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Surgical outcomes and prognosis of intracorporeal versus extracorporeal esophagojejunostomy after laparoscopic total gastrectomy for gastric cancer: a propensity score-matching study

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This study compared the surgical outcomes and long-term prognosis of intracorporeal and extracorporeal esophagojejunostomy after laparoscopic total gastrectomy (LTG) for gastric cancer patients. In total 228 clinical stage I gastric cancer patients undergoing LTG were enrolled from January 2012 and December 2022. Each case in the totally laparoscopic total gastrectomy (TLTG) group was 1:1 propensity score-matched to control cases in the laparoscopy-assisted total gastrectomy (LATG) group. In total, 95 and 93 LATG and TLTG patients were included after propensity score matching (PSM). Clinicopathological features, surgical outcomes, and survival variables were compared, and risk factors for postoperative complications were analyzed. Patient characteristics were well balanced between the LATG and TLTG groups after PSM. The TLTG group showed less blood loss, decreased frequency of analgesic use, and shorter duration of analgesic use. The TLTG group had significantly lower rates of intestinal obstruction and surgical site infection. Larger tumor size and advanced pTNM stage were independent risk factors for postoperative complications. There was no significant difference in overall survival (OS). Compared with LATG, TLTG was associated with better surgical outcomes and fewer postoperative surgical complications in gastric cancer patients although there was no significant difference in OS.

Keywords Gastric cancer, Total gastrectomy, Complication, Survival

Gastric cancer is the fifth most common cancer worldwide and has the fourth-highest mortality rate among all cancers[1]. Laparoscopic surgery for gastric cancer was explored early in the era of minimally invasive surgery. In 1994, Kitano et al. reported the first laparoscopic surgery for early gastric cancer, which was laparoscopy-assisted distal gastrectomy (LADG)[2]. Subsequently, the transition from LADG to totally laparoscopic distal gastrectomy (TLDG) began. However, despite the popularity of TLDG, laparoscopic total gastrectomy (LTG) was introduced at a relatively late stage because of difficult technique of anastomosis[3].

Several studies have evaluated the techniques and surgical outcomes of laparoscopy-assisted total gastrectomy (LATG) with extracorporeal esophagojejunal anastomosis[4,5]. They showed that the surgical outcomes of LATG were not inferior to the outcomes of open total gastrectomy. In 1999, Uyama et al. described a new technique for intracorporeal esophagojejunal anastomosis, totally laparoscopic total gastrectomy (TLTG)[6]. Despite technical difficulties, surgeons began to perform TLTG because it reduces postoperative pain and wound complications[7].

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The safety of TLTG has been a concern for surgeons. Although it is a minimally invasive procedure, its surgical outcomes and oncological safety have not been established. Several meta-analyses revealed that the surgical outcomes of TLTG were not inferior to the outcomes of LATG[8–10]. Moreover, the number of harvested lymph nodes and proximal and distal margins of TLTG was not inferior to those parameters in LATG, thus demonstrating the oncological safety of TLTG. A few studies have compared the surgical outcomes of LATG and TLTG, but articles comparing prognoses are scarce[8,11,12].

This study was performed to compare surgical outcomes and long-term prognosis of intracorporeal esophagojejunostomy and extracorporeal esophagojejunostomy after LTG for gastric cancer patients.

Methods

Patients

We evaluated data from 228 consecutively enrolled clinical stage I gastric cancer patients who underwent LTG with Roux-en-Y esophagojejunostomy in two institutions from January 2012 to December 2022. TLTG has been performed at our institution since 2013, and four surgeons performed reconstructions based on their preferences. Patients were divided into LATG and TLTG groups according to the reconstructive methods used, such as extracorporeal or intracorporeal reconstruction. Patients with remnant gastric cancer (n = 2), combined resection (n = 8), or neoadjuvant chemotherapy (n = 1) were excluded. Of the remaining 217 patients, 122 and 95 underwent LATG and TLTG, respectively, 95 and 93 from the respective groups were included in the final analysis after propensity score matching (PSM) (Fig. 1).

Clinicopathological data from surgical and pathological reports were retrospectively reviewed. Gastric cancer diagnosis and cTNM stage were confirmed before surgery based on preoperative examinations, including esophagogastroduodenoscopy (EGD) with biopsy and enhanced abdominal pelvis computed tomography (APCT). Comorbidities were evaluated using the American Society of Anesthesiologists (ASA) classification system to determine the general condition of each patient[13]. Clinical Stage I gastric cancer patients were determined using the 7th (from 2012 to 2017) and 8th Union for International Cancer Control (UICC)/American Joint Committee on Cancer (AJCC) staging system (from 2017 to 2022)[15]. Clinical stage I gastric cancer patients with tumors located in the upper and middle stomach had undergone LTG with standard D1 + or D2 lymph node dissection in accordance with the Korean Practice Guideline for Gastric Cancer[14]. Pathological stage was determined after surgery using the 7th (from 2012 to 2017) and 8th UICC/AJCCstaging ystem (from 2017 to 2022)[15]. Patients with pathological TNM (pTNM) stage ≥ II were treated with an S-1 or XELOX regimen for eight cycles as adjuvant chemotherapy. The patients were followed up for 6 months postoperatively, and then annually until death, cancer recurrence, or loss to follow-up by enhanced APCT and EGD. This study was approved by the Institutional Review Board of St. Vincent's Hospital, The Catholic University of Korea (VC23RASI0057), which waived the requirement for informed consent. All methods were performed in accordance with the relevant guidelines and regulations.

