J Gastric Cancer. 2023 Oct;23(4):561-573
https://doi.org/10.5230/jgc.2023.23.e35
pISSN 2093-582X·eISSN 2093-5641

jgc Journal of Gastric Cancer

Original Article

Long-term Functional and Patient-reported Outcomes Between Intra-corporeal Delta-shaped Gastroduodenostomy and Gastrojejunostomy After Laparoscopic Distal Gastrectomy

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Received: Apr 7, 2023
Revised: May 29, 2023
Accepted: Sep 4, 2023
Published online: Oct 10, 2023

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Funding
This study was supported by the National Cancer Center, Republic of Korea, Grant No. 2310270.

ABSTRACT

Purpose: This study aimed to compare the long-term functional and patient-reported outcomes between intra-corporeal delta-shaped gastroduodenostomy and gastrojejunostomy after laparoscopic distal gastrectomy for gastric cancer.
Materials and Methods: We retrospectively reviewed clinicopathological data from 616 patients who had undergone laparoscopic distal gastrectomy for stage I gastric cancer between January 2015 and September 2020. Among them, 232 patients who had undergone delta-shaped anastomosis and another 232 who had undergone Billroth II anastomosis were matched using propensity scores. Confounding variables included age, sex, body mass index, physical status classification, tumor location, and T classification. Postoperative complications, nutritional outcomes, endoscopic findings, and quality of life (QoL) were compared between the 2 groups.
Results: No significant differences in postoperative complications or nutritional parameters between the two groups were observed. Annual endoscopic findings revealed more residual food and less bile reflux in the delta group (P<0.001) than in the Billroth II group. Changes of QoL were significantly different regarding emotional function, insomnia, diarrhea, reflux symptoms, and dry mouth (P=0.007, P=0.002, P=0.013, P=0.001, and P=0.03, respectively). Among them, the delta group had worse insomnia, reflux symptoms, and dry mouth within three months postoperatively.
Conclusions: Long-term nutritional outcomes and QoL were comparable between the delta and Billroth II groups. However, more residual food and worse short-term QoL regarding insomnia, reflux symptoms, and dry mouth were observed in the delta group. Longer fasting time before endoscopic evaluation and short-term symptom management would have been helpful for the delta group.

Keywords: Stomach neoplasms; Laparoscopic surgical procedures; Nutritional status; Quality of life

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Conflict of Interest
No potential conflict of interest relevant to this article was reported.

Author Contributions
Data curation: P.S.H., Y.H.M., R.K.W., K.Y.W., E.B.W.; Formal analysis: Y.H.M., R.K.W., K.Y.W., H.M.; Funding acquisition: E.B.W.; Investigation: Y.H.M., R.K.W., K.Y.W.; Writing - original draft: P.S.H.; Writing - review & editing: E.B.W.

INTRODUCTION

Laparoscopic distal gastrectomy is a well-established procedure for both early and advanced gastric cancer [1-3]. In Korea, the proportion of laparoscopic approaches for gastric cancer was 64.9% in 2019 and continues to increase [4,5]. In the early period of laparoscopy, extra-corporeal anastomosis was commonly performed after gastrectomy. However, as surgical techniques have advanced and surgeons have gained more experience, intra-corporeal anastomosis has become popular. In a Korean nationwide survey, the proportion of intra-corporeal anastomosis was 84.9% among all laparoscopic gastrectomy cases in 2019 [5].

Three types of reconstruction after distal gastrectomy are common: Billroth I, Billroth II, and Roux-en-Y anastomoses. Billroth I is a popular method, because it preserves the physiological continuity of the gastrointestinal tract and requires a single anastomosis. For intra-corporeal Billroth I anastomosis, delta-shaped anastomosis was introduced by Kanaya et al. [6] in 2002 and is currently being used more frequently. In contrast to conventional Billroth I anastomosis, which is performed using a circular stapler, linear staplers are used in delta-shaped anastomosis.

