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Comparison of short-term efficacy of laparoscopic proximal gastrectomy with modified side overlap anastomosis and laparoscopic total gastrectomy with Roux-en-Y anastomosis

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Abstract

Background To investigate the short-term efficacy of laparoscopic proximal gastrectomy (LPG) with modified side overlap anastomosis in comparison with laparoscopic total gastrectomy (LTG) with Roux-en-Y anastomosis.

Methods A retrospective cohort study was conducted. The clinicopathological data of 262 patients who underwent LPG or LTG for upper gastric adenocarcinoma from January 2016 to December 2022 were collected. Among 262 patients, 20 who underwent LPG with a modified side overlap anastomosis were assigned to the side overlap group, and 242 who underwent LTG with Roux-en-Y anastomosis were assigned to the Roux-en-Y group. After 1:1 matching of patients in the side overlap and Roux-en-Y groups via the propensity score matching method, 15 patients were included in this study. The outcome measures included the following: (1) intraoperative conditions, (2) postoperative recovery and (3) follow-up information.

Results (1) Intraoperative conditions. Compared with the Roux-en-Y group, the side overlap group had a longer digestive tract reconstruction time. No significant difference was observed in the total operation time or amount of intraoperative blood loss. (2) Postoperative recovery. No statistically significant difference was detected between the side overlap and Roux-en-Y groups in terms of indicators, such as first anal exhaust time, first postoperative liquid intake time, postoperative hospitalization time and postoperative complications. (3) Follow-up information. The body mass index, haemoglobin, albumin, and Nutritional Risk Screening 2002 scores of the side overlap group were better than those of the Roux-en-Y group at 12 and 18 months after surgery. No significant difference was observed in the gastroesophageal reflux disease scale score or occurrence of ≥ Grade B reflux oesophagitis at 12 and 18 months after surgery between the side overlap and Roux-en-Y groups.

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Conclusions LPG with a modified side overlap anastomosis is safe and feasible for the treatment of upper gastric adenocarcinoma and can achieve good antireflux effects. In addition, compared with traditional LTG, the postoperative nutritional status after LTG is better.

Keywords Upper gastric adenocarcinoma, Laparoscopy, Proximal gastrectomy, Side overlap anastomosis, Roux-en-Y anastomosis

Introduction

Current evidence indicates that the prevalence of gastric cancer affecting the upper stomach is increasing [1]. Numerous clinical trials conducted in China, Japan, and South Korea, such as CLASS 02 [2], JCOG 1401 [3], and CLASSE 03 [4], have demonstrated that laparoscopic total gastrectomy (LTG) and laparoscopic proximal gastrectomy (LPG) are viable surgical interventions for early-stage gastric tumours located in the upper region of the stomach. Nevertheless, extensive clinical investigations have highlighted an increasing emphasis on maintaining the functional integrity of the digestive tract [5]. The recommendations of new guidelines have further contributed to a growing preference for laparoscopic approaches as methods that preserve essential functions. Compared with LTG, these laparoscopic techniques offer enhanced preservation of gastric capabilities, which play a significant role in improving postoperative nutritional well-being for patients.

However, there remains a notable incidence of reflux oesophagitis following conventional oesophagogastric reconnection, which is associated with an elevated risk of anastomotic narrowing [6]. The technique of side overlap anastomosis, developed by Yamashita et al. [7] in 2017, is relatively straightforward to implement and plays a crucial role in minimizing the risk of postoperative gastroesophageal reflux. This technique facilitates anastomosis between the lateral wall of the oesophagus and the anterior wall of the residual stomach through the rotation of a linear stapler.

Unfortunately, the effectiveness of this method is significantly influenced by the surgeon's expertise and individual assessment, which can lead to variability in outcomes. Consequently, Yamashita et al. [7] continued to refine the procedure to increase both its accuracy and stability at the anastomotic site while improving its mechanism for preventing reflux. Although studies have compared double-tract reconstruction via LPG with conventional LTG, few studies have addressed modified side overlap anastomosis in LPG versus LTG.

This study conducted a retrospective analysis of clinical and pathological data from 268 cancer patients diagnosed with tumours at the oesophagogastric junction or upper stomach who were treated at our institution from January 2016 to December 2022. The objective of this study was to evaluate the short-term clinical outcomes associated with modified side overlap anastomosis in LPG compared with Roux-en-Y reconstruction in LTG.

Materials and methods

Patients

This work is a retrospective cohort study involving the clinical and pathological data of patients with adenocarcinoma of the oesophagogastric junction or upper part of the stomach who were admitted to our centre between January 2016 and December 2022. This study was approved by the Ethics Committee of the Second Affiliated Hospital of Fujian Medical University (No. 2024062) and was conducted in accordance with the Declaration of Helsinki. Informed consent was waived by the Ethics Committee considering the retrospective design of the study. Among the initial 268 patients identified in our medical records, 20 had undergone LPG with a modified side overlap anastomosis, and the remaining 242 had undergone LTG with Roux-en-Y anastomosis. Significant differences were initially observed between the two groups in terms of preoperative albumin, maximum tumour diameter and pathological stage (all $P<0.05$) (Table 1). To ameliorate this condition, we matched patients in the side overlap and Roux-en-Y groups at a ratio of 1:1 via propensity score matching. The match tolerance was set to 0.08. Finally, 15 patients from the side overlap group and 15 patients from the Roux-en-Y group were included in this work. The baseline data of these groups were comparable (Table 2).

Inclusion and exclusion criteria

The inclusion criteria were as follows: (1) patients diagnosed with cancer of the upper part of the stomach through preoperative pathological examination of gastroscopy biopsy samples; (2) patients at clinical stage cT1-2N0M0 after preoperative enhanced computed tomography and endoscopic ultrasonography; (3) patients without preoperative distant metastasis; and (4) patients without a history of abdominal surgery.

