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ORIGINAL ARTICLE

Comparison of double-flap and OrVil techniques of laparoscopy-assisted proximal gastrectomy in preventing gastroesophageal reflux: a retrospective cohort study

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Abstract

Background Laparoscopy-assisted proximal gastrectomy (LAPG) with esophagogastrostomy using the double-flap technique has been reported to rarely cause gastroesophageal reflux. However, quantitative evaluation of the reflux has hardly been performed. The aim of this study was to clarify the superiority of the double-flap technique of LAPG with esophagogastrostomy compared with the OrVil technique in terms of preventing gastroesophageal reflux.

Methods A total of 40 and 51 patients who underwent LAPG with esophagogastrostomy using the double-flap and OrVil techniques, respectively, for upper one-third gastric cancer were included in this study. Of these, 22 and 13 patients in the double-flap and OrVil groups, respectively, consented to undergo a 24-h impedance-pH monitoring test at 3 months postoperatively. Postoperative complications, including gastroesophageal reflux and anastomotic stricture, were assessed retrospectively.

Results No significant differences were observed in the patients' background between both groups, except for a higher D1+ dissection rate observed in double-flap group than in the OrVil group (93% vs 25%, $P < 0.001$). Operative time was significantly longer in the double-flap group than in the OrVil group (353 min vs 280 min, $P < 0.001$). All reflux % time was significantly lower in the double-flap group than in the OrVil group (1.29% vs 2.62%, $P = 0.043$). On the other hand, the proportion of anastomotic stricture requiring endoscopic balloon dilatation was lower in the double-flap group than in the OrVil group but without statistical significance (18% vs 27%; $P = 0.32$).

Conclusions Despite its longer operative time and still relatively high anastomotic stricture rate, the double-flap technique would be better than the OrVil technique in terms of preventing gastroesophageal reflux in patients who underwent LAPG with esophagogastrostomy.

Keywords Laparoscopic surgery · Proximal gastrectomy · Esophagogastrostomy · Gastroesophageal reflux · Anastomotic stricture

Introduction

Gastric cancer is the third most frequent cause of cancer-related death (723,000 per year) and the fifth most common type of malignancy (951,000 per year) worldwide [1]. Although the incidence rate of gastric cancer in Japan is among the highest in the world, about 50% of all the patients were detected in the early stage owing to mass screening programs [2]. Patients with early stage gastric cancer undergoing curative surgery have a high potential for long-term survival. Thus, achieving and maintaining patients' quality of life (QOL) postoperatively should be one of the main goals of treatment.

Total gastrectomy or proximal gastrectomy is performed with curative intent for patients with upper-third early gastric cancer or gastric gastrointestinal stromal tumor (GIST) located near the esophagogastric junction. Proximal gastrectomy has been reported to be superior than total gastrectomy in terms of

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the nutritional aspect [3–5]. On the other hand, laparoscopic surgery is preferred to open surgery because of its short-term advantages [6–8]. For laparoscopy-assisted proximal gastrectomy (LAPG), a simple reconstruction, such as esophagogastrostomy, is preferred because of the restriction of instrumental movement in laparoscopic surgery. However, esophagogastrostomy sometimes causes gastroesophageal reflux or anastomotic stricture, which leads to the impairment of the patient's QOL due to heartburn or frequent endoscopic dilatation.

More recently, LAPG with esophagogastrostomy using the double-flap technique has been preferably performed in some institutions [9–13]. This type of anastomosis is reported to rarely cause gastroesophageal reflux. However, the quantitative evaluation of the reflux has hardly been performed. We hypothesized that the double-flap technique is better in terms of preventing gastroesophageal reflux and anastomotic stricture than the OrVil technique. This retrospective cohort study also aimed to compare the surgical outcomes between LAPG with esophagogastrostomy using the double-flap technique and LAPG with esophagogastrostomy using the OrVil technique.

Patients and methods

This study was conducted in accordance with the 1995 Declaration of Helsinki (as revised in Brazil 2013) and was approved by the Kitasato University School of Medicine Research Ethics Committee. The requirement for informed consent was waived because of the study's retrospective design. The manuscript was written according to the STROBE Statement.

Patients

We performed LAPG with esophagogastrostomy using the OrVil technique (Covidien Japan Co., Ltd., Tokyo, Japan) from 2008 to 2015 and LAPG with esophagogastrostomy using the double-flap technique from 2015 to 2018 in patients with upper one-third cT1 gastric cancer who did not meet the criteria for the endoscopic resection where more than two-thirds of the distal stomach could be preserved, or in those with gastric GIST located near the esophagogastric junction. Patients who underwent concurrent organ resection other than that of the gall bladder were excluded from this study. From 2008 to 2018, 1561 patients underwent surgical resection for gastric cancer and 112 underwent surgical resection for gastric GIST. Patients' flow is depicted in the Fig. 1. Of the 1561 patients with gastric cancer, 282 underwent open distal gastrectomy, 340 open total gastrectomy, 101 laparoscopic pylorus preserving gastrectomy, 103 laparoscopic proximal gastrectomy, 154 laparoscopic total gastrectomy, 579 laparoscopic distal gastrectomy, and 2 laparoscopic local resection. Of the 112 patients with gastric GIST, 2 underwent laparoscopic proximal gastrectomy, 1 laparoscopic total gastrectomy, 1 laparoscopic distal gastrectomy, 99 laparoscopic local resection, and 9 open local resection. Of the 105 patients undergoing laparoscopic proximal gastrectomy with gastric cancer or gastric GIST, 12 undergoing esophagogastrostomy using linear stapler and 2 undergoing double-tract reconstruction were excluded. The remaining 91 patients (51 undergoing OrVil reconstruction and 40 undergoing double-flap reconstruction) were included in this study.