Delta-shaped anastomosis has advantages such as the absence of mini-laparotomy, and less blood loss and pain compared to the same events associated with extra-corporeal Billroth I anastomosis [7]. However, it is also associated with several complications, including duodenal traction in the ventrodorsal direction, potential deterioration of the duodenal vascularity to ensure sufficient space around the duodenum, and difficulty in the cooperation between the surgeon and assistants [8]. Moreover, suitably sized remnant stomach and duodenum must be ensured for appropriate anastomotic tension. Numerous studies have reported the safety and feasibility of delta-shaped anastomosis [7,9]. However, only a few studies have evaluated the long-term nutritional and patient-reported outcomes associated with delta-shaped anastomosis [10,11].

In this study, we evaluated the long-term outcomes of patients who had undergone delta-shaped anastomosis compared with those of patients who had undergone Billroth II anastomosis, which are the most common anastomotic methods after distal gastrectomy in Korea [5]. Postoperative complications; long-term functional outcomes, including nutritional parameters and endoscopic findings; and patient-reported outcomes were assessed. Additionally, propensity score matching (PSM) was used to minimize selection bias.

MATERIALS AND METHODS

Patients

Medical records from 616 patients who had undergone delta-shaped or Billroth II anastomosis after total laparoscopic distal gastrectomy for pathological stage I gastric cancer at the National Cancer Center, Korea between January 2015 and September 2020 were retrospectively reviewed. Patients diagnosed with pathological stage II or higher gastric cancer were excluded, because adjuvant chemotherapy may affect postoperative nutritional status and quality of life (QoL). The anastomotic method is usually selected according to the surgeon's preference. However, in case of history of duodenal ulcer, duodenal adhesion, pyloric cancer, or short duodenal bulb, surgeons are highly likely to perform Billroth II anastomosis.

https://doi.org/10.5230/jgc.2023.23.e35

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This study was approved by the Institutional Review Board at the National Cancer Center, the Republic of Korea (No. NCC 2022-0023), which waived the requirement for patient informed consents because of the retrospective design of the study.

Delta-shaped anastomosis

After dissection of the infrapyloric and suprapyloric lymph nodes, the duodenal bulb was transected close to the pylorus, using a linear stapler [6]. Two-thirds of the stomach were divided, and small incisions were created along the edges of the remnant stomach and duodenum. The posterior walls of the remnant stomach and duodenum were approximated and stapled with a 45 mm linear stapler. Side-to-side anastomosis was performed, and the entry hole was closed using a 60 mm linear stapler.

Billroth II anastomosis

After two-thirds of the stomach were divided, a small incision was made in the greater curvature of the remnant stomach. The proximal jejunum was identified 20 cm distal of the ligament of Treitz and small incisions were made on the anti-mesenteric side. Stapling was performed with a linear stapler that was inserted into the small incisions of the remnant stomach and jejunum. The stapler entry hole was closed using barbed sutures. Braun anastomosis was not routinely performed after Billroth II anastomosis.

Clinicopathological evaluation

Histological types were classified according to the World Health Organization classification in two categories: differentiated, which includes papillary, well-differentiated, and moderately differentiated tubular adenocarcinoma and undifferentiated, which includes poorly differentiated tubular adenocarcinoma, poorly cohesive carcinoma (signet ring cell carcinoma), and mucinous adenocarcinoma [12,13]. The tumor stages were classified according to the 8th edition of the American Joint Committee on Cancer and the Union for International Cancer Control guidelines [14]. Postoperative complications were graded using the Clavien–Dindo classification [15].

Postoperative follow-up

Postoperatively, patients visited the outpatient clinic at 3 and 12 months postoperatively and every 6 months thereafter. Body weight, serum hemoglobin, and albumin levels were examined at each visit, while ferritin and vitamin B12 levels were estimated annually.

Annual endoscopic evaluations were performed to assess the presence of bile reflux, residual food, and reflux esophagitis. Bile reflux was defined as the presence or absence of bile in the remnant stomach. The amount of residual food was classified into four grades: no residual food, liquid only, soft diet residue, and nearly normal diet. Reflux esophagitis was evaluated according to the Los Angeles (LA) classification [16]: Normal; LA grade A, one or several erosions limited to the mucosal folds and no larger than 5 mm in size; LA grade B, one or several erosions limited to the mucosal folds and larger than 5 mm in size; LA grade C, erosion extending over the mucosal folds, but less than three-quarters of the circumference; and LA grade D, confluent erosions extending over more than 3-quarters of the circumference. The presence of reflux esophagitis indicated LA grade A or higher lesions.