The exclusion criteria were as follows: (1) patients who received preoperative neoadjuvant therapy; (2) patients with severe cardiopulmonary dysfunction or poor nutritional status and who displayed poor tolerance of surgery; (3) patients with concomitant malignant tumours; and (4) patients whose clinical and pathological data were incomplete.

Table 1 Comparison of baseline data comparison

	Side overlap group	Roux-en-Y group	Statistical value	*P* value
Sex			$x^2=2.568$	0.109
Male	17	164		
Female	3	78		
Age (y)	65.5(34.0–79.0)	64.0(27.0–83.0)	Z=-1.234	0.217
BMI (kg/m2)	21.3(14.4–30.0)	22.0(14.2–80.0)	Z=-0.302	0.762
Preoperative albumin (g/L)	43.2 ± 4.7	38.8 ± 5.2	t = 3.536	0.000
Maximum tumour diameter (cm)	2.5(0.5–3.8)	4.5(0.5–15.0)	Z=-5.100	0.000
Tumor differentiation grade			$x^2=4.222$	0.121
High	4	20		
Moderate	10	101		
Poor	6	122		
Pathological stage			$x^2=51.300$	0.000
I	16	28		
II	4	82		
III	0	132		

BMI: Body mass index

Table 2 Comparison of baseline data after propensity score matching

	Side overlap group	Roux-en-Y group	Statistical value	*P* value
Sex			$x^2=0.745$	0.195
Male	13	10		
Female	2	5		
Age (y)	65.0(34.0–79.0)	69.0(50.0–81.0)	Z=-0.332	0.740
BMI (kg/m2)	22.1 ± 3.6	21.4 ± 2.2	t = 0.608	0.548
Preoperative albumin (g/L)	42.6 ± 4.8	40.5 ± 5.1	t = 1.114	0.275
Maximum tumour diameter (cm)	3.0(1.0-3.8)	2.5(0.5–15.0)	Z=-0.313	0.755
Tumor differentiation grade			$x^2=1.235$	0.539
High	3	2		
Moderate	7	5		
Poor	5	8		
Pathological stage			$x^2=2.964$	0.227
I	11	10		
II	4	3		
III	0	2		

BMI: Body mass index

Surgical procedures

The same group of surgeons performed all surgeries in this study. Under intravenous and inhaled general anaesthesia, the patients were placed in a supine split-leg position with the head slightly raised, and the surgical site was disinfected routinely. The surgeon stood on the left side of the patient, the surgical assistant stood on the right, and the laparoscope holder was placed between the patient's legs. The five-port method was performed to place a 12 mm trocar under the umbilicus as the observation port from which pneumoperitoneum was established, with pressure being maintained at 12–15 mmHg (1 mmHg = 0.133 kPa). Next, a 12 mm trocar was installed 2 cm below the costal margin of the left anterior axillary line, and another 5 mm trocar was placed 2 cm above the level of the umbilicus at the left midclavicular line to establish the operating ports. The 5 mm trocars placed at the corresponding sites on the right side served as additional operating ports.

Laparoscopic exploration was performed to identify the tumour location, size, degree of infiltration and relationship with the surrounding organ tissue. The patients in the side overlap group underwent free resection of the proximal stomach along with D1 + or D2 lymphadenectomy. The surgical procedure was performed according to our previous research [8]. In contrast, the Roux-en-Y group received complete free resection of the entire stomach and D1 + or D2 lymphadenectomy. No. 10 lymph node dissection was not routinely performed and was conducted only for patients with enlargement of the No. 10 lymph nodes.

1. Roux-en-Y group.

The oesophagus was transected, and the entire stomach was removed. The jejunum was cut 15–20 cm from Treitz's ligament, and jejunal oesophageal anastomosis was performed using the distal end of the jejunal stump. Jejunojejunostomy was carried out using the proximal end of the jejunum 30–40 cm from the jejunal oesophageal anastomosis (Fig. 1).

2. Side overlap group.

The lower segment of the oesophagus was exposed to a length of ≥ 5 cm, and the oesophagus was transected near the cardia via an endoscopic linear stapler. Intraoperative gastroscopy or rapid frozen pathological examination was performed to ensure safe surgical margins. The abdominal segment of the oesophagus was preserved as much as possible, and a thread was placed in the middle of the lower edge of the oesophageal stump to facilitate subsequent traction. The bilateral diaphragmatic cruses were opened to expand the operating space. Subsequent suturing and fixation of the oesophageal stump were guided by marking the dorsal side 5 cm from the oesophageal stump with gentian violet.

A small median incision (5 cm) was made under the xiphoid process, and the stomach was removed to determine the tumour location. The stomach was dissected at