Surgical procedures

OrVil technique

The OrVil technique was performed as described previously [3]. A flexible fiber-optic laparoscope with a 10-mm tip (OLYMPUS LTF TYPE VH; Olympus Optical Co., Ltd., Tokyo, Japan) was inserted through a 12-mm umbilical camera port.

The extent of lymph node dissection was determined by using the Japanese Classification of Gastric Carcinoma (second English edition) [14] or Japanese Gastric Cancer Treatment Guidelines 2010 [15] according to the time of surgery. More than 70% of the patients underwent D1 lymph node dissection. After the lymph node dissection, the esophagus was transected using a linear stapler. An 18-Fr orogastric tube of the OrVil system was passed transorally by an anesthesiologist to place the anvil head at the center of the staple line (Fig. 2a). A 6-cm small incision was made in the upper abdomen to extract the stomach out of the abdominal cavity. The stomach was transected perpendicularly to its long axis.

A Premium Plus CEEA stapler (Covidien Japan Co., Ltd., Tokyo, Japan) was inserted through a 3-cm incision at the anterior wall of the antrum, and the center rod was pierced at the site 3–4 cm distal to the middle of the cut line of the remnant stomach. After tying the circular stapler, to which a surgical glove had been attached, and the remnant stomach, the abdominal cavity was insufflated again. The anvil head and the center rod were docked under laparoscopic vision (Fig. 2b). Firing was completed intracorporeally. The opening of the remnant stomach was closed manually under direct vision from the minilaparotomy. Fundoplication was performed so that the gastric remnant was wrapped about two-thirds of the circumference of the esophagus (Fig. 2c).

Double-flap technique

The double-flap technique was also performed as described previously [9]. A flexible 3D fiber-optic laparoscope with a 10-mm tip (OLYMPUS ENDOEYE FLEX 3D; Olympus

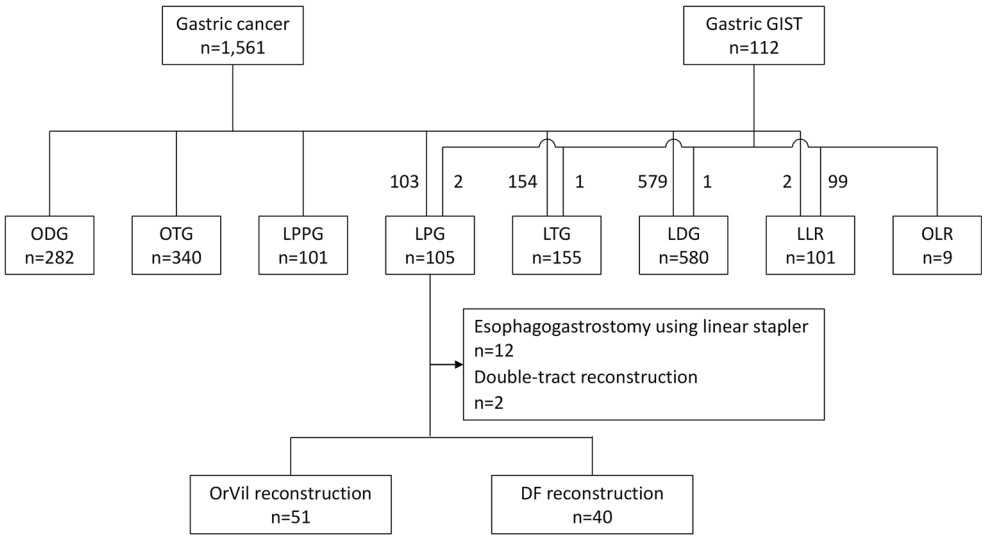

Fig. 1 Patient flowchart. ODG, open distal gastrectomy; OTG, open total gastrectomy; LPPG, laparoscopic pylorus preserving gastrectomy; LPG, laparoscopic proximal gastrectomy; LTG, laparoscopic total gastrectomy; LDG laparoscopic distal gastrectomy; LLR, laparoscopic local resection; OLR, open local resection

Optical Co., Ltd., Tokyo, Japan) was inserted through a 12-mm umbilical camera port.

The extent of lymph node dissection was different from that in the OrVil technique. More than 90% of the patients underwent D1+ lymph node dissection which includes dissection of the common hepatic artery lymph nodes and the proximal splenic artery lymph nodes. Resection of the stomach was almost the same except for the length of the incision that was about 4 cm in the double-flap technique.

