

Original Article



Esophagojejunal Anastomosis after Laparoscopic Total Gastrectomy for Gastric Cancer: Circular versus Linear Stapling

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ABSTRACT

Purpose: No standard technique has been established for esophagojejunal anastomosis during laparoscopic total gastrectomy (LTG) for gastric cancer owing to the technical difficulty and high complication rate of this procedure. This study was performed to compare the short-term outcomes of circular and linear stapling methods after LTG.

Materials and Methods: A total of 106 patients treated between July 2010 and July 2018 were divided into 2 groups according to the following anastomosis procedures: hemi-double-stapling technique (HDST; circular stapling method; group C, n=77) or overlap method (linear stapling method; group L, n= 29). The clinicopathological features and postoperative outcomes, including complications, were analyzed. Multivariate analysis was performed using a logistic regression model to identify the independent risk factors for anastomotic complications.

Results: The incidence of anastomotic complications was significantly higher in group C than in group L (28.0% vs. 6.9%, P=0.031). The incidence of anastomosis leakage did not differ between the groups (6.5% vs. 6.9%, P=1.000). However, anastomosis stricture occurred only in group C (13% vs. 0%, P=0.018). Multivariate analysis showed that the anastomosis type was significantly related to the risk of anastomotic complications (P=0.045).

Conclusions: The overlap method was superior to the HDST with respect to anastomotic complications, especially anastomosis stricture.

Keywords: Gastric cancer; Laparoscopy; gastrectomy; Anastomosis, Roux-en-Y; Postoperative complication

INTRODUCTION

Laparoscopic distal gastrectomy is widely used in the treatment of gastric cancer. Although laparoscopic total gastrectomy (LTG) is also used in gastric cancer treatment, it is less frequently applied, partly owing to the technical difficulty of esophagojejunostomy. Esophagojejunostomy is considered the most technically difficult procedure in LTG because of the limited viewing angle and the difficulty of manipulating stapler devices in the confined space. In addition, esophagojejunostomy is associated with fatal anastomotic complications

Author Contributions

Conceptualization: S.K.Y.; Data curation: P.K.B., K.E.Y.; Formal analysis: P.K.B., S.K.Y.; Investigation: P.K.B., S.K.Y.; Methodology: P.K.B.; Project administration: S.K.Y.; Resources: S.K.Y.; Supervision: S.K.Y.; Validation: K.E.Y., S.K.Y.; Writing - original draft: P.K.B.; Writing - review & editing: K.E.Y., S.K.Y.

Conflict of Interest

No potential conflict of interest relevant to this article was reported.

such as bleeding, leakage, and stricture [1]. Bleeding can lead to death in severe cases. Leakage may adversely affect the survival of patients with advanced gastric cancer [2]. Stricture can cause feeding problems and may require repeated endoscopic balloon procedures. These additional inconveniences are likely to adversely affect the patients' quality of life and increase medical costs. Therefore, the establishment of an appropriate esophagojejunostomy technique is important for the overall development of LTG and for improving the prognosis of patients.

In the initial period of LTG, extracorporeal anastomosis via an 8–10-cm mini-laparotomy on the abdominal midline is the most commonly used technique, which is similar to the technique used in conventional open total gastrectomy. However, as the size of the mini-laparotomy increases with the degree of obesity in the patient and the location of the esophageal transection, the advantage of minimally invasive surgery is likely to disappear. Therefore, the need for intracorporeal anastomosis has increased and various methods for this procedure have been developed. The main esophagojejunostomy techniques currently used can be largely divided into 2 methods, use of a circular stapler and use of a linear stapler [1]. Anastomosis with a circular stapler can be divided into 3 methods according to anvil insertion and the purse-string suture technique. The first method, similar to conventional esophagojejunostomy anastomosis, involves the use of manually placed purse-string sutures after the insertion of an anvil head into the esophageal stump. The second method involves the use of a transorally inserted anvil (OrVil™; Medtronic, Minneapolis, MN, USA). The third method is the hemi-double-stapling technique (HDST), in which the anvil is inserted before esophageal transection through esophagotomy near the esophagogastric junction. In contrast, anastomosis with a linear stapler avoids the burden of anvil insertion and purse-string suturing. It can be divided into 2 methods, functional end-to-end anastomosis (FEEA) and side-to-side anastomosis (also called the overlap method).

