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Clinical outcomes of double-flap technique versus gastric tube reconstruction following laparoscopic proximal gastrectomy: a multicenter propensity score-matched cohort study

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Abstract

Background Various anti-reflux procedures are currently utilized for digestive tract reconstruction following proximal gastrectomy (PG), but the optimal reconstruction method remains debated. This study aims to compare and analyze the clinical outcomes and postoperative quality of life between double-flap technique (DFT) and gastric tube (GT) reconstruction after laparoscopic proximal gastrectomy (LPG), providing a reference for selecting the appropriate digestive tract reconstruction method.

Methods This multicenter, retrospective cohort study employed propensity score matching (PSM) to address baseline imbalances. Clinical, pathological, and follow-up data were collected from 124 patients who underwent either LPG-GT or LPG-DFT between January 2016 and May 2023 at four medical centers in China. The surgical outcomes, incidence of postoperative gastroesophageal reflux and anastomotic stricture, postoperative nutritional status, and quality of life were compared between the two groups.

Results After 1:1 PSM, 41 patients were included in each group for analysis. Compared to the LPG-GT group, the LPG-DFT group had a longer operation time (340.0 min vs. 280.0 min, $P<0.001$) but less intraoperative blood loss (80.0 ml vs. 100.0 ml, $P<0.001$), a shorter time to nasogastric tube removal (3.0 days vs. 5.0 days, $P<0.001$), and shorter postoperative hospital stay (9.0 days vs. 12.0 days, $P<0.001$). The incidence of gastroesophageal reflux in the LPG-DFT and LPG-GT groups was 7.3% and 24.3% ($P=0.034$), respectively, and the incidence of anastomotic stricture requiring dilation was 14.6% and 7.3% ($P=0.480$). One year postoperatively, BMI (22.0 kg/m^2 vs. 20.6 kg/m^2, $P=0.010$) and albumin levels at six months postoperatively (41.6 g/L vs. 39.1 g/L, $P=0.033$) were significantly higher in the LPG-DFT

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group. However, albumin levels one year postoperatively showed no significant difference between the two groups (42.3 g/L vs. 40.7 g/L, $P=0.226$).

Conclusion The surgical outcomes suggest that both LPG-GT and LPG-DFT are safe and feasible methods. However, LPG-DFT provides better anti-reflux effects and may help reduce the risk of postoperative malnutrition.

Keywords Gastric cancer, Laparoscopic proximal gastrectomy, Double-flap technique reconstruction, Gastric tube reconstruction, Anti-reflux activity

Introduction

Gastric cancer is the fifth most common malignancy worldwide and the fourth leading cause of cancer-related deaths [1]. Although the overall incidence of gastric cancer is declining globally, the incidence of proximal gastric cancer is increasing annually, accompanied by a notable rise in early gastric cancer cases [2, 3].Laparoscopic proximal gastrectomy (LPG) is an effective treatment for early-stage and select advanced-stage proximal gastric cancers due to the low incidence of distant perigastric lymph node metastasis [4, 5].Compared to total gastrectomy (TG), proximal gastrectomy (PG) preserves part of the stomach's function, causes less tissue damage, and helps maintain postoperative nutritional status [6]. However, despite preserving some stomach function, PG disrupts the anatomical structure of the esophagogastric junction, resulting in the loss of the cardia's anti-reflux function. Furthermore, preserving the pylorus can delay gastric emptying, increasing the risk of severe complications such as reflux esophagitis and anastomotic stricture [7–9]. Therefore, selecting an optimal reconstruction method to minimize postoperative complications after proximal gastrectomy is crucial. Various reconstruction techniques, including the double-flap technique (DFT), gastric tube (GT) reconstruction, double-tract (DT) reconstruction, and jejunal interposition (JI) reconstruction, have been developed to address these issues [10]. However, due to the lack of large-scale, multicenter prospective studies, no consensus exists on the optimal reconstruction method after laparoscopic proximal gastrectomy(LPG).

To address this gap, a multicenter retrospective cohort study was conducted using propensity score matching (PSM) to compare and analyze the clinical outcomes and postoperative quality of life (QOL) associated with DFT and GT following LPG. The study aims to provide evidence-based recommendations for selecting the most appropriate digestive tract reconstruction method after LPG.

Materials and methods

Participants

Clinicopathological and follow-up data were collected from patients who underwent either laparoscopic proximal gastrectomy with gastric tube reconstruction (LPG-GT) or laparoscopic proximal gastrectomy with double-flap technique reconstruction (LPG-DFT) between January 2016 and May 2023. This multicenter, retrospective cohort study was conducted across four high-volume cancer surgery centers in China: The First Affiliated Hospital of Xiamen University, The First Affiliated Hospital of Fujian Medical University, Liaoning Cancer Hospital, and The First Affiliated Hospital of Nanjing Medical University.