After making a double-flap window with a dimension of 2.5 cm × 3.0–3.5 cm (width × height) (Fig. 2d), the abdominal cavity was insufflated again. The superior end of the mucosal window was fixed to the esophagus 4 cm above the cut end (Fig. 3a). Next, the esophageal orifice and the orifice of the remnant stomach were manually anastomosed laparoscopically (Figs. 2e and 3b, c). Finally, the anastomotic site was covered by the flaps to create the anastomotic valve (Figs. 2f and 3d). For the first 22 cases,

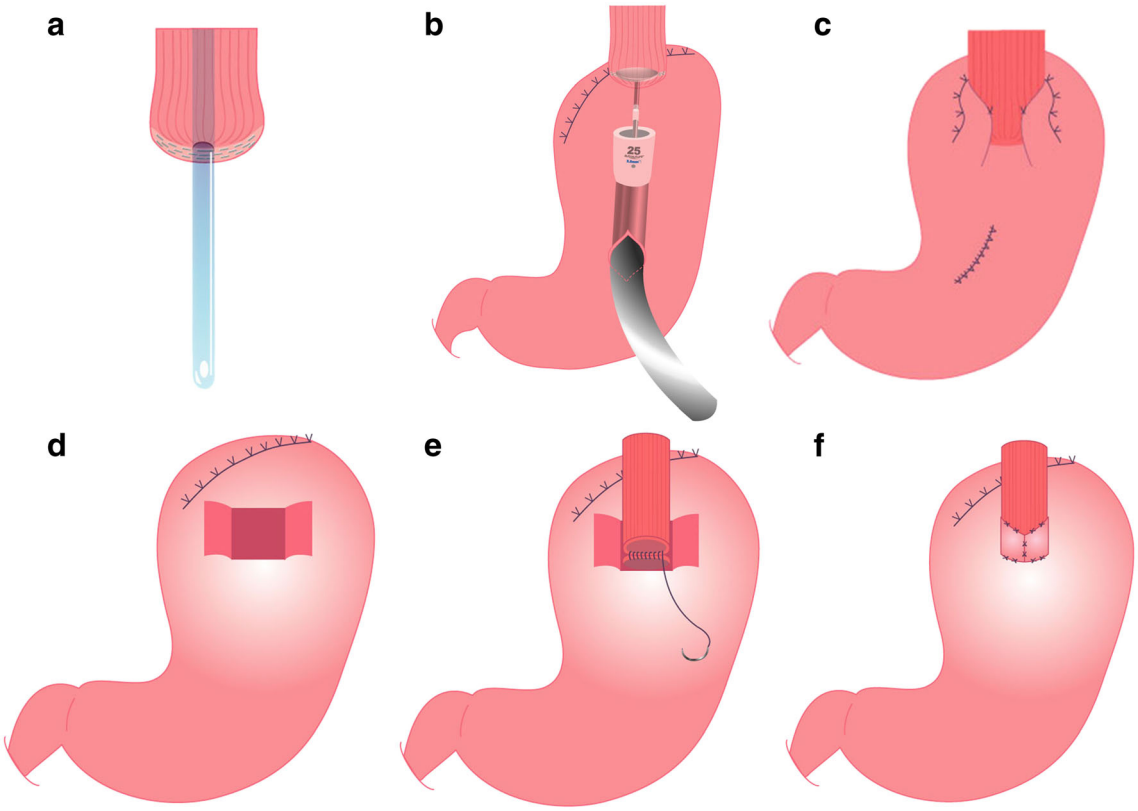

Fig. 2 Schematic pictures of the OrVil and the double-flap techniques

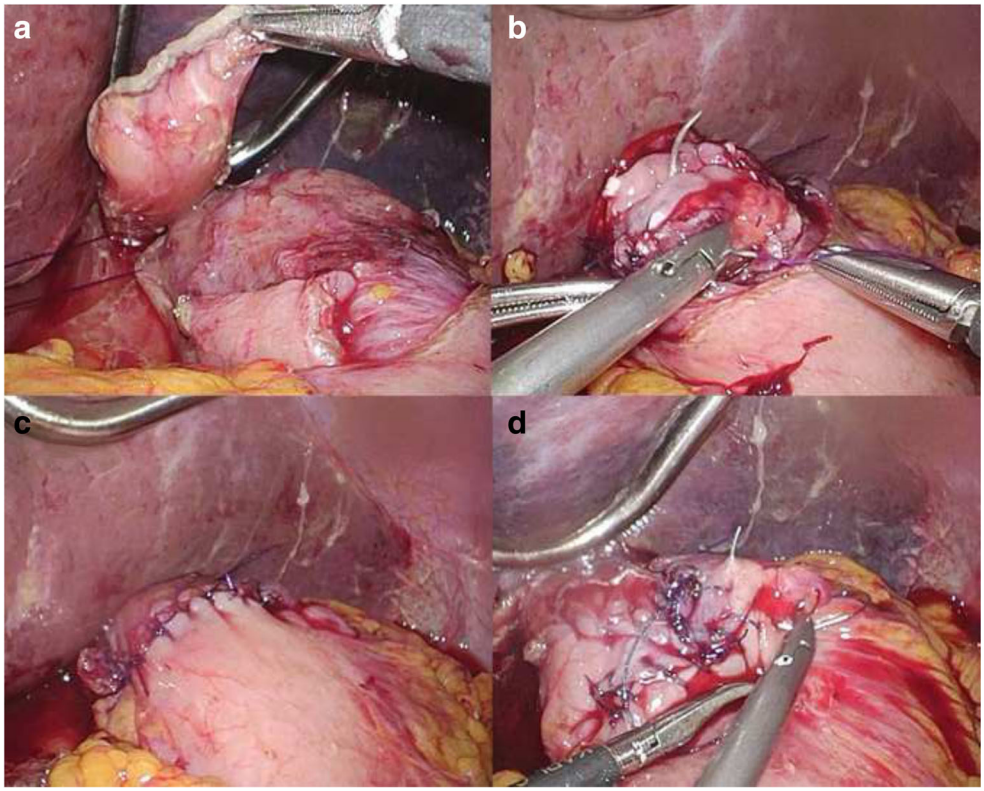

Fig. 3 Laparoscopy-assisted proximal gastrectomy with esophagogastrostomy using a double-flap technique. The superior end of the mucosal window is fixed to the esophagus 4 cm above the cut end (**a**). Suturing is performed between the posterior wall of the esophagus and superior opening of the mucosa on the remnant stomach using 3-0 PDS-II (**b**). Anastomosis between the esophageal orifice and the orifice of the remnant stomach is completed (**c**). The anastomotic site is covered by the flaps to create the anastomotic valve (**d**)