The efficacies of various anastomosis methods have been studied [3-7]. Although each method has been extensively investigated, relatively few studies have focused on the comparison of different anastomosis methods. Since 2010, esophagojejunostomy after LTG has been performed using the HDST or the overlap method at Seoul St. Mary's Hospital and Uijungbu St. Mary's Hospital. This study was performed to compare the short-term outcomes of the HDST and the overlap method to determine which technique is superior.

MATERIALS AND METHODS

Patients

Between July 2010 and July 2018, a total of 116 consecutive patients with gastric cancer underwent LTG with the HDST or overlap method at Seoul St. Mary's Hospital and Uijungbu St. Mary's Hospital. A single surgeon (S.K.Y) performed all surgeries. Patients who underwent completion total gastrectomy or robot-assisted total gastrectomy and those followed up for <3 months were excluded from the study. Finally, 106 patients were enrolled and divided into the following groups according to the esophagojejunostomy technique: group C, which included 77 patients treated with the HDST, and group L, which included 29 patients treated with the overlap method. The HDST was performed from January 2010 to August 2016 and the overlap method from April 2016 to December 2017 (**Fig. 1**). The method of esophagojejunostomy was selected according to the surgeon's preference. The patient's body shape and tumor location were used as additional criteria when both methods were

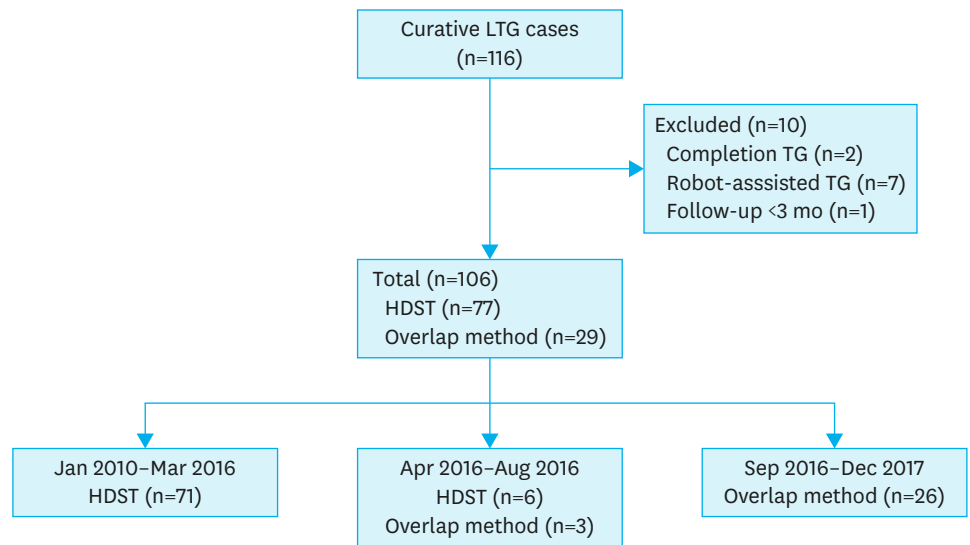


Fig. 1. Flow diagram of the study. LTG = laparoscopic total gastrectomy; TG = total gastrectomy; HDST = hemi-double-stapling technique.

considered. The clinicopathological features and operative outcomes of all patients were retrospectively analyzed. Lymph node dissection was performed as described in the 2010 Japanese Gastric Cancer Treatment guidelines [8]. The pathological stage was determined based on the 8th edition of the American Joint Committee on Cancer tumor–node–metastasis classification system [9]. The study was approved by the Institutional Review Boards of our hospitals (IRB No. XC19REDI0015).

Anastomosis procedure

In the HDST, a 25-mm anvil is prepared with a 2-0 silk or Vicryl suture tied in the hole of the tip. An approximately 4-cm mini-laparotomy is made on the left midaxillary line. A 3-cm gastrotomy is made 1–2 cm below the esophagogastric junction (**Fig. 2A**). The anvil is pushed into the gastrotomy site (**Fig. 2B**). The suture tied to the tip of the anvil is pulled upward, and esophageal transection is performed using an Endo GIA™ stapler (Medtronic; **Fig. 2C**). The suture is pulled out along with the central rod of the anvil, and the esophageal stump is prepared for esophagojejunostomy (**Fig. 2D**). The central rod of the anvil is removed, and an EEA™ stapler (Medtronic) is then introduced through the Roux limb (**Fig. 2E**). Esophagojejunostomy is accomplished by firing the stapler (**Fig. 2F**).

