



Comparing short-term outcomes after totally laparoscopic distal gastrectomy and laparoscopy-assisted distal gastrectomy with Billroth I anastomosis: early experience of a single institution

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Purpose: To determine the safety and feasibility of totally laparoscopic distal gastrectomy (TLDG) with modified delta-shaped anastomosis, we compared the short-term outcomes of TLDG to those of laparoscopy-assisted distal gastrectomy (LADG) with Billroth I anastomosis.

Methods: We analyzed the characteristics of 85 patients with gastric cancer who underwent laparoscopic distal gastrectomy with Billroth I anastomosis between January 2013 and December 2018. After propensity score matching, each group had 35 patients.

Results: Of these 85 patients, 44 underwent TLDG and 41 underwent LADG. Propensity score matching was performed with three covariates (age, underlying disease, and hypertension), and 35 patients from each group were matched 1:1. After matching, the TLDG group was older than the LADG group (64.5 ± 10.6 years vs. 56.3 ± 11.2 years, $p = 0.003$) and had more patients with hypertension (57.1% vs. 22.9%, $p = 0.003$). Tumors were larger in the TLDG group than in the LADG group (23.4 ± 16.2 mm vs. 16.0 ± 7.9 mm, $p = 0.018$). A greater proportion of patients had fever in the TLDG group than the LADG group (42.9% vs. 20.0%, $p = 0.039$), and C-reactive protein from postoperative days 3 to 6 was greater in the TLDG group (11.4 ± 5.7 mg/dL vs. 7.0 ± 5.0 mg/dL, $p = 0.001$).

Conclusion: Although our data represent only our early experience performing TLDG with modified delta-shaped anastomosis, this procedure is relatively safe and feasible. Nevertheless, compared to LADG, which is the conventional method, the operative time for TLDG was longer. Surgeons must also watch out for anastomotic complications.

Keywords: Gastroenterostomy, Laparoscopy, Stomach neoplasms

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INTRODUCTION

Gastric cancer is the fifth most common cancer worldwide, and its incidence is high in East Asia [1,2]. Moreover, the proportion of patients with early gastric cancer is increasing due to expanding interest in health care, improvements in diet, advancements in endoscopy, and increased range of health screening examinations [3,4].

Introduced in the early 1990s, laparoscopic gastrectomy is considered the standard treatment of early gastric cancer. The number of laparoscopic gastrectomy procedures is increasing with the increasing prevalence of early gastric cancer [5,6]. Furthermore, laparoscopic gastrectomy is being used to treat advanced gastric cancer by surgeons who perform laparoscopic D2 lymph node dissection [7-9].

Typically, laparoscopic distal gastrectomy requires extracorpo-

real anastomosis via mini-laparotomy of the upper abdomen; this technique is known as laparoscopy-assisted distal gastrectomy (LADG) [10]. Totally laparoscopic distal gastrectomy (TLDG) was developed in the early 2000s and uses various techniques to achieve intracorporeal anastomosis. Without mini-laparotomy of the upper abdomen, patients experience less pain, fewer wound complications, and may experience cosmetic benefits [11–14].

Billroth I anastomosis, which is a commonly used reconstruction method in distal gastrectomy, has some advantages over other reconstruction methods, including preserved duodenal passage, lower incidence of postoperative cholecystitis and cholelithiasis, use of a single anastomosis, and the possibility of endoscopic approach to the ampulla of Vater [15,16]. Therefore, when possible, surgeons at our institution perform Billroth I anastomosis in patients who require distal gastrectomy. At our institution, we began performing LADG with Billroth I anastomosis in the early 2000s; since 2015, we have used TLDG with modified delta-shaped anastomosis.

In this study, we investigated the short-term outcomes of our early experience performing TLDG with modified delta-shaped anastomosis at our institution, and we compared these outcomes to those of LADG with Billroth I anastomosis to analyze the safety and feasibility of TLDG.

