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Short-term outcomes and quality of life of esophagogastrostomy versus the double-tract reconstruction after laparoscopic proximal gastrectomy

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Abstract

Background There is no optimal reconstruction technique after proximal gastrectomy. The esophagogastrostomy (EG) is a rather simple procedure technically, but the incidences of reflux esophagitis and anastomotic stricture are higher. While the double-tract reconstruction (DTR) can lessen postoperative reflux esophagitis, it is technically complex with a long operation time. The purpose of this study was to evaluate the quality of life (QoL) and short-term outcomes of the two reconstruction techniques.

Methods We retrospectively collected consecutive patients with upper-third gastric adenocarcinoma and adenocarcinoma of the esophagogastric junction (AEG) at our center between 2019 June and 2023 May. Patients who underwent laparoscopic proximal gastrectomy (LPG) with EG or DTR were included in this study. A comparison was made between the clinical and pathological characteristics of patients and their surgical parameters, postoperative complications, and its 1-year QoL in two groups. The QoL of the two groups was assessed by Visick grading, the European Organization for Research and Treatment of Cancer (EORTC) QLQ-C30 and EORTC QLQ-STO22 scales at 1 year after operation. The nutritional status of the two groups was evaluated by BMI, hemoglobin and serum albumin.

Results All the qualified patients were divided EG group ($n=63$) and DTR group ($n=93$). Compared to the DTR group, the blood loss volume of EG group was more ($p=0.001$). There were no significant differences in operation duration, number of lymph nodes dissected, and postoperative length of stay between the two groups($p>0.05$). No statistical differences were observed in terms of the incidence of early complications and Clavien-Dindo classification as well($p>0.05$). After one year, the Visick grade of the DTR group was better than EG group ($p=0.040$). The multivariable logistic regression analysis showed the only independent risk factor for reflux esophagitis was the reconstruction method. According to the EORTC QLQ-C30 questionnaire, patients in the DTR group had a better global health status($p=0.001$) and complained less about nausea and vomiting($p=0.033$), and appetite loss ($p=0.022$). Patients in the DTR group complained less about reflux ($p=0.030$) based on the EORTC QLQ-STO22 questionnaire. The multiple linear regression analysis revealed that the reconstruction method, reflux esophagitis and age had a linear relationship with the global health status score. Regarding nutritional status, BMI of the two groups both decreased 1 year after

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operation, and BMI decline value of the DTR group was lower than EG group ($p = 0.001$). There is no statistically significant difference between the two groups as for postoperative change in hemoglobin and serum albumin.

Conclusion Our findings suggest that it is possible for skilled surgeons to achieve minimal blood loss volume without significantly increasing operation duration when performing DRT, which does not raise risk. In terms of anti-reflux, postoperative QoL and BMI maintenance, 1-year postoperative follow-up outcomes reveal the DTR is superior to EG, which deserve further research and promotion.

Keywords Laparoscopic proximal gastrectomy, Esophagogastrostomy, Double-tract reconstruction, Short-term outcome, Quality of life

Introduction

According to the latest statistical data of GLOBOCAN, gastric cancer is the fifth most common cancer and the fourth most common cause of death worldwide [1]. China has the greatest incidence rate of gastric cancer, with more than 40% of new cases identified globally [2]. The incidence of early gastric cancer (EGC), which includes upper-third gastric adenocarcinoma and esophagogastric junction adenocarcinoma, has been on the rise in recent years [3, 4]. Proximal gastrectomy (PG), which is one of the function-preserving procedures, has gained extensive attention [3, 5]. Base on the Japanese Gastric Cancer Treatment Guidelines 2021 (6th edition), PG is suggested for proximal gastric cancer with clinical stage of cT1N0 in order to preserve more than half of the distal stomach [6]. The remnant stomach's volume can be preserved by PG, and it can also maintain physiological processes such as intrinsic factor secretion. These benefits can reduce the incidence of postoperative body weight loss and anemia compared to total gastrectomy (TG) [7, 8]. However, the postoperative complications caused by PG, particularly the reflux esophagitis and anastomotic stricture, may seriously impair postoperative QoL because of the damage to the lower esophageal sphincter and the angle of His.