In the overlap method, esophageal transection is performed using an Endo GIA™ stapler, leaving 1 cm of the esophagus attached (**Fig. 3A**). The attached part is transected using a harmonic scalpel to create an opening (**Fig. 3B**). The true lumen of the esophageal stump is confirmed (**Fig. 3C**). The jejunum is approximated to confirm the tension of the Roux limb (**Fig. 3D**). To make a Roux limb, the jejunum is transected 20–30 cm below Treitz's ligament using an Endo GIA™ stapler. A small enterotomy is made in the anti-mesenteric border of the Roux limb, and 1 fork of the Endo GIA™ stapler is inserted thereafter. The other fork is inserted at the opening of the esophageal stump. After firing the Endo GIA™ stapler, esophagojejunostomy is performed in a side-to-side fashion (**Fig. 3E**). The opening hole is closed with continuous barbed sutures (**Fig. 3F**).

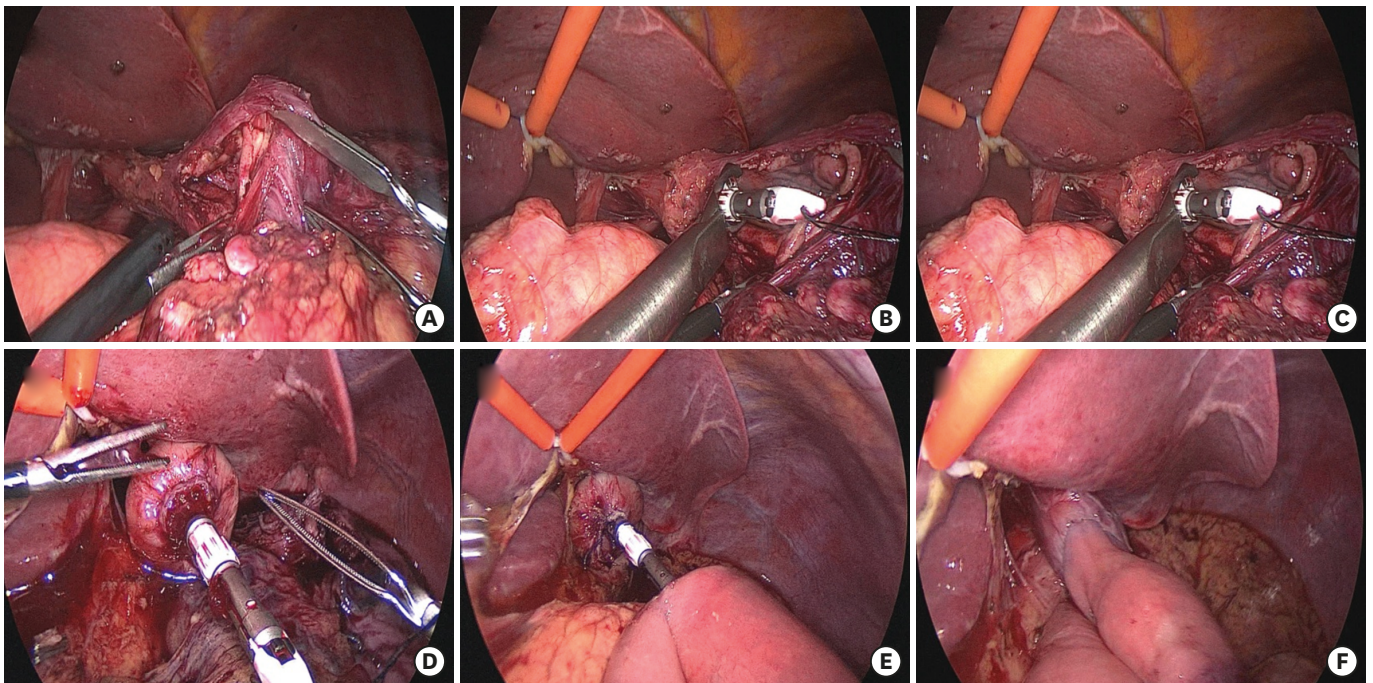


Fig. 2. Hemi-double-stapling technique. (A) A 3-cm vertical incision was made in the direction of the esophagus approximately 1-2 cm below the esophagogastric junction. (B) The anvil in the abdominal cavity was pushed into the opening using the anvil holder. (C) The thread tied to the central rod was held upward, and esophageal transection was performed using an Endo GIA™ linear stapler. (D) As the thread was subsequently pulled out, the central rod was pulled out of the esophageal stump. (E) The central rod was removed, and the anvil head and EEA™ stapler were connected. (F) Anastomosis between the jejunum and esophageal stump was performed.