MATERIALS AND METHODS

Patients

We enrolled all patients with gastric cancer who underwent laparoscopic distal gastrectomy with Billroth I anastomosis between January 2013 and December 2018 at Inje University Busan Paik Hospital. These operations were performed by one of two upper gastrointestinal tract surgeons. Between 2013 and 2015, patients with early gastric cancer as determined via preoperative esophagogastroduodenoscopy and abdominopelvic computed tomography underwent LADG. All tumors were marked with a clip during preoperative esophagogastroduodenoscopy, and the surgeon manually located this clip during upper mini-laparotomy. The resection margin was identified, and Billroth I anastomosis was performed when possible. Since October 2015, surgeons have identified this preoperative clip with intraoperative abdominal radiography. TLDG with modified delta-shaped anastomosis was performed when Billroth I anastomosis was possible. Moreover, since 2016, patients with advanced gastric cancer without metastasis or direct invasion to adjacent organs were also considered for laparoscopic surgery. For this study, we prospectively enrolled patients and retrospectively reviewed their medical records.

Surgical procedures and techniques

We performed all laparoscopic distal gastrectomy and lymph node dissection procedures according to the 2014 treatment guidelines of the Japanese Gastric Cancer Association (version 4) [17]. We used the conventional five-port method. Partial omentectomy and D1+ lymph node dissection were routinely performed; however, when necessary, total omentectomy and D2 lymph node dissection were performed instead. The proximal duodenum was divided with a linear stapler. After gastrectomy and reconstruction of the gastrointestinal tract, hemostasis was achieved and a surgical drain was inserted.

Totally laparoscopic distal gastrectomy

After duodenal division and determination of the resection margin, the stomach was resected with two linear staplers. If the appropriate resection margin was unclear, intraoperative supine abdominal radiography was used to confirm the location for endoscopic clipping. Entry holes were made at both the ventral edge of the duodenum and the greater curvature of the stomach. Gastroduodenostomy was performed by inserting a linear stapler into both entry holes, and the entry holes and stapled lines of the duodenal stump were resected with two additional linear staplers; this procedure is called modified delta-shaped anastomosis [18].

Laparoscopy-assisted distal gastrectomy

After duodenal division, a 6-cm incision was made in the upper abdomen. Then, the anvil was manually inserted extracorporeally into the duodenal stump, which was closed with purse-string sutures. The gastric lesion was detected, and the surgeon determined the resection margin by palpation or visual confirmation of the previously inserted endoscopic clip. Gastrotomy was performed on the distal side of the resection margin, and a circular stapler was inserted. Finally, gastroduodenostomy was performed at the posterior wall of the remnant stomach, and resection at the distal side of the resection margin was performed with a linear stapler.

Clinical outcomes

We retrospectively reviewed patient medical records, including the operative, pathologic, and nursing records. The pathologic tumor, node, metastasis (TNM) stage was recorded according to the seventh edition of *the Cancer Staging Manual* published by the American Joint Committee on Cancer [19]. The American Society of Anesthesiologists physical status (ASA PS) classification was determined by the anesthesiologists for each operation [20]. Pain medications, including tramadol, paracetamol, and nonsteroidal anti-inflammatory drugs, were recorded only when the

patient requested additional doses by injection. Fever was defined as a body temperature of 38.0°C or greater. All laboratory findings, which included hemoglobin and C-reactive protein (CRP) levels and white blood cell (WBC) count, were collected from postoperative days 3 to 6, regardless of whether tests were performed. If the laboratory tests were performed more than once per day, the results of the earliest tests were recorded. Change in hemoglobin was defined as the difference between the preoperative hemoglobin level and the mean value of postoperative days 3 to 6. The Clavien-Dindo (CD) classification was calculated according to the classifications for surgical complications by *the Annals of Surgery* (August 2004) [21]. A CD classification of III or greater was used to define the presence of major complications. Anastomotic complications included anastomotic leakage, stricture, delayed gastric emptying, and intraabdominal abscess. Readmission was defined as hospitalization within 30 days of the

initial discharge date.

Statistical analyses

We used the two-sample *t* test to analyze continuous variables and the Pearson chi-square or Fisher exact test to analyze categorical variables. A *p* value of <0.05 was considered statistically significant. Propensity score matching with nearest neighbor matching was performed, and we used age, underlying disease, and hypertension as covariates. We used R version 4.0.3 (R Foundation for Statistical Computing, Vienna, Austria) and IBM SPSS version 25 (IBM Corp., Armonk, NY, USA) to perform our analyses.

