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Comparisons of Postoperative Complications and Nutritional Status After Proximal Laparoscopic Gastrectomy with Esophagogastrostomy and Double-Tract Reconstruction

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ABSTRACT

Background The purpose of this study was to compare postoperative complications and nutritional status between esophagogastrostomy and double-tract reconstruction in patients who underwent laparoscopic proximal gastrectomy, and assess the advantages of both surgical procedures.

Methods Between 2010 and 2018, 47 cases underwent proximal gastrectomy with esophagogastrostomy (n = 23) or double-tract reconstruction (n = 24) at our institution for the treatment of clinical T1N0 adenocarcinoma located in the upper third of the stomach. Patient clinical characteristics, short-term outcomes, nutrition status, and skeletal muscle index were compared among the two groups.

Results There was no significant difference between esophagogastrostomy and double-tract reconstruction in terms of operation time, blood loss, and length of postoperative hospital stay. Reflux symptoms and anastomotic stenosis were significantly higher in the esophagogastrostomy group compared with the double-tract reconstruction group ($P < 0.001$ and $P = 0.004$, respectively). There was no significant difference in anastomotic leakage, surgical site infection, and pancreatic fistula. For the nutritional status, the decrease rate of cholinesterase was significantly higher in the esophagogastrostomy group compared with the double-tract reconstruction group at 6 months ($P = 0.008$) There was no significant difference in the decrease rate of skeletal muscle mass index at 1 year after surgery.

Conclusion Compared with esophagogastrostomy, double-tract reconstruction tends to have better short-term nutritional status and postoperative outcomes in terms of preventing the occurrence of gastroesophageal reflux and anastomosis stenosis. These findings suggest that double-tract reconstruction may be a useful method in laparoscopic proximal gastrectomy.

Key words esophagogastrostomy; gastric cancer; laparoscopic proximal gastrectomy

In recent years, the incidence of gastric cancer in the upper third of the stomach has steadily increased worldwide.[1] Proximal gastrectomy (PG) and total gastrectomy (TG) are surgical procedures performed for the treatment of early gastric cancer in the upper third of the stomach. In patients with early gastric cancer, these two procedures are associated with similar overall survival.[2, 3] According to the Japanese guidelines for the treatment of gastric cancer, PG is weakly recommended for cT1N0 tumors in the upper third of the stomach.[4] However, previous studies suggested that PG is superior to TG in the postoperative nutrient status.[5–8] Some studies reported equal lengths of hospital stay,[9, 10] while others suggested shorter stays with PG versus TG.[5–7] There are several reconstruction methods, such as esophagogastrostomy (EG), jejunal interposition (JIP), and double-tract (DT) reconstruction following PG.[11] EG is a simple and easy reconstruction method; however, this procedure often leads to severe reflux esophagitis. Some studies reported that JIP and DT reconstruction are advantageous with regard to the prevention of reflux esophagitis.[12, 13] However, the difference in nutritional status and skeletal muscle mass index (SMI) between reconstructive methods in PG has not been clarified. Hence, the type of operative reconstruction which is most effective after PG remains controversial.

In this study, we compared postoperative complications and the nutritional status between EG and DT in patients who underwent laparoscopic PG and assessed the advantages of both surgical procedures.

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Abbreviations: ALB, alubmin; ASA-PS, American society of anesthesiologists physical status classification; BMI, body mass index; DM, diabetes mellitus; DT, double tract; EG, esophagogastrostomy; HB, hemoglobin; HT, hypertension; PG, proximal gastrectomy; PNI, prognostic nutritional index; SMI, skeletal muscle mass index; TG, total gastrectomy; TLC, total lymphocyte count