Inclusion criteria: (1) Patients with a preoperative diagnosis of cT1 ~ 2N0M0 stage upper gastric cancer or Siewert type II and III esophagogastric junction cancer with a maximum tumor diameter of < 4 cm; (2) Underwent LPG-GT or LPG-DFT; (3) Achieved R0 resection in accordance with surgical standards; (4) No distant metastasis detected on preoperative imaging examinations such as CT or MRI.

Exclusion criteria: (1) History of other malignant tumors; (2) Previous abdominal surgery; (3) Emergency surgery; (4) Incomplete clinicopathological data or follow-up information.

Surgical procedure

LPG was performed by experienced gastrointestinal surgeons at each center, with each surgeon having completed over 200 laparoscopic gastrectomies for gastric cancer. The procedure preserved more than half of the distal stomach. The lead surgeon at each center selected either GT reconstruction or DFT reconstruction based on the patient's clinical condition and their own preference. The extent of gastrectomy and lymph node dissection followed the guidelines outlined in the 5th Edition of the Japanese Gastric Cancer Treatment Guidelines [10].

Surgical Approach: For cT1 stage tumors, a normal tissue margin of more than 2 cm was ensured. For cT2 stage and above, a distal margin of at least 3 cm was maintained for localized tumors and over 5 cm for infiltrative tumors. After proximal gastrectomy, more than 50% of the residual stomach volume was preserved, along with the right gastric and right gastroepiploic vessels. D1 or D1 + lymph node dissection was performed, with D1 including lymph node stations 1, 2, 3a, 4sa, 4sb, and 7, and D1 + adding stations 8a, 9, and 11p. In cases involving esophageal involvement, station 110 was also included.

Digestive Tract Reconstruction: (1) GT reconstruction: The residual stomach was trimmed along the greater curvature into a tubular shape approximately 20 cm long and 5 cm wide. A 25-mm tubular stapler was used, with the anvil positioned at the esophageal stump. A longitudinal incision (approximately 3 cm) was made on the anterior wall of the gastric body to insert the stapler, with the central rod protruding about 3 cm from the top of the residual stomach. A side-to-end anastomosis was performed between the esophageal stump and the residual stomach, reconstructing the gastric fundus (Fig. 1).

(2) DFT reconstruction: An "H"-shaped seromuscular flap (3.0 cm×3.5 cm) was created by dissecting the anterior wall of the residual stomach (1.5 cm from the top) near the greater curvature between the submucosa and muscular layers. The esophagus was retracted, and the posterior wall of the esophageal stump was sutured to the upper edge of the seromuscular flap, approximately 5 cm from the esophageal stump. The esophageal margin was then anastomosed with the mucosa and submucosa. Finally, the double muscle flaps were placed over the lower esophagus and anastomotic site in a "Y" shape to complete the reconstruction (Fig. 1).

Clinical analysis and surgical outcomes

Basic patient data were collected, including age, gender, height, weight, body mass index (BMI), preoperative hemoglobin levels, preoperative albumin levels, and adjuvant chemotherapy. Surgical data included operation duration, intraoperative blood loss, time to removal of the postoperative nasogastric tube, time to removal of the postoperative abdominal drainage tube, length of postoperative hospital stay, and short-term postoperative complications. Tumor status was evaluated based on the pathological TNM stage and histological differentiation. Postoperative complications were categorized using the Clavien-Dindo (CD) classification [11], with short-term complications defined as those occurring within 30 days after surgery.

Follow-up and postoperative nutritional status

Post-surgery, follow-up visits were scheduled every three months during the first two years, transitioning to every six months thereafter. Follow-up data included information from the one-year post-surgery period, which was categorized as follows: (1) Nutritional indicators: Patients' BMI, hemoglobin, and albumin levels were measured at 6 and 12 months post-surgery. (2) Gastroesophageal reflux and anastomotic stricture requiring dilation: Gastroesophageal reflux was evaluated using a combination of gastroscopy and the GERDQ scale, as not all patients underwent postoperative gastroscopy, thereby minimizing bias [12]. Anastomotic stricture was defined as cases requiring endoscopic balloon dilation. (3) Quality of Life: Symptoms such as acid reflux and dysphagia were documented, and their severity was assessed using the Visick grading system [13]. This system categorizes postoperative recovery into four levels: Visick I indicates good recovery with no significant discomfort; Visick II includes occasional symptoms, such as bloating and diarrhea, that do not interfere with daily life or work; Visick III includes mild to moderate dumping syndrome, gastroesophageal reflux, and other symptoms requiring medication but allowing normal life and work; Visick IV represents moderate to severe symptoms or complications that interfere significantly with normal life and work.Follow-up continued until June 1, 2024.