QoL assessment

The QoL was assessed preoperatively and at 1, 3, 12, 18, 24, 30, and 36 months postoperatively using the European Organization for Research and Treatment of Cancer Quality of Life

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Questionnaire Core 30 (EORTC QLQ-C30) and STO22 [17,18]. The EORTC QLQ-C30 comprises of one global health status, five functional scales (physical, role, emotional, cognitive, and social), and nine general symptom scales (fatigue, nausea and vomiting, pain, dyspnea, insomnia, appetite loss, constipation, diarrhea, and financial difficulties). The EORTC QLQ-STO22 comprises of nine stomach-specific symptom scales. Scores were converted to a 0–100 scale, according to the EORTC scoring manual. Higher global health status and functional scale scores indicated better QoL or functions. Conversely, high symptom scale scores on the EORTC QLQ C30 and STO22 represented severe symptoms.

Statistical analysis

Continuous variables were presented as means with standard deviations and categorical variables were presented as numbers with percentages. Statistical differences between the two groups were analyzed using a Student's t-test for continuous variables and the χ^2 test or Fisher's exact test for categorical variables.

Baseline clinicopathological characteristics were not balanced between patients, who had undergone delta-shaped anastomosis and those who had undergone Billroth II anastomosis. Thus, we conducted PSM analyses to minimize potential selection bias [19]. PSM was estimated using a multivariable logistic regression model. Potential confounding covariates included age, sex, body mass index (BMI), American Society of Anesthesiologists physical status classification, tumor location, and pathological T classification. A 1:1 nearest-neighbor matching was used with a caliper of 0.1 without replacement.

Nutritional and QoL outcomes were analyzed using a linear mixed model for repeated measures to compare changes from baseline over time between the two groups. Least-squares means and standard errors of each subscale were estimated with a first-order autoregressive covariance structure using visit, group, and visit-by-group interactions as fixed effects and adjustment for baseline values.

All data were analyzed using SAS version 9.4 (SAS Institute Inc., Cary, NC) and R version 4.2.1 (R Foundation for Statistical Computing, Vienna, Austria). P-values less than 0.05 were considered statistically significant.

RESULTS

Baseline clinicopathological characteristics

This study included 273 patients who had undergone delta-shaped anastomosis (delta group) and 343 who had undergone Billroth II anastomosis (Billroth II group). Baseline clinicopathological factors, including BMI, tumor location, histological type, and pathological T category were significantly different (**Table 1**). After PSM of 232 pairs, no significant difference in the clinicopathological characteristics was observed between the 2 groups.

Surgical outcomes in PSM patients

The proportion of D2 lymph node dissections was higher in the Billroth II group than in the delta group (24.6 vs. 4.7%, P<0.001) (**Table 2**). The delta group was characterized by longer operating time (186.8 vs. 161.5 minutes, P<0.001) and less blood loss (32.2 vs. 54. 2 mL, P<0.001). However, the overall incidence of complications, type of complications, or severity grade did not differ significantly between the two groups. Patients who experienced delayed

https://doi.org/10.5230/jgc.2023.23.e35

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Table 1. Clinicopathological characteristics of patients before and after propensity score matching