all suturing was carried out in a continuous manner using V-Loc 180 (Covidien Japan Co., Ltd., Tokyo, Japan). Given the high stricture rate of 10% [9], we changed the suturing methods to interrupted suturing using 3-0 PDS-II (Ethicon Japan Co., Ltd., Tokyo, Japan) for the following 15 cases hoping to lower the rate of anastomotic stricture. However, because of the relatively high anastomotic stricture rate and cumbersome procedure of interrupted suturing, we performed continuous suturing again for the last three cases.

The OrVil reconstruction was performed by nine surgeons, six of whom had the experience of minimally invasive gastric surgery for less than 5 years and performed 60% of the surgery in the OrVil group. The double-flap procedure was performed by KH or HM (qualified surgeons, certified by Japan Society of Endoscopic Surgery). KH and HM had adequate surgical education for minimally invasive surgery and experienced minimally invasive gastric surgery for more than 3 years and 6 years, respectively.

Postoperative management

A nasogastric tube was removed during the operation in both groups. Water intake began on postoperative day 2 and oral feeding on postoperative day 3. A proton pump inhibitor (PPI) was routinely administered for several months after the surgery.

Clinical analysis

The patients' medical records were reviewed, and their age, sex, body mass index (BMI), intraoperative findings, and length of postoperative hospital stay were obtained. Postoperative complications including anastomotic stricture were assessed according to the Clavien–Dindo classification [16, 17]. All the patients were followed up for more than 4 months postoperatively to assess any occurrence of late complications. The median follow-up time was 17 and 49 months in the double-flap and OrVil groups, respectively. The resected specimens were histopathologically examined to determine tumor size, histological type, depth of tumor invasion, extent of lymph node metastasis, and pathological tumor stage according to the Japanese Classification of Gastric Carcinoma [18].

Twenty-two and 13 patients in the double-flap and OrVil groups, respectively, consented to undergo 24-h impedance-pH monitoring using the ambulatory multichannel intraluminal impedance (MII) and pH monitoring system (Sleuth; Sandhill Scientific, Inc., Highland Ranch, CO, USA) about 3 months postoperatively.

The 2.1-mm outer diameter study catheter was composed of six electrode pairs measuring intraluminal impedance 3, 5, 7, 9, 15, and 17 cm above the LES, and an antimony pH sensor 5 cm above the LES. Reflux analysis was performed using an impedance probe placed 5 cm above the site of esophagogastrostomy. An impedance amplifier delivers

ultra-low current in a range of 1–2 kHz with resulting current flow variations in response to intraluminal impedance changes. The signals from six impedance channels and on pH channel are recorded at 50 samples per second. The data were stored in an ambulatory recorder and saved on a 128 MB CompactFlash card. The study was performed as an inpatient after overnight fast. After LES location by esophageal manometry, the 24-h impedance pH catheter was placed. The study catheter was attached to an ambulatory monitor. The patients were asked to remain upright during the day and lie down only at their usual bedtime. Event markers on the monitor recorded meal times and posture changes. Between meals, patients were asked to avoid frequent snacks, beverages with a pH < 5. After 24-h monitoring of the change of the impedances and pH level, the catheter was removed, and data were transferred to a computer for analysis. Meal times were excluded from analysis.

PPIs act by irreversibly blocking the H+/K+ ATPase in the gastric parietal cells with covalent bond. Recovery of full acid secretion after PPI treatment discontinuation was reported to require about 96 h in humans [19]. The Esophageal Diagnostic Advisory Panel reached the consensus that pH testing at least 7 days off acid suppression should be performed in all patients with gastroesophageal reflux [20]. Thus, we discontinued PPI for more than 2 weeks before the test to eliminate the effect of PPI completely.

Normal gastroesophageal reflux was defined as follows: acid percent time of less than 1.1%, which was derived from the study that calculated the normal pH values at 5 cm above the LES from 110 healthy adults consisting of 47 men and 63 women with a mean age of 38 years (range 20–84) [21], and all reflux percent time of less than 1.4%, which was derived from the study that calculated the total liquid exposure at 5 cm above the LES from 60 healthy adults consisting of 30 men and 30 women with a mean age of 39 (range 22–62) [22].

To include patients who did not consent to undergo 24-h impedance-pH monitoring test, we interviewed all the patients that we were able to contact by telephone and asked them about abdominal symptoms using the Gastrointestinal Symptom Rating Scale (GSRS) [23]. The questionnaire includes 15 items and uses a 7-graded Likert scale defined by descriptive anchors. The higher the scores, the more pronounced are the symptoms. The items are grouped into three dimensions: dyspeptic syndrome (abdominal pain, heartburn, acid regurgitation, sucking sensations, nausea and vomiting), indigestion syndrome (Borborygmus, abdominal distension, eructation, increased flatus), and bowel dysfunction syndrome (decreased passage of stools, increased passage of stools, loose stools, hard stools, urgent need for defecation, feeling of incomplete evacuation).