Table 1. Clinical characteristics of patients

Characteristic	Total population				Propensity matched population			
	TLDG (n = 44)	LADG (n = 41)	<i>p</i> value	Standardized difference ^{a)}	TLDG (n = 35)	LADG (n = 35)	<i>p</i> value	Standardized difference ^{a)}
Age (yr)	63.6 ± 11.6	57.4 ± 11.5	0.015	4.6728	64.5 ± 10.6	56.3 ± 11.2	0.003	-2.5235
Sex			0.165				0.039	
Male	33 (75.0)	24 (58.5)			28 (80.0)	20 (57.1)		
Female	11 (25.0)	17 (41.5)			7 (20.0)	15 (42.9)		
Body mass index (kg/m ²)	24.0 ± 3.1	23.4 ± 2.5	0.287		24.1 ± 2.3	23.3 ± 2.6	0.186	
ASA			0.100				0.025	
I	10 (22.7)	18 (43.9)			7 (20.0)	16 (45.7)		
II	26 (59.1)	19 (46.3)			20 (57.1)	17 (48.6)		
III	8 (18.2)	4 (9.8)			8 (22.9)	2 (5.7)		
Underlying disease			0.083	0.4022			0.092	0.6995
No	15 (34.1)	22 (53.7)			12 (34.3)	19 (54.3)		
Yes	29 (65.9)	19 (46.3)			23 (65.7)	16 (45.7)		
Hypertension	25 (56.8)	10 (24.4)	0.004	0.4111	20 (57.1)	8 (22.9)	0.003	0.7471
Diabetes mellitus	11 (25.0)	5 (12.2)	0.169		9 (25.7)	4 (11.4)	0.124	
Obstructive lung disease	4 (9.1)	2 (4.9)	0.677		3 (8.6)	1 (2.9)	0.614	
Ischemic heart disease	1 (2.3)	3 (7.3)	0.349		1 (2.9)	0 (0.0)	>0.999	
Arrhythmia	2 (4.5)	0 (0.0)	0.495		2 (5.7)	0 (0.0)	0.493	
Chronic kidney disease	1 (2.3)	0 (0.0)	>0.999		1 (2.9)	0 (0.0)	>0.999	
Liver cirrhosis	1 (2.3)	1 (2.4)	>0.999		1 (2.9)	1 (2.9)	>0.999	
Previous operation history	9 (20.5)	8 (19.5)	>0.999		7 (20.0)	7 (20.0)	>0.999	

Values are presented as mean ± standard deviation or number (%).

TLDG, totally laparoscopic distal gastrectomy; LADG, laparoscopy-assisted distal gastrectomy; ASA, American Society of Anesthesiologists physical status classification.

^{a)}In general, if the standardized difference is less than 0.1, the difference in the covariate can be neglected.

RESULTS

We included 85 patients who underwent laparoscopic distal gastrectomy; 44 patients underwent TLDG and 41 underwent LADG. Propensity score matching was performed with three covariates (age, underlying disease, and hypertension), and 35 patients from each group were matched 1:1.

Clinical characteristics

Table 1 lists the clinical characteristics of the enrolled patients. After matching, the TLDG group included 28 males (80.0%) and seven females (20.0%), with a mean age of 64.5 ± 10.6 years. The LADG group included 20 males (57.1%) and 15 females (42.9%), with a mean age of 56.3 ± 11.2 years. The groups were statistically different in terms of sex ($p = 0.039$), and the mean age was significantly greater in the TLDG group ($p = 0.003$). Mean body