EG is the conventional and most widely performed reconstructive technique after proximal gastrectomy [9], The primary shortcomings of EG may be the high incidence of reflux esophagitis. It has been reported that the incidence of reflux esophagitis after EG varies between 9.1% and 35.3% [10, 11]. Conversely, several studies have reported that DTR may reduce the incidence of reflux esophagitis following proximal gastrectomy [12–14]. However, DTR is more complicated than esophagogastrostomy. On the other hand, whether the QoL and nutritional condition of patients after DTR are better than those of EG is still controversial. Therefore, the purpose of the present study is to compare the early surgical outcomes and QoL between DTR and EG after LPG.

Patients and methods

Inclusion and exclusion criteria

We screened 720 patients who were diagnosed with gastric cancer at our hospital from June 2019 to May 2023. Patients undergoing laparoscopic radical proximal gastrectomy with EG or DTR were included in the present study. All patients were diagnosed with upper-third gastric adenocarcinoma at an early stage or adenocarcinoma of the esophagogastric junction with a tumor size less than 4 cm. Patients were excluded if they had (a) preoperative chemoradiation therapy, (b) open gastrectomy, (c) other malignancies, (d) distant metastasis, (e) combined resection of other organs. The flowchart of the patients' selection is shown in Fig. 1. As a result, 156 patients were eligible for inclusion in the present study. Enhong Zhao, an experienced surgeon with over 20 years of clinical practice and more than 1000 gastrectomy cases—both open and laparoscopic—performed the procedures on all of the patients.

Treatment strategy

The multidisciplinary team (MDT) was in charge of deciding on the treatment strategies. Patients and surgeons discussed and decided on the type of digestive reconstruction after LPG. After learning of DTR's advantages, patients with early-stage disease were more likely to select it. Furthermore, as DTR necessitates more staplers and increases the cost load, a patient's socioeconomic level plays a significant role in determining the reconstruction method they choose. The surgeon made a decision based on the actual surgical conditions if the patient was unable to decide on the reconstruction approach.

While several anti-reflux techniques are currently available to prevent postoperative reflux esophagitis in patients undergoing EG, no anti-reflux procedure was carried out during the EG surgery at our facility. We observed the percentage of postoperative reflux esophagitis could drop after a modified esophagogastrostomy, such as SOFY, mSOFY or fundoplication [10, 15, 16]. Surgery applications are limited, nevertheless, because in clinical practice these procedures necessitate the preservation of a substantial remnant stomach and the