We also conducted univariate and multivariate analysis for typical gastroesophageal reflux-related symptoms of heartburn and regurgitation using explanatory variables of age (< 70 or > 70), sex (male or female), body mass index (< 25 kg/m^2 or > 25 kg/m^2), esophageal invasion of the tumor (yes or no), and anastomosis methods (OrVil or double-flap).

Annual endoscopic findings after the operation were examined for 36 patients in the double-flap group and 51 patients in the OrVil group to assess the degree of reflux esophagitis according to the Los Angeles classification.

Statistical analysis

The categorical variables were compared using Fisher's exact probability test, whereas the continuous variables were analyzed using unpaired *t* tests. The results of impedance-pH monitoring (% time) and the GSRS scores were expressed with mean ± standard deviation. All calculations were performed using JMP® 11.2.0 software (SAS Institute Inc., Cary, NC, USA), with *P* values less than 0.05 considered statistically significant.

Results

Patient characteristics and the extent of lymph node dissection

The characteristics of patients are detailed in Table 1. No significant differences were observed in age, sex, BMI, pathological stage, and histology between the double-flap and OrVil groups. D1+ dissection was significantly more frequently performed in the double-flap group than in the OrVil group (93% vs 25%, $P < 0.001$).

The OrVil reconstruction was performed by 9 surgeons, 6 of whom had the experience of laparoscopic gastric surgery for less than 5 years and performed 61% (31/51) of the surgery with the OrVil reconstruction. Meanwhile, the double-flap reconstruction was performed by 2 surgeons and 88% (35/40) of the surgery was performed when the surgeons had the experience of laparoscopic gastric surgery for more than 5 years. The median years of the experience of the surgeons for laparoscopic gastric surgery in the double-flap technique were longer than those in the OrVil technique (6 years vs 3 years).

Surgical outcomes

The surgical outcomes of patients are detailed in Table 2. No significant differences were observed in the estimated blood loss, combined resection of the gall bladder, and days of postoperative hospital stay between the double-flap and OrVil groups. On the other hand, operative time was significantly longer in the double-flap group than in the OrVil group (353 min [247–662] vs 280 min [200–510], $P < 0.001$). In

Table 1 Patient characteristics

	OrVil ($n = 51$)	Double-flap ($n = 40$)	*P* value
Age, years	69.7 ± 9.0 (50–85)	69.5 ± 11.0 (34–88)	0.93
Male	38 (75)	36 (90)	0.06
BMI (kg/m^2)	23.1 ± 2.6 (17.7–28.6)	23.8 ± 3.0 (18.1–29.3)	0.24
Tumor size, (cm) (excluding GIST)	2.7 ± 1.1 (0.8–4.8)	2.7 ± 1.4 (0.7–5.5)	0.84
pT			0.47
0	0	2 (5)	
1a	4 (8)	6 (15)	
1b	35 (69)	25 (63)	
2	6 (12)	4 (10)	
3	4 (8)	2 (5)	
4a	1 (2)	0	
GIST	1 (2)	1 (3)	
pN (excluding GIST)			0.32
0	47 (94)	33 (85)	
1	2 (4)	5 (13)	
2	1 (2)	1 (3)	
pStage (excluding GIST)			0.46
0	0	2 (5)	
IA	39 (78)	28 (72)	
IB	6 (12)	6 (15)	
IIA	2 (4)	1 (3)	
IIB	1 (2)	2 (5)	
IIIA	2 (4)	0	
Histology			0.25
Differentiated	32 (63)	31 (78)	
Undifferentiated	18 (35)	8 (20)	
GIST	1 (2)	1 (3)	
Lymph node dissection			< 0.001*
D1	38 (75)	3 (8)	
D1+ or more	13 (25)	37 (93)	

Data expressed as mean ± standard deviation (range) or *n* (%)

BMI body mass index

*$P < 0.05$ was considered statistically significant

one patient in the double-flap group, the surgical procedure was converted to open surgery because of massive intraoperative bleeding. No mortality was found in both groups. Around seven cases were needed for the operative time to reach a plateau level in the two operators involved in the double-flap technique.

Table 2 Surgical outcomes

	OrVil ($n = 51$)	DF ($n = 40$)	P value
Operative time (min) [median (range)]	280 (200–510)	353 (247–662)	< 0.001*
Estimated blood loss (mL) [median (range)]	60 (minimal–1410)	65 (minimal–1595)	0.90
Combined resection of the gall bladder [*n* (%)]	8 (16)	1 (3)	0.072
Days of postoperative hospital stay [median (range)]	10 (7–65)	9 (7–29)	0.14
Conversion to open surgery [*n (%)*]	0 (0)	1 (3)	0.44

DF double-flap technique

*$P < 0.05$ was considered statistically significant

Surgical complications graded II or more in the Clavien-Dindo classification system are detailed in Table 3. On the whole, 16 (31%) and 13 (33%) patients in the OrVil and double-flap groups, respectively, had surgical complications with no statistical differences ($P = 1$). The proportion of anastomotic stricture that needed endoscopic balloon dilatation was lower in the double-flap group than in the OrVil group but without statistical significance (14/51 [27%] vs 7/40 [18%]; $P = 0.32$). The median rounds of endoscopic balloon dilatation in the double-flap and OrVil groups were 4 (range 2–10) and 4 (range 1–11), respectively. In the double-flap group, the proportion of the anastomotic stricture was significantly higher in the patients with interrupted suturing than in those with continuous suturing (5/15 [33%] vs 2/25 [8%]; $P = 0.041$) (Fig. 4).