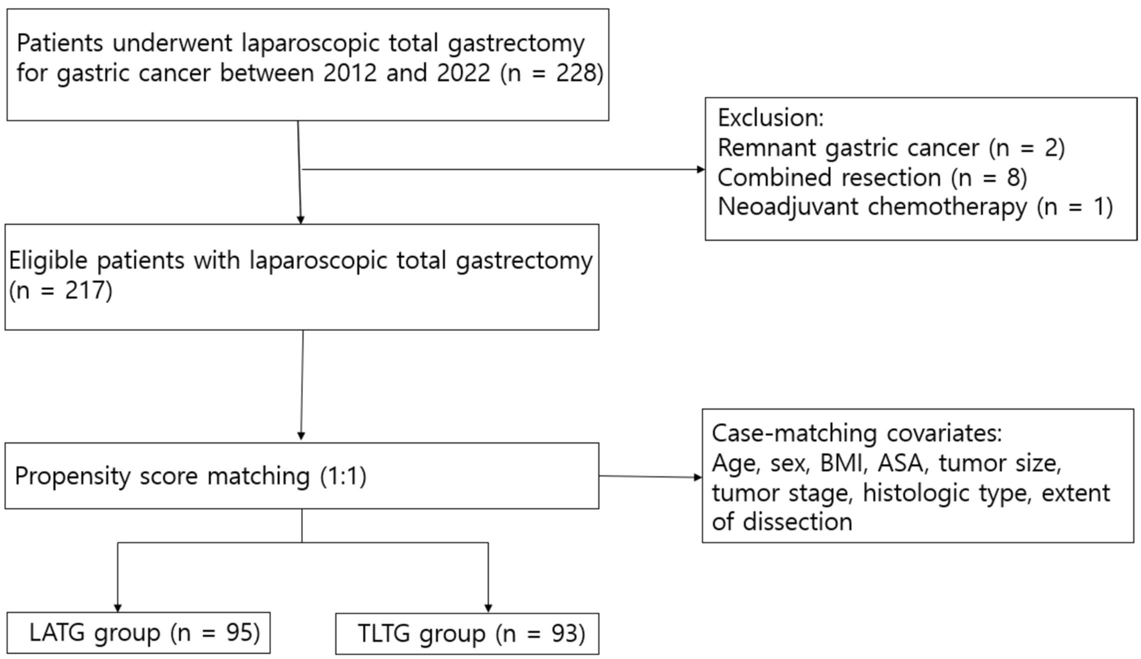

Figure 1. Flow diagram. 228 patients were diagnosed with gastric cancer. 217 cases met the inclusion and exclusion criteria. After propensity score matching (PSM), there were 95 cases in LATG group and 93 cases in TLTG group. *LATG* laparoscopic assisted total gastrectomy, *TLTG* totally laparoscopic total gastrectomy, *BMI* body mass index, *ASA* American Society of Anesthesiologist.

Characteristics	All patients (n = 217) LATG (n = 122)	TLTG (n = 95)	*P* value	Patients after propensity matching (n = 188) LATG (n = 95)	TLTG (n = 93)	*P* value
Age (years) < 60 ≥ 60	42 (34.1) 80 (65.9)	25 (26.3) 70 (73.7)	0.45	21 (22.5) 74 (77.5)	23 (25.6) 70 (74.4)	0.79
Gender Male Female	88 (71.8) 34 (28.2)	74 (78.4) 21 (21.6)	0.42	66 (70.0) 29 (30.0)	74 (79.5) 19 (20.5)	0.43
BMI (kg/m^2) < 25 ≥ 25	72 (58.8) 50 (41.2)	68 (71.6) 27 (28.4)	0.08	55 (57.5) 40 (42.5)	67 (71.8) 26 (28.2)	0.24
ASA 0–1 ≥ 2	109 (89.4) 13 (10.6)	69 (72.5) 26 (27.5)	0.01	83 (87.3) 12 (12.7)	69 (74.2) 24 (25.8)	0.23
Tumor size (cm) < 5 ≥ 5 Location EGJ invasion Non-EGJ invasion	96 (78.8) 26 (21.2) 10 (8.2) 112 (91.8)	71 (74.7) 24 (25.3) 7 (7.4) 88 (92.6)	0.82 0.85	76 (80.0) 19 (20.0) 9 (9.5) 86 (90.5)	69 (74.4) 24 (25.6) 7 (7.5) 86 (92.5)	0.78 0.74
pT stage T1 T2-4	80 (65.9) 42 (34.1)	50 (52.9) 45 (47.1)	0.14	59 (62.5) 36 (37.5)	48 (51.3) 45 (48.7)	0.21
pN stage N0 N1-3	105 (85.9) 17 (14.1)	73 (76.8) 22 (23.2)	0.04	83 (87.5) 12 (12.5)	72 (76.9) 21 (23.1)	0.25
pTNM stage I II III	94 (77.1) 21 (17.2) 7 (5.7)	57 (60.0) 23 (24.2) 15 (15.7)	< 0.01	67 (70.0) 21 (22.5) 7 (7.5)	57 (61.5) 21 (23.1) 15 (15.4)	0.35
Histologic type Differentiated Undifferentiated	57 (47.1) 65 (52.9)	53 (55.8) 42 (44.2)	0.34	50 (52.5) 45 (47.5)	51 (54.8) 42 (45.2)	0.56
Extent of dissection D1 + D2	29 (23.5) 93 (76.5)	9 (9.5) 86 (90.5)	0.03	10 (10.0) 85 (90.0)	9 (10.3) 84 (89.7)	1.00

Table 1. Comparison of clinicopathological characteristics of LATG and TLTG groups.

