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Overlap method versus functional method for esophagojejunal reconstruction using totally laparoscopic total gastrectomy

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Abstract

Background Laparoscopic intracorporeal esophagojejunostomy (EJ) is a useful method in totally laparoscopic total gastrectomy (TLTG) for treating upper-third gastric cancer. The two methods of laparoscopic intracorporeal EJ—functional and overlap—have not been compared side-by-side in terms of safety and feasibility.

Methods Retrospective review and analysis of the data of 490 consecutive patients who underwent TLTG by either functional method ($n=365$) or overlap ($n=125$) method for upper- or middle-third gastric cancer was conducted between January, 2011 and May, 2018 at Asan Medical Center (Seoul, Korea). One-to-one propensity score matching (PSM) was performed to compare age, sex, body mass index, American Society of Anesthesiologist score, the presence of comorbidity, number of comorbidities, clinical T stage, clinical nodal stage, clinical TNM stage, history of previous abdominal surgery, and combined surgery. After PSM, 244 patients were divided into functional method group and overlap method group ($n=122$, each). The surgical outcomes and EJ-related complications were compared between the two groups.

Results No significant difference was found between the two groups in terms of early surgical outcomes such as operative time, time to first flatus, postoperative hospital stay, transfusion during surgery, transfusion after surgery, and administration of analgesics. However, the pain score was significantly lower in overlap method group (6.21 ± 1.83) than functional method group (6.97 ± 2.09, $p<0.05$). The overlap method was also associated with significantly fewer late complications (3.28% vs. 12.30%; $p<0.05$), lower Clavien–Dindo classification grade ($p<0.05$), and fewer EJ-related complications (0.82% vs. 6.56%; $p<0.05$), as compared with the functional method.

Conclusion The overlap method was safer and more feasible than the functional method for TLTG in gastric cancer patients, based on the finding of significantly lower incidence of EJ-related complications.

Keywords Laparoscopic surgery · Total gastrectomy · Esophagojejunostomy · Gastric cancer · Complication

Owing to the worldwide expansion of screening tests, the detection of gastric cancer has significantly increased [1–4]. As a result, the attention on intracorporeal anastomosis in laparoscopic gastrectomy and minimally invasive treatments for upper-third gastric cancer has recently grown. However, totally laparoscopic total gastrectomy (TLTG) is regarded as a technically challenging procedure due to the complexity of intracorporeal esophagojejunostomy (EJ). Various types of intracorporeal esophagojejunal reconstruction methods that utilize circular or linear staplers have been implemented to overcome such obstacles. However, there is no consensus on the ideal anastomosis method for EJ in TLTG [5–8].

Okabe et al. first reported the functional method for intracorporeal EJ [9]. This novel method substantially reduced the technical difficulties of TLTG and presented a secure and easy method of intracorporeal EJ in laparoscopic surgery. However, the functional method has disadvantages such as requirement of extensive mobilization of the jejunal limb to reduce the tension of the anastomosis and possible kinking of the efferent loop in the hiatal area. In contrast, the overlap method, first reported by Inaba et al., has several advantages including a change in the direction of the jejunal limb to alleviate tension at the anastomosis. This modification was

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implemented to reduce the incidence of postoperative complications such as anastomotic leakage and stricture. Several studies reported that TLTG using the overlap method is safe and feasible [10–12].

Although several studies investigated the short-term surgical outcomes of TLTG using the functional and overlap method, a comparative study between the two methods has not been carried out. Therefore, it is unclear which method is superior for use in EJ reconstruction in patients undergoing TLTG. Our study aimed to compare the functional and overlap methods in TLTG in terms of feasibility and safety for intracorporeal esophagojejunal anastomosis.

Materials and methods

Patients

We retrospectively reviewed the data of 490 patients who underwent TLTG by a single experienced surgeon using either the functional ($n = 365$) or the overlap method ($n = 125$) for upper- or middle-third gastric cancer between January, 2011 and May, 2018 at Asan Medical Center, a tertiary referral center in Seoul, Korea. The patients were selected based on the preoperative stage under clinical T3N3 staging in accordance with the American Joint Committee on Cancer (AJCC)—International Union for Cancer Control (UICC) 7th edition [13]. All patients underwent D2 lymph node dissection in compliance with the gastric cancer treatment guidelines [14]. Preoperative examinations including esophagogastroduodenoscopy, endoscopic ultrasound, and computed tomography were performed on selected patients for tumor staging. Based on the operative findings, patients with serosa exposure were converted to open surgery, and those were excluded from this study. The protocols of this study were approved by the Institutional Review Board of Asan Medical Center (2018-1005).

Surgical techniques

We adopted the surgical procedures of Kim et al. [6, 15–18] for laparoscopy, posture of patients, gastrectomy, and lymph node dissection. We performed intracorporeal EJ using the functional [6, 15–18] or the overlap method [12] as follows.