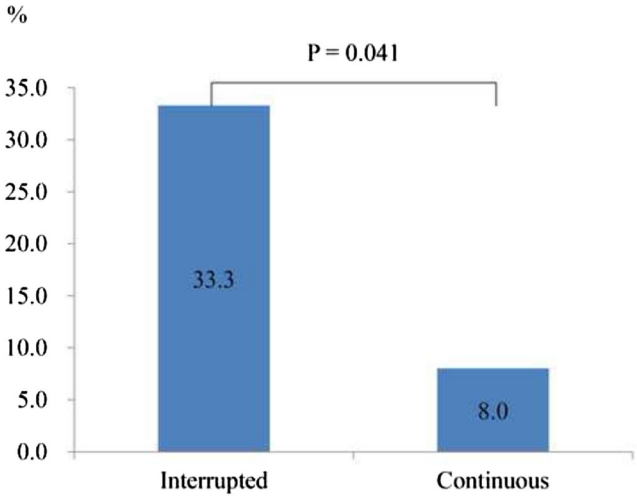

Fig. 4 Anastomotic stricture rate in the double-flap group. The anastomotic stricture rate is significantly higher in the patients with interrupted suturing than in those with continuous suturing (5/15 [33%] vs 2/25 [8%]; $P = 0.041$)

Impedance-pH monitoring and reflux-related symptoms

No significant difference was observed in % time of gastric pH < 4.0 and % time of acid reflux between the OrVil and double-flap groups (34.3 ± 11.4% vs 45.2 ± 8.8%, $P = 0.46$; 0.50 ± 0.21% vs 0.37 ± 0.16%, $P = 0.62$). However, the double-flap group had significantly less all reflux % time than the OrVil group (1.29 ± 0.38% vs 2.62 ± 0.50%, $P = 0.043$) (Fig. 5).

The necessity of PPI usage was significantly lower in the double-flap group than in the OrVil group (18% [7/40] vs 37% [19/51], $P = 0.038$). The proportion of patients experiencing typical reflux symptoms of regurgitation or heartburn was significantly lower in the double-flap group than in the OrVil group (18% [7/40] vs 51% [26/51], $P = 0.001$). Serious symptoms such as aspiration pneumonia were not found in either group.

We were able to contact 75% (30/40) and 65% (33/51) of patients in the double-flap and the OrVil groups, respectively, and asked them about the 4 questions included in the

Table 3 Postoperative complications

	OrVil ($n = 51$)		DF ($n = 40$)		P value
	CD		CD		
	II	IIIa	II	IIIa	
Anastomotic leakage	1	3	1	0	0.38
Anastomotic stricture	0	14	0	7	0.32
Abdominal abscess	0	0	3	0	0.081
Anastomotic bleeding	0	1	0	0	1
Pleural effusion	0	0	0	2	0.19
Cardiac tamponade	0	0	0	1	0.44
Total n (%)	16 (31)		13 (33)		1

DF double-flap technique, *CD* Clavien-Dindo grade

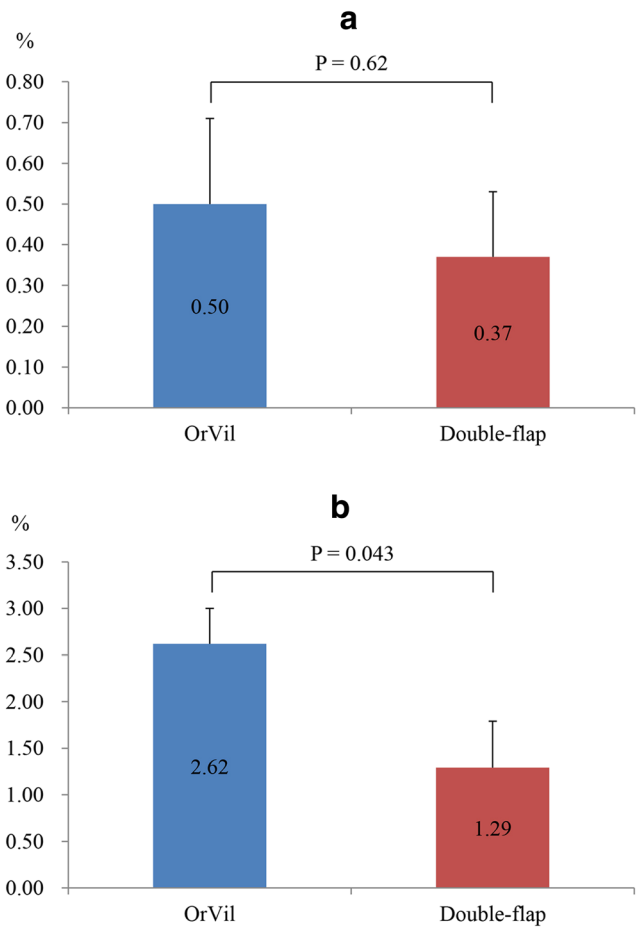

Fig. 5 Percent times of gastroesophageal reflux in the OrVil ($n = 13$) and double-flap ($n = 22$) groups. No significant difference was observed in % time of acid reflux between the OrVil and double-flap groups (0.50 ± 0.21% vs. 0.37 ± 0.16%, $P = 0.62$) (**a**). The double-flap group had significantly less all reflux % time than the OrVil group (1.29 ± 0.38% vs. 2.62 ± 0.50%, $P = 0.043$) (**b**)

dimension of dyspeptic syndrome. Median intervals between the surgery and the date of questionnaire were 25 (range 5–41) and 79 (range 44–110) months in the double-flap and the OrVil groups, respectively. The dyspeptic syndrome score of the GSRS tended to be better in the double-flap group than in the OrVil group (1.2 ± 0.5 vs 1.5 ± 0.8, $P = 0.087$). Of the four items which we used in the questionnaire, acid regurgitation was significantly better in the double-flap group than in the OrVil group (1.2 ± 0.8 vs 2.0 ± 1.8, $P = 0.045$) (Table 4).