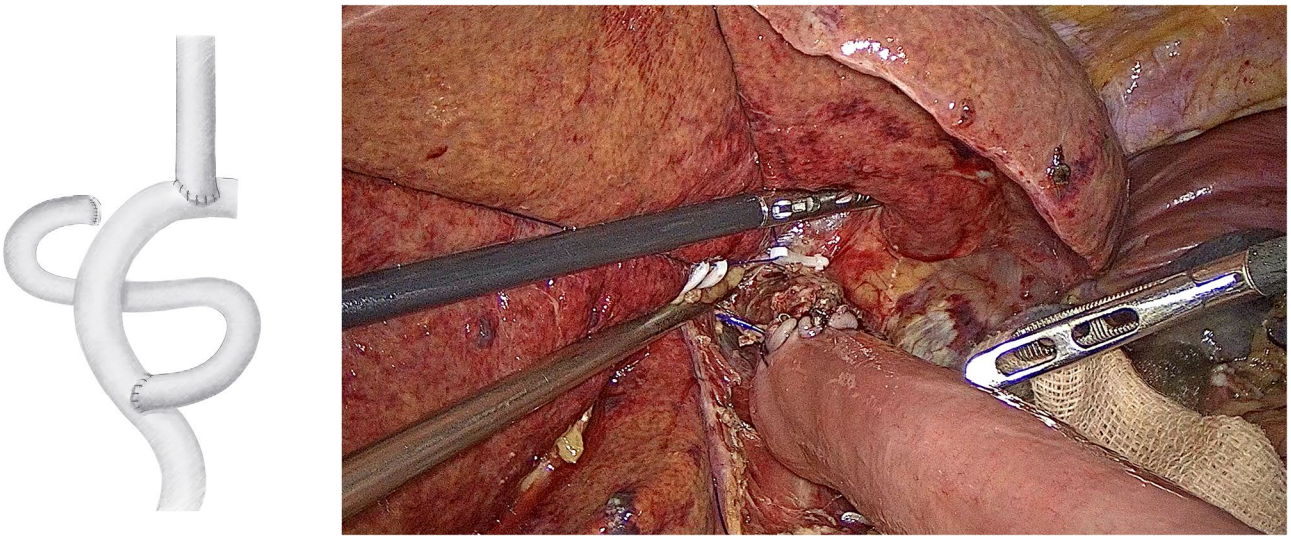

Fig. 1 Roux-en-Y anastomosis

the proximal end with a linear stapler 3 cm away from the distal end of the tumour, and the stump was fortified via intermittent suture. The cutting line was ensured to be perpendicular to the long axis of the stomach as much as possible to preserve the remaining stomach volume. A 5 cm longitudinal mark was made with gentian violet at the median of the anterior wall of the remnant stomach to be anastomosed with the oesophagus. The pneumoperitoneum was reestablished by returning the remnant stomach to the abdominal cavity.

At the gentian violet mark, the centre of the upper edge of the remnant stomach was fixed via a continuous suture of the dorsal side of the lower oesophagus. A barbed suture ensured that the lower oesophagus accurately overlapped and was fixed at the centre of the anterior wall of the remnant stomach during subsequent oesophagogastric anastomosis. A gastric tube served as a guide to make a small incision on the right wall of the lower oesophageal stump via an electric hook and another at the lower end of the gentian violet mark on the anterior wall of the remnant stomach (Fig. 2a). The left side of the oesophageal stump was lifted and rotated counterclockwise by 90°. With the gentian violet mark on the anterior wall of the remnant stomach as a guide, the long axis of the oesophagus was made parallel and overlapping with the long axis of the stomach. A 45 mm linear stapler was inserted through the opening of the oesophagus and remnant stomach to conduct a side-to-side anastomosis between them (Fig. 2b). The entry hole was closed with a longitudinal continuous barbed suture (Fig. 2c). Blue staplers were used, and a thicker staple cartridge was applied on the thick parts of the stomach or oesophageal wall. The lower margin of the oesophageal stump was continuously fixed by sutures to the anterior wall of the remnant stomach from the left side of the lower oesophagus, using a barbed suture to embed the cut edge of the lower oesophagus. The left and right ends of the remnant stomach were suture-fixed to the left and right diaphragmatic cruses to reconstruct an artificial gastric fundus. The left and right sides of the lower oesophagus were continuously suture-fixed with the anterior wall of the remnant stomach for 270° embedding to ensure a tight fit between the lower oesophagus and the anterior wall of the remnant stomach. Reconstruction of the digestive tract was completed (Fig. 2d).

Finally, the anastomotic site was carefully examined for bleeding, stricture or incomplete closure through intraoperative gastroscopy, and a narrow and elongated posterior wall of the oesophagus on the anastomosis adhered to the anterior wall to prevent gastroesophageal reflux (Fig. 2e).

Outcome measures and evaluation criteria

The outcome measures were as follows: (1) intraoperative data, including total surgery duration, intraoperative blood loss volume and digestive tract reconstruction duration; (2) postoperative recovery period, measured as the time to first postoperative anal exhaust, time to first postoperative liquid food intake, length of postoperative hospital stay and postoperative complications, including intestinal obstructions, lymphatic stenosis, abdominal bleeding, anastomotic fistula and pulmonary infections; and (4) follow-up data, including the number of patients followed up, follow-up duration, nutritional status after discharge, presence of reflux oesophagitis and anastomotic condition.

The evaluation criteria were as follows: (1) nutritional status assessment comprising body mass index (BMI) haemoglobin, albumin, and Nutritional Risk Screening 2002 (NRS 2002) score [9]; (2) oesophageal reflux