In the functional method, approximately two-thirds of the esophagus diameter was transected above sufficient proximal resection margin from the tumor using an endoscopic linear stapler (Fig. 1A). To prevent inadvertent spread of the cancer cells, the unstapled esophagus was cut with laparoscopic scissors after application of metallic clips 1 cm below the end part (Fig. 1B). The specimen was subsequently removed through the umbilical port site by extending the incision. After the specimen was removed, the jejunum was then transected 30–40 cm below the

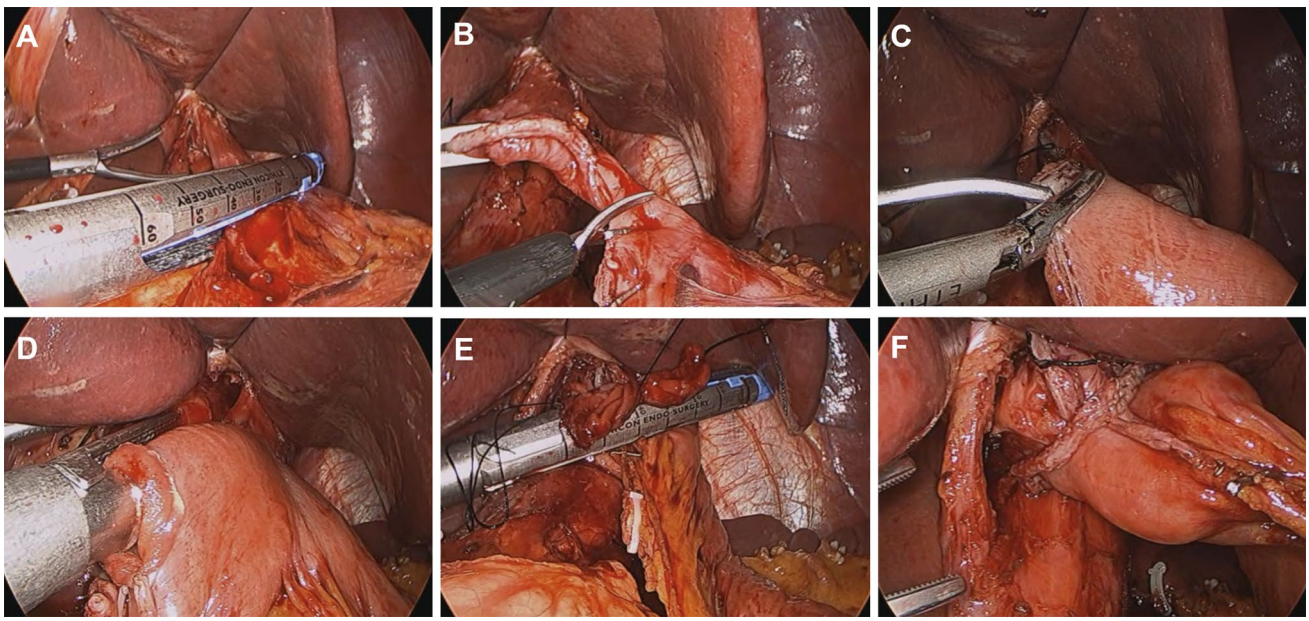

Fig. 1 Functional method of totally laparoscopic total gastrectomy. **A** Nearly two-thirds of the esophageal diameter is transected from a sufficient proximal resection margin above the gastroesophageal junction by using an endoscopic linear stapler. **B** The unstapled esophagus is transected with laparoscopic scissors. **C** Enterostomy is made at the end of the jejunum. **D** An endoscopic linear stapler is inserted between the esophagostomy and enterostomy at the end of the jejunum. **E** After constructing a common channel of the EJ, the entry hole is held with three sutures for tissue approximation. Subsequently, the entry hole is closed using an endoscopic linear stapler. **F** EJ after completion of the reconstruction

ligament of Treitz using an endoscopic linear stapler, and an efferent loop was turned counterclockwise to reconstruct the EJ. An enterostomy was performed at the end of the jejunum on the anti-mesenteric side of the Roux-en-Y limb using an ultrasonic scalpel (Fig. 1C) and an endoscopic linear stapler was inserted into the esophagostomy and enterostomy of the jejunum to form an EJ (Fig. 1D).

In the overlap method, the esophagus was rotated 90° counterclockwise and transected by two-thirds of the esophageal diameter, which enabled esophagostomy at the posterior side of the esophagus (Fig. 2A). The unstapled esophagus was transected with laparoscopic scissors (Fig. 2B). An endoscopic linear stapler was used to transect the jejunum at a point 30–40 cm distal to the ligament of Treitz. A small enterotomy was made on the anti-mesenteric side of the efferent jejunum 5–6 cm from the end of the jejunum (Fig. 2C). An endoscopic linear stapler was inserted into the esophagostomy and enterostomy of the jejunum to form an EJ (Fig. 2D).

In both methods, after the reconstruction of the common channel for EJ, the entry hole was closed using three sutures for tissue approximation and fully closed using an endoscopic linear stapler (Figs. 1E and 2E), and finally, EJ was constructed (Figs. 1F and 2F). A jejunojejunal side-to-side anastomosis was made approximately 40–50 cm below the EJ. Finally, we sutured between the mesentery of the jejunum to prevent internal herniation.

Clinical evaluation of surgical outcomes

The patient's data were collected as follows: The age, sex, body mass index (BMI), American Society of Anesthesiologist (ASA) score, presence of comorbidity, number of comorbidities, history of abdominal surgery, operative time, time to first flatus, intra- and postoperative transfusion, postoperative hospital stay, tumor size, number of retrieved lymph nodes, resection margins, and cancer stage based on the AJCC/UICC 7th edition [13], pick of pain score using the visual analog scale (VSA), and number of analgesics administered. Postoperative pain control consisted of intravenous, patient-controlled analgesia (fentanyl 1500 to 3000 μg or oxycodone 100 to 200 mg) and intermittent analgesic infusions. The severity of postoperative pain was assessed using the VSA and the number of additional doses of analgesics required during the hospital stay.