Table 2. Pathologic outcomes

Variable	Total population			Propensity matched population		
	TLDG (n = 44)	LADG (n = 41)	p value	TLDG (n = 35)	LADG (n = 35)	p value
Tumor size (mm)	23.3 ± 18.7	16.5 ± 8.1	0.040	23.4 ± 16.2	16.0 ± 7.9	0.018
Harvested lymph nodes	32.6 ± 9.2	34.5 ± 11.7	0.393	32.1 ± 9.0	35.6 ± 12.4	0.166
T stage			0.072			0.235
T1	37 (84.1)	38 (92.7)		29 (82.9)	33 (94.3)	
T2	2 (4.5)	2 (4.9)		2 (5.7)	2 (5.7)	
T3	2 (4.5)	0 (0)		2 (5.7)	0 (0)	
T4	2 (4.5)	0 (0)		2 (5.7)	0 (0)	
N stage			0.228			0.203
N0	36 (81.8)	38 (92.7)		28 (80.0)	33 (94.3)	
N1	3 (6.8)	1 (2.4)		3 (8.6)	0 (0)	
N2	3 (6.8)	2 (4.9)		3 (8.6)	2 (5.7)	
N3	1 (2.3)	0 (0)		1 (2.9)	0 (0)	
Stage			0.096			0.177
I	38 (86.4)	39 (95.1)		29 (82.9)	33 (94.3)	
II	3 (6.8)	2 (4.9)		3 (8.6)	2 (5.7)	
III	3 (6.8)	0 (0)		3 (8.6)	0 (0)	
Cell differentiation			0.254			0.212
Differentiated	30 (68.2)	23 (56.1)		25 (71.4)	20 (57.1)	
Undifferentiated	12 (27.3)	16 (39.0)		10 (28.6)	15 (42.9)	
Lauren classification			0.704			0.394
Intestinal	30 (68.2)	22 (53.7)		25 (71.4)	21 (60.0)	
Diffuse	8 (18.2)	12 (29.3)		7 (20.0)	12 (34.3)	
Mixed	4 (9.1)	2 (4.9)		3 (8.6)	2 (5.7)	
(−)	1 (2.3)	1 (2.4)		0 (0)	0 (0)	
Invasion						
Lymphatic	8 (18.2)	3 (7.3)	0.203	8 (22.9)	3 (8.6)	0.101
Venous	1 (2.3)	0 (0)	>0.999	1 (2.9)	0 (0)	>0.999
Neural	5 (11.4)	1 (2.4)	0.206	5 (14.3)	1 (2.9)	0.198

Values are presented as mean ± standard deviation or number (%).

TLDG, totally laparoscopic distal gastrectomy; LADG, laparoscopy-assisted distal gastrectomy.

mass index was similar between groups ($24.1 \pm 2.3 \text{ kg/m}^2$ for the TLDG group vs. $23.3 \pm 2.6 \text{ kg/m}^2$ for the LADG group, $p = 0.186$). Preoperative ASA PS classification was significantly higher in the TLDG groups (in the TLDG group, seven patients [20.0%] had ASA I, 20 [57.1%] had ASA II, and eight [22.9%] had ASA III; in the LADG group, 16 patients [45.7%] had ASA I, 17 [48.6%] had ASA II, and two [5.7%] had ASA III; $p = 0.025$).

More patients who underwent TLDG had underlying disease than those who underwent LADG (23 patients [65.7%] vs. 16 [45.7%], respectively), but this difference was not statistically significant ($p = 0.092$). Patients in the TLDG group had hypertension (20 patients [57.1%]), diabetes mellitus (nine [25.7%]), obstructive lung disease (three [8.6%]), ischemic heart disease (one [2.9%]), arrhythmia (two [5.7%]), chronic kidney disease (one [2.9%]), and liver cirrhosis (one [2.9%]). Patients in the LADG group had hy-

pertension (eight patients [22.9%]), diabetes mellitus (four [11.4%]), obstructive lung disease (one [2.9%]), and liver cirrhosis (one [2.9%]), but no patient had ischemic heart disease, arrhythmia, or chronic kidney disease. Only the prevalence of hypertension was significantly different between groups ($p = 0.003$). Similar numbers of patients had a history of abdominal surgery (seven patients [20.0%] in the TLDG group vs. seven [20.0%] in the LADG group, $p > 0.999$).

Pathologic outcomes

Table 2 lists the pathologic outcomes. After matching, the mean \pm standard deviation of tumor size was $23.4 \pm 16.2 \text{ mm}$ in the TLDG group and $16.0 \pm 7.9 \text{ mm}$ in the LADG group ($p = 0.018$). The number of harvested lymph nodes was 32.1 ± 9.0 in the