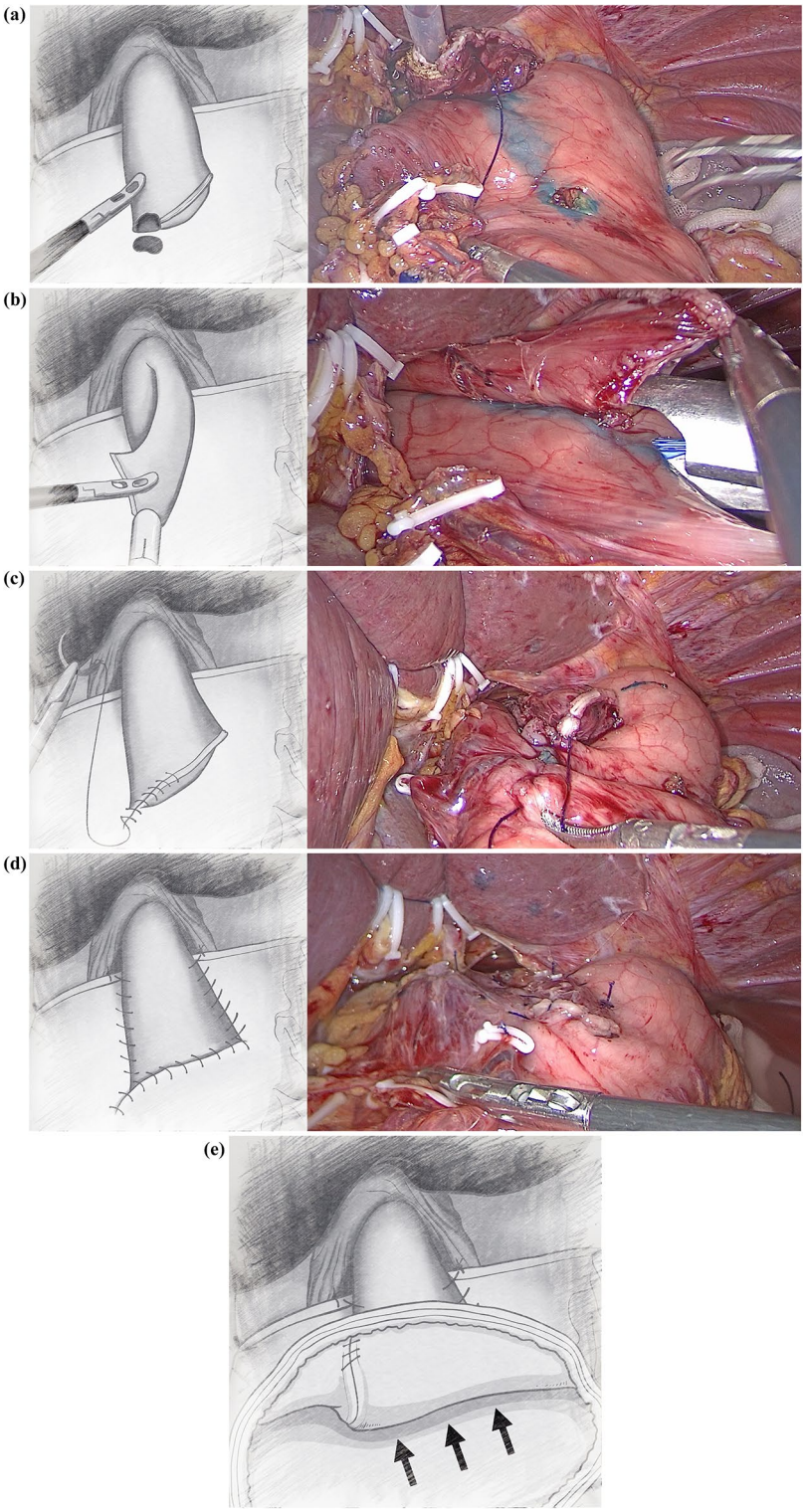

Fig. 2 (**a**) A gastric tube served as a guide to make a small incision on the right wall of the lower oesophageal stump via an electric hook and another at the lower end of the gentian violet mark on the anterior wall of the remnant stomach. Figure 2(**b**) A 45 mm linear stapler was inserted through the opening of the oesophagus and remnant stomach to conduct a side-to-side anastomosis between them. Figure 2(**c**) The entry hole was closed with a longitudinal continuous barbed suture. Figure 2(**d**) The left and right sides of the lower oesophagus were continuously suture-fixed with the anterior wall of the remnant stomach for 270° embedding to ensure a tight fit between the lower oesophagus and the anterior wall of the remnant stomach. The reconstruction of the digestive tract was completed. Figure 2(**e**) The narrow and elongated posterior wall of the oesophagus on the anastomosis adhered to the anterior wall to prevent gastroesophageal reflux

Table 3 Comparison of intraoperative data

	Side overlap group	Roux-en-Y group	Statistical value	*P* value
Total surgery duration (min)	83.0(77.0-116.0)	39.4(37.5–46.2)	Z=-4.672	0.000
Digestive tract reconstruction duration (min)	196.4 ± 9.5	224.9 ± 58.8	t=-1.851	0.075
Intraoperative blood loss volume (ml)	21.0(17.0–27.0)	31.0(12.0–48.0)	Z=-0.603	0.546

Table 4 Comparison of postoperative recovery

	Side overlap group	Roux-en-Y group	Statistical value	*P* value
Time to first postoperative anal exhaust (d)	1.0(1.0–3.0)	2.0(1.0–3.0)	Z=-1.907	0.057
Time to first postoperative liquid food intake (d)	1.0(2.0–4.0)	3.0(2.0–5.0)	Z=-1.946	0.052
Length of postoperative hospital stay (d)	7.0(7.0–9.0)	8.0(7.0–9.0)	Z=-1.619	0.106
Postoperative complications	2	1	x2 = 0.000	1.000
Intestinal obstruction	0	0		
Anastomotic stenosis	0	0		
Anastomotic bleeding	1	0		
Anastomotic fistula	0	0		
Pulmonary infection	1	1		

symptom score on the gastroesophageal reflux disease questionnaire (GerdQ) scale [10]; (3) reflux oesophagitis diagnosed through gastroscopy and the severity of lesions assessed via the Los Angeles grading system [11]; and (4) the condition of the anastomotic site determined via upper gastrointestinal angiography.

Follow-up

All patients were followed up for a minimum of 18 months, with the follow-up period ending in June 2024. Follow-ups were conducted during outpatient visits, through telephone consultations and/or online via WeChat to evaluate the patients' nutritional status, reflux oesophagitis and the condition of the anastomotic site.

Statistical analysis

Normally distributed data are expressed as x ± s and were analysed through t tests for intergroup comparisons. Data with skewed distributions are expressed as median values (ranges), and the results of the intergroup comparisons were analysed via Mann–Whitney U tests. The grade data were analysed via the nonparametric rank-sum test. Count data are expressed as absolute numbers, and intergroup comparisons were conducted via X2 tests or Fisher's exact tests. A P value < 0.05 was considered to indicate statistical significance.