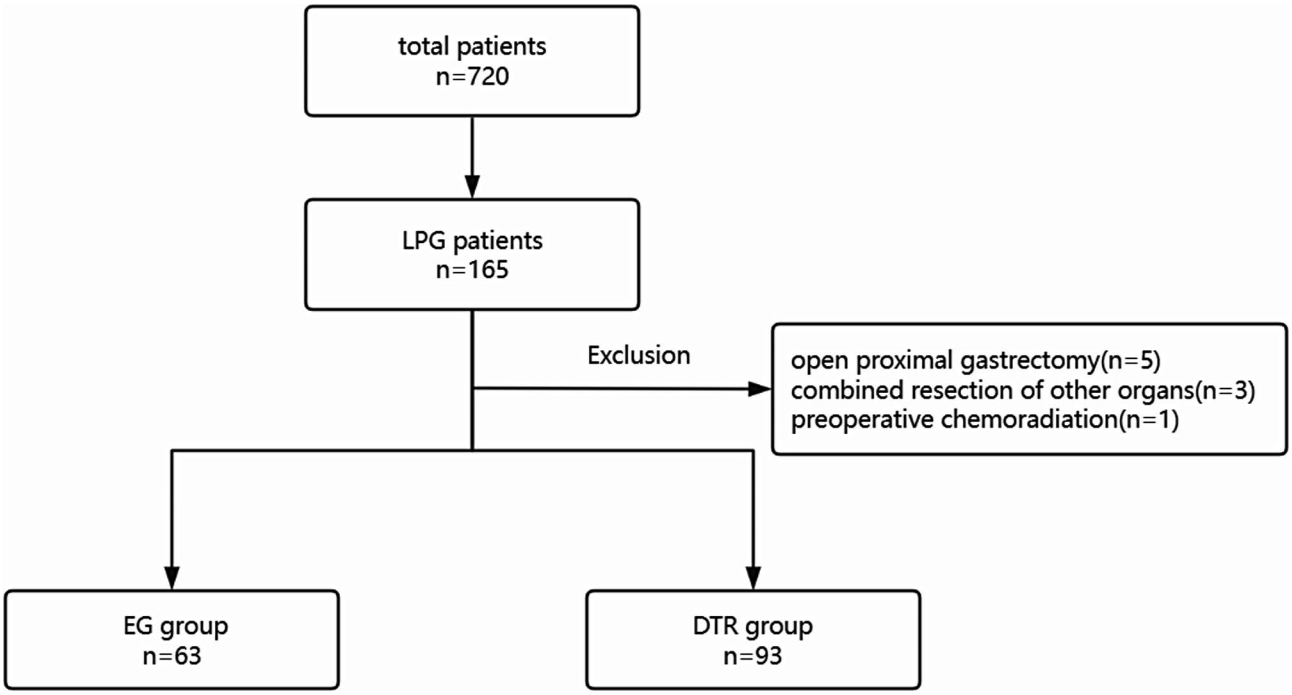

Fig. 1 Flowchart showing patient enrollment

abdominal esophagus. EG with double-flap technique (DFT) had the lowest incidence of reflux esophagitis [16]. On the other hand, this method is highly time-consuming and technically demanding. Multiple gastrointestinal surgeons are still hesitant to undertake this procedure. Another reason why we did not add anti-reflux procedure is because EG is a well-established procedure in our institution. The efficacy of the patient's quality of life is still acceptable, based on a strict understanding of the important elements of surgery, otherwise we would abandon this reconstruction method. In additional, this type of anastomosis requires less surgical instruments, such as staplers, making it incredibly affordable and a common choice among low-income patients. Consequently, EG without anti-reflux procedure is still in use in our hospital nowadays.

Surgical procedure

All patients enrolled in our study underwent LPG with D1+lymph node dissection (No. 1, 2, 3a, 4sa, 4sb, 7, 8a, 9 and 11p) following Japanese Gastric Cancer Treatment Guidelines 2021 (6th edition) [6]. The LPG procedures were performed with five abdominal trocar sites, including one 12 mm trocar below the umbilicus for the camera and additional four trocars for working ports. EG reconstruction was performed by an end-to-side anastomosis using a circular stapler between the esophagus and remnant stomach. The anastomosis was located on the anterior wall of the remnant stomach. To prevent anastomotic leakage, the anastomosis was routinely reinforced with intermittent sutures, and there was no anti-reflux procedure was carried out. Concerning the DTR, the jejunum 25 cm below the Treitz ligament was transected, distal limb of the jejunum was elevated to prepare the esophagojejunostomy. An end-to-side esophagojejunostomy was performed with a circular stapler, and the jejunal stump was closed with a linear stapler. After that, a side-to-side gastrojejunostomy was performed 15 cm distal to the esophagojejunostomy (with a linear stapler). Lastly, a side-to-side jejunojejunostomy was executed 15–20 cm below the gastrojejunostomy (with a linear stapler, too). None of the anastomoses were reinforced with intermittent sutures.

Data collection and outcome assessment

Demographic information was collected from all the qualified patients, including age, gender, body mass index (BMI), physical status according to the American Society of Anesthesiology (ASA), tumor location and pathological and clinical stage and pathological characteristics, according to the 8th edition of the International Union Against Cancer (UICC) TNM classification [17].

Surgery-related indices were collected, including operation duration, blood loss volume, number of retrieved LNs, and postoperative hospital stay, postoperative pathological data and outcomes, 30-day reoperation rate, and 30-day mortality rate. Postoperative complications were defined as issues that patients suffered during the hospital stay following surgery, including anastomotic leakage, fever, pulmonary infection, hemorrhage, gastric

emptying disorder etc. These problems were categorized using the Clavien-Dindo classification system [18].