We also gathered information regarding combined major surgeries such as pancreatic, bile duct, colorectal cancer surgery, hysterectomy, salpingo-oophorectomy, adrenalectomy, and hepatic cyst surgery and combined minor surgeries such as appendectomy, cholecystectomy and splenectomy. A postoperative complication was defined as any event requiring conservative or surgical treatment postoperatively. Early complications were defined as events occurring within 30 days and late complications as those occurring 30 days postoperatively. These complications were reviewed and classified based on the Clavien–Dindo classification system (CDC) [19].

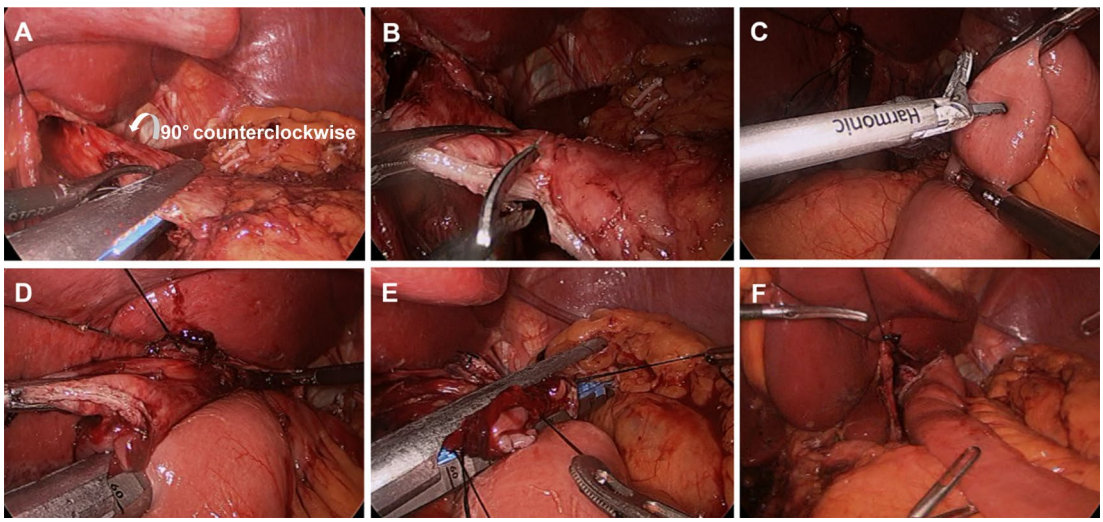

Fig. 2 The overlap method in totally laparoscopic total gastrectomy. **A** The axis of the esophagus is rotated 90° counterclockwise and nearly two-thirds of the esophageal diameter is transected using an endoscopic linear stapler. **B** The unstapled esophagus is transected with laparoscopic scissors. **C** Enterostomy is made 5–6 cm from the end of the jejunum. (D) An endoscopic linear stapler is inserted between the esophagostomy and enterostomy 5–6 cm from the end of the jejunum. **E** After constructing a common channel of the EJ, the entry hole is held with three sutures for tissue approximation. Subsequently, the entry hole is closed using an endoscopic linear stapler as in the functional method. **F** EJ after completion of the reconstruction

Statistical analysis

Data were analyzed using the SPSS version 18.0 (SPSS Inc., Chicago, IL, USA). The Chi-squared test or Fisher exact test for categorical variables and the *t*-test or Mann–Whitney *U* test for continuous variables were used to compare the two groups. To reduce the impact of treatment selection bias and potential confounding in an observational study, we also performed propensity score matching (PSM). The propensity scores were estimated with gastrectomy type as the dependent variable by multiple logistic regression analysis. A full non-parsimonious model was developed, which included age, sex, body mass index, American Society of Anesthesiologist score, the presence of comorbidity, number of comorbidities, clinical T stage, clinical nodal stage, clinical tumor stage, history of abdominal surgery, and combination surgery. We used a 1:1 ratio for Greedy matching using a caliper of 0.2 standard deviations of the logistical regression of the estimated propensity score without replacement. The absolute standardized differences were used to diagnose balance after PSM. All absolute standardized differences after matching were < 0.1. In a propensity score-matched cohort, McNemar or marginal homogeneity test for categorical variables and paired *t*-test or Wilcoxon signed rank test for continuous variables were used to compare the two groups. Moreover, the risks of binary outcomes were estimated using logistic regression with generalized estimating equations that accounted for the clustering of matched pairs [20]. *p*-values < 0.05 were considered statistically significant.

Results

Patient characteristics

Table 1 shows the clinical characteristics of functional and overlap method groups. Prior to PSM, significant differences of the age, clinical T stage, clinical TNM stage, and combined surgery were observed between the two groups (all, $p < 0.05$), whereas after PSM, no significant differences of any of the baseline characteristics were observed between the two groups. All baseline variables included in the model were well-balanced variables within the standardized difference < 0.1.