SUBJECTS AND METHODS

Patients

Between 2010 and 2018, a total of 64 patients who underwent PG were admitted to the Department of Gastrointestinal Surgery, Tottori University Hospital (Tottori, Japan). The inclusion criteria for this retrospective study were as follows: histologically confirmed adenocarcinoma of the stomach; preoperative diagnosis of clinical T1N0 adenocarcinoma located in the upper third of the stomach without distant metastasis; and laparoscopic gastrectomy. Patients who underwent surgery for remnant gastric cancer or diseases other than gastric cancer were excluded from this study. The clinicopathological features of these patients were reviewed retrospectively using hospital records. In a previous study at our hospital, Roux-en-Y reconstruction in total gastrectomy had fewer stenosis and reflux symptoms than EG in PG. We expect that DT will have fewer complications than EG, and since 2014 DT has been the first choice for reconstruction of PG at our hospital. Before 2014, EG was the first choice of reconstruction in PG. Finally, 23 and 24 patients who underwent PG with EG and DT reconstruction, respectively, were enrolled in this study. The clinical characteristics and postoperative nutritional status were compared between the EG and DT groups. The clinicopathological findings were determined according to the Japanese Classification of Gastric Carcinoma.[14]

Surgical procedure

The extent of systemic lymph node dissection was determined according to the Japanese Classification of Gastric Carcinoma,[4] and all the cases underwent D1 + lymph node dissection. All PG procedures were performed by one of the five experienced surgeons who were board-certified as "qualified surgeons" by the Japanese Society for Endoscopic Surgery.

Reconstruction for PG with EG using OrVil

EG was performed using the OrVil technique (Covidien Japan Co., Ltd., Tokyo, Japan). An anesthesiologist orally inserted OrVil into the stump of the esophagus, and a surgeon made a hole in the stump of the esophagus and removed the OrVil. Following incision of the anterior wall of the antrum of the stomach in the long axis direction, a 25-mm diameter circular stapler was inserted into the stomach. The anvil tip trocar was removed from the stomach at a 2.5-cm distance from the cut end of the stomach and lesser gastric curvature. Subsequently, dock with OrVil and circular stapler to anastomoses. The hole used to insert the circular stapler was closed with a linear stapler in the short axis direction of the stomach.

All EGs were performed with fundoplication as follows to prevent reflux esophagitis. The greater curvature of the gastric dissection end was wrapped halfway around the abdominal esophagus through the posterior surface of the EG, and sutured to the median arcuate ligament.

DT reconstruction for PG

The jejunum was cut at 20 cm from the ligament of Treitz using a linear stapler, and the anal-side jejunum and oral-side jejunum were anastomosed side to side at 40 cm from the stump.

The esophagojejunostomy was performed through the overlap method using a linear stapler. A small hole was opened at the jejunum 13 cm caudal from the esophagojejunostomy and the anterior wall of the major curvature 2 cm from the stump of the remnant distal stomach. Subsequently, a linear stapler was inserted 5 cm into the stomach and toward the oral-side jejunum anastomosis. The entry hole was closed with a linear stapler.

Follow-up

We conducted a follow-up examination in all cases at 1 month after surgery and every 3 months until 2 years postsurgery. From year 3 after surgery, follow-up examination was conducted every 6 months. Blood testing was conducted at all outpatient visits. As postoperative surveillance, we performed a computerized tomography and an esophagogastroduodenoscopy (EGD) once annually. For cases followed up at other hospitals, a survival survey was conducted using a questionnaire. Follow-up was completed after 5 years without recurrence, and a survival survey was conducted with a questionnaire. Diagnosis of reflux symptoms and stenosis was made by subjective symptoms during hospitalization, and by outpatient hearing or annual EGD findings after discharge. All patients with anastomotic stenosis underwent balloon dilatation, and with reflux symptoms were prescribed PPI.

Postoperative complications and nutritional outcomes

Clinical features [age, sex, height, weight, tumor size, comorbidities, Charlson comorbidity index (CCI), American Society of Anesthesiologists physical status (ASA-PS)], body mass index, albumin (ALB), hemoglobin (HB), total lymphocyte count (TLC), cholinesterase (CHE), SMI, and prognostic nutritional index (PNI) of the patients were analyzed based on information retrospectively collected in gastric cancer databases in our hospital. The CCI was developed to