Variable	Before matching			After matching		
	Delta (n=273) (%)	Billroth II (n=343) (%)	P-value	Delta (n=232) (%)	Billroth II (n=232) (%)	P-value
Age (yr)	58.5±9.6	57.9±10.6	0.443	58.8±9.6	58.7±10.1	0.865
Sex			0.851			0.775
Male	166 (60.8)	206 (60.1)		143 (61.6)	140 (60.3)	
Female	107 (39.2)	137 (39.9)		89 (38.4)	92 (39.7)	
BMI (kg/m^2)	23.8±3.1	24.6±3.4	0.001	24.1±3.1	24.0±2.9	0.737
ASA score			0.083			0.696
1	118 (43.2)	124 (36.2)		89 (38.4)	84 (36.2)	
2	136 (49.8)	181 (52.8)		124 (53.4)	124 (53.4)	
3	19 (7.0)	38 (11.1)		19 (8.2)	24 (10.3)	
Comorbidity			0.162			0.642
No	150 (54.9)	169 (49.3)		122 (52.6)	117 (50.4)	
Yes	123 (45.1)	174 (50.7)		110 (47.4)	115 (49.6)	
Tumor location			<0.001			0.726
Upper third	1 (0.4)	6 (1.7)		1 (0.4)	1 (0.4)	
Middle third	125 (45.8)	232 (67.6)		125 (53.9)	134 (57.8)	
Lower third	147 (53.8)	105 (30.6)		106 (45.7)	97 (41.8)	
Histological type			0.039			0.094
Differentiated	147 (53.8)	156 (45.5)		132 (56.9)	114 (49.1)	
Undifferentiated	126 (46.2)	187 (54.5)		100 (43.1)	118 (50.9)	
Tumor size (cm)	2.9±1.7	3.0±1.6	0.710	2.9±1.6	2.9±1.5	0.528
Pathological T category			0.017			0.675
T1	260 (95.2)	309 (90.1)		219 (94.4)	221 (95.3)	
T2	13 (4.8)	34 (9.9)		13 (5.6)	11 (4.7)	
Retrieved lymph nodes†	36.0±12.2	34.6±13.0	0.176	35.8±12.5	35.3±13.0	0.705
Pathological N category			0.507			1.000
N0	250 (91.6)	319 (93.0)		214 (92.2)	214 (92.2)	
N1	23 (8.4)	24 (7.0)		18 (7.8)	18 (7.8)	
Stage			0.128			1.000
IA	239 (87.5)	284 (82.8)		203 (87.5)	202 (87.1)	
IB	34 (12.5)	59 (17.2)		29 (12.5)	30 (12.9)	

Values are presented as means ± standard deviations or as numbers (%). Potential confounding covariables included in propensity score matching are age, sex, BMI, ASA score, tumor location, and T classification.
BMI = body mass index; ASA = American Society of Anesthesiologists physical status classification.

gastric emptying (n=13) and anastomotic ischemia (n=2) were treated with supportive care without additional interventions. One patient who had undergone Billroth II anastomosis died of septic shock due to internal herniation and mesenteric infarction one year postoperatively.

Nutritional outcomes in PSM patients

Nutritional parameters were assessed at baseline and 3, 12, 24, and 36 months postoperatively. Data on body weight, hemoglobin, and albumin were collected from all matched patients. However, baseline ferritin and vitamin B12 levels were assessed in just 194 patients (164 and 88 patients in the delta group and the Billroth II group, respectively). **Fig. 1** shows the changes in each nutritional parameter from baseline. Body weight and hemoglobin decreased by approximately 4–5 kg and 1 g/dL, respectively, at three months postoperatively and was maintained for the following 3 years. Serum albumin decreased by approximately 0.2 g/dL and gradually increased until 36 months postoperatively. Serum ferritin and vitamin B12 levels also decreased by approximately 40–60 ng/dL and 40–130 pg/mL, respectively, 24 months postoperatively, and did not recover until 36 months postoperatively. No significant differences in any of the nutritional parameters between the delta and Billroth II groups (P=0.281, P=0.51, P=0.209, P=0.679, and P=0.729 for body weight, hemoglobin, albumin, ferritin, and vitamin B12, respectively) were observed.

https://doi.org/10.5230/jgc.2023.23.e35

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Table 2. Surgical outcomes in propensity score-matched patients