Statistical analysis

Normally distributed variables were expressed as means ± standard deviations, and group comparisons were performed using the t-test. Variables with skewed

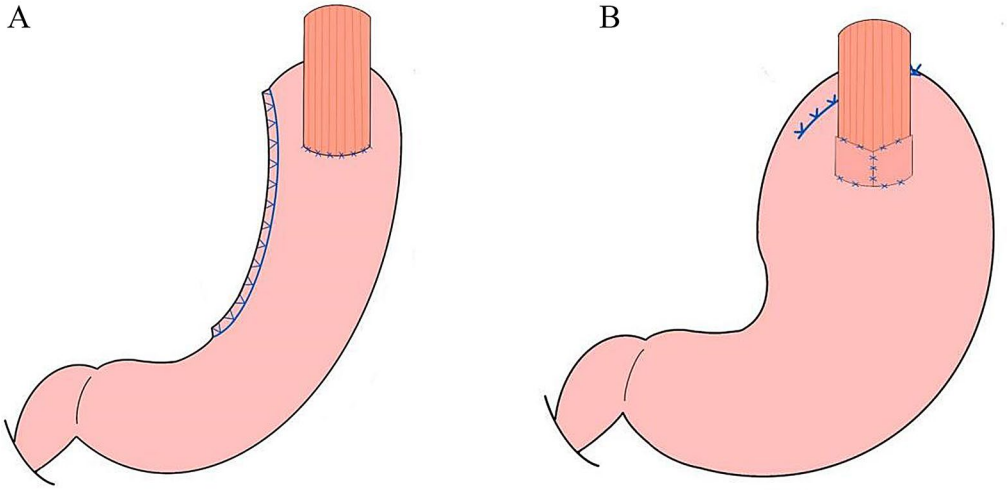

Fig. 1 **A** Schematic of the gastric tube (GT). **B** Schematic of the double-flap technique (DFT)

distributions were reported as medians with interquartile ranges (IQR), and comparisons were conducted using nonparametric tests. Categorical data were presented as frequencies and percentages, with group comparisons performed using the Chi-square test, Fisher's exact test, or the Mann-Whitney U test, as appropriate. All statistical tests were two-tailed, and a P-value of < 0.05 was considered statistically significant.

To improve the study's reliability, propensity score matching (PSM) was employed to address baseline imbalances [14]. Propensity scores for each patient were calculated using multiple logistic regression, incorporating variables such as gender, age, height, weight, BMI, preoperative hemoglobin, preoperative albumin, adjuvant chemotherapy, histological differentiation, and pathological TNM stage. One-to-one nearest-neighbor matching was performed with a calliper width of 0.2. Statistical analyses were conducted using IBM SPSS software for Windows (version 26.0; IBM Corp., Armonk, New York, USA) and R software (version 4.2.0; R Foundation for Statistical Computing, Vienna, Austria).

Results

Clinicopathological characteristics

After applying the inclusion and exclusion criteria, 124 eligible patients were selected for the study (Fig. 2). All patients underwent either LPG-GT or LPG-DFT. Among them, 56 cases were from The First Affiliated Hospital of Xiamen University, 37 from The First Affiliated Hospital of Fujian Medical University, 18 from Liaoning Cancer Hospital, and 13 from The First Affiliated Hospital of Nanjing Medical University. Of the 124 patients,