Table 1. Patient characteristics

	EG (n = 23)	DT (n = 24)	P-value
Age (years)†	65 (30–86)	73.5 (55–87)	0.082
Sex (Male/ Female)	15 (65.2%)/ 8 (34.8%)	17 (70.8%)/ 7 (29.2%)	0.680
Height (cm)†	162.5 (132.8–174.6)	162.4 (135.0–174.7)	0.958
Weight (kg)†	59.5 (43.2–89.5)	62.2 (44.8–81.0)	0.890
Body mass index (kg/m^2)†	23.0 (17.8–34.8)	23.3 (18.3–34.5)	0.702
Serum albumin (g/dL)†	4.4 (3.8–4.9)	4.05 (3.5–4.7)	0.004**
Serum hemoglobin (mg/dL)†	13.2 (9.7–14.9)	12.6 (8.6–14.8)	0.157
Skeletal muscle mass index (cm^2/m^2)†	42.9 (32.3–68.2)	47.3 (30.3–58.5)	0.196
Prognostic nutritional index†	52.5 (41.5–61.5)	48.5 (44.5–61.0)	0.01*
Hypertention	9 (39.1%)	4 (16.7%)	0.085
Diabetes mellitus	4 (17.4%)	5 (20.8%)	1.000
Tumor size (mm)†	20.0 (12.0–50.0)	22.5 (8.0–55.0)	0.709
pathological T (1/ 2)	22 (95.7%)/ 1 (4.3%)	23 (95.8%)/ 1 (4.2%)	0.976
pathological lymph node metastasis (0/ 1)	22 (95.7%)/ 1 (4.3%)	20 (83.3%)/ 4 (16.7%)	0.176
Charlson comorbidity index ‡	2.35 ± 0.83	2.38 ± 0.71	0.623
ASA-PS (1/ 2/ 3)	7 (30.4%)/ 14 (60.9%)/ 2 (8.7%)	1 (4.2%)/ 15 (62.5%)/ 8 (33.3%)	0.005**

†Values are presented as the median (min–max) or number (%). ‡Values are presented as the mean ± SD. P = 0.05 denoted a statistically significant difference. *P < 0.05, **P < 0.01, ***P < 0.001. ASA-PS, American Society of Anesthesiologists physical status; DT, double-tract reconstruction; EG, esophagogastrostomy.

predict the short-term risk of death for patients based on the complications of chronic illness.[15] The SMI was calculated from the computed tomography image of skeletal muscle mass at the height of the third lumbar vertebrae (L3) lateral protrusion.[16] The PNI equation is, PNI = 10 × Serum ALB (g/dL) + 0.005 × TLC (/μL).[17] The rate of change in ALB, HB, TLC, CHE, SMI, and PNI were evaluated at 6 months and 1 year following surgery compared with the preoperative values.

Statistical analysis

All statistical calculations were performed with the SPSS Statistics (version 25.00.1; International Business Machines Corporation, Armonk, NY) software. The demographic and clinicopathological characteristics were summarized using a descriptive analysis. The Mann–Whitney U test and Pearson's χ^2 test were used to compare continuous and categorical variables, respectively. All values were two-tailed, and P-values < 0.05 denoted statistically significant differences.

Ethical considerations

All procedures were performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments. Written informed consent was obtained from the patient for publication of this article. The institutional review board of our institution approved the study (#18A154).

RESULTS

Patient characteristics

A total of 47 patients with gastric cancer in the upper third of the stomach were included in the study (EG group: 23 patients; DT reconstruction group: 24 patients). The baseline characteristics of the EG and DT reconstruction groups are summarized in Table 1. Preoperative ALB and PNI were significantly higher in the EG group versus the DT reconstruction group (P = 0.004 and P = 0.01, respectively). The ASA-PS class was significantly higher in patients with DT reconstruction than in those with EG (P = 0.005). However, there were no significant differences observed in age, sex, height, weight, body mass index, HB, diabetes mellitus, and Charlson comorbidity index between the two groups. No patients received chemotherapy.