Follow-up

Patients' QoL was evaluated by the validated Chinese Mandarin edition of the EORTC QLQ-C30 ver. 3.0 questionnaire, EORTC QLQ-STO22 questionnaire and Visick grading [19–22]. The follow-up assessments were conducted through telephone interviews or outpatient examination at 12 months after the operation. The Visick grade and nutritional parameters including BMI, hemoglobin (Hb) and serum albumin (ALb) were recorded, the patients were also invited to complete these two questionnaires. The last follow-up date was 2024.4.30.

Statistical analysis

All continuous variables were presented as mean with standard deviation (SD) and the Student's t test or Mann-Whitney U test were used to compare them. All categorical variables were presented as frequency and percentage and chi-square test or Fisher's exact test was used to compare them. Simple and multiple linear regression analyses were conducted in order to identify possible effects on the blood loss volume, operation duration and global health status score on the EORTC QLQ-C30 questionnaire. The risk factors for reflux esophagitis were identified using the univariate and multivariate logistic regression analysis. When the p-value is less than 0.05, statistical significance was considered. All statistical analyses were performed using SPSS Statistics 25 (IBM, Armonk, NY, USA).

Results

Clinical and pathological characteristics

Altogether, 156 patients were included in this study. 63 patients underwent EG reconstruction and 93 patients underwent DTR. Age, gender, BMI, ASA score, tumor location, differentiation, number of retrieved LNs were comparable between the two groups (Table 1). The proportion of patients with pT4 stage was higher in the EG group than in the DTR group (p=0.018). The tumor

Table 1 Clinicopathological characteristics between the EG and DTR group

Variables	EG (n=63)	DTR (n=93)	*P* value
Age	61.70 ± 8.306	63.16 ± 9.752	0.331
Gender			0.466
Male	47(74.6%)	74(79.6%)	
Female	16(25.4%)	19(20.4%)	
BMI	23.20 ± 3.399	23.08 ± 3.645	0.807
ASA-PS			0.199
II	48(76.2%)	59(63.4%)	
III	15(23.8%)	33(35.5%)	
IV	0	1(1.1%)	
Tumor location			0.417
AEG	40(63.5%)	53(57.0%)	
Upper third of the stomach	23(36.5%)	40(43.0%)	
Tumor size	3.825	3.349	0.012
Differentiation			0.830
Well	5(7.9%)	6(6.5%)	
Moderate	39(61.9%)	55(59.1%)	
Poor	19(30.2%)	32(34.4%)	
pT stage			0.018
T1	2(3.2%)	6(6.5%)	
T2	18(28.6%)	36(38.7%)	
T3	26(41.3%)	43(46.2%)	
T4	17(27.0%)	8(8.6%)	
Number of retrieved LNs	16.81	18.10	0.127
pN stage			0.905
N0	27(42.9%)	36(38.7%)	
N1	7(11.1%)	12(12.9%)	
N2	15(23.8%)	26(28.0%)	
N3	14(22.2%)	19(20.4%)	

ASA-PS The American Society of Anesthesiology Physical Status Classification

TNM staging was based on the recent 8th edition of the AJCC Cancer Staging Manual

Table 2 perioperative parameters of the patients the EG and DTR group

Variable	EG ($n=63$)	DTR ($n=93$)	*P* value
Operation duration (min)	174.06	166.38	0.122
Blood loss volume (mL)	150.16	113.23	0.001
Postoperative hospital stay (day)	13.11	13.83	0.205
Overall complication(n, %)[a]	10(15.9%)	16(17.2%)	0.827
Grade I or II(n, %)[a]	5(7.9%)	11(11.8%)	0.432
Pulmonary infection	1(1.6%)	5(5.4%)	
fever	0	2(2.2%)	
Intestinal obstruction	1(1.6%)	2(2.2%)	
Wound infection	0	2(2.2%)	
Delayed gastric emptying	1(1.6%)	0	
Anastomosis stenosis	2(3.2%)	0	
Grade III or IV(n, %)[a]	5(7.9%)	5(5.4%)	0.522
Anastomosis leakage	5(7.9%)	4(4.3%)	
Anastomosis bleeding	0	1(1.1%)	

[a] Clavien-Dindo's classification of surgical complication

Table 3 Simple linear regression analysis of operation duration

Simple analysis			
Variable	**P value**	**Variable**	**P value**
Age	0.205	Tumor location	0.013*
Gender	0.176	pT stage	0.130
BMI	0.163	pN stage	0.830
ASA-PS	0.714	Number of LNs	0.587
Differentiation	0.879	Tumor size	0.594
Tumor size	0.594	Different group	0.122

ASA-PS The American Society of Anesthesiology Physical Status Classification. *$p<0.05$

size was smaller in the DTR group than in the EG group ($p=0.012$).