Variables	Delta (n=232)	Billroth II (n=232)	P-value
Length of resection margin (cm)			
Proximal margin	4.0±2.6	4.7±2.9	0.009
Distal margin	7.0±2.9	6.4±3.7	0.034
Lymph node dissection			<0.001
D1+	221 (95.3)	175 (75.4)	
D2	11 (4.7)	57 (24.6)	
Operating time (min)	186.8±43.0	161.5±41.7	<0.001
Estimated blood loss (mL)	32.2±44.5	52.4±66.8	<0.001
Hospital stay (days)	7.7±2.5	8.1±6.7	0.465
Overall complications			0.899
Absence	194 (83.6)	196 (84.5)	
Presence	38 (16.4)	36 (15.5)	
Type of complications			
Wound complication	1 (0.4)	3 (1.3)	0.623
Bleeding	2 (0.9)	4 (1.7)	0.685
Fluid collection	1 (0.4)	3 (1.3)	0.623
Anastomotic leakage	7 (3.0)	3 (1.3)	0.338
Anastomotic stricture	5 (2.2)	3 (1.3)	0.724
Ileus	7 (3.0)	14 (6.0)	0.180
Delayed gastric emptying	10 (4.3)	3 (1.3)	0.091
Pneumonia	6 (2.6)	2 (0.9)	0.285
Pancreatic fistula	4 (1.7)	0 (0.0)	0.123
Other*	4 (1.7)	7 (3.0)	0.542
Clavien–Dindo grade			0.924
I	8 (3.4)	11 (4.7)	
II	16 (6.9)	12 (5.2)	
IIIA	8 (3.4)	6 (2.6)	
IIIB	5 (2.2)	4 (1.7)	
IVA	1 (0.4)	1 (0.4)	
IVB	0 (0.0)	1 (0.4)	
V	0 (0.0)	1 (0.4)	
Grade IIIA or more	14 (6.0)	13 (5.6)	0.999
Mortality	0 (0.0)	1 (0.4)	0.999

Values are presented as means ± standard deviations or as numbers (%).
*Other: cholangitis (n=4), anastomosis ischemia (n=2), incisional hernia (n=1), ileal perforation (n=1), ascites (n=1), urethral injury (n=1), and pseudomembranous colitis (n=1).

Endoscopic findings in PSM patients

Data on endoscopic findings were collected from 455 (98.0%), 411 (88.6%), and 306 (65.9%) patients at 1, 2, and 3 years postoperatively, respectively. The delta group had a significantly higher incidence of residual food than that of the Billroth II group (P<0.001, P<0.001, and P=0.002 at 1, 2, and 3 years postoperatively, respectively) (**Fig. 2A**). Residual food was observed in approximately half of the patients in the delta group at 1 year postoperatively and the proportion decreased to 35.5% at 3 years. In contrast, less than 20% of the patients in the Billroth II group had residual food at all time points.

The incidence of bile reflux was significantly lower in the delta group than in the Billroth II group (26.9%–44.8%, vs. 11.0%–13.8%, P<0001) (**Fig. 2B**). The proportion of the patients with reflux esophagitis (LA-A or higher) was not different between the two groups (0.4%–1.4% and 0.6%–3% in the delta and Billroth II groups, respectively) (**Fig. 2C**).

QoL in PSM patients

The response rates to QoL questionnaire were 100%, 65.3%, 38.3%, 67.5%, 54.1%, 54.3%, 40.3%, and 36.0% at baseline and 1, 3, 12, 18, 24, 30, and 36 months postoperatively, respectively. Among the subscales of the EORTC QLQ-C30, significant differences were