Early surgical outcomes and pathologic results after PSM

Table 2 presents details of the early surgical outcomes and postoperative pathologic results of patients in functional and overlap method groups. The mean numbers of retrieved lymph nodes were 41.20 ± 16.17 and 35.27 ± 14.77 in functional and overlap method groups, respectively ($p = 0.003$). Other pathological characteristics such as tumor size, resection margin, and pathologic TNM stage were not significantly different between the two groups. In overlap method group, the pain scores were significantly reduced (6.97 ± 2.09 vs. 6.21 ± 1.83 days; $p = 0.003$), as compared to those in functional method group, and hospital stay for fewer days postoperatively was achieved, without statistical significance (10.57 ± 12.00 vs. 7.39 ± 3.94 days; $p = 0.080$). The two groups did not exhibit any statistically significant differences with regards to other early surgical outcomes.

Postoperative complications after PSM

Early and late postoperative complications are presented in Table 3. No significant differences in early postoperative overall complications were noted between the two groups ($p = 0.123$). However, the rate of late complications was significantly lower in overlap method group ($n = 4$, 3.28%) versus functional method group ($n = 15$, 12.30%, $p = 0.012$), and significantly lower CDC scores were attained in overlap method group as compared to those in functional method group (early complications, $p = 0.049$; late complications, $p = 0.004$).

EJ-related complications after PSM

EJ-related complications are presented in Table 4. The number of late and total EJ-related complications was significantly different between the two groups ($p < 0.05$). Late EJ-related complications were observed in four patients (3.28%) in functional method group, whereas no cases were reported from overlap method group ($p = 0.046$). In addition, eight cases (6.56%) of total EJ-related complications were observed in functional method group, whereas only one case (0.82%) of EJ-related complication was detected in overlap method group ($p = 0.020$).

Discussion

This is the first PSM study to compare the surgical outcomes between the functional and overlap methods for EJ in TLTG. The results of this study show that the overlap method was associated with statistically significantly lower number of EJ-related complications than the functional technique.

TLTG is increasingly performed for upper-third gastric cancer because of the technical development in laparoscopic instruments and the accumulation of experience in surgeons. TLTG is a safe and feasible technique that is comparable to laparoscopic-assisted total gastrectomy using extracorporeal EJ or open total gastrectomy. TLTG not only yields a wider visual field, but also has shorter operative time, time to first flatus, commencement of soft diet, and postoperative

Table 1 Clinical characteristics of patients who underwent the functional and overlap methods

Variable	Total set ($n=490$)		p-Value	Stddiff	PSM set (1:1) ($n=244$)		Stddiff
	Functional method ($n=365$)	Overlap method ($n=125$)			Functional method ($n=122$)	Overlap method ($n=122$)	
Age (years, mean ± SD)	58.48 ± 11.00	61.60 ± 12.72	0.015	0.245	61.30 ± 10.87	61.25 ± 12.68	0.003
Sex			0.498	0.072			0.053
Male	239 (65.48)	86 (68.80)			86 (70.49)	83 (68.03)	
Female	126 (34.52)	39 (31.20)			36 (29.51)	39 (31.97)	
BMI (kg/m^2)	23.97 ± 3.02	24.45 ± 3.12	0.132	0.153	24.15 ± 3.01	24.40 ± 3.08	0.082
ASA score			0.455	0.130			0.050
I	223 (61.1)	71 (56.80)			70 (57.38)	71 (58.20)	
II	122 (33.42)	49 (39.20)			48 (39.34)	48 (39.34)	
III	20 (5.48)	5 (4.00)			4 (3.28)	3 (2.46)	
Number of comorbidities(number, mean ± SD)	0.59 ± 0.83	0.68 ± 0.94	0.414	0.100	0.61 ± 0.82	0.61 ± 0.83	0.009
Presence of comorbidity				0.070			0.017
No	220 (60.27)	71 (56.8)			70 (57.38)	71 (58.20)	
Yes	145 (39.73)	54 (43.2)			52 (42.62)	51 (41.80)	
Clinical T stage			0.004	0.320			0.060
cT1	299 (81.92)	88 (70.40)			86 (70.49)	86 (70.49)	
cT2	42 (11.51)	17 (13.60)			19 (15.57)	17 (13.93)	
cT3	24 (6.58)	20 (16.00)			17 (13.93)	19 (15.57)	
Clinical nodal stage			0.364	0.089			0.082
Negative	305 (83.56)	100 (80.00)			94 (77.05)	98 (80.33)	
Positive	60 (16.44)	25 (20.00)			28 (22.95)	24 (19.67)	
Clinical tumor stage			0.043	0.248			0.060
I	315 (86.30)	96 (76.80)			92 (75.41)	94 (77.05)	
II	34 (9.32)	19 (15.20)			19 (15.57)	19 (15.57)	
III	16 (4.38)	10 (8.00)			11 (9.02)	9 (7.38)	
History of abdominal surgery			0.820	0.065			0.025
None	287 (78.63)	95 (76.00)			96 (78.69)	95 (77.87)	
Minor surgery	43 (11.78)	17 (13.60)			15 (12.30)	16 (13.11)	
Major surgery	35 (9.59)	13 (10.40)			11 (9.02)	11 (9.02)	
Combined surgery			0.001	0.352			0.045
None	337 (92.33)	101 (80.80)			99 (81.15)	101 (82.79)	
Minor surgery	22 (6.03)	21 (16.80)			20 (16.39)	18 (14.75)	
Major surgery	6 (1.64)	3 (2.40)			3 (2.46)	3 (2.46)	

Values are expressed as mean ± SD or n (%)

PSM propensity score matching, *Stddiff* standardized difference, *BMI* body mass index, *ASA* American Society of Anesthesiologists Physical Status Classification

hospital stay [16–18, 21–23]. In TLTG, intracorporeal EJ is performed in several ways, of which the most widely utilized conventional methods include transorally inserted anvil (orvil) using a circular stapler, functional technique, and overlap method using a linear stapler.