Perioperative parameters

All patients in two groups underwent R0 resection, no deaths occurred during the perioperative period. As shown in Table 2, the EG group had a more blood loss volume($P=0.001$), compared with the DTR group. There were no significant differences in operation duration, number of LNs and postoperative hospital stay ($p>0.05$). In the DTR group, there were 16 cases of complications including 5 pulmonary infection, 2 intestinal obstruction, 2 wound infections, 2 fever, 4 anastomosis leakage and 1 anastomosis bleeding. In the EG group, there were 10 cases including 1 pulmonary infection, 1 gastric emptying disorder, 1 bowel obstruction, 2 anastomosis stricture and 5 anastomosis leakage. The incidence of short-term complication was 15.9% and 17.2% in EG and DTR groups, respectively ($p>0.05$). Besides, no significant difference was observed in terms of mild (grades I and II) and severe (grades III and IV) complications between groups.

A univariate analysis was carried out to identify the risk factors for the operation duration and blood loss volume (Tables 3 and 4). The multiple linear regression analysis included all variables with a p-value of less than 0.1. Ultimately, the findings demonstrated that the only independent risk factor for the operation duration was tumor location($p=0.013$) (Table 3), and the reconstruction method was the only independent risk factor for the blood loss volume ($p<0.001$) (Table 4).

Reflux esophagitis

After 12 months of follow-up, all patients in the two groups survived. The Visick score showed that 60 cases (64.5%) in DTR group ($n=93$) had Visick grade I, 25 cases (26.9%) with Visick grade II, and 8 cases (8.6%) with Visick grade III. In the EG group ($n=63$), there were 14 cases

Table 4 Simple and multiple linear regression analyses of blood loss volume

Simple analysis				Multiple analysis	
Variable	**P value**	**Variable**	**P value**	**Variable**	**P value**
Age	0.561	Tumor location	0.037*	Different group	<0.001*
Gender	0.318	pT stage	0.135	Tumor location	0.053
BMI	0.522	pN stage	0.223		
ASA-PS	0.920	Number of LNs	0.587		
Differentiation	0.693	Tumor size	0.641		
Tumor size	0.641	Different group	0.001*		

ASA-PS The American Society of Anesthesiology Physical Status Classification. *$p<0.05$

Table 5 Univariate analysis and multivariate logistic regression analysis of reflux esophagitis

Univariate analysis		Multivariate analysis		
Variable	**P value**	**Variable**	**OR(95%CI)**	**P value**
Age	0.029*	Different group		
Gender	0.783	EG	1	<0.001*
BMI	0.837	DTR	0.079(0.008 ~ 0.647)	
ASA-PS	0.040*	Age		0.173
Tumor size	0.110	ASA-PA		0.281
Tumor location	0.037*	Tumor location		0.110
Differentiation	0.590			
pT stage	0.196			
pN stage	0.360			
Operation duration	0.432			
Blood loss volume	0.173			
Number of retrieved LNs	0.118			
Postoperative complication	0.791			
Postoperative hospital stay	0.465			
Different group	0.001*			

ASA-PS The American Society of Anesthesiology Physical Status Classification. *$p<0.05$

Table 6 The scores of EORTCQLQ-C30 questionnaire and EORTCQLQ-STO22 questionnaire