Variables	All patients (n = 217) LATG (n = 122)	TLTG (n = 95)	*P* value	Patients after propensity matching (n = 188) LATG (n = 95)	TLTG (n = 93)	*P* value
Operation time (min)	262.6 ± 69.6	236.8 ± 97.1	0.05	268.9 ± 55.2	250.9 ± 66.4	0.07
EBL (mL)	248.6 ± 226.2	94.1 ± 97.5	< 0.01	244.2 ± 217.0	101.0 ± 103.4	< 0.01
No. of retrieved lymph node	38.8 ± 13.8	44.7 ± 19.1	0.10	39.4 ± 13.3	45.3 ± 19.3	0.14
No. of metastatic lymph node	0.7 ± 2.6	1.1 ± 2.5	0.02	1.0 ± 3.6	1.1 ± 2.5	0.28
Analgesic frequency	6.0 ± 4.6	5.5 ± 9.7	0.08	6.7 ± 7.8	5.4 ± 8.7	0.01
Duration of analgesic (days)	4.8 ± 3.0	4.1 ± 5.9	0.29	5.5 ± 6.1	4.4 ± 5.4	0.04
Time to flatus (days)	4.3 ± 1.0	4.5 ± 0.8	0.44	4.4 ± 1.0	4.4 ± 0.8	0.93
Time to liquid diet (days)	6.3 ± 1.1	6.4 ± 3.6	0.90	6.6 ± 1.4	6.7 ± 4.0	0.95
Time to soft diet (days)	7.4 ± 1.5	8.3 ± 4.6	0.22	7.8 ± 2.0	8.6 ± 5.1	0.14
Hospital stays (days)	13.3 ± 8.7	11.4 ± 6.3	0.17	12.0 ± 4.7	12.7 ± 6.9	0.43

Table 2. Surgical outcomes of LATG and TLTG groups.

Surgical procedure: esophagojejunostomy

LTG was conducted with D1 + β or D2 lymph node dissection, in accordance with the Korean Gastric Cancer Treatment Guidelines[14].

For TLTG, a small opening was created in the end of the esophageal stapler line to insert a linear stapler. A Roux limb of the jejunum was prepared intracorporeally. A 45 mm- linear stapler was inserted between the esophagus and the prepared Roux limb of the jejunum to form a side-to-side esophagojejunostomy (Supplementary Fig. 1). The entry hole was closed by a linear stapler after three sutures had been inserted at the edge of the opening for traction (Supplementary Fig. 2). Side-to-side jejunojejunostomy was also performed intracorporeally using a linear stapler. A 3 to 5 cm laparotomy was created in the umbilicus, and the specimen was extracted from the abdominal cavity.

Variables	All patients (n = 217)			Patients after propensity matching (n = 188)		
	LATG (n = 122)	TLTG (n = 95)	*P* value	LATG (n = 95)	TLTG (n = 93)	*P* value
Total complications	70 (57.3)	43 (45.1)	0.21	53 (55.7)	38 (40.8)	0.65
Surgical complications	38 (31.1)	15 (15.7)	< 0.01	26 (27.3)	12 (12.9)	0.12
Delayed gastric emptying	0 (0)	0 (0)	NA	0 (0)	0 (0)	NA
Anastomotic bleeding	1 (0.8)	1 (1.0)	1.0	1 (1.1)	1 (1.1)	0.49
Anastomotic leakage	8 (6.5)	5 (5.3)	1.0	3 (3.1)	4 (4.3)	0.10
Intestinal obstruction	11 (9.1)	3 (3.1)	< 0.01	9 (9.5)	2 (2.2)	0.02
Surgical site infection	14 (11.5)	4 (4.2)	< 0.01	11 (11.6)	3 (3.2)	0.02
Intraabdominal abscess	0 (0)	0 (0)	NA	0 (0)	0 (0)	NA
Intraabdominal bleeding	0 (0)	2 (2.1)	0.13	0 (0)	2 (2.2)	0.49
Stenosis (EJ)	4 (3.2)	0 (0)	0.29	2 (2.1)	0 (0)	1.0
Medical complications	32 (26.2)	28 (29.4)	0.70	27 (28.4)	26 (27.9)	0.26
Pulmonary complications	25 (20.5)	23 (24.2)	0.84	20 (21.1)	22 (23.5)	0.45
Cardiovascular disease	1 (0.8)	2 (2.1)	0.37	2 (2.1)	2 (2.2)	0.49
Others	6 (4.9)	3 (3.1)	0.71	5 (5.2)	2 (2.2)	1.0
Clavien-Dindo classification						
Higher than II	37 (30.6)	24 (25.5)	0.56	19 (20.0)	29 (30.8)	0.31

Table 3. Postoperative complications of LATG and TLTG groups.

Variables			Univariate analysis		*P* value	Multivariate analysis		*P* value
			OR	95% CI		OR	95% CI	
Age (years) < 60 ≥ 60			1 1.573	0.455–5.436	0.09			
Gender Male Female			1 0.354	0.096–1.306	0.07	1 0.4	0.173–0.923	0.08
BMI (kg/m^2) < 25 ≥ 25			1 0.741	0.246–2.233	0.59			
ASA 0–1 ≥ 2			1 0.517	0.068–3.926	0.98			
pT stage T1 T2-4			1 7.177	0.982–52.467	0.19			
pN stage N0 N1-3			1 8.117	0.629–104.796	0.12			
pTNM I II III			0.018 0.055 1	0.0001–1.104 0.005–0.589	0.01	0.366 1	0.156–0.861	0.02
Tumor size (cm) < 5 ≥ 5			1 2.197	0.571–8.447	0.05	1 2.359	0.902–6.171	0.03
Histologic type Differentiated Undifferentiated			1 0.903	0.309–2.641	0.52			
Staplers Circular Linea			1 1.065	0.259–4.384	0.69			
Reconstructive method Extracorporeal Intracorporeal			1 2.469	0.532–11.468	0.67			

Table 4. Univariate and multivariate analyses of risk factors of postoperative complications after PSM.