Although TLTG has many advantages, it is associated with a high incidence rate of postoperative complication of 10–40% [24]. Especially, EJ-related complications may lead to morbidity and mortality. The rates of EJ anastomotic complications such as EJ stenosis or leakage were higher with the use of orvil than with a linear stapler (leakage rate, 4.1% vs. 0.7%, $p=0.106$, stenosis rate 4.1% vs. 0%, $p=0.017$) [25]. Another study reported a higher incidence of EJ stenosis when the orvil device was used (8.8%) than with other procedures such as side-to-side anastomosis using a linear stapler (1.0%) or double-stapling technique using a circular stapler with a transabdominally inserted anvil (3.6%) [26]. Furthermore, the risk of developing

Table 2 Early surgical outcomes and pathologic results in patients undergoing the functional and overlap methods

Variable	PSM set (1:1) ($n=244$)		p-Value
	Functional method ($n=122$)	Overlap method ($n=122$)	
Operative time (min)	160.31 ± 46.47	170.76 ± 42.23	0.075
Time to first flatus (days)	3.38 ± 0.88	3.42 ± 0.91	0.569
Transfusion during surgery (n)			0.317
No	121 (99.18)	122 (100.00)	
Yes	1 (0.82)	0 (0.00)	
Transfusion after surgery (n)			0.059
No	108 (88.52)	116 (95.08)	
Yes	14 (11.48)	6 (4.92)	
Pick of pain score	6.97 ± 2.09	6.21 ± 1.83	0.003
Administration of analgesics (n)	4.70 ± 5.58	3.65 ± 4.89	0.053
Hospital day after surgery (days)	10.57 ± 12.00	7.39 ± 3.94	0.080
Tumor size (cm)	3.86 ± 2.57	4.62 ± 3.47	0.065
Tumor location			0.736
Upper	104 (85.25)	101 (82.79)	
Middle	18 (14.75)	21 (17.21)	
Retrieved LN	41.20 ± 16.17	35.27 ± 14.77	0.003
PRM (cm)	2.25 ± 2.36	2.29 ± 3.28	0.561
DRM (cm)	13.07 ± 5.06	12.17 ± 4.21	0.139
T stage			0.309
T1	74 (60.66)	61 (50.00)	
T2	24 (19.67)	26 (21.31)	
T3	16 (13.11)	22 (18.03)	
T4	8 (6.56)	13 (10.66)	
N stage			0.359
N0	92 (75.41)	89 (72.95)	
N1	10 (8.20)	17 (13.93)	
N2	14 (11.48)	9 (7.38)	
N3	6 (4.92)	7 (5.74)	
TNM stage			0.383
I	87 (71.31)	79 (64.75)	
II	21 (17.21)	25 (20.49)	
III	13 (10.66)	18 (14.75)	
IV	1 (0.82)	0 (0.00)	

Values are expressed as mean ± SD or number (%) or median (range)

PSM propensity score matching, *LN* lymph node, *PRM* proximal resection margin, *DRM* distal resection margin

postoperative throat pain is higher, and esophageal injury may occur following transoral insertion. Therefore, intracorporeal EJ with an endoscopic linear stapler has been a popular surgical procedure in TLTG for upper-third gastric cancer patients.

Multiple studies have been carried out on the rate of EJ-related complication in the functional method using linear staplers, which ranged from 0 to 6.45% [6, 15, 16, 27, 28]; in contrast, there are only very few reports on EJ-related complications for the overlap method [10–12, 25]. Moreover, no study to date has compared the results of these two methods side-by-side, and selecting a safer and more feasible procedure for TLTG has remained difficult. We therefore conducted a PSM analysis for the two methods, and showed that the overlap method was associated with significantly fewer numbers of EJ-related complications. When using the overlap method, there was only one case (0.82%) of EJ leakage and no cases of EJ stricture. In contrast, five patients (4.10%) had EJ strictures and three patients (2.46%) had EJ leakages after surgery with the functional method.

There are several possible explanations as to why the overlap method demonstrated favorable outcomes. First, the

Table 3 Postoperative complications

Variable	PSM set (1:1) ($n=244$)		p-Value
	Functional method ($n=122$)	Overlap method ($n=122$)	
Early complications			
Overall complications			0.123
No	90 (73.77)	100 (81.97)	
Yes	32 (26.23)	22 (18.03)	
Clavien–Dindo classification			0.049
0	90 (73.77)	100 (81.97)	
1	3 (2.46)	2 (1.64)	
2	16 (13.11)	17 (13.93)	
3	12 (9.84)	3 (2.46)	
4	1 (0.82)	0 (0.00)	
Late complications			
Overall complications			0.012
No	107 (87.70)	118 (96.72)	
Yes	15 (12.30)	4 (3.28)	
Clavien–Dindo Classification			0.004
0	107 (87.70)	118 (96.72)	
1	2 (1.64)	0 (0.00)	
2	2 (1.64)	0 (0.00)	
3	11 (9.02)	2 (1.64)	
4	0 (0.00)	2 (1.64)	
5	0 (0.00)	0 (0.00)	