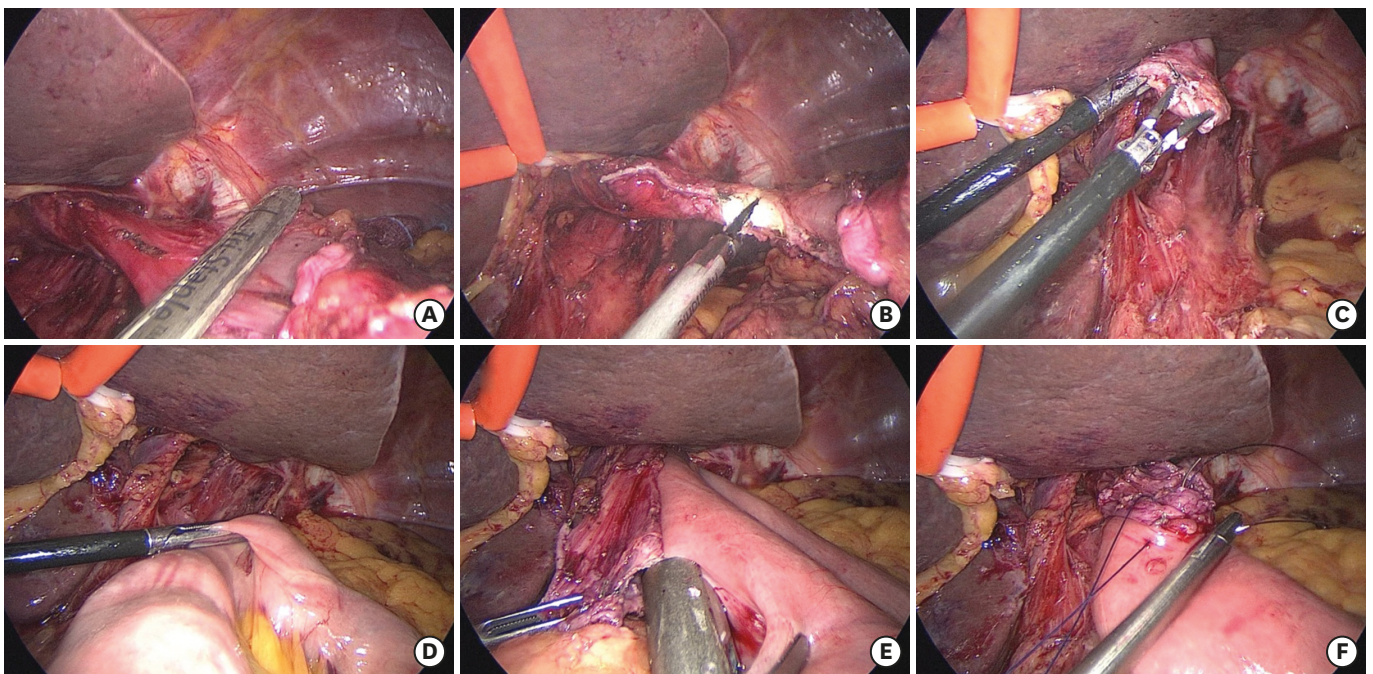


Fig. 3. Overlap method. (A) Esophageal transection was performed using an Endo GIA™ linear stapler, leaving about 1 cm of the left side of the esophagus attached. (B) The remaining 1-cm portion was resected using a harmonic scalpel to create an opening. (C) The true lumen of the esophageal stump was confirmed. (D) The jejunum was approximated to confirm the tension of the Roux limb. (E) Esophagojejunostomy was performed using an Endo GIA™ linear stapler. (F) The entry hole was closed in 2 layers using barbed sutures.

Postoperative complications

All patients were followed up every 3 months until 2 years after surgery, then every 6 months up to 5 years, and finally every year or until death. Postoperative complications were classified as anastomotic or non-anastomotic. Anastomotic complications (bleeding, leakage, and stricture) were confined to the esophagojejunostomy site and occurred within 3 months after surgery. Regardless of the patient's symptom, if a stricture was detected on endoscopic examination, anastomotic stricture was diagnosed. The severity of anastomotic complications was assessed using the Clavien–Dindo classification (CDC) [10]. To confirm all anastomotic complications, upper gastrointestinal series at 1 week and endoscopy at 2–3 months were routinely performed after surgery. When any suspicious symptom was detected, additional examinations, including blood tests and computed tomography, were performed.