Scale	EG($n=63$)	DT($n=93$)	P-value
EORTC QLQ-C30			
Global health status	50(50,58.3)	83.3(75.0,83.3)	<0.001
Functional scales			
Physical functioning	80.0(66.7,93.3)	86.7(86.7,93.3)	0.280
Role functioning	66.7(66.7,100)	83.3(66.7,100)	0.484
Emotional functioning	70.8(58.3,75)	70.8(66.7,75)	0.616
Cognitive functioning	100(83.3,100)	100(100,100)	0.461
Social functioning	66.7(50,83.3)	66.7(66.7,83.3)	0.300
Symptom scales			
Fatigue	33.3(33.3, 33.3)	22.2(22.2, 33.3)	0.473
Nausea and vomiting	66.7(66.7,66.7)	25(16.7,33.3)	0.033
Pain	16.7(16.7,33.3)	16.7(0,33.3)	0.299
Dyspnea	0.0(0.0,33.3)	33.3(0.0,33.3)	0.532
Insomnia	33.3(0.0,33.3)	0.0(0.0,0.0)	0.075
Appetite loss	66.7(66.7,100)	33.3(33.3,33.3)	0.022
Constipation	16.7(0.0,33.3)	0.0(0.0,33.3)	0.575
Diarrhea	0.0(0.0,33.3)	33.3(0.0,33.3)	0.269
Financial difficulties	33.3(0.0,33.3)	33.3(0.0,33.3)	0.638
EORTC QLQ-STO22			
Dysphagia	16.7(0-33.1)	27.8 (11.1–33.1)	0.214
Pain	8.33(0-16.6)	8.33 (8.33–16.6)	0.737
Reflux	48.9 (27.8–66.6)	11.1 (5.55–27.8)	0.030
Eating	25.0 (16.1–66.7)	29.1 (16.1–33.3)	0.884
Anxiety	27.8 (22.2–44.4)	22.2 (22.2–33.3)	0.615
Dry mouth	0 (0-33.3)	16.7 (0.0-33.3)	0.661
Taste	33.3 (0.0-33.3)	33.3 (0.0-33.3)	0.317
Body image	0.0 (0.0–0.0)	0.0 (0.0–0.0)	1.000
Hair loss	0.0 (0.0-33.3)	0.0 (0.0–0.0)	0.494

(22.2%) with Visick class I, 31 cases (49.2%) with Visick class II., and 18 cases (28.6%) with Visick class III. The Visick grade in the DTR group was better than that in the EG group, and the difference was statistically significant ($p<0.05$).

A univariate analysis was conducted to investigate the risk factors for postoperative reflux esophagitis (Table 5). The multivariable logistic regression analysis then included every factor with a p-value less than 0.1. In the end, it was discovered that the only independent risk factor for reflux esophagitis was the reconstruction method($P<0.001$) (Table 5).

Quality of life

The EORTCQLQ-C30 questionnaire survey 1 year after surgery (Table 6) showed that compared with the EG group, the patients in the DTR group had better overall health and fewer symptoms of nausea, vomiting and loss of appetite ($P<0.05$). The EORTCQLQ-STO22 questionnaire (Table 6) showed that compared with the EG group, patients in the DTR group complained less about reflux ($P<0.05$), there were no significant differences in swallowing symptoms, pain, food restriction, anxiety, dry mouth, taste changes, body image, and hair loss ($P>0.05$).

Age ($p=0.006$), reflux esophagitis ($p=0.044$), blood loss volume ($p=0.007$), and reconstruction method ($p=0.001$) were all correlated with global health status in the simple linear regression analysis (Table 7). All variables with a p-value less than 0.1 were included in the multiple linear regression analysis. It was found that there was a linear relationship between the global health status score and reconstruction method($p<0.001$), reflux esophagitis($p=0.044$), and age ($p<0.001$), (Table 7).

Table 7 Simple and multiple linear regression analyses of global health status

Simple analysis				Multiple analysis	
Variable	**P value**	**Variable**	**P value**	**Variable**	**P value**
Age	0.006*	Tumor location	0.222	Different group	<0.001*
Gender	0.328	pT stage	0.059	Reflux esophagitis	0.044*
BMI	0.824	pN stage	0.317	Age	<0.001*
ASA-PS	0.855	Number of LNs	0.122	Blood loss volume	0.674
Differentiation	0.708	Postoperative complication	0.594		
Tumor size	0.120	hospital stay	0.534		
Operation duration	0.280	Reflux esophagitis	0.044*		
Blood loss volume	0.007*	Different group	0.001*		