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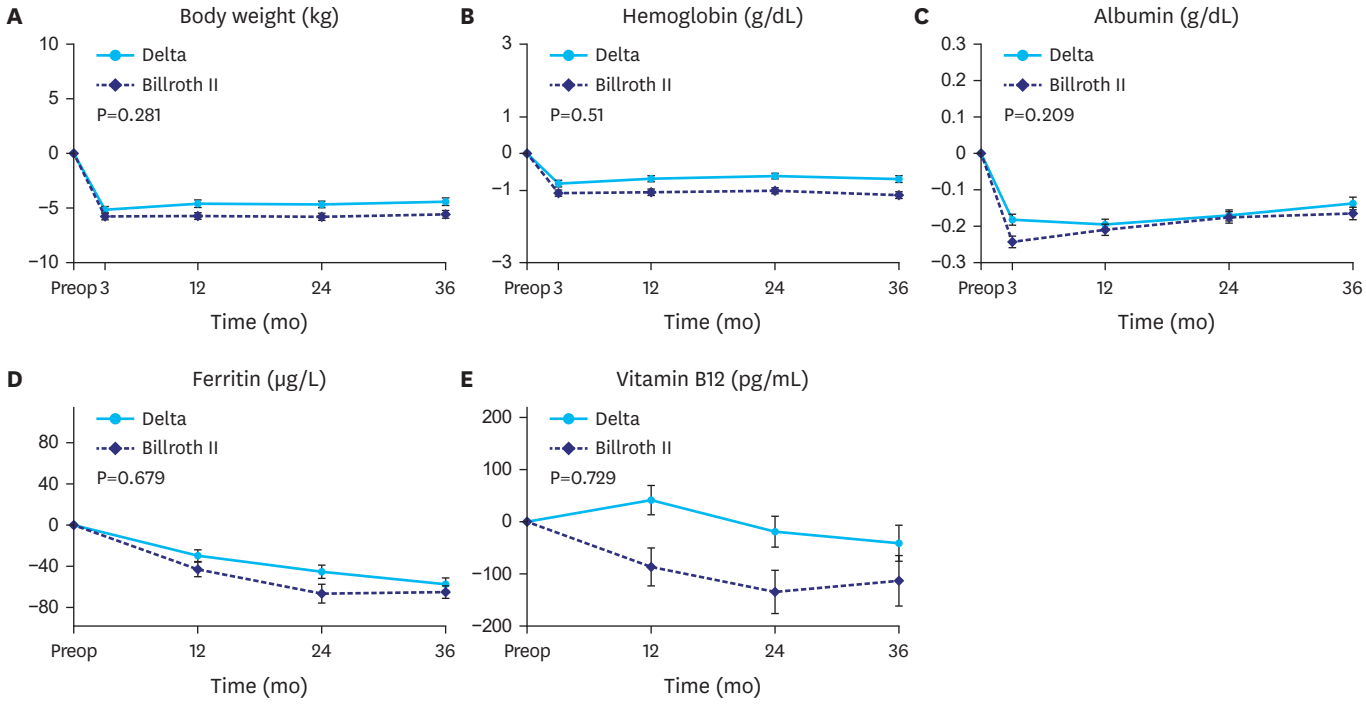

Fig. 1. Postoperative nutritional parameters. (A) Change in body weight (kg), (B) Change in serum hemoglobin (g/dL), (C) Change in serum albumin (g/dL), (D) Change in serum ferritin (μg/L), and (E) Change in serum vitamin B12 (pg/mL).