Surgical outcomes

The surgical outcomes of patients undergoing EG and DT reconstruction are detailed in Table 2. There were no significant differences observed in operation time, blood loss, and length of postoperative hospital stay between the two groups (P = 0.733, P = 0.256, and P = 0.709,

Table 2. Surgical outcomes

	EG (n = 23)	DT (n = 24)	P-value
Operation time (min)†	366 (254–683)	355 (247–544)	0.733
Blood loss (mL)†	20 (5–920)	12.5 (5–102)	0.256
Length of hospital stay (day)†	15 (10–44)	14.5 (9–62)	0.709
Reflux symptoms	17 (74.0%)	3 (12.5%)	< 0.001***
Anastomotic leakage	3 (13.0%)	4 (16.7%)	1.000
Anastomotic stenosis	7 (30.4%)	0 (0%)	0.004**
Surgical site infection	4 (17.4%)	1 (4.2%)	0.188
Pancreatic fistula	3 (13.0%)	0 (0%)	0.109
Reoperation	1 (4.3%)	1 (4.2%)	1.000

†Values are presented as medians (min–max) or numbers (%). $P = 0.05$ denoted a statistically significant difference. *$P < 0.05$, **$P < 0.01$, ***$P < 0.001$. DT, double-tract reconstruction; EG, esophagogastrostomy.

Table 3. Comparison of postoperative change rate in nutritional status between groups (reconstruction method)

	EG (n = 23)	DT (n = 24)	P-value
Total lymphocyte count 6M	0.83 ± 18.25%	8.84 ± 37.63%	0.813
Total lymphocyte count 1Y	21.15 ± 73.07%	–0.98 ± 25.03%	0.206
Albumin 6M	–4.69 ± 9.44%	–1.01 ± 7.67%	0.238
Albumin 1Y	–1.04 ± 8.77%	–2.45 ± 11.64%	0.606
Hemoglobin 6M	–5.99 ± 9.19%	–3.61 ± 8.08%	0.113
Hemoglobin 1Y	–3.75 ± 8.92%	–1.01 ± 6.56%	0.331
Cholinesterase 6M	–21.77 ± 16.97%	–8.96 ± 15.20%	0.008**
Cholinesterase 1Y	–13.96 ± 12.83%	–4.66 ± 14.97%	0.06
Prognostic nutritional index 6M	–2.72 ± 8.12%	–0.52 ± 9.87%	0.443
Prognostic nutritional index 1Y	–0.14 ± 10.02%	–2.45 ± 10.50%	0.388
Skeletal muscle mass index 1Y	–9.30 ± 10.66%	–9.57 ± 6.71%	0.942

Values are presented as the mean ± SD. $P = 0.05$ denoted a statistically significant difference. *$P < 0.05$, **$P < 0.01$, ***$P < 0.001$. 1Y, 1 year after surgery; 6M, 6 months after surgery; DT, double-tract reconstruction; EG, esophagogastrostomy.

respectively). Reflux symptoms were significantly more prevalent in the EG group versus the DT reconstruction group (74.0% vs. 12.5%, respectively; $P < 0.001$). Anastomotic stenosis was significantly more prevalent in the EG group versus the DT reconstruction group (30.4% vs. 0%, respectively; $P = 0.004$). Anastomotic leakage was similar in the two groups (13.0% vs. 16.7%, respectively; $P = 1.000$). Surgical site infection and pancreatic fistula were not significantly different between the groups (17.4% vs. 4.2%, respectively; $P = 0.188$; and 13.0% vs. 0%, respectively; $P = 0.109$). Two reoperations were performed for one EG (due to delayed anastomotic leakage and strong stenosis) and one DT reconstruction (due to diagnosis of a positive margin); TG was performed in both cases.