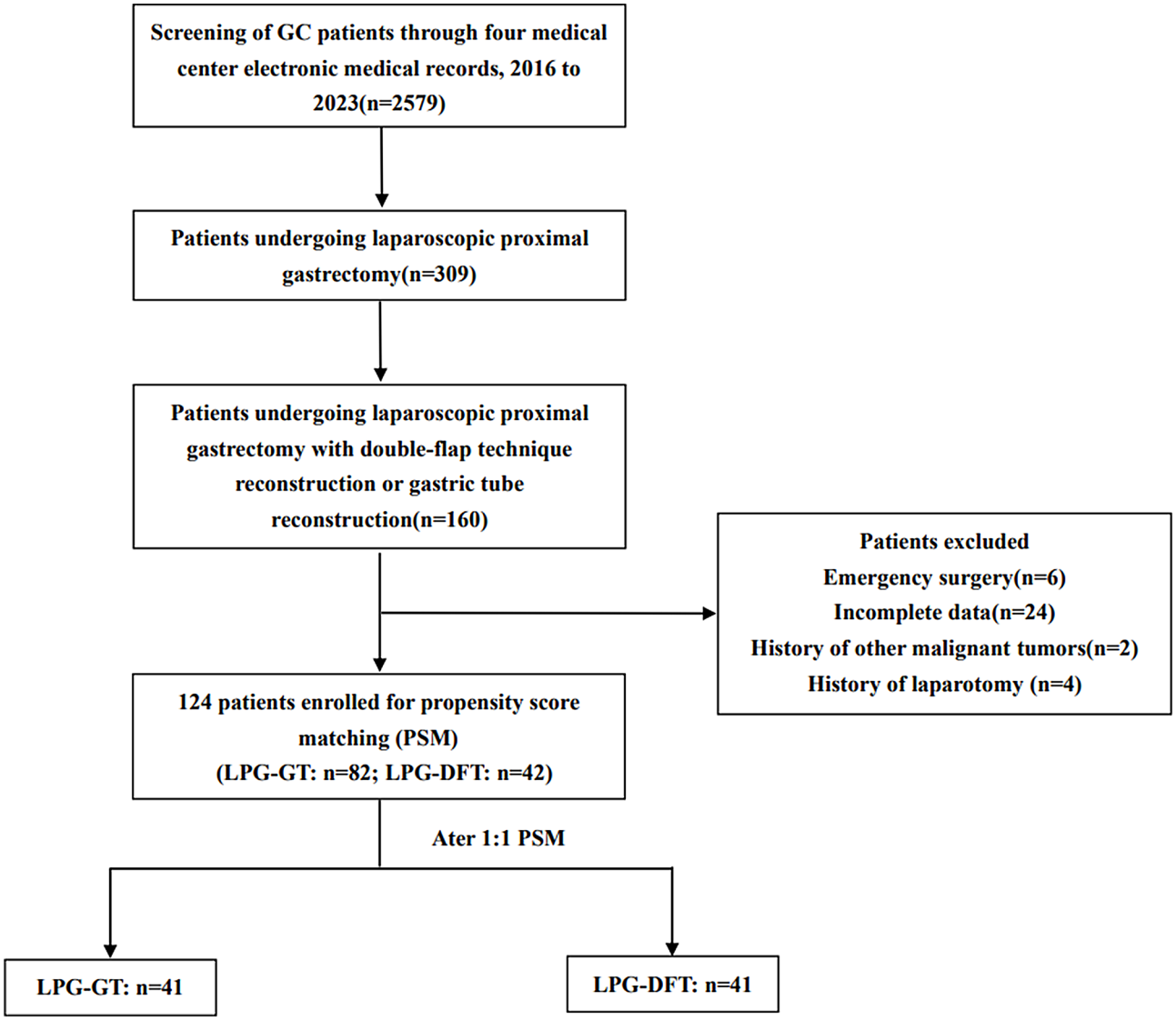

Fig. 2 Flowchart of the study population. LPG-GT, laparoscopic proximal gastrectomy with gastric tube reconstruction. LPG-DFT, laparoscopic proximal gastrectomy double-flap technique reconstruction

82 underwent LPG-GT, and 42 underwent LPG-DFT. After PSM, 41 patients were included in each group for analysis.

Table 1 shows the clinicopathological characteristics of the 124 patients before and after PSM. Before matching, the LPG-DFT group had significantly higher weight ($P=0.009$), BMI ($P=0.033$), and preoperative hemoglobin levels ($P=0.004$) compared to the LPG-GT group. However, after PSM, no significant differences in clinicopathological characteristics were observed between the two groups ($P>0.05$), indicating that a good balance was achieved.

Surgical outcomes and early postoperative complications

Both patient groups successfully underwent surgery without conversion to open surgery or any fatalities. The surgical outcomes and early postoperative complications are summarized in Table 2. Compared to the LPG-GT group, the LPG-DFT group had a significantly longer operative time (340.0 min vs. 280.0 min, $P<0.001$). However, the LPG-DFT group exhibited significantly lower intraoperative blood loss (80.0 mL vs. 100.0 mL, $P<0.001$), shorter time to postoperative nasogastric tube removal (3.0 days vs. 5.0 days, $P<0.001$), and a reduced postoperative hospital stay (9.0 days vs. 12.0 days, $P<0.001$). No statistically significant differences were found between the two groups in overall short-term postoperative complications (26.8% vs. 31.7%, $P=0.627$). Pulmonary infection was the most common postoperative complication (14.6% vs. 17.1%, $P=0.762$), and no significant difference was observed in the Clavien-Dindo short-term complication classification between the two groups ($P=0.797$).

Postoperative conditions in follow-up period

Gastroesophageal reflux and anastomotic stricture requiring dilation

Gastroesophageal reflux was observed in 10 cases (24.3%) in the LPG-GT group and 3 cases (7.3%) in the LPG-DFT group, indicating a statistically significant difference between the two groups ($P=0.034$). Anastomotic stricture requiring dilation occurred in 3 cases (7.3%) in the LPG-GT group and 6 cases (14.6%) in the LPG-DFT group, however, this difference was not statistically significant ($P=0.480$).

