However, the short- and mid-term surgical outcomes of our novel technique were meaningful considering the rarity of Siewert type II adenocarcinoma. Second, the degree of RE using this technique was not verified with 24-hour impedance pH monitoring. Third, we did not compare the outcomes between this technique and other conventional reconstruction techniques, such as DFT, SOFY, and double-tract reconstruction, used for laparoscopic intraabdominal PG. Further studies are warranted to investigate anastomotic complications, RE, and nutritional status after surgery to identify optimal methods for laparoscopic transhiatal reconstruction in patients with Siewert type II tumors.

## Conclusion

This study demonstrated that the y-shaped overlap esophagogastric tube reconstruction of a pseudo-fornix and His angle with laparoscopic transhiatal approach was a safe and feasible approach. This technique should be considered as an alternative for laparoscopic transhiatal esophagogastric anastomosis for Siewert type II tumors with an esophageal invasion of  $\leq 4.0$  cm.

## Declarations

**Funding:** No funding was received for conducting this study.

**Conflict of interest:** We certify that there is no actual or potential conflict of interest in relation to this article. All authors have no conflict of interest.

**Ethical approval:** 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. This article does not contain any studies involving animals.

This study was approved by the Ethics Committee of the Hyogo Cancer Center and Kobe University.

**Informed consent:** All patients provided written informed consent about permission for use of anonymous data pertaining to their surgery.

**Author contributions:** SK was involved in the study conception and design, participated in the sequence alignment, and drafted the manuscript. RS, MY, and KT were involved in the acquisition of data. HG, HH, KY, and TO contributed to the analysis and interpretation of data. NO, HH, TM, and SS participated in critical revision of the manuscript. YK conceived the study, participated in its design and coordination, and helped to draft the manuscript. All authors read and approved the final manuscript.

**Informed consent to participate:** All patients provided written informed consent for use of anonymous data related to their surgery.

**Informed consent to publish:** The authors affirm that the human research participants provided informed consent for publication of the images in Figure(s) 1a, 1b, and 1c.

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## Tables

**Table 1.** Characteristics of patients with Siewert type II adenocarcinoma who underwent y-shaped overlap esophagogastric tube reconstruction

Variable	No. of patients (n = 30)
Age, years	74 (47–89)
Sex (male/female)	25/5
BMI, kg/m <sup>2</sup>	23.3 (16.4–29.8)
CCI, n (0/1/2)	16/11/3
ASA score, n (1/2/3)	0/22/8
Histology (differentiated/undifferentiated)	21/9
Length of esophageal invasion, mm	20 (2–50)
Length of resected esophagus, mm	40 (20–80)
Additional surgery after ESD (yes/no)	8/22
Preoperative chemotherapy (yes/no)	11/19
cT stage (1/2/3/4) †	14/8/7/1
cN stage (0/1/2/3) †	20/7/2/1
cStage (I/II/III/IV) †	17/9/4/0
pT stage (0/1/2/3/4) †	2/16/4/7/1
pN stage (0/1/2/3) †	19/6/3/2
pStage (0/I/II/III/IV) †	2/16/6/6/0
Adjuvant chemotherapy (yes/no)	7/23

ASA, American Society of Anesthesiologists; BMI, body mass index; CCI, Charlson comorbidity index; ESD, endoscopic submucosal dissection

Continuous data are presented as medians with ranges.

† Classified based on TNM staging according to the Japanese Classification of Gastric Carcinoma, 3rd English edition [17]

**Table 2.** Short- and mid-term surgical outcomes of y-shaped overlap esophagogastric tube reconstruction

Variables	No. of patients (n = 30)
Operative time, min	369 (327–467)
Estimated blood loss, mL	28 (0–100)
Conversion to other approaches	0
Intraoperative complications	0
All early complications <sup>a</sup> (0–30 days), n (%)	12 (40)
Grade II <sup>a</sup>	
Atelectasis/pleural effusion, n (%)	7 (23)
Anastomotic leakage, n (%)	1 (3)
Pulmonary infection, n (%)	1 (3)
Intraabdominal abscess, n (%)	1 (3)
Grade IIIa <sup>a</sup>	
Anastomotic leakage, n (%)	1 (3)
Diaphragmatic hernia, n (%)	1 (3)
All late complications ( $\geq 30$ days), n (%) <sup>a</sup>	0 (0)
Amount of oral intake at discharge, %	10 (8–10)
Postoperative hospital stay, days	18 (15–23)
Postoperative mortality	0
PPI use at 1 year, n (%)	29 (97)
Reflux symptoms, I/II/III/IV <sup>d</sup>	26/3/1/0
Endoscopic findings at one year, (Normal, LA grades A/B/C/D), n <sup>b</sup>	16/3/7/4/0
Endoscopic residual food at 1 year, (0/1/2/3), n <sup>c</sup>	22/8/0/0
Duration after operation, months	37 (18–47)

LA, Los Angeles classification; PPI, proton pump inhibitor

The median and interquartile ranges (IQR) are provided for continuous values.