Complications not related to the esophagojejunostomy site were defined as non-anastomotic complications and classified as either systemic or local. Systemic complications included death and respiratory and urinary complications. Local complications included ileus, internal hernia, intra-abdominal fluid collection, pancreatitis, phlebitis, splenic vein bleeding, and wound problems.

Statistical analysis

Data were analyzed using the SPSS software (version 24.0 for Windows; SPSS Inc., Chicago, IL, USA). Continuous variables were analyzed using Student's t-test or the Mann–Whitney U test. Categorical variables were compared with the χ^2 test or Fisher's exact test. Multivariate analysis was performed using a logistic regression model. In all analyses, $P < 0.05$ was considered to indicate statistical significance.

RESULTS

Patient characteristics

Table 1 shows the clinicopathological features and surgical outcomes of the 2 groups. The proportion of female patients was significantly greater in group C than in group L ($P = 0.032$). Age, body mass index, comorbidities, and history of previous abdominal surgeries did not significantly differ between the groups. With respect to surgical outcomes, the operation duration, estimated blood loss, and extent of lymph node dissection did not differ between the groups. In one case, intraoperative conversion from the HDST to the overlap method was required. The pathological stages were significantly more advanced in group L than in group C ($P = 0.001$).

Postoperative complications

Table 2 shows the anastomotic complications that occurred in the 2 groups. The incidence of anastomotic complications was significantly higher in group C (20/77, 28.0%) than in group L (2/29, 6.9%; $P = 0.031$). The incidence of anastomotic leakage did not significantly differ between the groups. However, anastomosis stricture occurred only in group C, with CDC grade I stricture occurring in 3 (4.0%) patients and CDC grade IIIa stricture occurring in 10 (13.3%) patients. Bleeding occurred only in group C, including CDC grade IIIa in one (1.3%) patient and CDC grade V in one (1.3%) patient. The incidence of non-anastomotic complications did not significantly differ between the groups (**Table 3**). There was 1 death due to atrial fibrillation in group C and 1 death due to hepatic failure in group L.

Table 1. Clinicopathological characteristics and surgical outcomes in groups C and L

Variables	Group C (n=77)	Group L (n=29)	P-value
Sex			0.032
Male	50 (64.9)	25 (86.2)	
Female	27 (35.1)	4 (13.8)	
Age (yr)	57.5±11.5	56.8±14.6	0.785
Body mass index (kg/m ²)	23.7±3.3	23.7±3.1	0.992
Comorbidity			0.227
Absent	35 (45.5)	17 (58.6)	
Present	42 (54.5)	12 (41.4)	
Previous abdominal operation			0.769
Absent	63 (81.8)	23 (79.3)	
Present	14 (18.2)	6 (20.7)	
Duration of operation (min)	200.8±32.9	199.0±45.4	0.555
Estimated blood loss (mL)	109.8±91.0	132.1±156.2	0.243
Extent of lymph node dissection			0.411
D1	11 (14.3)	7 (24.1)	
D1+	52 (67.5)	16 (55.2)	
D2	14 (18.7)	6 (20.7)	
Tumor location			0.967
Esophageal gastric junction	2 (2.6)	1 (3.4)	
Upper 1/3	38 (49.4)	15 (51.7)	
Middle 1/3	34 (44.2)	12 (41.4)	
Lower 1/3	3 (3.9)	1 (3.4)	
Pathological stage			0.001
I	68 (88.3)	16 (55.2)	
II	5 (6.5)	6 (20.7)	
III	4 (5.2)	7 (24.1)	

Data are shown as mean±standard deviation or number (%).

Table 2. Anastomotic complications in groups C and L

Variables	Group C (n=77)	Group L (n=29)	P-value
Anastomotic complications	20 (26.0)	2 (6.9)	0.031
Leakage	5 (6.5)	2 (6.9)	1.000
I	0	0	
II	0	0	
IIIa	5 (6.5)	1 (3.4)	
IIIb	0	1 (3.4)	
IV	0	0	
V	0	0	
Stricture	13 (17.3)	0	0.018
I	3 (4.0)	0	
II	0	0	
IIIa	10 (13.3)	0	
IIIb	0	0	
IV	0	0	
V	0	0	
Bleeding	2 (2.6)	0	1.000
I	0	0	
II	0	0	
IIIa	1 (1.3)	0	
IIIb	0	0	
IV	0	0	
V	1 (1.3)	0	

Data are shown as number (%).