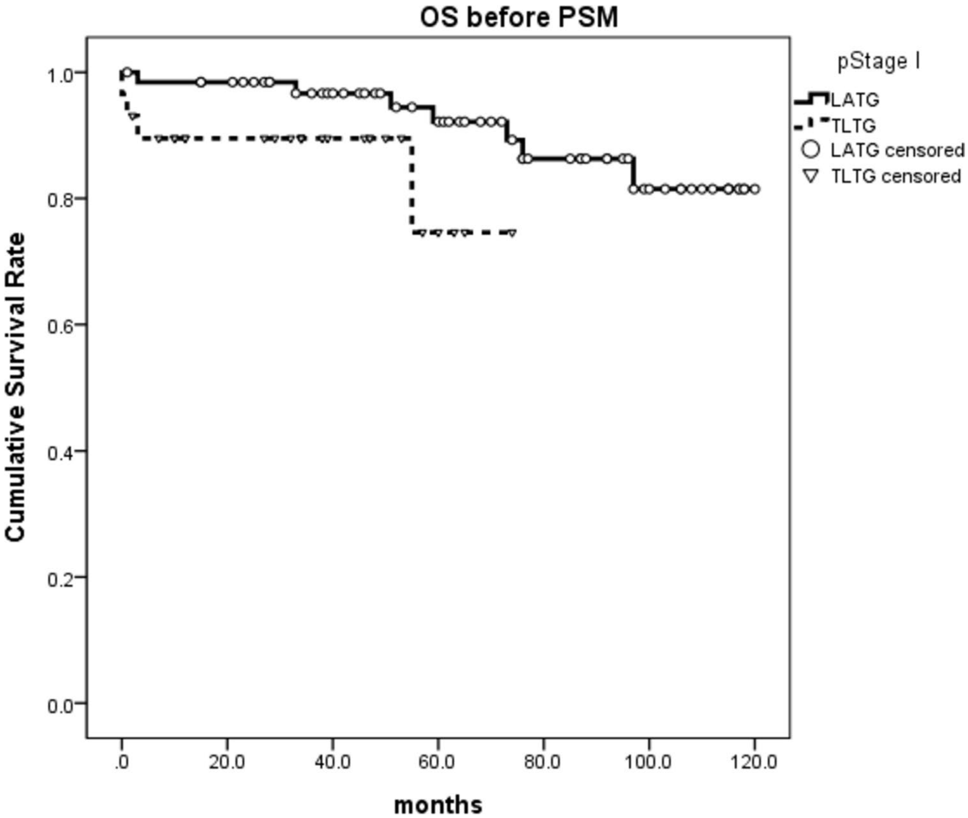

Figure 2. The cumulative survival rates for pathological stage I were similar between LATG and TLTG groups before PSM ($P=0.06$).

For LATG, an upper midline incision (~ 8 cm) was created at the epigastrium. Under direct vision through the mini-laparotomy, a purse-string suture and device were applied to the esophageal stump. The anvil head of the circular stapler (EEA, 25–4.8 mm, Covidien, Mansfield, MA, USA) was inserted into the esophagus and the purse-string suture was secured to fasten the anvil rod (Supplementary Fig. 3). End-to-side esophagojejunostomy was performed with a 25 mm circular stapler through the mini-laparotomy incision (Supplementary Fig. 4). Side-to-side jejunojejunostomy was performed through the mini-laparotomy incision in a manner similar to the jejunojejunostomy for TLTG.

Propensity score matching and statistical analysis

To minimize the effect of selection bias in this non-randomized trial, PSM was performed to balance the groups in terms of baseline characteristics. Each case from the TLTG group was 1:1 propensity score matched to a control case in the LATG group. Matching variables included age, sex, body mass index (BMI), ASA classification, tumor size, location, pathological T and N stage, histological type, and extent of dissection. A propensity score was derived for each patient by logistic regression and matched nearest-neighbor value within a caliper 0.02 times the standard deviation of the estimated score. After PSM, the balance of covariates between TLTG and LATG group was evaluated by calculating the standardized mean difference.

The groups were compared using Student's t-test, the χ^2 test, and the Fisher's exact test. Kaplan–Meier curves were used for overall survival (OS) to compare patients with each stage based on the length of time between surgical treatment and the final follow up or death, and differences in the survival rate between the groups were compared using the log-rank test. A Cox regression model was used to identify variables that influenced OS and postoperative complications. Multivariate analysis was performed using variables that were significantly and independently associated with postoperative complications. The threshold for statistical significance was defined as $P<0.05$. All statistical analyses were performed using SPSS software ver. 21 (IBM Corp., Armonk, NY, USA).

Results

Clinicopathological characteristics

The clinicopathological characteristics of all patients who underwent LTG, before and after PSM, are shown in Table 1. Before PSM, there were 217 patients in total, including 122 who underwent LATG and 95 who underwent TLTG. There were significant differences between the two in terms of ASA classification ($P=0.01$), pN stage ($P=0.04$), pTNM stage ($P<0.01$), and extent of lymph node dissection ($P=0.03$). After PSM, the LATG and TLTG groups consisted of 95 and 93 patients, respectively, all baseline variables were well balanced between the two groups.