Change rate of nutritional status

The change rates of the nutritional status at 6 months and 1 year after surgery compared with the preoperative value are shown in Table 3. In each group, the change rates in ALB, HB, PNI, and SMI were reduced after surgery, and there were no significant differences between the groups. However, at 6 months after surgery, the decrease rate of CHE was significantly higher ($P = 0.008$) in the EG group versus the DT reconstruction group. At 1 year following surgery, this rate tended to be higher in the former group versus the latter group ($P = 0.06$). The decrease rate of ALB and PNI tended to be higher in the EG group versus the DT reconstruction group, without statistical significance. There was no significant difference in the change rate of TLC between the two groups. Next, the change rates of the nutritional

Table 4. Comparison of postoperative change rate in nutritional status between groups (reflux symptoms)

	Group A (n = 27)	Group B (n = 20)	P-value
Total lymphocyte count 6M	6.13 ± 31.29%	4.99 ± 27.17%	0.855
Total lymphocyte count 1Y	–0.40 ± 24.79%	24.71 ± 71.46%	0.344
Albumin 6M	–2.27 ± 7.45%	–3.62 ± 10.16%	0.905
Albumin 1Y	–0.94 ± 7.03%	–3.11 ± 13.00%	0.675
Hemoglobin 6M	–2.78 ± 9.19%	–7.48 ± 7.66%	0.056
Hemoglobin 1Y	–1.00 ± 7.02%	–3.97 ± 8.52%	0.385
Cholinesterase 6M	–10.19 ± 15.24%	–22.68 ± 17.29%	0.011*
Cholinesterase 1Y	–5.22 ± 15.51%	–14.50 ± 11.82%	0.066
Prognostic nutritional index 6M	–0.88 ± 8.51%	–2.16 ± 9.96%	0.618
Prognostic nutritional index 1Y	–0.17 ± 6.41%	–3.47 ± 13.52%	0.860
Skeletal muscle mass index 1Y	–8.57 ± 9.52%	–10.31 ± 8.05%	0.732

Group A had no reflux symptoms and Group B had reflux symptoms. Values are presented as the mean ± SD. $P = 0.05$ denoted a statistically significant difference. *$P < 0.05$, **$P < 0.01$, ***$P < 0.001$. 1Y, 1 year after surgery; 6M, 6 months after surgery.

Table 5. Comparison of postoperative change rate in nutritional status between groups (anastomotic stenosis)

	Group C (n = 40)	Group D (n = 7)	P-value
Total lymphocyte count 6M	5.63 ± 31.32%	1.13 ± 20.12%	1.000
Total lymphocyte count 1Y	10.10 ± 57.74%	6.33 ± 27.85%	0.519
Albumin 6M	–3.03 ± 9.21%	–2.43 ± 6.24%	0.706
Albumin 1Y	–1.91 ± 10.63%	–0.95 ± 8.61%	0.958
Hemoglobin 6M	–4.67 ± 9.26%	–5.82 ± 4.69%	0.550
Hemoglobin 1Y	–2.28 ± 8.21%	–2.78 ± 5.51%	0.720
Cholinesterase 6M	–15.33 ± 18.27%	–19.24 ± 11.28%	0.426
Cholinesterase 1Y	–7.99 ± 15.08%	–16.72 ± 6.70%	0.203
Prognostic nutritional index 6M	–1.31 ± 9.48%	–2.57 ± 7.33%	0.419
Prognostic nutritional index 1Y	–1.35 ± 10.78%	–2.18 ± 7.26%	0.571
Skeletal muscle mass index 1Y	–8.82 ± 8.80%	–13.25 ± 8.12%	0.160

Group C had no anastomotic stenosis. Group D had anastomotic stenosis and underwent balloon dilatation. Values are presented as the mean ± SD. $P = 0.05$ denoted a statistically significant difference. *$P < 0.05$, **$P < 0.01$, ***$P < 0.001$. 1Y, 1 year after surgery; 6M, 6 months after surgery.

status were examined based on the presence or absence of reflux symptoms as shown in Table 4. In the group with reflux symptoms, the rate of decrease in CHE was significantly higher at 6 months after surgery ($P = 0.011$). A similar examination was performed in anastomotic stenosis, but there were no significant differences as shown in Table 5.

DISCUSSION

In this study, reflux symptoms and anastomotic stenosis were significantly higher in the EG group compared with the DT reconstruction group. Regarding the nutritional status, the decrease rate of CHE was significantly higher in the EG group compared with the DT reconstruction group at 6 months and 1 year following surgery. The decrease rate of ALB and PNI at 6 months after surgery tended to be higher in the EG group versus the DT reconstruction group, without statistical significance. There was no significant difference in the decrease rate of SMI at 1 year following surgery.