Values are expressed as mean ± SD or number (%)

PSM propensity score matching

Table 4 Esophagojejunostomy-related complications

Variable	PSM set (1:1) ($n=244$)		p-Value
	Functional method ($n=122$)	Overlap method ($n=122$)	
EJ-related complications (early)			0.180
No	118 (96.72)	121 (99.18)	
Yes	4 (3.28)	1 (0.82)	
EJ-related complications (late)			0.046
No	118 (96.72)	122 (100.00)	
Yes	4 (3.28)	0 (0.00)	
EJ-related complications (total[a])			0.020
No	114 (93.44)	121 (99.18)	
Yes	8 (6.56)	1 (0.82)	
Leakage	3 (2.46)	1 (0.82)	
Stricture	5 (4.10)	0 (0.00)	

Values are expressed as mean ± SD or number (%)

PSM propensity score matching

[a]Total: Early and late EJ-related complications

functional method requires longer esophagus and entails a more extensive division of the jejunal mesentery to safely perform EJ anastomosis and to reduce tension at the EJ site [10]. Therefore, the functional method is difficult to adequately carry out in patients with obesity in whom vasculature tracing and mesentery division is challenging, or in those with short mesentery of the small bowel, which complicates mobilization of the Roux limb; in such patients, the overlap method may be better because it induces less tension at the EJ site and thereby reduces the incident of EJ leakage. Second, in order to secure sufficient surgical field for EJ with endoscopic linear stapler, the functional method often requires wide division of the left crus muscle for tumors that involve the gastroesophageal junction or in cases of short esophagus. Intentionally divided crus muscle may constitute surgical trauma that induces adhesion between efferent loop of the EJ and the crus muscle, thereby resulting in EJ stricture. Third, in the overlap method, EJ is made on the posterior side of the esophagus, which readily adjusts to the oval shape of hiatal opening; therefore, the overlap method allows for easier passage of food with less probability of obstruction by the crus muscle. On the contrary, after using the functional method, the axis of the jejunal limb at the EJ is upward and the jejunal limb is positioned on the left side of the esophagus; therefore, the functional method results in kinking or narrowing of the lifted efferent loop just below the EJ, which results in increased incidence of EJ stricture.

Out of the nine patients with EJ-related complications (early and late), four patients had EJ leakage and five patients had EJ stricture. Among these patients, eight had CDC 3 complications, whereas the remaining patient fully recovered via conservative care comprising antibiotics, fasting, and total parenteral nutrition. Of the eight patients with CDC 3, six required interventions such as endoscopic ballooning, stent insertion, or pigtail drainage, and two required surgery (Table 5). Postoperative mortality was absent in all patients. EJ-related complications are severe complications that require intervention or reoperation, thereby increasing postoperative hospital stay and morbidity. Other studies also showed that EJ-related complications are associated with high morbidity, high mortality, and fatal prognosis [29, 30]. Thus, selecting a safe and appropriate EJ method is important because EJ-related complications in TLTG have adverse effects on postoperative recovery. Our results showed that TLTG using the overlap method had more favorable surgical outcomes, including less pain scores, fewer late complications, and lower morbidity. The results of our current study may be helpful for selection of the optimal method for intracorporeal EJ by the surgeons.

Table 5 Characteristics of patients with EJ-related complications

Case	Sex	Age	Primary operation	TNM stage	Early or late	Type of complication	CDC	Treatment	Outcomes
1	M	71	Functional	IA	Early	Leakage	3A	Intervention	Full recovery
2	F	65	Functional	IIB	Late	Stricture	3A	Intervention	Full recovery
3	F	53	Functional	IIIC	Late	Stricture	3A	Intervention	Full recovery
4	F	54	Functional	IB	Early	Stricture	3A	Intervention	Full recovery
5	M	58	Functional	IB	Early	Leakage	3A	Intervention	Full recovery
6	M	62	Functional	IIA	Late	Stricture	3A	Intervention	Full recovery
7	M	54	Functional	IB	Early	Leakage	3B	Operation	Full recovery
8	M	59	Overlap	IA	Early	Leakage	2	Conservative	Full recovery
9	M	64	Functional	IB	Late	Stricture	3B	Operation	Full recovery

CDC Clavien–Dindo classification

With regard to early surgical outcomes, the number of the retrieved lymph nodes (35.27 ± 14.77) in overlap method group was significantly smaller than that in functional method group (41.20 ± 16.17; $p = 0.003$). Both methods utilized D2 lymph node dissection, which may explain our finding of comparable levels of lymph node dissection between the two groups; although we obtained statistical significance for those results, we considered that the difference of number of the retrieved lymph nodes may not have clinical significance, since both methods retrieved sufficient number of the lymph nodes within the recommended limit of at least 16 regional nodes required for pathological assessment according to the 8th edition of the AJCC cancer staging [31]. In addition, we observed fluid collection as a possible complication of lymph node dissection in 10 and 11 cases in the functional and overlap methods, respectively, and no occurrence of pancreatic fistula in both methods, which supports that the difference in the number of lymph nodes retrieved in the two methods may not have clinical significance.