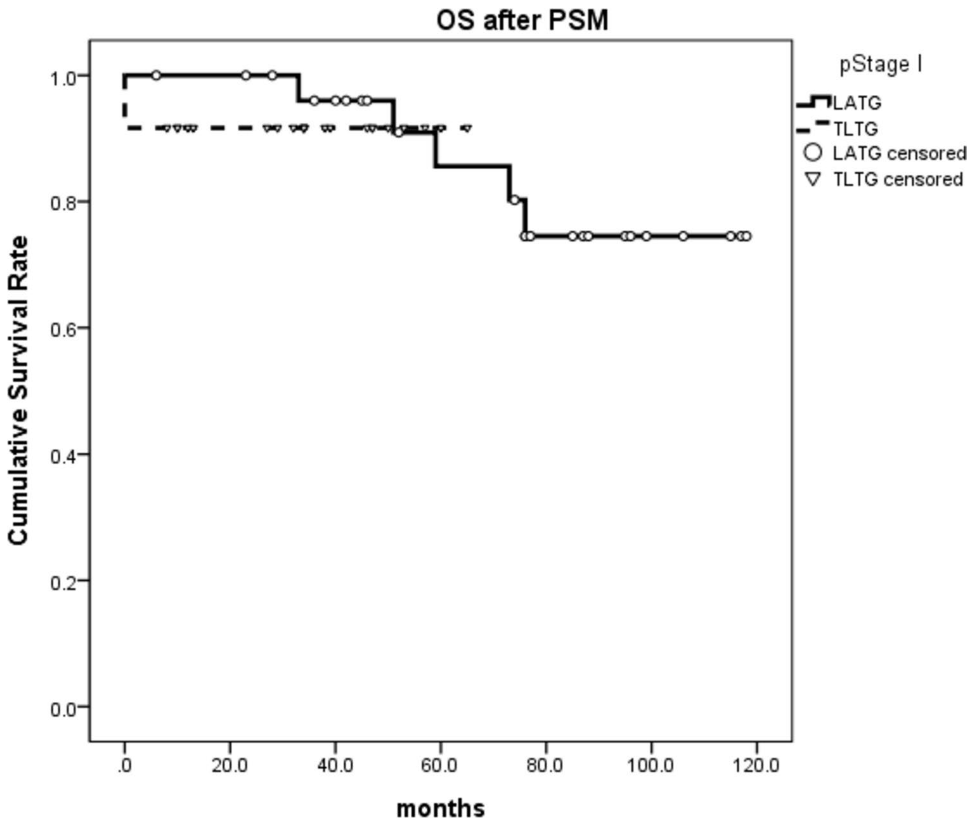

Figure 3. The cumulative survival rates for pathological stage I were similar between LATG and TLTG groups after PSM ($P = 0.653$).

Surgical outcomes

Before PSM, there were significant differences in the operation time ($P = 0.05$), blood loss ($P < 0.01$), and number of metastatic lymph nodes ($P = 0.02$) between the two groups. After PSM, the TLTG group exhibited significantly less blood loss (244.2 ± 217.0 *vs* 101.0 ± 103.4 cc $P < 0.01$), decreased frequency of analgesic use (6.7 ± 7.8 *vs* 5.4 ± 8.7 times $P = 0.01$), shorter duration of analgesic use (5.5 ± 6.1 *vs* 4.4 ± 5.4 days $P = 0.04$) (Table 2) compared with the LATG group. Additionally, the TLTG group tended to show a shorter operation time compared with the LATG group (268.9 ± 55.2 *vs* 250.9 ± 66.4 min. $P = 0.07$).

Postoperative complications

Before PSM, there were significant group differences in terms of surgery-related complications ($P < 0.01$), including intestinal obstruction ($P < 0.01$) and surgical site infection ($P < 0.01$). After PSM, there were no significant differences between the groups in terms of the total number of postoperative complications including surgery-related and medical complications. However, the TLTG group had significantly lower rates of intestinal obstruction (9.5% *vs* 2.2%, $P = 0.02$) and surgical site infection (11.6% *vs* 3.2%, $P = 0.02$), compared with the LATG group. The incidence of complications (≥ grade II on the Clavien-Dindo classification system) did not significantly differ between groups (Table 3).

Univariate and multivariate analysis of risk factors for postoperative complications

Univariate and multivariate logistic regression analyses were performed to identify risk factors for postoperative complications. In univariate analysis, pTNM stage ($P = 0.01$) and tumor size ($P = 0.05$) were significantly associated with postoperative morbidity. In multivariate analysis, tumor size ($P = 0.03$) and pTNM stage ($P = 0.02$) were independent risk factors for postoperative complications (Table 4).

Survival

Both before and after PSM, the cumulative survival of patients in both the LATG and TLTG groups gradually decreased with increasing pathological stage, indicating a close correlation between survival and pathological stage (data not shown). Kaplan–Meier curves of the OS of patients in both groups according to pathological stage, both before and after PSM, are shown in Figs. 2, 3, 4, 5, 6, 7. The median follow-up duration was 49.5 months