<sup>a</sup> Grade II or higher according to Clavien–Dindo classification [20]

<sup>b</sup> According to the Visick score [21]

<sup>d</sup> According to the Los Angeles classification [22]

<sup>c</sup> According to the residue/gastritis/bile classification [23]

**Table 3.** Mid-term nutritional outcomes after surgery with y-shaped overlap esophagogastric tube reconstruction

Variables	No. of patients (n = 30)
Postoperative BMI, kg/m <sup>2</sup>	
Before surgery	23.3 (16.4–29.8)
6 months	20.4 (13.4–25.4)
12 months	20.0 (13.4–24.7)
Hb, g/dL	
Before surgery	12.9 (8.5–16.7)
6 months	12.5 (8.1–14.2)
12 months	12.2 (8.5–16.3)
Alb, g/dL	
Before surgery	4.1 (2.2–5.0)
6 months	4.1 (2.8–4.6)
12 months	4.1 (2.2–4.8)
TP, g/dL	
Before surgery	6.7 (5.3–8.0)
6 months	6.8 (5.9–7.6)
12 months	6.7 (5.3–7.1)

Alb, serum albumin; BMI, body mass index; Hb, hemoglobin; TP, total protein

Continuous data are presented as medians with ranges.

**Table 4.** Comparison of surgical outcomes using the overlap method based on stapler length

Variables	Stapler length		P value
	>35 mm (n = 21)	≤35 mm (n = 9)	
Anastomotic leakage <sup>a</sup> , n (%)	2 (9.5)	0 (0)	0.48
Stenosis <sup>a</sup> , n (%)	0 (0)	0 (0)	1.00
Amount of oral intake at discharge, %	100 (80–100)	80 (75–100)	0.60
Postoperative hospital stay, days	20 (16–27)	15 (14–19)	0.08
Endoscopic findings 1 year after surgery, ≥LA grade C <sup>b</sup> , n (%)	3 (14)	1 (11)	0.8
Endoscopic residual food 1 year after surgery, ≥1 <sup>c</sup> , n (%)	6 (29)	2 (22)	0.72
Reflux symptoms, ≥II <sup>d</sup>	4 (19)	0 (0)	0.22
BMI 1 year after surgery <sup>e</sup> , %	-16.9	-18.3	0.75
Hb 1 year after surgery <sup>e</sup> , %	-3.5	+4.5	0.09
Alb 1 year after surgery <sup>e</sup> , %	0	+11	0.05
TP 1 year after surgery <sup>e</sup> , %	-1.4	+4.8	0.06

Alb, serum albumin; BMI, body mass index; Hb, hemoglobin; LA, Los Angeles classification; TP, total protein

The median and interquartile ranges (IQR) are provided for continuous values.

<sup>a</sup> Grade II or higher according to the Clavien–Dindo classification [20]

<sup>b</sup> According to the Los Angeles classification [22]

<sup>c</sup> According to the residue/gastritis/bile classification [23]

<sup>d</sup> According to the Visick score [21]

<sup>e</sup> Decreasing rates are presented median relative to preoperative data

## Figures



## Figure 1

Creation of the gastric tube via a small abdominal incision

**a.** After examining the lesion, a gastric tube, 40–50 mm in size, is created using a linear stapler along the planned purple line. **b.** A small opening 60 mm distal to the top of the gastric tube is created.

## Figure 2

Schematic illustration of y-shaped overlap esophagogastric tube reconstruction

**a.** To create the pseudo-fornix and an angle of His, the stapling direction formed by the distal esophagus and gastric tube is simulated with a 45°–60° angle in a “y” shape. **b.** A linear stapler is inserted from the assistant’s lower left port, and esophagogastric tube anastomosis is performed with a length of 25–40 mm, using a 45-mm stapler. **c.** After stapling, the uncut section of the distal esophagus, approximately 20–30 mm in length, is on the anterior side of the gastric tube. **d.** The common entry point is closed using a full-thickness intracorporeal running suture. **e.** The seromuscular layer is closed using a running suture through not only the common entry hole but also the left and right walls of the distal esophagus to be fixed flat on the anterior gastric tube. **f.** A soft silicone drain is placed around the anastomotic site through the seventh intercostal trocar and the left diaphragmatic opening is closed using nonabsorbable suture.

## Figure 3

Typical endoscopic findings 1 year after surgery (**a–c**) and upper gastrointestinal series 5 days after surgery (**d**)

**a.** View from the esophagus showing circular anastomosis with a slightly smaller diameter created using a 30-mm length stapler and no signs of reflux esophagitis. **b.** View from the gastric tube showing a pseudo-His angle formed by the distal esophagus and pseudo-fornix (yellow arrowheads). **c.** View from the gastric tube showing pseudo-fornix (white arrowheads). **d.** Upper gastrointestinal series showing no reflux of the contrast agent into the esophagus by pooling the in the pseudo-fornix, with the patient in the Trendelenburg position.

## Supplementary Files

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