Table 3. Surgical outcomes

Variable	Total population			Propensity matched population		
	TLDG (n = 44)	LADG (n = 41)	p value	TLDG (n = 35)	LADG (n = 35)	p value
Blood loss (mL)	106.6 \pm 102.5	145.6 \pm 117.7	0.106	94.9 \pm 65.1	145.4 \pm 116.9	0.029
Operation time (min)	215.8 \pm 39.6	167.5 \pm 32.0	<0.001	211.3 \pm 30.3	168.0 \pm 33.8	<0.001
Full liquid diet started (day)	4.4 \pm 0.9	5.1 \pm 1.2	0.007	4.6 \pm 1.0	5.1 \pm 1.2	0.053
Gas first passed (day)	3.6 \pm 1.5	3.8 \pm 1.6	0.718	3.8 \pm 1.6	3.8 \pm 1.6	0.94
Length of hospital stay (day)	10.1 \pm 7.4	10.0 \pm 9.5	0.962	10.6 \pm 8.2	8.6 \pm 1.8	0.159
Readmission within 30 days	3 (6.8)	1 (2.4)	0.617	3 (8.6)	0 (0)	0.239
Additional use of pain medications	2.4 \pm 2.4	3.4 \pm 3.0	0.502	2.4 \pm 2.4	3.3 \pm 2.8	0.164
Body temperature, $\geq 38.0^\circ\text{C}$			0.081			0.039
No	26 (59.1)	32 (78.0)		20 (57.1)	28 (80.0)	
Yes	18 (40.9)	9 (22.0)		15 (42.9)	7 (20.0)	
Change in hemoglobin	2.6 \pm 1.3	2.5 \pm 1.1	0.818	2.5 \pm 1.3	2.6 \pm 1.2	0.796
WBC (cell/nL), POD 3–6	7,769.0 \pm 2,386.8	7,725.1 \pm 2,400.7	0.933	7,883.5 \pm 2,513.6	7,371.9 \pm 2,059.6	0.355
CRP (mg/dL), POD 3–6	11.3 \pm 6.5	7.48 \pm 5.7	0.005	11.4 \pm 5.7	7.0 \pm 5.0	0.001
CD classification			0.212			0.325
0	20 (45.5)	23 (56.1)		16 (45.7)	22 (62.9)	
I	6 (13.6)	5 (12.2)		5 (14.3)	5 (14.3)	
II	14 (31.8)	11 (26.8)		11 (31.4)	8 (22.9)	
III	2 (4.5)	2 (4.9)		2 (5.7)	0 (0)	
IV	1 (2.3)	0 (0)		1 (2.9)	0 (0)	
V	1 (2.3)	0 (0)		0 (0)	0 (0)	
Major complication ^{a)}	4 (9.1)	2 (4.9)	0.677	3 (8.6)	0 (0)	0.239

Values are presented as mean \pm standard deviation or number (%).

TLDG, totally laparoscopic distal gastrectomy; LADG, laparoscopy-assisted distal gastrectomy; WBC, white blood cell count; POD, postoperative day; CRP, C-reactive protein; CD, Clavien-Dindo.

^{a)}CD classification > II.

Table 4. Details of anastomotic complications

Variable	Total population			Propensity score matching		
	TLDG (n = 44)	LADG (n = 41)	<i>p</i> value	TLDG (n = 35)	LADG (n = 35)	<i>p</i> value
Anastomotic complication	5 (11.4)	2 (4.9)	0.435	5 (14.3)	0 (0.0)	0.054
Delayed gastric emptying	1	0		1	0	
Anastomotic stricture	1	1		1	0	
Anastomotic leakage	1	0		1	0	
Intraabdominal abscess	2	1		2	0	

Values are presented as number (%) or number only.

TLDG, totally laparoscopic distal gastrectomy; LADG, laparoscopy-assisted distal gastrectomy.

TLDG group and 35.6 ± 12.4 in the LADG group ($p = 0.166$). In the TLDG group, 29 patients (82.9%) had T1 stage disease, two (5.7%) had T2, two (5.7%) had T3, and two (5.7%) had T4. In the LADG group, 33 patients (94.3%) had T1 stage disease, two (5.7%) had T2, and no one had T3 or T4. The groups were similar in terms of T stage ($p = 0.235$). The TLDG group had more patients with advanced-stage gastric cancer (29 patients [82.9%] had stage I, three [8.6%] had stage II, and one [8.6%] had stage III) than the LADG group (33 [94.3%] had stage I, two [5.7%] had stage II, and no one had stage III), but the groups were statistically similar ($p = 0.177$). Groups were similar in terms of cell differentiation, Lauren classification, and lymphatic, venous, and neural invasion.