ASA-PS The American Society of Anesthesiology Physical Status Classification.
*$p<0.05$

Table 8 Comparison of postoperative change in BMI, Hb and Alb

category	EG($n=63$)	DTR($n=93$)	*P*-value
BMI before surgery	23.20 ± 3.399	23.08 ± 3.645	0.827
BMI 1 year after surgery	21.39 ± 3.251	21.69 ± 3.623	0.578
Difference of BMI	1.81 ± 0.759	1.40 ± 0.655	0.010*
Alb before surgery	40.62 ± 3.178	40.20 ± 3.264	0.443
Alb 1 year after surgery	38.44 ± 2.875	38.23 ± 3.742	0.648
Difference of Alb	2.15 ± 2.064	1.97 ± 3.175	0.735
Hb before surgery	128.13 ± 20.037	132.28 ± 19.20	0.489
Hb 1 year after surgery	121.98 ± 9.986	125.32 ± 10.426	0.062
Difference of Hb	6.58 ± 15.124	5.47 ± 13.915	0.764

*$p<0.05$

Nutritional status

Table 8 showed the comparison of postoperative change in BMI, hemoglobin and albumin. There is no statistical difference between the two groups in terms of Hb and ALb. Regarding postoperative BMI, the DTR group had a lesser 1-year BMI decline compared to the EG group ($P=0.010$).

Discussion

PG has the advantage over total gastrectomy (TG) in that it preserves the physiologic function of the remnant stomach, improving postoperative nutritional condition [8, 10, 13, 23, 24]. The reconstruction methods after PG include esophagogastric anastomosis and esophagojujenal anastomosis. EG is a traditional reconstruction method after proximal gastrectomy with technical simplicity and safety benefits. However, esophagogastrostomy is related to a high incidence of postoperative reflux esophagitis [16]. While DTR, a form of esophagojujenal anastomosis, has been regarded an effective reconstructive procedure for reflux prevention [14, 25]. However, whether patients' QoL following DTR are superior to those of esophagogastric anastomosis is still controversial; in fact, some studies have produced wildly divergent findings [14, 26].

In the present study, we retrospectively investigated the clinical information of multiple patients with AEG and upper-third gastric adenocarcinoma. Compared to EG group, the DTR group experienced a lower volume of blood loss($P=0.001$). Nevertheless, there was no significant difference in the operation duration, which was inconsistent with previous studies. Most studies showed that the DTR procedure is more complex than the esophagogastrostomy technique, it makes sense that the operation duration of DTR was longer than that of EG [14]. However, the advantage of shorter operation duration was not observed in our study. We believe the following factors could be the reason for the shorter surgery time shown in the DRT group. While our experience with LPD has grown substantially, the size or depth of the tumor does not greatly increase the complexity of the surgery without resulting in a major increase in the duration of the procedure. On the other hand, the use of linear staplers in the DTR group can simplify the process and reduce the duration of the operation. This is because the circular stapler method is relatively cumbersome, which may prolong the anastomosis period [27]. Additionally, in the EG group, the anastomosis was routinely reinforced with intermittent sutures after completing esophagogastrostomy in our institution. The deep esophagogastric anastomosis makes reinforcing extremely difficult and increases the risk of bleeding, which might extend the whole surgical duration. While in the DTR group, none of the anastomoses were reinforced, which can shorten the operation time to some certain extent. The findings suggest that it is possible for skilled surgeons to achieve minimal blood loss volume without significantly increasing the operation time, in spite of the DTR procedure being more complicated than the esophagogastrostomy.