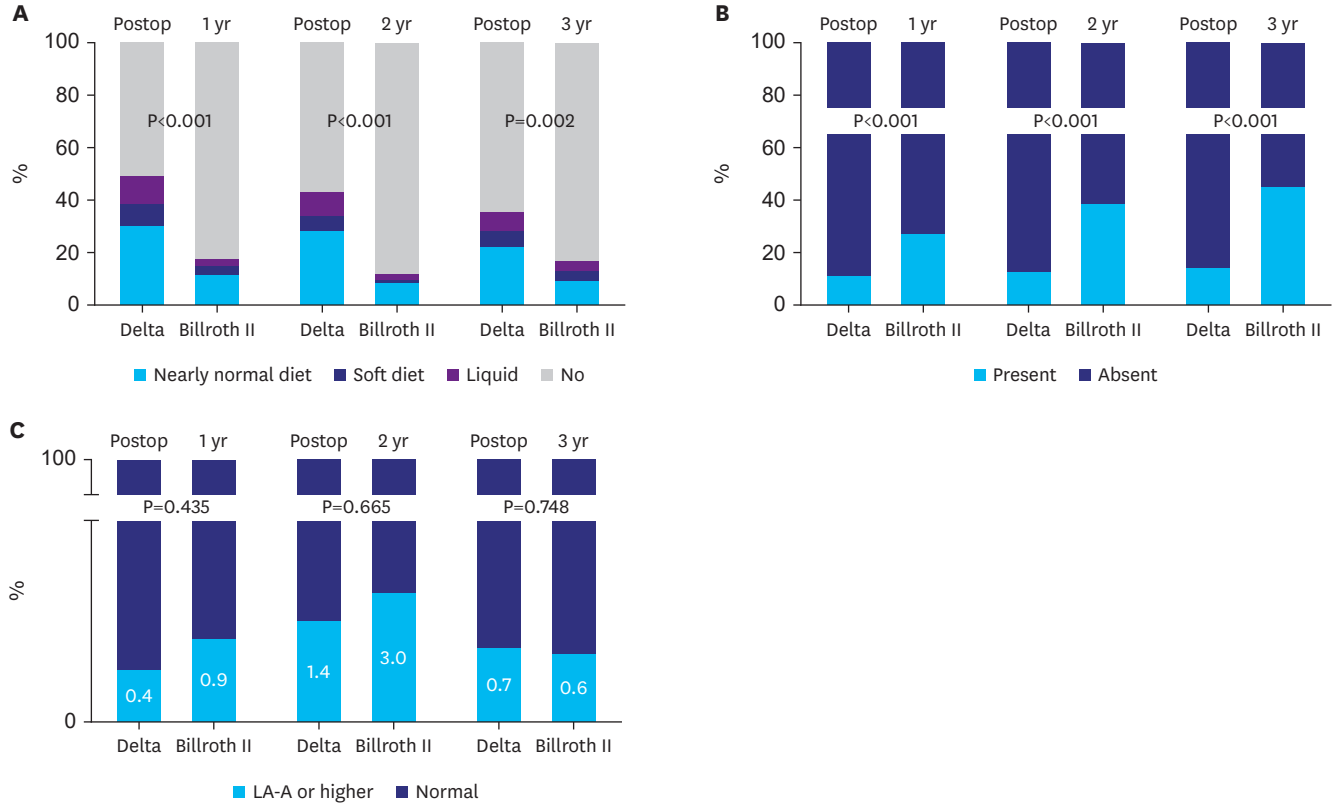

Fig. 2. Endoscopic findings in propensity score-matched patients. Graph showing the proportion of patients with (A) residual food, (B) bile reflux, and (C) presence of reflux esophagitis (LA-A or higher).

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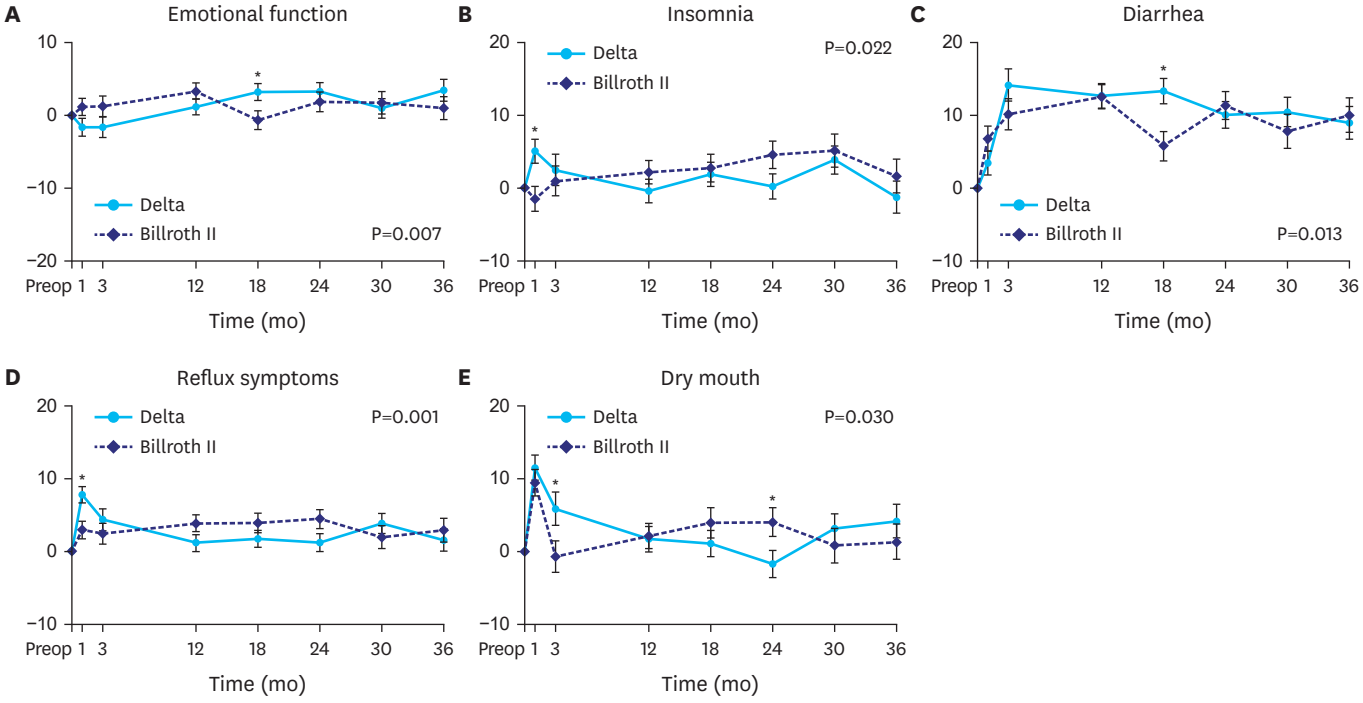