Results

Surgical conditions

All patients underwent successful LPG and LTG, with no conversions to open surgery occurring during the procedures. The digestive tract reconstruction times for the patients in the side overlap and Roux-en-Y groups were 83.0 (77.0–116.0) and 39.4 (37.5–46.2) min, respectively. The between-group differences at these times were statistically significant ($P < 0.05$). The mean surgery durations for the side overlap and Roux-en-Y groups were 196.4 ± 9.5 and 224.9 ± 58.8 min, respectively, with no significant difference between the two groups. The intraoperative blood loss volumes were 21.0 (17.0–27.0) and 31.0 (12.0–48.0) mL for the side overlap and Roux-en-Y groups, respectively, with no significant difference. Table 3 summarizes the surgical outcome data.

Postoperative recovery

The time to first postoperative anal exhaust, time to first postoperative liquid food intake and length of postoperative hospital stay were 1.0 (1.0–3.0), 1.0 (2.0–4.0) and 7.0 (7.0–9.0) days, respectively, for the side overlap group and 2.0 (1.0–3.0), 3.0 (2.0–5.0), and 8.0 (7.0–9.0) days, respectively, for the Roux-en-Y group. No statistically significant differences were found between the groups (all $P > 0.05$). The incidence of postoperative complications in the side overlap group included one case of anastomotic bleeding and one case of pulmonary infection. In contrast, the Roux-en-Y group had one case of pulmonary infection. No statistically significant differences were detected in these indicators between the two groups (all $P > 0.05$). The postoperative recovery data are presented in Table 4. All complications in both groups improved after conservative treatment, and all patients achieved a state of tumour-free survival following surgical intervention.

Follow-up outcomes

All patients were followed up at 12 and 18 months after surgery. Table 5 shows the follow-up data for the two groups. The BMI at 12 and 18 months reached 22.0 ± 3.6 and 19.8 ± 1.8 kg/m2 for the side overlap group and 21.8 ± 3.3 and 19.5 ± 1.6 kg/m2 for the Roux-en-Y group, respectively. The haemoglobin levels at 12 and 18 months were 124.5 ± 11.2 and 126.3 ± 13.5 g/L for the side overlap group and 113.3 ± 17.8 and 115.7 ± 14.6 g/L for the Roux-en-Y group, respectively. The albumin concentrations at 12 and 18 months were 41.3 ± 3.9 and 41.9 ± 3.7 g/L for the side overlap group and 36.5 ± 7.0 and 36.4 ± 7.1 g/L for the Roux-en-Y group, respectively. The NRS 2002 scores at 12 and 18 months after surgery were 2 (1–2) and 2

Table 5 Comparison of follow-up data

	Side overlap group	Roux-en-Y group	Statistical value	*P* value
BMI at 12 months(kg/m^2)	22.0 ± 3.6	19.8 ± 1.8	t = 2.059	0.049
BMI at 18 months(kg/m^2)	21.8 ± 3.3	19.5 ± 1.6	t = 2.458	0.020
Hemoglobin at 12 months(g/L)	124.5 ± 11.2	113.3 ± 17.8	t = 2.070	0.048
Hemoglobin at 18 months(g/L)	126.3 ± 13.5	115.7 ± 14.6	t = 2.076	0.047
Albumin at 12 months(g/L)	41.3 ± 3.9	36.5 ± 7.0	t = 2.296	0.032
Albumin at 18 months(g/L)	41.9 ± 3.7	36.4 ± 7.1	t = 2.657	0.015
NRS 2002 scores at 12 months	2(1–2)	2(1–3)	Z=-2.249	0.025
NRS 2002 scores at 18 months	2(1–2)	2(1–3)	Z=-3.023	0.003
GerdQ scale scores at 12 months	3(2–4)	3(2–4)	Z=-0.207	0.836
GerdQ scale scores at 18 months	3(2–4)	3(2–4)	Z=-0.115	0.909
≥ grade B reflux esophagitis at 12 months	0	1	x2 = 0.000	1.000

BMI: Body mass index

NRS 2002: Nutritional Risk Screening 2002

GerdQ: Gastroesophageal reflux disease questionnaire

(1–3) points, respectively, for the side overlap group. For the Roux-en-Y group, the scores were 2 (1–2) points at 6 months and 2 (1–3) points at 12 months after surgery. At both follow-up times, the between-group differences in the above data were statistically significant ($P < 0.05$). Furthermore, the GerdQ scale scores of the side overlap group reached 3 (2–4) and 3 (2–4) points at 12 and 18 months, respectively, and those of the Roux-en-Y group were 3 (2–4) points and 3 (2–4) points, respectively. One year after surgery, the Roux-en-Y group had one case of ≥ grade B reflux oesophagitis. The occurrence of reflux oesophagitis in this particular patient may be attributed to his previous cholecystectomy, which led to a continuous flow of bile into the small intestine without any storage capacity. This condition was further exacerbated by obesity, which compromised the antireflux mechanism. Except for this patient, who exhibited reflux oesophagitis and subsequently received oral PPI treatment until the end of our follow-up period, the other patients did not routinely use PPIs. No cases of anastomotic stenosis were found via postoperative upper gastrointestinal angiography in any of the patients. Table 5 summarizes the follow-up outcome data. Figure 3 presents the postoperative upper gastrointestinal angiography results for the modified side overlap anastomosis. Postoperative endoscopic examination revealed a narrow and elongated anastomotic site after the modified side overlap anastomosis (Fig. 4).

Fig. 3 Postoperative upper gastrointestinal angiography image of the modified side overlap anastomosis

Discussion

An increasing trend in the incidence of gastric cancer, particularly in the upper gastric region, has led to increased attention being given to this health issue. A national study conducted in South Korea revealed an increase in cases of proximal gastric cancer, with rates increasing from 11.2 to 16% by 2014 [12]. Until recently, the conventional approach for treating gastric cancer located in the upper stomach involved total gastrectomy. However, advancements in medical practices and improved early detection rates have enabled physicians to enhance the preservation of gastric functionality during comprehensive tumour excision. Therefore, researchers have developed innovative techniques for proximal gastrectomy aimed at preserving stomach function.