The present study has some limitations. First, it is a retrospective study from a single institution, with all operations performed by a single surgeon. Although PSM analysis was used to reduce differences in the patient's baseline characteristics, the study design may have selection bias. Therefore, a large, randomized, multicenter clinical trial is needed to confirm the safety and efficacy of intracorporeal EJ methods. In addition, use of the functional method and overlap method differed according to the study period: The functional method was mostly used in the early phase of the study period, whereas the overlap method was performed in addition to that in the later phase of the study period based on recent reports of the favorable outcomes obtained [10, 11]. A surgeon with good experience in laparoscopy [6, 15–18] can achieve comparable surgical outcomes by both methods; based on this fact, we considered that the difference of the time of use between the two methods may not be a significant influencing factor of our results.

In conclusion, in gastric cancer patients who underwent TLTG for laparoscopic intracorporeal EJ, the overlap method resulted in significantly fewer EJ-related complications than in the functional method. Surgeons should consider the overlap method as method of choice based on its superior safety and feasibility as compared to the functional method, especially for TLTG in patients with short esophagus and mesentery.

Author contributions CSK, CSG, BSK, and HSK performed literature search, conception and design, and drafting of the manuscript. SOK performed analysis and interpretation. All authors were involved in critical revision and final approval of the manuscript.

Compliance with ethical standards

Disclosure Chang Seok Ko, Chung Sik Gong, Byung Sik Kim, Seon Ok Kim, and Hee Sung Kim have no conflicts of interest or financial ties to disclose.

References

1. Ahn HS, Lee HJ, Yoo MW, Jeong SH, Park DJ, Kim HH, Kim WH, Lee KU, Yang HK (2011) Changes in clinicopathological features and survival after gastrectomy for gastric cancer over a 20-year period. Br J Surg 98:255–260. https://doi.org/10.1002/bjs.7310
2. Blaser MJ, Saito D (2002) Trends in reported adenocarcinomas of the oesophagus and gastric cardia in Japan. Eur J Gastroenterol Hepatol 14:107–113. https://doi.org/10.1097/00042737-200202000-00003
3. Blot WJ, Devesa SS, Kneller RW, Fraumeni JF Jr (1991) Rising incidence of adenocarcinoma of the esophagus and gastric cardia. JAMA 265:1287–1289. https://doi.org/10.1001/jama.265.10.1287
4. Steevens J, Botterweck AA, Dirx MJ, van den Brandt PA, Schouten LJ (2010) Trends in incidence of oesophageal and