Roman numbers indicate the Clavien–Dindo classification grade.

Risk factors for anastomotic complications

Table 4 shows the results of the multivariate analysis of risk factors for anastomotic complications. The type of anastomosis was significantly associated with the risk of anastomotic complications (odds ratio, 4.74; 95% confidence interval, 1.03–21.7; P=0.045).

Table 3. Non-anastomotic complications in groups C and L

Variables	Group C (n=77)	Group L (n=29)	P-value
Non-anastomotic complications	21 (27.3)	11 (37.9)	0.287
Systemic complications	10 (13.0)	5 (17.2)	
Death	1 (1.3)	1 (3.4)	
Respiratory	6 (7.8)	3 (10.3)	
Urinary	3 (3.9)	1 (3.4)	
Local complications	11 (14.3)	6 (20.6)	
Ileus	3 (3.9)	1 (3.4)	
Internal hernia	0	2 (6.8)	
Intra-abdominal fluid collection	4 (5.2)	1 (3.4)	
Pancreatitis	1 (1.3)	0	
Phlebitis	0	2 (6.8)	
Splenic vein bleeding	1 (1.3)	0	
Wound problem	2 (2.6)	0	

Values are presented as number (%).

Table 4. Multivariate analysis of risk factors for anastomotic complications

Variables	Unadjusted OR (95% CI)	P-value	Adjusted OR (95% CI)	P-value
Age (yr)			-	-
≤65	Reference	-		
>65	1.17 (0.39–3.58)	0.778		
Sex			-	-
Male	Reference	-		
Female	1.18 (0.41–3.39)	0.763		
Comorbidity			-	-
Absent	Reference	-		
Present	1.03 (0.34–3.07)	0.963		
Type of anastomosis				
Overlap method	Reference	-	Reference	-
HDST	3.68 (0.74–18.29)	0.111	4.74 (1.03–21.7)	0.045
Pathological stage			-	-
Stage I	Reference	-		
Stage II and III	0.49 (0.09–2.53)	0.391		
Tumor location			-	-
Upper part of the stomach	Reference	-		
Lower part of the stomach	1.25 (0.47–3.34)	0.662		
Lymph node dissection			-	-
D1 and D1+	Reference	-		
D2	1.12 (0.31–4.07)	0.867		

OR = odds ratio; CI = confidence interval; HDST = hemi-double-stapling technique.

DISCUSSION

In intracorporeal esophagojejunostomy with a circular stapler, anvil insertion and purse-string suturing remain challenging. The conventional anvil insertion technique, which involves the manual placement of purse-string sutures, is technically demanding. Methods involving purse-string suturing with a semiautomated suturing device or an endoscopic purse-string instrument have also been studied; however, these devices are not commonly used [11,12]. The OrVil™ procedure and the HDST were developed to reduce the burden associated with the use of purse-string sutures. Some studies have reviewed the safety of the OrVil™ procedure and reported disadvantages such as the risk of bacterial migration during transoral anvil insertion. In addition, the procedure entails a high risk of stricture because small anvils must be used to prevent esophageal tearing [13]. A systematic review showed that the incidences of anastomotic leakage and stricture are higher with the OrVil™ procedure than with other procedures [14]. Unlike the OrVil™ procedure, the HDST does not require the use of a small anvil. In addition, as anvil insertion is performed before esophageal

transection, esophageal injury caused by anvil insertion can be prevented. Moreover, the thread on the central rod acts as a bougie, allowing the rod to pass through the narrow exit hole, making it appear as a tight purse-string suture. However, cancer cells can spread into the abdominal cavity during gastrotomy. In the present study, to reduce the risk of spreading cancer cells, immediate suctioning after gastrotomy was performed to prevent the contents from flowing into the abdominal cavity. We have previously investigated the feasibility of the HDST, and concluded that it is a safe and simple method [7]. Kunisaki et al. [14] also reported that the HDST was the best among the methods they investigated. In many respects, the HDST is a good option for anastomosis with a circular stapler.