Nutritional status

The patients' BMI, hemoglobin, and albumin levels were evaluated at 6 months and 1 year postoperatively. Table 3; Fig. 3 present changes in nutritional status before and after surgery in both groups. No statistically significant differences were observed in preoperative nutritional status between the two groups. However, at 1 year postoperatively, the LPG-DFT group demonstrated a significantly higher BMI (22.0 kg/m² vs. 20.6 kg/m², $P=0.010$), and at

Table 1 Basic characteristics of patients before and after propensity score matching

Variable	Before PSM			After PSM		
	LPG-GT($n=82$)	LPG-DFT($n=42$)	*P*	LPG-GT($n=41$)	LPG-DFT($n=41$)	*P*
Gender, (n%)			0.947			0.391
Male	64	33		35	32	
Female	18	9		6	9	
Age, years	61.3 ± 9.7	59.9 ± 10.0	0.469	61.2 ± 8.6	59.9 ± 10.1	0.996
Height [a], cm	168.0(163.0-170.0)	170.0(162.8-174.3)	0.569	169.0(165.0-170.5)	170.0(162.5-174.5)	0.699
Weight, Kg	61.9 ± 9.4	66.8 ± 10.5	0.009	65.89 ± 9.0	66.5 ± 10.4	0.786
BMI, Kg/m2	22.2 ± 3.1	23.5 ± 3.2	0.033	23.4 ± 3.1	23.4 ± 3.2	0.953
Hemoglobin [a], g/L	137.5 ± 23.7	144.0 ± 14.9	0.063	142.9 ± 22.9	143.8 ± 15.0	0.820
Albumin [a], g/L	41.1 ± 4.1	43.3 ± 3.7	0.004	42.8 ± 3.1	43.3 ± 3.7	0.448
Adjuvant chemotherapy, N (%)			0.588			0.755
Yes	17	7		8	7	
No	65	35		33	34	
Differentiation degree, N (%)			0.130			0.965
High	11	9		9	9	
Medium	37	23		21	22	
Low	34	10		11	10	
pTNM stag, (n%)			0.180			0.262
I	37	22		20	22	
II	26	16		13	16	
III	19	4		8	3	

LPG-GT, laparoscopic proximal gastrectomy with gastric tube reconstruction

LPG-DFT, laparoscopic proximal gastrectomy double-flap technique reconstruction

BMI, body mass index; TNM, tumor-node-metastasis. TNM staging was performed according to the AJCC 8th edition

[a] Variables are described using medians and interquartile ranges (IQR), and the P valueswere calculated using the Mann-Whitney U-test

Table 2 Surgical outcomes and early postoperative complications

Variable	LPG-GT(*n* = 41)	LGP-DFT(*n* = 41)	*P*
Operation time (min)[a]	280.0 (240.0-300.0)	340.0 (300.0-395.0)	< 0.001
Estimated blood loss (ml)[a]	100.0 (100.0-200.0)	80.0 (50.0-100.0)	< 0.001
Gastric tube removal time (days) [a]	5.0 (5.0-6.5)	3.0 (2.0–4.0)	< 0.001
Removal of abdominal drainage (days) [a]	8.0 (7.0–10.0)	7.0 (5.0–10.0)	0.056
Postoperative hospital stays (days) [a]	12.0 (9.5–14.5)	9.0 (7.0-11.5)	< 0.001
Postoperative mortality in 30 days; N (%)	0 (0.0%)	0 (0.0%)	1.000
Overall short-term postoperative complications; N (%)	13 (31.7%)	11 (26.8%)	0.627
Pulmonary infection; N (%)	7 (17.1%)	6 (14.6%)	0.762
Pleural effusion; N (%)	6 (14.6%)	3 (7.3%)	0.480
Wound infection; N (%)	3 (7.3%)	1 (2.4%)	0.608
Anastomotic leakage; N (%)	5 (12.2%)	1 (2.4%)	0.201
Gastric paralysis; N (%)	2 (4.8%)	1 (2.4%)	1.000
Clavien–Dindo classification; N (%)			0.949
I	5 (12.2%)	5 (12.2%)	
II	4 (9.6%)	3 (7.3%)	
III	4 (9.6%)	3 (7.3%)	
IV	0(0.0%)	0(0.0%)	
V	0(0.0%)	0(0.0%)	

LPG-GT, laparoscopic proximal gastrectomy with gastric tube reconstruction

LPG-DFT, laparoscopic proximal gastrectomy double-flap technique reconstruction

[a] Variables are described using medians and interquartile ranges (IQR), and the P values were calculated using the Mann-Whitney U-test

6 months postoperatively, significantly higher albumin levels (41.6 g/L vs. 39.1 g/L, $P = 0.033$) compared to the LPG-GT group. No statistically significant differences in hemoglobin level changes were observed between the two groups.