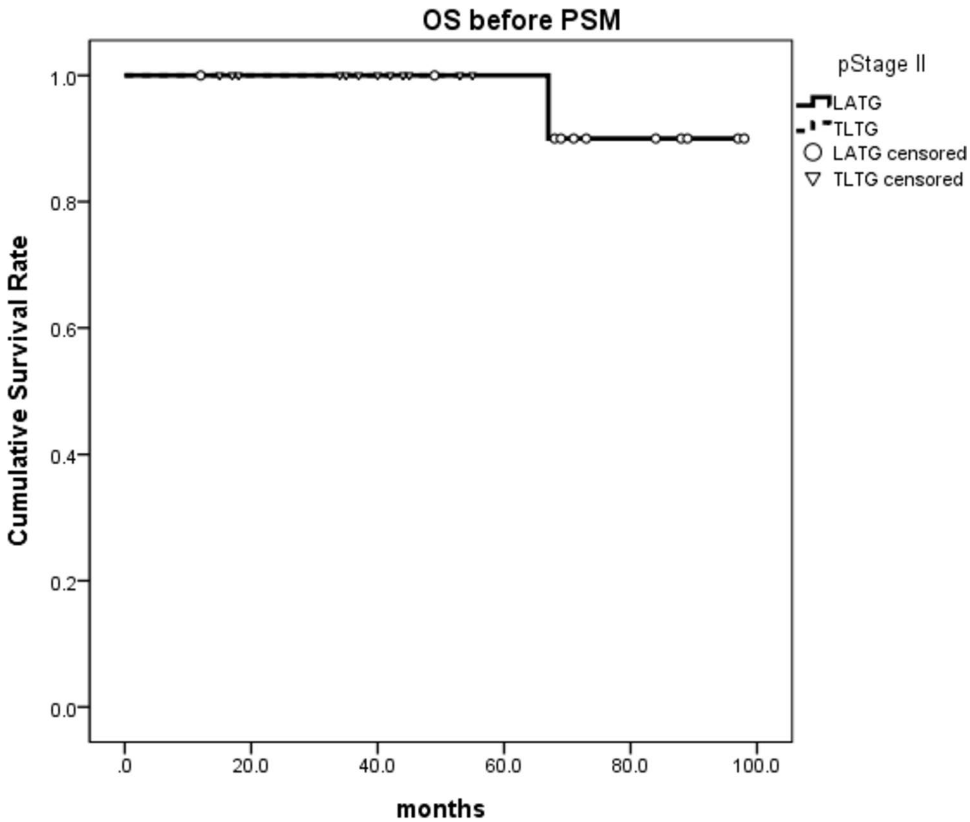

Figure 4. The cumulative survival rates for pathological stage II were similar between LATG and TLTG groups both before PSM ($P=1.0$) after PSM ($P=1.0$).

(range 0–120 months). Before PSM, the cumulative survival rate at each stage was comparable between the LATG and TLTG groups (stage I, log-rank $P=0.06$, stage II, log-rank $P=1.0$, stage III log-rank $P=0.968$). After PSM, OS rates were remained similar between the two groups (stage I, log-rank $P=0.653$, stage II, log-rank $P=1.0$, stage III, log-rank $P=0.157$).

Discussion

In this study, surgical outcomes and prognosis were compared between LATG and TLTG groups. After PSM, the TLTG group had less blood loss, decreased frequency of analgesic use, and shorter duration of analgesic use. Moreover, in terms of postoperative complications, the TLTG group had significantly lower rates of intestinal obstruction and surgical site infection, compared with the LATG group. According to multivariate analysis, larger tumor size and advanced pathological stage were independent risk factors for postoperative complications. However, OS did not significantly differ between the two groups.

Surgical outcomes such as operation time, number of retrieved lymph nodes, number of metastatic lymph nodes, time to diet, and duration of hospitalization were not significantly different between our LATG and TLTG groups. However, estimated blood loss, frequency of analgesic use, and duration of analgesic use were superior in the TLTG group. In a review of studies involved TLTG, Umemura et al. concluded that it has advantages in terms of estimated blood loss or postoperative recovery[16]. TLTG also has the advantage of less intraoperative traction, which reduces the risk of injury to tissues near organs and incision sites[17]. Avoidance of tissue injury due to intraoperative traction might result in less intraoperative blood loss. When LATG is performed, the stomach and abdominal esophagus must be mobilized from the esophageal hiatus to ensure that the operating field is adequate; this mobilization is achieved via mini-laparotomy, using a flat retractor[18]. We usually make a 10 cm midline incision during LATG to create an esophagojejunostomy using a circular stapler. After the incision line has been made, an assistant typically creates traction to ensure sufficient space for dissection and anastomosis. However, this procedure may result in tissue injury, followed by intraoperative bleeding. Moreover, a long incisional wound and intraoperative traction are likely to cause postoperative pain, thus requiring the use of more analgesic in LATG patients.

There were no significant differences in postoperative medical complications, such as pulmonary complications or cardiovascular diseases, between the LATG and TLTG groups in the present study. Moreover, postoperative surgical complications including anastomotic bleeding, anastomotic leakage, intraabdominal abscess, and

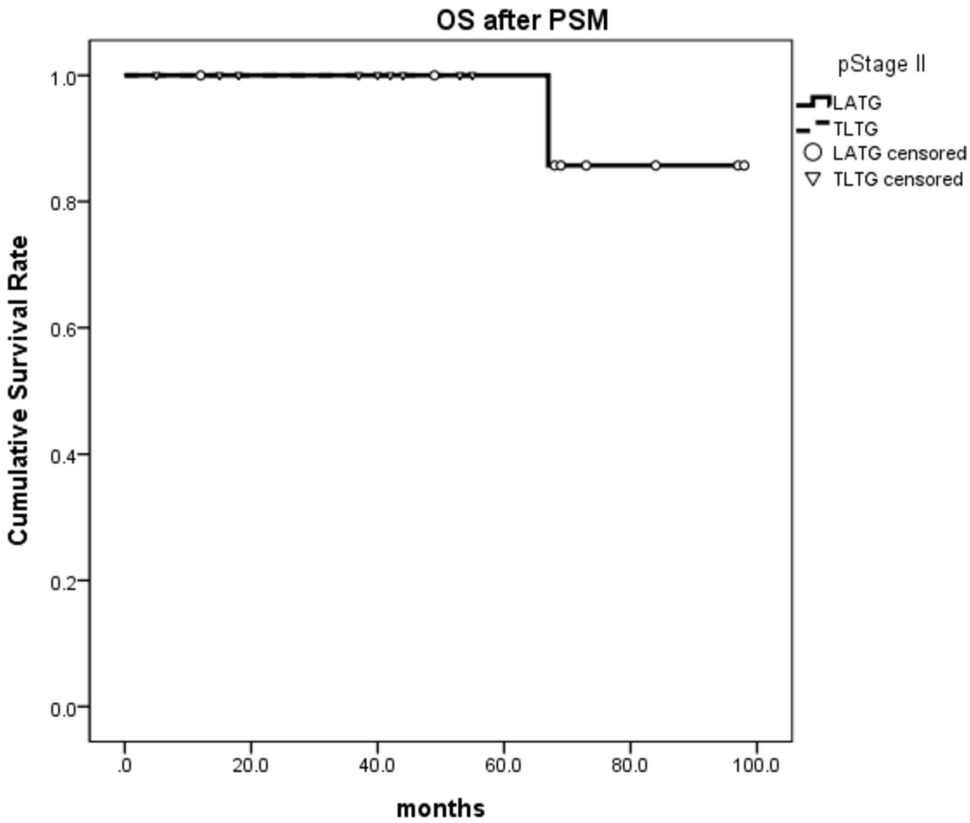

Figure 5. The cumulative survival rates for pathological stage II were similar between LATG and TLTG groups after PSM ($P = 1.0$).