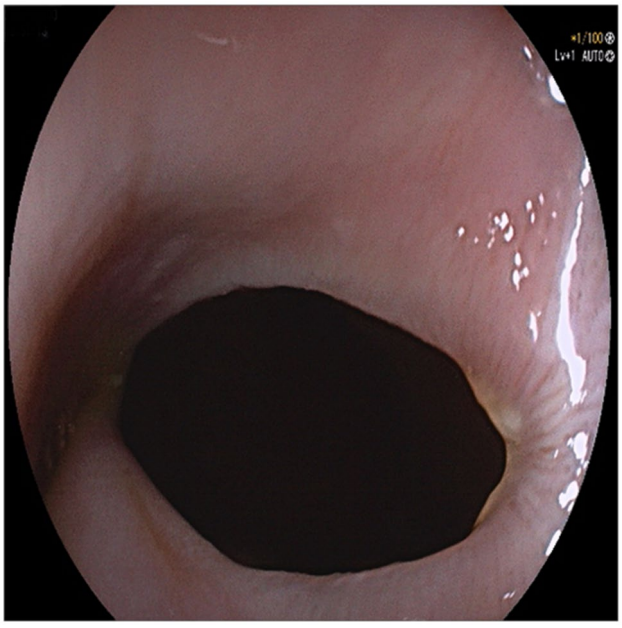

Fig. 4 Postoperative endoscopic examination showing a narrow and elongated anastomotic site after the modified side was overlapped with the anastomosis

Recent advancements in these techniques for treating early-stage gastric cancer have demonstrated the ability to improve patients' nutritional recovery after surgery while maintaining long-term survival rates. Nevertheless, this procedure may disrupt the reflux prevention mechanism of the cardia; studies indicate that the occurrence of reflux oesophagitis following standard oesophagogastric anastomosis ranges between 21.8% and 71.6% [13]. This situation significantly diminishes patients' quality of life after surgery.

In 2017, Yamashita et al. [7] introduced the technique of side overlap anastomosis, which has demonstrated significant effectiveness in preventing reflux. The conventional side overlap anastomosis technique, which uses only a linear stapler, is generally straightforward and cost-effective. A critical aspect of this procedure involves counterclockwise rotation, followed by activation of the linear stapler to perform a side-to-side anastomosis between the lateral wall of the oesophagus and the anterior wall of the remnant stomach. Notably, the anterior wall of the remnant stomach closely adheres to the adjacent lateral surface of the oesophagus. Subsequently, anchoring is performed on both the left and right crus of the diaphragm to create an artificial fundus. As pressure within this newly formed gastric fundus increases, the distal portion of the oesophagus closes to prevent reflux.

However, Yamashita et al. reported instances of an anastomotic shift towards the lesser curvature of the remnant stomach in a subset comprising 27 patients treated with this modified side overlap anastomosis technique. This phenomenon results in inadequate overlap between the lower oesophagus and anterior wall of the remnant stomach, ultimately leading to ineffective closure as pressure within the artificial gastric fundus escalates. This observation can be attributed to alignment discrepancies among three key components: the long axis of the oesophagus, the long axis of the remnant stomach, and the rotational axis of the linear stapler at that moment of activation.

On this basis, Yamashita et al. [7] modified the side overlap method to increase the stability of the antireflux mechanism. In the present study, we employed the revised technique of side overlap in laparoscopic gastric procedures. Initial observations associated with this revised technique included the following: (1) Compared with the conventional side overlap anastomosis technique, a significant modification in our technique involved replacing the initial side-to-side anastomosis between the left lateral wall of the lower oesophagus and the anterior wall of the remnant stomach with one performed between the right lateral wall of the lower oesophagus and the anterior wall of the remnant stomach. The conventional side overlap anastomosis procedure primarily depends on subjective assessment and surgeon expertise, which have been linked to complications such as anastomotic shift and suboptimal treatment outcomes. In contrast, during our modified side overlap anastomosis, we rotated the oesophagus 90° counterclockwise to align its long axis with the middle long axis of the remnant stomach. A preestablished mark facilitated alignment for subsequent connection between both structures, ensuring precise fitting while significantly minimizing misalignment risks in their axes during anastomosis via a linear stapler. (2) The left and right cruses of the diaphragm were incised to expand the surgical workspace and create an artificial gastric fundus by elevating the remnant stomach. This technique enhances the exposure length of the oesophagus, effectively addressing challenges associated with retraction following oesophageal resection and facilitating the anastomosis process after significant resection; consequently, this laid a solid foundation for future anastomosis and the establishment of an antireflux mechanism. (3) In a manner analogous to fundoplication, 270° embedding was executed by suturing both sides of the lower oesophagus to the anterior wall of the remnant stomach. This technique enhances pressure within the gastric fundus and establishes mechanisms that prevent reflux. (4) The margin of the lower oesophageal incision was meticulously embedded to prevent leakage at the anastomosis site postsurgery.

This reconstructed anastomotic stoma exhibited a valve-like appearance. As the pressure within the artificial gastric fundus increased, the posterior wall of the oesophagus at the anastomosis adhered to its anterior

wall, effectively preventing gastroesophageal reflux. Compared with the 25 mm circular stapler, the side-to-side overlap anastomosis facilitated the establishment of a broad and lengthy anastomosis. To mitigate complications such as anastomosis stricture postoperatively, it is essential to avoid shifts in the long axis of the oesophagus, the remnant stomach and the linear stapler. Should any shifts occur, intraoperative widening of the anastomosis can be achieved by adjusting the suture direction at the common opening.