Quality of life

All 82 patients completed the postoperative quality-of-life follow-up. The most common symptom affecting quality of life was acid reflux, followed by varying degrees of difficulty eating. Quality of life was evaluated using the Visick grading system (Table 4). In the LPG-GT group, the numbers of patients with Visick grades I, II, III, and IV were 21 (51.2%), 8 (19.5%), 10 (24.3%), and 2 (4.9%), respectively. In the LPG-DFT group, the corresponding numbers were 25 (60.9%), 9 (22.0%), 6 (14.6%), and 1 (2.4%), respectively. No statistically significant differences were found in overall Visick grading between the two groups ($P = 0.682$). Both groups were predominantly composed of patients with Visick grades I-II, indicating that they were either asymptomatic or had mild symptoms not requiring additional intervention in daily life.

Table 3 Nutritional status of the two groups

		LPG-GT	LPG-DFT	*P*
BMI(Kg/m^2)	**Preoperative**	23.4 ± 3.1	23.4 ± 3.0	0.996
	6 months after the operation	20.9 ± 2.5	21.6 ± 2.5	0.171
	1 year after the operation	20.6 ± 2.5	22.0 ± 2.4	0.010
Hemoglobin (g/L)	Preoperative	142.9 ± 22.9	143.8 ± 15.0	0.820
	6 months after the operation	132.2 ± 19.0	137.6 ± 12.8	0.129
	1 year after the operation	138.8 ± 19.2	141.5 ± 17.3	0.512
Albumin (g/L)	Preoperative	42.8 ± 3.1	43.3 ± 3.8	0.488
	6 months after the operation	39.1 ± 5.5	41.6 ± 5.3	0.033
	1 year after the operation	40.7 ± 6.8	42.3 ± 5.3	0.226

LPG-GT, laparoscopic proximal gastrectomy with gastric tube reconstruction

LPG-DFT, laparoscopic proximal gastrectomy double-flap technique reconstruction

Data are shown as mean ± SD

Discussion

LPG is a function-preserving gastric surgery designed to reduce the long-term nutritional deficiencies and weight loss associated with TG, thereby improving QOL [14–17]. However, while this procedure preserves the pylorus, it disrupts the anti-reflux mechanism at the gastroesophageal junction, potentially resulting in delayed gastric emptying and an increased incidence of gastroesophageal reflux. Common postoperative complications include gastroesophageal reflux, anastomotic stricture, and nutritional disorders [7–9, 18]. Studies have shown that, compared to traditional esophagogastrostomy (EG), GT reconstruction and DFT reconstruction offer significant advantages in anti-reflux efficacy, QOL, and nutritional status [19–23]. Consequently, this study, conducted in collaboration with multiple medical centers, compared the surgical outcomes, anti-reflux effects, changes in nutritional status, and QOL between LPG-GT and LPG-DFT. To our knowledge, this is the first multicenter cohort study employing PSM to evaluate the clinical efficacy of these two techniques.

The surgical outcomes demonstrate that both LPG-GT and LPG-DFT are safe and feasible procedures. However, the operation time for the LPG-DFT group was significantly longer than that for the LPG-GT group (340.0 min vs. 280.0 min, $P < 0.001$). Shoji et al. [24] reported a median operation time of 420 min in a study of 147 LPG-DFT cases, attributing the prolonged duration primarily to the procedure's complexity, particularly the increased