In the univariate analysis for typical symptoms of heartburn and regurgitation, occurrence rate of the symptoms was significantly lower in the double-flap group than in the OrVil group (18% [7/40] vs 51% [26/51], $P = 0.001$). In the multivariate analysis, double-flap method was also selected as the independent factor for the better gastroesophageal reflux-related symptoms (OR 0.20, 95% CI 0.07–0.55, $P < 0.001$) (Table 5).

The proportion of patients who had the experience of having grade B or more reflux esophagitis by postoperative annual endoscopies were 8.3% (3/36) in the double-flap group and 13.7% (7/51) in the OrVil group ($P = 0.51$).

Discussion

In this study, we noted two major findings. One is that all reflux % time significantly decreased in the double-flap group compared with the OrVil group. The other is that LAPG with esophagogastrostomy using the double-flap technique slightly lowered the rate of anastomotic stricture than that on using the OrVil technique, but the rate of anastomotic stricture still remained high. On the other hand, the double-flap technique with interrupted suturing worsened the rate of anastomotic stricture.

All reflux % time significantly decreased in the double-flap group than in the OrVil group. In addition, multivariate analysis for typical reflux symptoms of heartburn and regurgitation revealed that double-flap method was selected as the independent factor for the better outcome. For the patients undergoing LAPG with esophagogastrostomy using the OrVil technique, we performed Toupet-like fundoplication to reduce gastroesophageal reflux. This fundoplication is sometimes difficult to perform when the remnant stomach is too small and thin to wrap the esophagus properly. On the other hand, vulvoplasty using the double-flap technique almost always results in the same anastomotic shape, if a 2.5 × 3.0–3.5-cm window would be created on the remnant stomach. This might explain the better outcome of the double-flap technique in terms of preventing gastroesophageal reflux.

LAPG with esophagogastrostomy using the double-flap technique lowered the rate of anastomotic stricture than that using the OrVil technique but without statistical significance. The anastomotic stricture rate in LAPG with esophagogastrostomy using a circular stapler has been reported to be 13.9–28.6% [3, 24–26]. Although all strictures were reportedly relieved by endoscopic dilatation, more than 10 times dilatation was sometimes needed [3]. On the other hand, the stricture rate of the double-flap technique has been reported to be 4.7–25% [10–13]. The anastomotic stricture rate of 18% in the double-flap group of this present study is relatively high; hence, we do not consider the double-flap technique as the standard approach for LAPG with esophagogastrostomy. We considered that the reason of the anastomotic stricture might be due to continuous suturing using V-Loc, because the more we pulled the thread, the shorter the suture line becomes. However, surprisingly enough, the anastomotic stricture rate in the 15 patients in the double-flap group who underwent interrupted suturing for the anastomosis was significantly higher than that in the other 25 patients who had continuous suturing. Continuous suturing probably should be performed in LAPG with esophagogastrostomy using the double-flap technique to reduce the occurrence of anastomotic stricture. Another speculative reason of the relatively high anastomotic stricture rate in the double-

Table 4 Univariate analysis of each item in the dyspeptic syndrome score in the GSRS

Items	Double-flap		OrVil		*P* value
	Mean	SD	Mean	SD	
Dyspeptic sydrome score	1.2	0.5	1.5	0.8	0.087
Abdominal pain	1.3	0.8	1.4	1.5	0.60
Heartburn	1.2	0.6	1.5	1.1	0.12
Acid regurgitation	1.2	0.8	2.0	1.8	0.045*
Sucking sensations in the epigastrium	1.1	0.4	1.1	0.3	0.68

The questionnaire of each item uses a 7-graded Likert scale defined by descriptive anchors. Higher scores indicate worse conditions

GSRS gastrointestinal symptom rating scale, *SD* standard deviation

*$P < 0.05$ was considered statistically significant

Table 5 Univariate and multivariate analysis for typical symptoms of gastroesophageal reflux

	Symptom (+)	Symptom (−)	*P* value	Multivariate analysis		
	n = 33	*n* = 58		OR	95% CI	*P* value
Age(years)			0.80			0.88
< 70	14	23				
≥ 70	19	35				
Sex			0.64			0.76
Male	26	48				
Female	7	10				
Body mass index (kg/m^2)			0.14			0.25
< 25	26	37				
> 25	7	21				
Tumor with esophageal invasion			0.26			0.18
Y	11	13				
N	22	45				
Anastomosis method			0.001*			< 0.001*
OrVil	26	25				
Double-flap	7	33		0.20	0.07–0.55	

OR odds ratio of positive symptoms, *CI* confidence interval

*$P < 0.05$ was considered statistically significant

flap group is the ischemia of the lower esophagus caused by extensive exfoliation of the lower esophagus. Avoiding extensive exfoliation of the lower esophagus might lead to the reduction of the anastomotic stricture rate.