In the present study, the modified side overlap group required a longer duration for reconstruction of the digestive tract than did the Roux-en-Y group; this may be attributed to the intricate and challenging nature of the surgical technique employed. Conversely, the time needed for lymph node dissection was reduced in the former group. Consequently, there was no significant difference in overall surgical duration between the two patient cohorts.

This technique is recommended for patients with early-stage tumours in which the dentate line is not compromised. This technique can facilitate execution of the surgical procedure while enhancing safety during intervention. Furthermore, no significant differences were identified between patients in the modified side overlap group and those in the Roux-en-Y group regarding the time to first postoperative anal exhaust, time to first postoperative liquid food intake, length of postoperative hospital stay or incidence or types of postoperative complications. These findings suggest that both LPG and conventional LTG are comparable in terms of surgical safety and recovery outcomes following surgery.

Our comparative analysis revealed that the modified side overlap group presented greater BMI, haemoglobin, albumin, and NRS 2002 scores than did the Roux-en-Y group at both 12 and 18 months postoperatively. This outcome can be attributed to the preservation of the distal part of the stomach following LPG, which facilitates a certain amount of food consumption. Furthermore, this technique enhances the stomach's capacity for digestion, secretion, and storage of food, leading to substantial enhancements in nutritional status following surgery [14–16]. These findings are consistent with studies conducted in Japan and South Korea, further corroborating the advantages of LPG for patients' postoperative nutritional outcomes [17–20]. In both groups, comparable incidences of oesophageal reflux were observed throughout the follow-up period. This finding indicates that the antireflux mechanism established by the modified side overlap anastomosis is effective in preventing reflux while still facilitating normal food consumption.

This study has several limitations. First, the patient cohort analysed was relatively small, and the group of individuals who underwent LPG was also modest in size. In the context of digestive tract reconstruction following LPG, our centre not only employed this modified side overlap anastomosis technique but also explored various other methods, including oesophagogastric tube anastomosis, double-tract anastomosis, and Kamikawa anastomosis. Future research will focus on further investigating the comparative clinical effectiveness of various techniques for digestive reconstruction following LPG. These investigations will contrast these techniques with Roux-en-Y anastomosis, which is commonly employed in LTG. Additionally, we will analyse the clinical outcomes associated with different reconstruction methods used in LPG.

Second, our centre has previously adopted LTG combined with Roux-en-Y anastomosis as a standard treatment protocol for early upper gastric cancer. With increasing emphasis on functional preservation and nutritional enhancement, the number of patients undergoing LPG for early upper gastric cancer has gradually increased. Consequently, the follow-up period for assessments within the modified side overlap group was notably limited. Therefore, extending the follow-up duration is crucial to adequately evaluate the clinical outcomes, nutritional health status, and survival rates associated with these techniques.

Ultimately, this study was conducted at a single centre; thus, its findings may have limited generalizability. To achieve a more comprehensive assessment of surgical techniques for upper gastric cancer, it is imperative to conduct additional prospective multicentre clinical trials to validate these results.

In addition, we employed modified side overlap anastomosis performed ex vivo to create the remnant stomach. Not all procedures were conducted within the abdominal cavity; thus, they can be characterized as laparoscopy-assisted surgeries. Previous reports indicate that total laparoscopic surgery offers superior postoperative recovery compared with that of laparoscopy-assisted surgery [21–22]. However, in our study, the modified side overlap anastomosis was not executed entirely under laparoscopic conditions. The rationale for this approach is that performing proximal gastrectomy and embedding the stump under direct vision ex vivo is both faster and safer than doing so via laparoscopy; moreover, the length of the abdominal incision does not exceed that of the Roux-en-Y group. Consequently, conducting proximal gastrectomy externally has emerged as a mainstream surgical method for LPG at present. For future research endeavours, we plan to perform proximal gastrectomy with modified side overlap anastomosis under total laparoscopy to further explore the advantages associated with total laparoscopic surgery versus laparoscopy-assisted surgery.

Conclusions

The use of a modified side overlap anastomosis during laparoscopic procedures for resection of early gastric cancer located in the upper stomach is distinguished by its safety and practicality. The effectiveness of this technique is comparable to that of the Roux-en-Y anastomosis employed during LTG, but it also offers the additional advantage of improved nutritional outcomes for patients in the postoperative period. Therefore, this surgical technique not only demonstrates safety and efficacy but also significantly contributes to improving the nutritional well-being of patients following surgery, rendering it a valuable option for the treatment of upper gastric cancer.

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Author contributions
All authors have made substantial contributions to this article. CYW: Data curation, Investigation, Methodology, Software, Writing– original draft. YJZ: Data curation, Investigation, Methodology, Software, Writing– original draft. KY: Writing– review & editing. All authors read and approved the final manuscript.

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Data availability
The data sets used and analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
The Ethics Committee of the Second Afliated Hospital of Fujian Medical University approved the study protocol (approval No. 2024062), and it was performed in accordance with the Declaration of Helsinki and its subsequent amendments. Because the study was retrospective, participants were not asked to provide written informed consent when enrolled, and the need for consent to participate was waived by The Ethics Committee of the Second Afliated Hospital of Fujian Medical University.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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References