intraabdominal bleeding did not significantly differ between the two groups. However, the incidences of surgical site infection and intestinal obstruction were significantly higher in the LATG group. Several studies revealed that female sex, older age, high BMI, diabetes mellitus, open gastrectomy, and a longer operation time were risk factors for surgical site infection[19–22]. Female patients tend to have more subcutaneous fat, which might increase the risk of superficial incisional site infection[19]. In the present study, there were more female patients in the LATG group than in the TLTG group, although the difference was not statistically significant. Additionally, the LATG group included more patients with a BMI > 25 kg/m^2 and had longer operation times, although these differences also were not statistically significant. The performance of esophagojejunostomy after mini-laparotomy in the LATG group could have affected the incidence of surgical site infection. Longer operative time and frequent use of opiates may be risk factors for postoperative intestinal obstruction[23]. Moreover, a meta-analysis revealed that laparoscopic surgery reduced the likelihood of intestinal obstruction[24]. Laparoscopic surgery is less traumatic than open surgery, and could promote more rapid recovery of postoperative bowel function[25]. The levels of circulating cytokines and C-reactive protein, which reflect the degree of systemic inflammation, are lower in laparoscopic surgery[26]. LATG is not a totally laparoscopic procedure, and it may cause more tissue trauma than TLTG. Furthermore, in the present study, the frequency and duration of analgesia were significantly greater in the LATG group, which might have influenced the incidence of intestinal obstruction.

Our multivariate analysis showed that advanced pathological stage and tumor size > 5 cm were risk factors for postoperative complications. A multi-institutional retrospective analysis demonstrated that older age, a larger number of comorbidities, larger tumor size, and more advanced disease were risk factors for postoperative abdominal complications[27]. Additionally, a case-control study revealed that male sex, clinical stage II or III disease, and total or proximal gastrectomy were risk factors for postoperative complications[28]. These results are consistent with the findings in the present study. Patients with advanced pathological stage tend to show greater immunosuppression because tumor immune tolerance is induced during tumor progression[29]. A reduction in cytokine production is more likely prevalent in such patients, indicating that immune function is reduced in advanced cancer stage patients[30]. This immunosuppressed condition increases vulnerability to postoperative complications such as abdominal abscess and surgical site infection.

Regardless of pathological stage, OS did not significantly differ between LATG and TLTG groups in the present study. This finding indicates that patient prognosis is not influenced by the surgical method used in each pathological stage. Several studies comparing surgical outcomes between open total gastrectomy and LATG

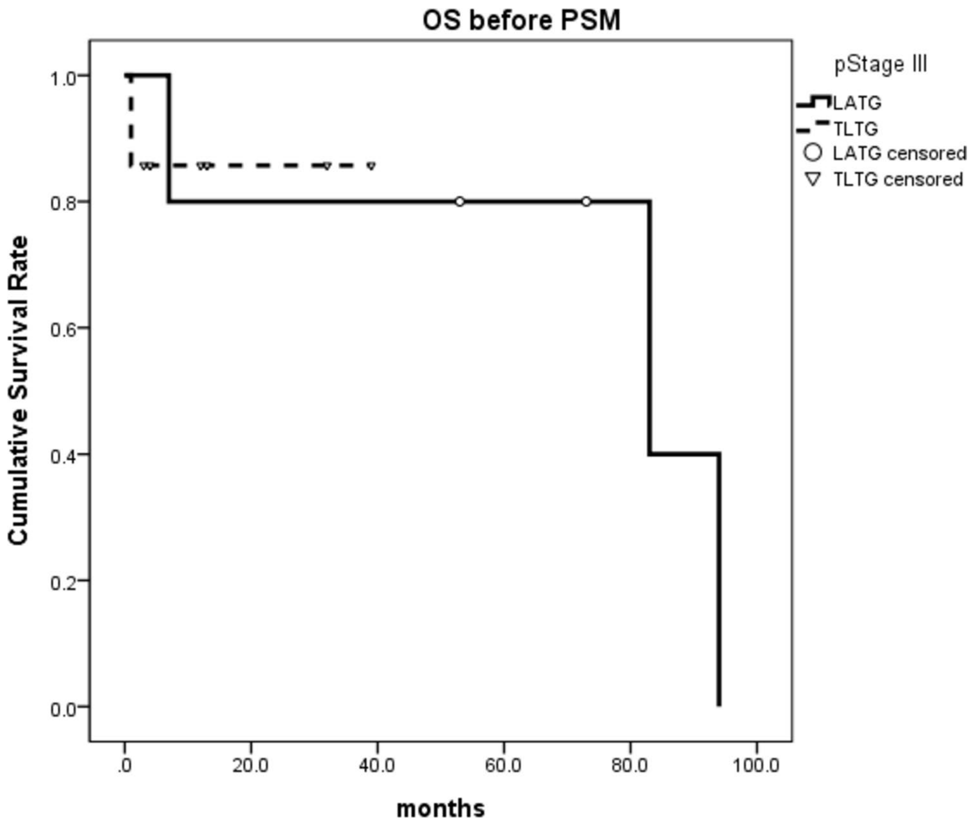

Figure 6. The cumulative survival rates for pathological stage III were similar between LATG and TLTG groups before PSM ($P = 0.968$).

showed that long-term survival was not affected by the type of surgery performed in the various pathological stages[31,32]. Few studies have compared OS between LATG and TLTG patients, although one article reported no significant difference in 3 year OS between TLTG and LATG groups, consistent with our findings[32]. In the present study, 5 year OS did not differ between the LATG and TLTG groups regardless of pathological stage, including stage III gastric cancer.