stomach cancer subtypes in Europe. Eur J Gastroenterol Hepatol 22:669–678. https://doi.org/10.1097/MEG.0b013e32832ca091
5. Chen K, He Y, Cai JQ, Pan Y, Wu D, Chen DW, Yan JF, Maher H, Mou YP (2016) Comparing the short-term outcomes of intracorporeal esophagojejunostomy with extracorporeal esophagojejunostomy after laparoscopic total gastrectomy for gastric cancer. BMC Surg 16:13. https://doi.org/10.1186/s12893-016-0130-9
6. Kim HS, Kim MG, Kim BS, Yook JH, Kim BS (2012) Totally laparoscopic total gastrectomy using endoscopic linear stapler: early experiences at one institute. J Laparoendosc Adv Surg Tech A 22:889–897. https://doi.org/10.1089/lap.2012.0238
7. Kim JJ, Song KY, Chin HM, Kim W, Jeon HM, Park CH, Park SM (2008) Totally laparoscopic gastrectomy with various types of intracorporeal anastomosis using laparoscopic linear staplers: preliminary experience. Surg Endosc 22:436–442. https://doi.org/10.1007/s00464-007-9446-y
8. Shim JH, Yoo HM, Oh SI, Nam MJ, Jeon HM, Park CH, Song KY (2013) Various types of intracorporeal esophagojejunostomy after laparoscopic total gastrectomy for gastric cancer. Gastric Cancer 16:420–427. https://doi.org/10.1007/s10120-012-0207-9
9. Okabe H, Obama K, Tanaka E, Nomura A, Kawamura J, Nagayama S, Itami A, Watanabe G, Kanaya S, Sakai Y (2009) Intracorporeal esophagojejunal anastomosis after laparoscopic total gastrectomy for patients with gastric cancer. Surg Endosc 23:2167–2171. https://doi.org/10.1007/s00464-008-9987-8
10. Inaba K, Satoh S, Ishida Y, Taniguchi K, Isogaki J, Kanaya S, Uyama I (2010) Overlap method: novel intracorporeal esophagojejunostomy after laparoscopic total gastrectomy. J Am Coll Surg 211:e25–29. https://doi.org/10.1016/j.jamcollsurg.2010.09.005
11. Kitagami H, Morimoto M, Nakamura K, Watanabe T, Kurashima Y, Nonoyama K, Watanabe K, Fujihata S, Yasuda A, Yamamoto M, Shimizu Y, Tanaka M (2016) Technique of Roux-en-Y reconstruction using overlap method after laparoscopic total gastrectomy for gastric cancer: 100 consecutively successful cases. Surg Endosc 30:4086–4091. https://doi.org/10.1007/s00464-015-4724-6
12. Lee TG, Lee IS, Yook JH, Kim BS (2017) Totally laparoscopic total gastrectomy using the overlap method; early outcomes of 50 consecutive cases. Surg Endosc 31:3186–3190. https://doi.org/10.1007/s00464-016-5343-6
13. The Union for International Cancer Control's What is TNM? https://www.uicc.org/resources/tnm. Accessed 27 Dec 2018
14. Japanese gastric cancer treatment guidelines (2014) ver. 4. Gastric Cancer 20:1–19. https://doi.org/10.1007/s10120-016-0622-4
15. Kim HS, Kim BS, Lee S, Lee IS, Yook JH, Kim BS (2013) Reconstruction of esophagojejunostomies using endoscopic linear staplers in totally laparoscopic total gastrectomy: report of 139 cases in a large-volume center. Surg Laparosc Endosc Percutan Tech 23:e209–216. https://doi.org/10.1097/SLE.0b013e31828e3b79
16. Gong CS, Kim BS, Kim HS (2017) Comparison of totally laparoscopic total gastrectomy using an endoscopic linear stapler with laparoscopic-assisted total gastrectomy using a circular stapler in patients with gastric cancer: A single-center experience. World J Gastroenterol 23:8553–8561. https://doi.org/10.3748/wjg.v23.i48.8553
17. Kim HS, Kim BS, Lee IS, Lee S, Yook JH, Kim BS (2013) Comparison of totally laparoscopic total gastrectomy and open total gastrectomy for gastric cancer. J Laparoendosc Adv Surg Tech A 23:323–331. https://doi.org/10.1089/lap.2012.0389
18. Kim HS, Kim MG, Kim BS, Lee IS, Lee S, Yook JH, Kim BS (2013) Comparison of totally laparoscopic total gastrectomy and laparoscopic-assisted total gastrectomy methods for the surgical treatment of early gastric cancer near the gastroesophageal junction. J Laparoendosc Adv Surg Tech A 23:204–210. https://doi.org/10.1089/lap.2012.0393
19. Dindo D, Demartines N, Clavien PA (2004) Classification of surgical complications: a new proposal with evaluation in a cohort of 6336 patients and results of a survey. Ann Surg 240:205–213. https://doi.org/10.1097/01.sla.0000133083.54934.ae
20. Robins JM, Hernan MA, Brumback B (2000) Marginal structural models and causal inference in epidemiology. Epidemiology 11:550–560. https://doi.org/10.1097/00001648-200009000-00011
21. Chen K, Pan Y, Cai JQ, Wu D, Yan JF, Chen DW, Yu HM, Wang XF (2016) Totally laparoscopic versus laparoscopic-assisted total gastrectomy for upper and middle gastric cancer: a single-unit experience of 253 cases with meta-analysis. World J Surg Oncol 14:96. https://doi.org/10.1186/s12957-016-0860-2
22. Chen K, Pan Y, Zhai ST, Yu WH, Pan JH, Zhu YP, Chen QL, Wang XF (2017) Totally laparoscopic versus open total gastrectomy for gastric cancer: a case-matched study about short-term outcomes. Medicine (Baltimore) 96:e8061. https://doi.org/10.1097/md.0000000000008061
23. Haverkamp L, Weijs TJ, van der Sluis PC, van der Tweel I, Ruurda JP, van Hillegersberg R (2013) Laparoscopic total gastrectomy versus open total gastrectomy for cancer: a systematic review and meta-analysis. Surg Endosc 27:1509–1520. https://doi.org/10.1007/s00464-012-2661-1
24. Kunisaki C, Makino H, Takagawa R, Kimura J, Ota M, Ichikawa Y, Kosaka T, Akiyama H, Endo I (2015) A systematic review of laparoscopic total gastrectomy for gastric cancer. Gastric Cancer 18:218–226. https://doi.org/10.1007/s10120-015-0474-3
25. Kawamura H, Ohno Y, Ichikawa N, Yoshida T, Homma S, Takahashi M, Taketomi A (2017) Anastomotic complications after laparoscopic total gastrectomy with esophagojejunostomy constructed by circular stapler (OrVil™) versus linear stapler (overlap method). Surg Endosc 31:5175–5182. https://doi.org/10.1007/s00464-017-5584-z
26. Inokuchi M, Otsuki S, Fujimori Y, Sato Y, Nakagawa M, Kojima K (2015) Systematic review of anastomotic complications of esophagojejunostomy after laparoscopic total gastrectomy. World J Gastroenterol 21:9656–9665. https://doi.org/10.3748/wjg.v21.i32.9656
27. Ebihara Y, Okushiba S, Kawarada Y, Kitashiro S, Katoh H (2013) Outcome of functional end-to-end esophagojejunostomy in totally laparoscopic total gastrectomy. Langenbecks Arch Surg 398:475–479. https://doi.org/10.1007/s00423-013-1051-z
28. Lee IS, Kim TH, Kim KC, Yook JH, Kim BS (2012) Modified techniques and early outcomes of totally laparoscopic total gastrectomy with side-to-side esophagojejunostomy. J Laparoendosc Adv Surg Tech A 22:876–880. https://doi.org/10.1089/lap.2012.0177
29. Sierzega M, Kolodziejczyk P, Kulig J (2010) Impact of anastomotic leakage on long-term survival after total gastrectomy for carcinoma of the stomach. Br J Surg 97:1035–1042. https://doi.org/10.1002/bjs.7038
30. Gong W, Li J (2017) Combat with esophagojejunal anastomotic leakage after total gastrectomy for gastric cancer: a critical review of the literature. Int J Surg 47:18–24. https://doi.org/10.1016/j.ijsu.2017.09.019
31. Amin MB (2017) AJCC cancer staging manual, 8th edn. Springer, Chicago, IL