Surgical and clinical outcomes

Table 3 shows the surgical and clinical outcomes. After matching, blood loss was lower in the TLDG group than in the LADG group (94.9 ± 65.1 mL vs. 145.4 ± 116.9 mL, respectively; $p = 0.029$). However, operative time was significantly longer in the TLDG group than in the LADG group (211.3 ± 30.3 minutes vs. 168.0 ± 33.8 minutes, respectively; $p < 0.001$). The number of days before patients first passed gas was similar between groups, but patients in the TLDG group tended to consume a full liquid diet earlier than those in the LADG group (4.6 ± 1.0 days vs. 5.1 ± 1.2 days after surgery, respectively; $p = 0.053$). Postoperative length of stay in the hospital was 10.6 ± 8.2 days in the TLDG group vs. 8.6 ± 1.8 days in the LADG group ($p = 0.159$). Similar numbers of patients were readmitted within 30 days (three patients [8.6%] in the TLDG group vs. no one in the LADG group, $p = 0.239$). In addition, patients requested similar number of additional injections for pain (2.4 ± 2.4 times in the TLDG group vs. 3.3 ± 2.8 times in the LADG group; $p = 0.164$).

Overall, 15 patients (42.9%) in the TLDG group had a fever vs. seven patients (20.0%) in the LADG group ($p = 0.039$). Change in hemoglobin was similar between groups (2.5 ± 1.3 g/dL for the TLDG group vs. 2.6 ± 1.2 g/dL for the LADG group; $p = 0.796$).

Mean WBC counts on postoperative days 3 to 6 were also similar ($7,883.5 \pm 2,513.6$ cells/nL for the TLDG group vs. $7,371.9 \pm 2,059.6$ cells/nL for the LADG group; $p = 0.355$). However, mean CRP on postoperative days 3 to 6 was greater in the TLDG group than in the LADG group (11.4 ± 5.7 mg/dL vs. 7.0 ± 5.0 mg/dL, respectively; $p = 0.001$).

Patients had similar CD classifications. More patients in the TLDG group had major complications (8.6% of the TLDG group vs. 0% of the LADG group), but this difference was not significant ($p = 0.239$).

Anastomotic complications

Table 4 shows data on anastomotic complications. After matching, a greater proportion of patients in TLDG group had anastomotic complications than patients in the LADG group (14.3% vs. 0%, respectively; $p = 0.054$). In the TLDG group, one patient had delayed gastric emptying, one had an anastomotic stricture, one had anastomotic leakage, and two had an intraabdominal abscess.

DISCUSSION

Many surgeons prefer Billroth I anastomosis to other reconstruction methods because of its physiologic advantages, such as preserved duodenal passage and reduced postoperative incidence of cholecystitis and cholelithiasis [15,16]. Furthermore, multiple anastomoses may be burdensome for surgeons, possibly leading to a longer operative time and increased risk for postoperative anastomotic leakage. For these reasons, we performed Billroth I anastomosis during TLDG, as well as during LADG, by utilizing modified delta-shaped anastomosis [19]. This procedure involves removing all staple lines used in duodenal division by adding stapling to the delta-shaped anastomosis. Studies have reported that this procedure is safe, but few studies have compared the outcomes of LADG with Billroth I anastomosis performed with a circular stapler to those of TLDG with modified delta-shaped

anastomosis [22,23]. Therefore, we compared the methods to confirm feasibility and safety.

We observed older age, higher ASA PS classification, and higher incidence of hypertension in the TLDG group; however, these findings may have been due to the retrospective nature of this study without variable control. The higher incidence of underlying disease in the TLDG group may also be explained by the same reasons. To overcome these limitations, we performed propensity score matching with nearest neighbor matching; however, this may have been insufficient to statistically compare our groups. Since 2016, laparoscopic distal gastrectomy has been performed to treat patients with advanced gastric cancer, which may explain why tumor size was larger in the TLDG group; nevertheless, groups were similar in terms of T stage and final stage.

A number of studies have reported a tendency of shorter operation time in TLDG compared with LADG by 10 to 50 minutes, due to lack of the process of creation and closure of the mini-laparotomy. However, in our study, the operation time for TLDG was longer (211.3 minutes vs. 168.0 minutes, respectively); this is probably because of insufficient proficiency in anastomotic techniques. LADG, on the other hand, has been practiced for many years by the same surgeons, and the anastomosis is therefore more easily and quickly performed. However, the mean operative time of TLDG was similar to those reported by previous studies (range, 115.6–298.0 minutes) [22,23]. Patients in the TLDG group had significantly less intraoperative bleeding than those in the LADG group (94.9 mL vs. 145.4 mL, respectively), and other studies have reported similar results (range, 21.2–200.0 mL). However, changes in hemoglobin levels were similar between groups [22,24–26]. All patients received patient-controlled analgesia, and any additional injections were recorded to compare postoperative pain between groups. We hypothesized that patients in the TLDG group would experience less pain due to the lack of mini-laparotomy, but these patients received a mean of 2.4 injections and those in the LADG group received 3.3 injections; this difference was not significant.