1. Ferlay J, Soerjomataram I, Dikshit R, et al. Cancer incidence and mortality worldwide: sources, methods and major patterns in GLOBOCAN 2012. Int J Cancer. 2015;136(5):E359–86. https://doi.org/10.1002/ijc.29210.
2. Liu F, Huang C, Xu Z, et al. Morbidity and mortality of laparoscopic vs open total gastrectomy for clinical stage I gastric cancer: the CLASS02 multicenter randomized clinical trial. JAMA Oncol. 2020;6(10):1590–7. https://doi.org/10.1001/jamaoncol.2020.3152.
3. Katai H, Mizusawa J, Katayama H, et al. Single-arm confirmatory trial of laparoscopy-assisted total or proximal gastrectomy with nodal dissection for clinical stage I gastric cancer: Japan clinical oncology group study JCOG1401. Gastric Cancer. 2019;2(5):999–1008. https://doi.org/10.1007/s10120-019-00929-9.
4. Hyung WJ, Yang HK, Han SU, et al. A feasibility study of laparoscopic total gastrectomy for clinical stage I gastric cancer: a prospective multi-center phase II clinical trial, KLASS 03. Gastric Cancer. 2019;22(1):214–22. https://doi.org/10.1007/s10120-018-0864-4.
5. Wang FH, Zhang XT, Li YF, et al. The Chinese society of clinical oncology (CSCO): clinical guidelines for the diagnosis and treatment of gastric cancer, 2021. Cancer Commun(Lond). 2021;41(8):747–95. https://doi.org/10.1002/cac2.12193.
6. Xu Y, Tan Y, Wang Y, et al. Proximal versus total gastrectomy for proximal early gastric cancer: a systematic review and meta-analysis. Medicine(Baltimore). 2019;98(19):e15663. https://doi.org/10.1097/MD.0000000000015663.
7. Yamashita Y, Tatsubayashi T, Okumura K, et al. Modified side overlap esophagogastrostomy after laparoscopic proximal gastrectomy. Ann Gastroenterol Surg. 2022;6(4):594–9. https://doi.org/10.1002/ags3.12549.
8. Wu CY, Zhong WJ, Ye K. Comparison of the efficacy, safety and postoperative quality of life between modified side overlap anastomosis and double-tract anastomosis after laparoscopic proximal gastrectomy. Updates Surg. 2024;76(6):2255–65. https://doi.org/10.1007/s13304-024-01830-6.
9. Kondrup J, Rasmussen HH, Hamberg O et al. Nutritional risk screening (NRS 2002): a new method based on an analysis of controlled clinical trials. Clin Nutr. 2003; 22(3): 321–36. https://doi.org/10.1016/s0261-5614(02)00214-5
10. Neto RML, Herbella FAM, Schlottmann F, et al. Does demeester score still define GerdQ? Dis Esophagus. 2019;32(5):doy118. https://doi.org/10.1093/dote/doy118.
11. Lundell LR, Dent J, Bennett JR, et al. Endoscopic assessment of oesophagitis: clinical and functional correlates and further validation of the Los Angeles classification. Gut. 1999;45(2):172–80. https://doi.org/10.1136/gut.45.2.172.
12. Namikawa T, Oki T, Kitagawa H, et al. Impact of jejunal pouch interposition reconstruction after proximal gastrectomy for early gastric cancer on quality of life: short-and long-term consequences. Am J Surg. 2012;204(2):203–9. https://doi.org/10.1016/j.amjsurg.2011.09.035.
13. Shiraishi N, Hirose R, Morimoto A, et al. Gastric tube reconstruction prevented esophageal reflux after proximal gastrectomy. Gastric Cancer. 1998;1(1):78–9. https://doi.org/10.1007/s101209800023.
14. Ahn SH, Jung DH, Son SY, et al. Laparoscopic double-tract proximal gastrectomy for proximal early gastric cancer. Gastric Cancer. 2014;17(3):562–70. https://doi.org/10.1007/s10120-013-0303-5.
15. Masuzawa T, Takiguchi S, Hirao M, et al. Comparison of perioperative and long-term outcomes of total and proximal gastrectomy for early gastric cancer: a multi-institutional retrospective study. World J Surg. 2014;38(5):1100–6. https://doi.org/10.1007/s00268-013-2370-5.
16. Kano Y, Ohashi M, Nunobe S. Laparoscopic Function-Preserving gastrectomy for proximal gastric Cancer or esophagogastric junction cancer: A narrative review. Cancers (Basel). 2023;15(1):311. https://doi.org/10.3390/cancers15010311.
17. Sugiyama M, Oki E, Ando K, et al. Laparoscopic proximal gastrectomy maintains body weight and skeletal muscle better than total gastrectomy. World J Surg. 2018;42(10):3270–6. https://doi.org/10.1007/s00268-018-4625-7.
18. Kim DJ, Kim W. Laparoscopy-assisted proximal gastrectomy with double tract anastomosis is beneficial for vitamin B12 and iron absorption. Anticancer Res. 2016;36(9):4753–8. https://doi.org/10.21873/anticanres.11031.
19. Lee I, Oh Y, Park SH, et al. Postoperative nutritional outcomes and quality of life-related complications of proximal versus total gastrectomy for upper-third early gastric cancer: a meta-analysis. Sci Rep. 2020;10(1):21460. https://doi.org/10.1038/s41598-020-78458-0.
20. Furukawa H, Kurokawa Y, Takiguchi S, et al. Short-term outcomes and nutritional status after laparoscopic subtotal gastrectomy with a very small remnant stomach for cStage I proximal gastric carcinoma. Gastric Cancer. 2018;21(3):500–7. https://doi.org/10.1007/s10120-017-0755-0.
21. Park SH, Suh YS, Kim TH, et al. Postoperative morbidity and quality of life between totally laparoscopic total gastrectomy and laparoscopy-assisted total gastrectomy: a propensity-score matched analysis. BMC Cancer. 2021;21(1):1016. https://doi.org/10.1186/s12885-021-08744-1.
22. Lin GT, Chen JY, Chen QY, et al. Patient-Reported outcomes of individuals with gastric Cancer undergoing totally laparoscopic versus laparoscopic-Assisted

total gastrectomy: A Real-World, propensity Score-Matching analysis. Ann Surg Oncol. 2023;30(3):1759–69. https://doi.org/10.1245/s10434-022-12764-x.

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