The linear stapling method has several merits over the circular stapling technique. A linear stapler can be manipulated through a trocar, thus permitting the minimization of the mini-laparotomy to only the length required for removing the specimen from the abdominal cavity. In addition, as the intraluminal status can be observed after anastomosis, complications such as bleeding can be prevented. As mentioned above, esophagojejunostomy using a linear stapler can be performed through FEEA or the overlap method. FEEA requires extensive mobilization of the jejunum, and mechanical closure of the opening of the anastomosis site may be difficult owing to the limited hiatal field provided by the pneumoperitoneum environment. Therefore, several studies have examined the efficacy and safety of the overlap method [6,15]. No standard method for esophagojejunostomy has been established. We previously reported our early experience with the 3 methods involving the use of a circular stapler and the overlap method, and concluded that further research is needed to determine which of these methods is the best [16]. In the present study, we attempted to identify the better procedure between the HDST and the overlap method by comparing the short-term outcomes.

A previous study reported a leakage incidence rate of 4.1% in the circular stapling group and 0.7% in the linear stapling group [17]. In a systematic review published in 2015, the incidence of anastomotic leakage after LTG was 2.1% [18]. The incidence rates of leakage in the present study were 6.5% in group C and 6.9% in group L, which were somewhat higher than those in other studies. As discussed in our previous report [7], in the case of the HDST, most cases of leakage occurred early in the series. A study reported that an experience of <45 cases of LTG with circular stapling is a risk factor for postoperative morbidity [19]. In addition, the routine use of upper gastrointestinal series after surgery may have affected the incidence of leakage because even minor leaks were detected. The same reasons may explain the high incidence of leakage in group L. In the present study, stricture occurred in 17.3% of cases in group C but in none in group L. In a previous study, the use of the double-stapling technique was a risk factor for stricture development based on the results of multivariate analysis [20]. One reason for this association is local ischemia in which the staple lines overlap, which can lead to fibrosis and subsequently to stricture. The HDST reduces the overlap of staple lines; however, the risk of stricture may be higher than that with the overlap method because one crossover is required.

In this study, multivariate analysis was performed to identify the risk factors for anastomotic complications. A previous study reported that the incidence of anastomotic stricture was significantly lower with the overlap method than with the OrVil™ procedure. In addition, the anastomosis procedure was the only factor that affected anastomotic complications [17]. In another study that compared esophagojejunostomy procedures used in LTG, the incidences of anastomotic leakage and stricture were higher with circular stapling than with linear stapling [1]. Several studies, including those mentioned above, have demonstrated that anastomosis with a linear stapler is associated with a lower incidence of stricture than procedures using

a circular stapler. These results may contribute to the role of the type of anastomosis procedure as a risk factor for anastomotic complications. Therefore, to prevent anastomotic complications, especially stricture, anastomosis with the overlap method is recommended.

However, the overlap method also has some drawbacks. If the length of the esophageal stump is not sufficient, use of the stapler becomes challenging. The anastomosis site may slip into the mediastinum, which can be fatal if leakage is present [1]. In addition, as the overlap method requires laparoscopic suturing skill to close the opening, it may be technically more difficult than the HDST. Use of a nasogastric tube may be required to avoid the insertion of the stapler fork into the pseudolumen of the esophageal stump [14]. In one study, the nasogastric tube was caught in the staple line during anastomosis with a linear stapler and repeat anastomosis was performed through a thoracotomy [21]. In addition, several studies have yielded findings different from those of the present study. A systematic review published in 2015 revealed no significant difference in complications according to the method of anastomosis [22]. Kyogoku et al. [23] also reported no difference in the incidence of complications between the circular and linear stapling methods. These discrepancies likely reflect inconsistencies in the definitions of anastomotic complications and LTG. Nevertheless, the discrepancies and imperfection of the procedures underscore the need for further detailed experimental studies.

This study has some limitations. It has a retrospective design and likely has important selection bias. The sex ratio and pathological stage differed between group C and group L. However, as group L included more advanced cases, the difference in pathological stage did not likely affect the results of this study. In addition, one expert surgeon performed all operations in this study, and the time periods of cases differed between group C and group L. The surgeon's proficiency may have influenced the incidence of anastomotic complications and other surgical outcomes. However, the effect of the surgeon's proficiency could not be sufficiently evaluated because of the lack of data for analyzing the influence of the learning curve. Further studies with respect to the learning curve should be conducted.

In conclusion, the incidence of anastomotic complications, especially stricture, is lower with the overlap method than with the HDST. Therefore, the overlap method may be more suitable than the HDST for esophagojejunostomy in LTG.

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