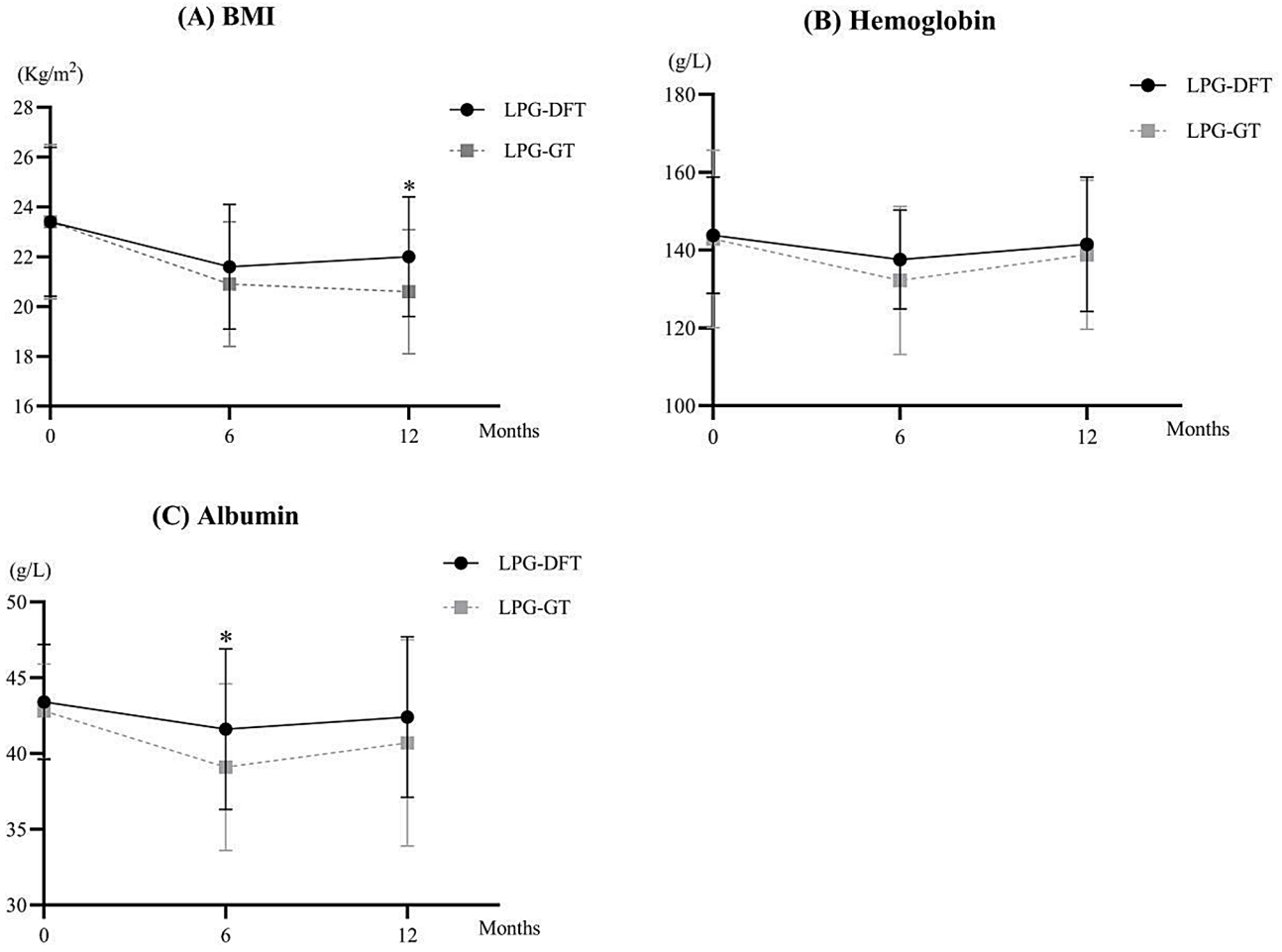

Fig. 3 Comparison of changes in the (**A**) body mass index (BMI), (**B**) Albumin Hemoglobin (Hb) and (**C**) Albumin(Alb) between the laparoscopic proximal gastrectomy double-flap technique reconstruction (LPG-DFT) and laparoscopic proximal gastrectomy with gastric tube reconstruction (LPG-GT). * P less than 0.05 between two groups

Table 4 The Visick grade of the two groups

Visick grade	LPG-GT	LPG-DFT	*P*
			0.682
I; N (%)	21(51.2%)	25(60.9%)	
II; N (%)	8(19.5%)	9(22.0)	
III; N (%)	10(24.3%)	6(14.6%)	
IV; N (%)	2(4.9%)	1(2.4%)	
≤II; N (%)	29(70.7%)	34(82.9%)	0.195

LPG-DTR = laparoscopic proximal gastrectomy with double-tract reconstruction

LPG-TLR = laparoscopic proximal gastrectomy with tube-like stomach reconstruction

technical demands of laparoscopic suturing [20]. Despite the longer operation time, this study highlights several advantages of LPG-DFT. Compared to the LPG-GT group, the LPG-DFT group exhibited significantly lower median intraoperative blood loss (80.0 mL vs. 100.0 mL, $P<0.001$), a shorter nasogastric tube removal time (3.0 days vs. 5.0 days, $P<0.001$), and a reduced postoperative hospital stay (9.0 days vs. 12.0 days, $P<0.001$). Although the leak rate tended to be lower in the LPG-DFT group compared to the LPG-GT group (2.4% vs. 12.2%, $P=0.201$), this difference was not statistically significant. This trend is likely attributable to the technical characteristics of DFT, which involves a single anastomosis reinforced with a double-flap, providing greater security and reducing the risk of anastomotic leaks [19]. This may also explain the shorter nasogastric tube removal time and hospital stay observed in the LPG-DFT group compared to the LPG-GT group. Furthermore, there was no statistically significant difference in overall short-term postoperative complications between the two groups (31.7% vs. 26.8%, $P=0.627$), consistent with previous studies comparing LPG-DFT and LPG-GT [19, 20, 22–24]. Therefore, despite the longer operation time and the complexity of the LPG-DFT procedure, it does not increase the risk of short-term postoperative complications.

Gastroesophageal reflux is the most common long-term complication following LPG and significantly affects patients' postoperative quality of life[[7–9, 18].