The superiority of the reconstruction method in PG during the perioperative period is controversial. In previous research comparing DT, JIP, and TG, postoperative weight was significantly retained in patients who

underwent DT and JIP. In addition, intestinal absorption and gastrointestinal hormone secretion were less affected by body position in DT than in JIP.[18, 19] Moreover, a study reported that the number of anastomoses does not affect the occurrence of anastomotic leakage or stenosis.[11] Laparoscopic surgery is preferred to open surgery owing to its short-term advantages.[20, 21] We typically perform EG using OrVil, because a simple reconstruction (such as EG), is preferred for laparoscopy-assisted PG. The use of OrVil facilitates the insertion of anvil even i*n* cases with a short esophageal stump.[22–24] However, EG has been associated with a higher rate of reflux[25] and anastomotic complications[26, 27] compared with other reconstruction methods. These results were consistent with those of the present study. In this study, we performed EG with fundoplication to prevent reflux esophagitis; however, the incidence of reflux esophagitis was high. Sakuramoto et al. reported good clinical outcomes in patients with reconstruction by EG with Toupet-like partial fundoplication.[28] More recently, laparoscopic PG with EG using the double-flap technique has been preferably performed in some institutions.[29–31] This type of anastomosis is reported to rarely cause gastroesophageal reflux. When performing EG in patients with PG, the double-flap technique may prevent gastroesophageal reflux and anastomotic stricture versus the OrVil technique.

The preoperative nutritional status of the patients in this study showed significantly different ALB and PNI. There was no significant difference in age. However, the fact that EG tended to be used in younger patients and the greater number of patients in the lower ASA-PS class versus DT may be related to these characteristics.

The perioperative nutritional status, including sarcopenia and skeletal muscle mass, affects the prognosis of cancer.[32–35] Previous studies have shown that the perioperative SMI was maintained more in patients with PG than in those with TG.[36] However, the difference in SMI between reconstructive methods in PG has not been clarified. In this study, the SMI did not differ significantly between the groups in terms of both the median and change rate. The change rate of the SMI was similar to that previously reported by Sugiyama et al.[36] They retrospectively evaluated 10 patients who underwent laparoscopic PG with DT reconstruction and 20 patients who underwent laparoscopic TG. They reported that the SMI change rate of PG with DT reconstruction was almost identical with that recorded in our results and superior to laparoscopic TG. For the postoperative nutritional status, only the decrease rate of CHE at 6 months after surgery was significantly higher in patients who underwent EG than in those who underwent DT reconstruction. The decrease rate of ALB and PNI at 6 months after surgery tended to be higher in the EG group versus the DT group, without statistical significance. These results indicate that the high complication rate, such as anastomotic stenosis and reflux esophagitis, may be related to poor nutritional status in the EG group. This leads to the conclusion that the short-term nutritional status of DT reconstruction may be superior to that of EG. However, these nutritional factors and SMI did not exhibit differences in the first year after surgery and may be influenced by symptom control, such as oral medication.

This study had several limitations. Firstly, the analysis was based on retrospective data collected at a single institution. Secondly, there were numerous data deficiencies in body weight. Although body weight is a simple index to estimate the nutritional status, it was often measured only in patients who complained of difficulty in oral intake, especially in older patients. Hence, this index was unsuitable for this study. Instead, we evaluated the SMI in this study. Thirdly, the SMI was not evaluated at 6 months, because computed tomography was not routinely performed at 6 months after operation. Finally, the actual motor function and activities of daily living were not evaluated.

In conclusion, DT reconstruction tends to have a better short-term nutritional status and postoperative outcomes in terms of preventing the occurrence of gastroesophageal reflux and anastomosis stenosis. These findings suggest that DT reconstruction is a useful method in PG. Larger-scale, multi-institutional, comparative studies are warranted to confirm the advantages of DT reconstruction over EG.

The authors declare no conflict of interest.

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