Both TLTG and LATG procedures have advantages and disadvantages. TLTG procedure has an advantage of better operative field visualization during the esophagojejunostomy. It also maintains stable operative field during the whole time whereas LATG sometimes fails to provide a good operative field and ensure a proper working space. On the other hand, when esophagojejunostomy is performed during LATG procedure, a surgeon can check the anastomosis area by touching it directly with his hands. Moreover, it makes easier for an operator do reinforcement suture of anastomosis, preventing esophagojejunostomy leakage. During TLTG, it is difficult to perform reinforcement suture. TLTG was preferable for patients with high BMI and younger female patients. Patients with high BMI usually have a lot of subcutaneous fat tissues. It usually causes more wound complication. Also, younger female patients tend to be sensitive to wound because of cosmesis. On the other hand, LATG is preferable for patients with short and thick small bowel mesentery or short esophagus. In patients with short and thick small bowel mesentery, mini-laparotomy is helpful due to better operative field and easier dissection. Also, in patients with short esophagus, linear stapler is hard to enter the esophageal stump lumen.

This study had several limitations. First, it was a retrospective study involving only two institutions, and its sample size was small. Furthermore, the procedure was selected on the basis of the operating surgeons' preferences and each patient's characteristics, which could have led to selection bias. Therefore, a randomized clinical trial is necessary to confirm our findings, although we sought to limit bias via PSM. Second, because LATG and TLTG were performed in different time periods, laparoscopic surgical skill might have differed between the two groups. Although this time difference was unavoidable, our analysis minimized bias, by including all patients in TLTG patients consecutively recruited from the first case onward, along with all patients in the LATG group who were recruited during the same period. Despite these limitations, this study is notable for comparing long-term prognoses between LATG and TLTG.

In conclusion, compared with LATG, TLTG is associated with better surgical outcomes and fewer postoperative surgical complications in patients with gastric cancer. Moreover, TLTG is comparable with LATG in terms of long-term outcomes, such as OS. The present study provides useful reference data for future randomized

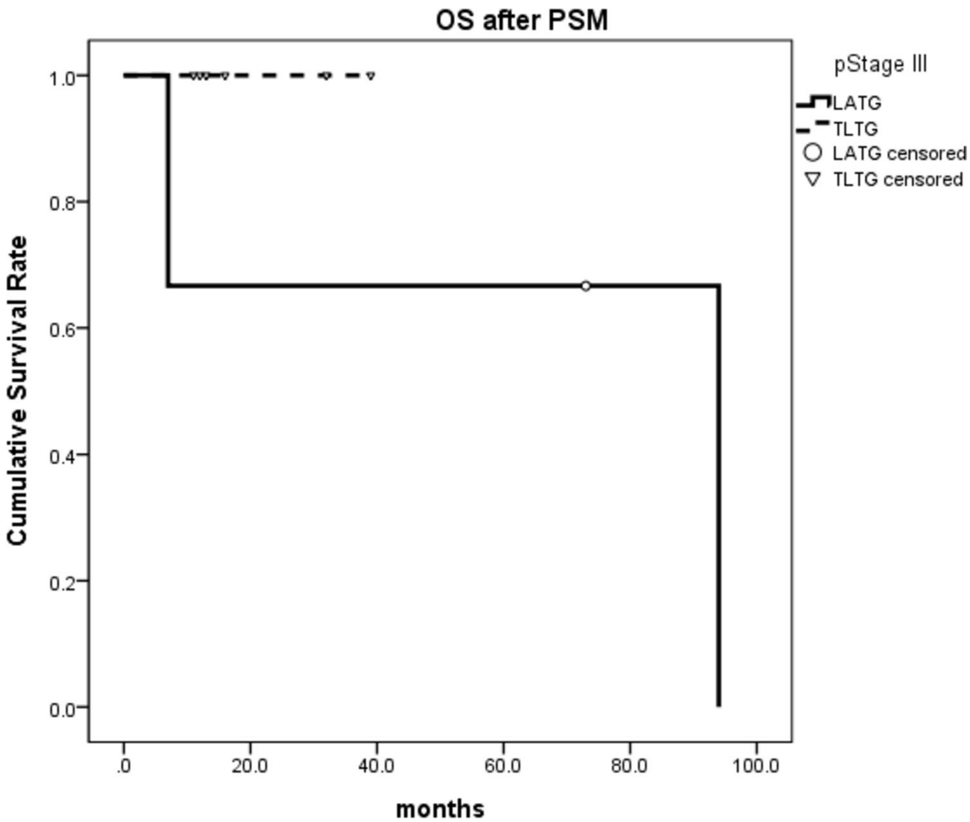

Figure 7. The cumulative survival rates for pathological stage III were similar between LATG and TLTG groups after PSM ($P = 0.157$).

clinical trials and may encourage more widespread use of totally laparoscopic surgery in the management of gastric cancer.

Data availability

All data underlying the results are available as part of the article and no additional source data are required.

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J. W. S.: conceived and drafted the manuscript; K. B. P. and H. M. C.: performed investigation and statistical analysis; J. W. S. and E. Y. K.: performed data acquisition and reviewed the data; K. H. J.: gave critical comments and revised the manuscript. All the authors were involved in the critical revision and final approval of the article.

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