To determine differences in postoperative inflammation between groups, we recorded the number of patients who developed fever and calculated the mean WBC counts and CRP values. We postulated that the postoperative inflammatory response would be affected because TLDG is a less-invasive procedure and requires a smaller incision than LADG. Contrary to this notion, significantly more patients in the TLDG group had postoperative fever, and mean CRP from postoperative days 3 to 6 was also statistically higher in this group; however, mean WBC counts from postoperative days 3 to 6 were similar. Anastomotic complications may have affected these inflammatory changes, and the effects of atelectasis due to longer operative time cannot be overlooked.

Although the incidence rates of major complications were not

significantly different between groups, approximately twice as many patients in the TLDG group experienced complications. This is probably due to the learning curve for this procedure, but differences in age and underlying diseases between groups may have had an effect. Nonetheless, compared to the rates of other published studies (range, 1.1%–8.0%), the rate of major complications in our study is not higher [26]. Additional studies with greater numbers of patients are needed to accurately evaluate this difference. In our study, one patient in the TLDG group had a grade IV complication and one patient had a grade V complication. The grade IV complication occurred in a 64-year-old male patient with hypertension, diabetes mellitus, obstructive coronary artery disease, atrial fibrillation, chronic kidney disease, and chronic hepatitis. He developed acute kidney injury due to chronic kidney disease, which required intermittent hemodialysis. One patient died suddenly due to a clinical course with similarities to intraabdominal bleeding; she was 56-year-old and had hypertension, diabetes mellitus, and breast cancer.

Anastomotic complications in the TLDG group included one case of delayed gastric emptying, one case of anastomotic stricture, one case of anastomotic leakage, and two cases of intraabdominal abscess. In the LADG group, one patient developed an anastomotic stricture and one developed intraabdominal abscess. Although the incidence rates of anastomotic complications were statistically similar, significantly more complications developed in the TLDG group, and this difference was even greater after propensity score matching. These complications may have developed because creation of a modified delta-shaped anastomosis with an even shape is more difficult to achieve with linear staples instead of a circular stapler; therefore, the learning curve for this procedure should also be taken into consideration. However, our results are similar to those of other studies. Delayed gastric emptying after TLDG is an anastomosis-related complication that requires caution. One patient in our study developed this complication, and our rate is comparable to that of other studies (range, 0%–3.3%). Therefore, this complication may not have a substantial impact on short-term outcomes. However, this assumption is based on the result of a small number of patients, and therefore future studies should enroll a greater number of patients to validate our results. Based on the results of this study, caution must be taken to lower the incidence of anastomosis-related complications in patients who undergo modified delta-shaped anastomosis, particularly among patients being treated by surgeons who are learning to perform this type of anastomosis [24–29].

The heterogeneity of the patient groups may have affected the results, and this is a limitation of this retrospective study. This limitation may erroneously indicate that TLDG is not feasible. Multicenter, randomized clinical trials are needed to confirm the results of this analysis. Furthermore, the possible effects of the learning curve for TLDG are difficult to rule out. This may

have also negatively affected our interpretation of the safety and feasibility of TLDG; therefore, additional studies that analyze the effects of the learning curve are needed. Lastly, we compared the outcomes of LADG with TLDG performed with only Billroth I anastomosis. However, to confirm the safety and feasibility of TLDG with Billroth I anastomosis, additional studies are needed to analyze the outcomes of TLDG with Billroth II and Roux-en-Y anastomosis.

In our early experience, TLDG is a relatively safe and feasible procedure. However, a longer operative time is required compared to that of conventional LADG, and surgeons must watch out for anastomosis-related complications.

NOTES

Ethical statements

This study was approved by the Institutional Review Board of Inje University Busan Paik Hospital with a waiver of informed consent (IRB No. 20-0122).

Authors' contributions

Conceptualization: IL

Data curation: HJB, SHS, SHK

Formal analysis: SHS

Investigation: IL, MSA

Methodology: KHK, SHO

Project administration: SHO, YHP, SHS

Writing—original draft: IL

Writing—review & editing: IL, KHK

All authors read and approved the final manuscript.

Conflict of interest

All authors have no conflicts of interest to declare.

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