The incidence of perioperative complications is an important factor in evaluating safety of surgery. In this study, no deaths occurred during the perioperative period. The overall complication rates of EG and DTR in this study were 15.9% and 16.7%, respectively. In comparison to previous studies, the morbidity rates, which varied from 4.8–52.6% [28–31], were acceptable. the overall complications rate of the two groups did not differ significantly. The occurrence rates of anastomotic leak (7.9%vs.4.3%) and gastric emptying disorder (1.6%vs.0%) were more common in the EG group than in the DTR group, yet there was no statistically significant difference in their incidence rates. Also, It is important to note that the occurrence rates of pulmonary infection were 5.4% in DTR group and 1.6% in EG group ($P>0.05$). There were

five patients experienced pulmonary infection in the DTR group. we reviewed their past histories and found that two of the five cases of pneumonia were elderly males with a history of heavy smoking, and the other three were middle-aged women with moderate-to-severe chronic obstructive pulmonary disease (COPD). All of them have a high chance of developing pneumonia. Additionally, the postoperative hospital stay was comparable. In the current study, postoperative complications and length of postoperative hospital stay were both similar between the two reconstruction methods. These results revealed that the complexity of DTR did not increase the risk of the procedure.

In terms of the postoperative quality of life, the DTR group's Visick grade was better than the EG group's ($P=0.040$) one year later. The DTR group used significantly less proton pump inhibitor (PPI) than the EG group did. In the DTR group, few patients needed PPI postoperatively. To alleviate their reflux symptoms, more individuals in the EG group required long-term use of PPI. The results showed that the DTR was better in avoiding the occurrence of postoperative reflux. Moreover, our findings revealed that the DTR group had a lower BMI decrease value than the EG group($P=0.010$), attributed to the relatively serious postoperative reflux symptoms suffered by patients with EG, which influenced their diet and required long-term use of PPI.

The DTR group outperformed the EG group in the current study. In accordance with the EORTC scoring guideline, a higher score represented a greater degree of functioning, or a worse level of symptoms [20]. Based on the EORTC QLQ-C30 questionnaire, patients in the DTR group complained less of nausea and vomiting($P=0.033$) as well as appetite loss($P=0.022$), and their overall health status was improved ($P=0.001$) (Table 6). Patients in the DTR group had fewer reflux complaints ($P=0.03$) on the EORTC QLQ-STO22 questionnaire; still there were no significant differences in symptoms related to swallowing, discomfort, food restriction, anxiety, dry mouth, taste alterations, body image, or hair loss. (Table 6).

There are limitations that should be noted. First, this is a retrospective single-center study, selective bias was hard to avoid. The T stage and tumor's size of the two groups were not equivalent, which led to differences in the clinical stages. This phenomenon was mainly caused by the different options of the patients. In our facility, patients and doctors collaborated to decide on the reconstruction method. After learning about double-tract reconstruction's superiority, younger patients with early-stage disease were more inclined to select it because they might be more concerned with their quality of life after the operation. Additionally, low-income patients tended to choose EG approach to decrease the financial burden. Therefore, the bias could be a result of the shared decision-making method. Multiple linear regression analysis and multivariable logistic regression analysis, nevertheless, could be able to neutralize these factors' confounding effects. Second, the current study's sample size was insufficient, which could lessen the validity of its findings. Third, the patients' nutritional condition may not have been fully understood due to the lack of comprehensiveness of the nutrition indicators used. Lastly, the present study included only short-term outcomes, with no long-term follow-up data.

In summary, double-tract reconstruction has more advantages than esophagogastric anastomosis in terms of anti-reflux, postoperative BMI maintenance and QoL, which deserves further research and promotion. This procedure is predicted to become the preferred technique for gastrointestinal reconstruction after proximal gastrectomy at this moment.

Abbreviations

PG	Proximal gastrectomy
TG	Total gastrectomy
EGC	Early gastric cancer
LPG	Laparoscopic proximal gastrectomy
EG	Esophagogastrostomy
DTR	Double-tract reconstruction
MDT	Multidisciplinary team
DFT	Double-flap technique
QoL	Quality of life
ASA	American Society of Anesthesiology
BMI	Body mass index
LNs	Lymph nodes
EORTC	European Organization for Research and Treatment of Cancer
PPI	Pronton pump inhibitor

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Author contributions
Y Sun contributed to the study design and drafted the manuscript. Y Sun and L Hou contributed to the data analysis. Y Sun and C Chen contributed to the data collection and extraction. E Zhao revised the manuscript. All authors have read and approved the final manuscript.

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Data availability
The data that support the findings of this study are available on request from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate
The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the Ethics Committee of Affiliated Hospital of Chengde Medical University (CYFYLL2023544) and informed consent was taken from all the patients.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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