The findings of this study indicate that, during long-term follow-up, the incidence of gastroesophageal reflux was significantly lower in the LPG-DFT group compared to the LPG-GT group (7.3% vs. 24.3%, $P=0.034$). The DFT technique utilizes double muscle flaps to cover and embed the lower esophagus between the submucosal and muscular layers of the stomach. After eating, the increased intragastric pressure compresses the lower esophagus, functioning as a one-way valve and thereby providing an anti-reflux effect [25]. Furthermore, the incidence of gastroesophageal reflux in both reconstruction methods was lower than the 32–74% reported with traditional EG [26, 27], indicating that both digestive tract reconstruction techniques effectively prevent reflux. In this study, the incidence of anastomotic stricture was 14.6% in the LPG-DFT group compared to 7.3% in the LPG-GT group ($P=0.480$). Previous studies have reported that the incidence of gastroesophageal reflux and anastomotic stricture after DFT ranges from 0 to 6% and 4.7–29.1%, respectively [9, 15, 20–23]. Typically, the incidence of anastomotic stricture after DFT is higher than that of gastroesophageal reflux. Given the close relationship between anastomotic stricture and gastroesophageal reflux, meticulous surgical techniques are essential to ensure effective anti-reflux measures while preventing anastomotic stricture. Muraoka et al. [28] reported that performing intraoperative endoscopy during DFT can significantly reduce the incidence of anastomotic stricture.

LPG-DFT demonstrated significant advantages in postoperative nutritional status. One year after surgery, the LPG-DFT group had a significantly higher BMI (22.0 kg/m^2 vs. 20.6 kg/m^2, $P=0.010$) and higher hemoglobin levels at 6 months postoperatively (41.6 g/L vs. 39.1 g/L, $P=0.033$) compared to the LPG-GT group. It is hypothesized that the lower incidence of gastroesophageal reflux in the LPG-DFT group may contribute to reduced occurrences of anorexia and an improved quality of life. Previous studies have also demonstrated that DFT provides significant benefits over JI in terms of long-term nutritional outcomes [29].

In this study, the Visick grading system was used to comprehensively assess patients' postoperative QOL. This method is simple to administer and effectively evaluates the overall status of patients' lives. No significant difference was observed in the overall comparison of Visick grades between the two groups. Visick Grade I indicates the absence of symptoms, while Grade II signifies mild discomfort that does not require additional intervention. The combined incidence of Visick Grades I and II was 82.9% in the LPG-DFT group and 70.7% in the LPG-GT group ($P=0.195$), suggesting that most patients did not experience significant discomfort during postoperative follow-up. These findings demonstrate that both digestive tract reconstruction methods can provide an acceptable QOL, with the LPG-DFT group showing more favorable outcomes overall.

This study has several limitations. First, the follow-up period was relatively short, preventing the assessment of the long-term clinical efficacy of the two digestive tract reconstruction methods beyond one year post-surgery. Additionally, oncological follow-up data were unavailable, particularly for cases of gastric cancer with advanced pathological staging, underscoring the need for further research into the oncological safety of these reconstruction methods. Second, potential selection bias may have occurred, as the choice of reconstruction method was likely influenced by the surgeons' experience and preferences. Third, the Visick grading system has inherent limitations and may not comprehensively capture patient-reported symptoms or psychological impacts. Future studies should incorporate validated, gastric cancer-specific QOL scales to address this issue. Fourth, postoperative nutritional indicators were limited to BMI, Hb, and Alb, which are susceptible to confounding factors that may affect result accuracy. Finally, the retrospective design and small sample size of this study highlight the need for larger, prospective studies to validate these findings.

Conclusion

Both LPG-GT and LPG-DFT are safe and feasible surgical techniques. Although LPG-DFT involves a longer surgical duration compared to LPG-GT, it offers superior postoperative anti-reflux effects and may reduce the risk of postoperative malnutrition. Therefore, it is recommended that experienced surgeons consider using the DFT technique for reconstruction following LPG, provided oncological safety is ensured. However, due to the limitations of this study, these findings require further validation through more rigorous research. Future large-scale, multicenter, prospective, randomized trials are necessary to provide stronger clinical evidence to guide clinical practice.

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Author contributions
ZJT, CSQ, ZT, YL and YJ contributed to the study's conception and design. Data acquisition was performed by YS, HQQ, LHX, CYN, and YXJ. Statistical analysis and writing the first draft of the manuscript were performed by ZJT, CSQ, ZT, YL and YJ. All authors reviewed and approved the final manuscript.

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Data availability
No datasets were generated or analysed during the current study.

Declarations

Institutional review board
The ethics committees of all four centres approved this study (The First Affiliated Hospital of Xiamen University, The First Affiliated Hospital of Fujian Medical University, Liaoning Cancer Hospital, and The First Affiliated Hospital of Nanjing Medical University, No. XMYY-2022KY073).

Informed consent
Written informed consent was obtained from all patients included in the study.

Competing interests
The authors declare no competing interests.

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