The operative time was much longer in the double-flap group than in the OrVil group. One of the reasons for this longer operative time is putatively because of the extent of lymph node dissection, which was wider in the double-flap group than in the OrVil group. We had performed D1 dissection for cT1a cancer that was estimated by gastric endoscopy or endoscopic ultrasonography. However, endoscopic diagnosis is sometimes unable to accurately predict the true vertical invasion of the cancer. On the other hand, with our experience in laparoscopic gastrectomy, D1+ node dissection became a safe procedure. Therefore, we tended to perform D1+ node dissection for almost all cT1 gastric cancer patients. Another reason for this longer operative time is the longer anastomotic time in the double-flap group compared to the OrVil group. The patients included in this study are 40 consecutive patients from the first batch of patients who underwent LAPG using the double-flap technique. Regarding learning curves of the two surgeons involved in the double-flap group, around seven cases were needed to reach a plateau level. With much more experience of this technique, operative time would become shorter.

The OrVil reconstruction was performed by nine surgeons, six of whom had the experience of laparoscopic gastric surgery for less than 5 years and performed 61% (31/51) of the surgery with the OrVil reconstruction. Meanwhile, the double-flap reconstruction was performed by two surgeons and 88% (35/40) of the surgery was performed when the surgeons had the experience of laparoscopic gastric surgery for more than 5 years. The median years of the experience of the surgeons for laparoscopic gastric surgery in the double-flap technique were longer than those in the OrVil technique (6 years vs 3 years). The significant difference of the number of dissected lymph nodes might be caused not only by the difference of extent of lymph node dissection but also by this improved overall surgical technique of the surgeons.

There are some reconstruction methods after proximal gastrectomy other than esophagogastrostomy. The representative methods of these are double tract reconstruction and Merendino procedures. In a systematic review, anastomotic stricture rate and reflux esophagitis rate in the double tract reconstruction are reported to be 4.7% and 4.7%, while those in the Merendino procedure to be 9.6% and 4.5%, respectively [27]. Meanwhile, anastomotic stricture rate and reflux esophagitis rate in the double-flap group in the present study were 18% and 8.3%, respectively. Gastroesophageal acid reflux seldom occurs after proximal gastrectomy with double tract reconstruction or Merendino reconstruction. However, endoscopic screening of the remnant stomach is more difficult after double tract reconstruction or Merendino reconstruction than esophagogastrostomy. The antrum mucosa, which is at considerable risk for recurrent cancer, is present in the remnant stomach following LAPG. When cancer of the remnant stomach arises, laparoscopic or open surgery may be needed. On the other hand, gastroesophageal acid reflux relatively frequently occurs after proximal

gastrectomy with esophagogastrostomy. However, Endoscopic screening of the remnant stomach is easier after esophagogastrostomy. When cancer of the remnant stomach arises, it can be treated by endoscopic resection. In fact, all the five patients who developed remnant stomach cancer during the follow-up period in the present study were able to be treated by endoscopic resection. In any case, due to lack of large randomized studies, optimal reconstruction methods remain to be determined.

The current study has several limitations. First, the analysis was based on retrospectively collected data from a single institution. Second, we converted the reconstruction method used in LAPG with esophagogastrostomy from the OrVil technique to the double-flap technique. Therefore, the results of this study would possibly represent only the technical transition. Moreover, the two compared cohorts are essentially different in both the teams' surgical expertise and standard surgical technique, especially regarding lymph node dissection. There might have been different results regarding surgical outcomes including postoperative complications if the same surgical team had performed the two different anastomoses with the same extent of lymph node dissection. Third, only 13 and 22 patients in the OrVil and double-flap groups, respectively, consented to undergo the 24-h impedance-pH monitoring test postoperatively, because the test has to be performed while the patients are hospitalized. In addition, we had not recognized the importance of the change of the degree of gastroesophageal reflux obtained by both pre- and postoperative pH monitoring until we started the research of the present study. That is the reason why we did not perform 24-h impedance-pH monitoring for all the patients both pre- and post-operatively. If we had performed this test both pre- and post-operatively, more detailed information about advantages and disadvantages of both procedures had been obtained. To reduce selection bias, we interviewed all the patients that we were able to contact and asked them about the GSRS. However, we were unable to interview all the included patients, which may still cause various biases. Therefore, the fact that the incidence of gastroesophageal reflux is lesser in the double-flap technique is merely speculative. A randomized controlled study is needed to assess definitively whether the double-flap technique is superior to the OrVil technique or other techniques for patients with upper-third cT1 gastric cancer.

In conclusion, although a longer operative time is needed and the anastomotic stricture rate remained high in LAPG with esophagogastrostomy using the double-flap technique, this approach would be better in terms of preventing gastroesophageal reflux. A randomized controlled trial comparing the double-flap technique with the other techniques is required to demonstrate the superiority of the double-flap technique.

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Compliance with ethical standards

This study was conducted in accordance with the 1995 Declaration of Helsinki (as revised in Brazil 2013) and was approved by the Kitasato University School of Medicine Research Ethics Committee. The requirement for informed consent was waived because of the study's retrospective design. The manuscript was written according to the STROBE Statement.

Conflict of interest The authors declare that they have no conflicts of interest.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent For this type of study, formal consent is not required.

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