Fig. 3. Quality of life in propensity score-matched patients. (A) Emotional function, (B) Insomnia, (C) Diarrhea, (D) Reflux symptoms, and (E) Dry mouth.
*P<0.05.

observed in emotional function, insomnia, and diarrhea (P = 0.007, 0.022, and 0.013, respectively) (**Fig. 3A-C**). The delta group had better emotional function at 18 months postoperatively. The insomnia score of the delta group was significantly higher at one month postoperatively, indicating severe symptoms, which subsequently decreased. The diarrhea score in the delta group was also significantly higher at 18 months postoperatively, and subsequently decreased. No significant differences were observed in other subscales (**Supplementary Fig. 1**).

Among the subscales of the EORTC QLQ-STO22, significant differences were observed in reflux symptoms and dry mouth (P=0.001 and P=0.03, respectively) (**Fig. 3D and E**). The reflux symptoms score in the delta group was higher at one month postoperatively and subsequently comparable to that of the Billroth II group. The dry mouth score in the delta group was also higher at three months postoperatively and subsequently decreased. No significant differences were observed in other subscales (**Supplementary Fig. 2**).

DISCUSSION

In this study, we evaluated the long-term surgical outcomes, including postoperative complications, nutritional and patient-reported outcomes, in patients who underwent either delta-shaped or Billroth II anastomosis following laparoscopic distal gastrectomy. No significant differences were observed in postoperative complications, long-term nutritional outcomes, or QoL between the two groups. However, the delta group had a higher incidence of residual food during a period of three years postoperatively and worse insomnia, reflux symptoms, and dry mouth in the immediate postoperative period (up to 3 months).

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Many studies have evaluated the long-term functional outcomes after distal gastrectomy. In a recent meta-analysis, eight randomized controlled trials comparing outcomes between Billroth I, Billroth II, and Roux-en-Y anastomosis were analyzed [20]. Most studies identified a comparable incidence of overall complications, nutritional outcomes, and QoL between Billroth I and Roux-en-Y anastomoses [21-25]. However, the Billroth I group had a higher frequency of remnant gastritis and bile reflux in postoperative endoscopic examinations than those observed in the Roux-en-Y group. Several retrospective studies also demonstrated similar results, including comparable complication rates and nutritional outcomes and higher frequency of residual food and bile reflux in the Billroth I or II groups compared to those associated with the Roux-en-Y group [26,27]. In these studies, Billroth I anastomosis was performed via open or laparoscopy-assisted approaches using hand-sewing sutures or circular staplers. However, linear staplers are used in delta-shaped anastomosis, and studies that examine the long-term outcomes of delta-shaped anastomosis are lacking.

Studies on delta-shaped anastomoses have focused on short-term outcomes [9]. In these studies, the delta group had better short-term outcomes in terms of operating time, blood loss, time to oral intake, hospital stay, and postoperative complications than the same parameters associated with extra-corporeal Billroth I anastomosis. Only a few studies analyzed long-term functional outcomes with postoperative endoscopic findings and showed that the delta group had a higher incidence of bile reflux or reflux esophagitis than those observed in the Roux-en-Y group [8,28]. Regarding long-term patient-reported outcomes, very few studies have compared outcomes between delta-shaped and extra-corporeal anastomoses, and no study has compared the long-term QoL between delta and other anastomoses [11]. This is the first study that compares long-term functional and patient-reported outcomes between patients who underwent delta-shaped and Billroth II anastomoses.

The most notable finding of this study was the higher grade of residual food in the delta group. On postoperative endoscopic evaluation, the proportion of patients having residual food was significantly higher in the delta group compared to that in the Billroth II group. Regarding this delayed passage, Kanaya et al. [29] mentioned that stasis may have been the consequence of duodenal twisting at the site of the delta-shaped anastomosis. Anastomotic twisted alignment interrupts food passage, which results in high grade of residual food. Another study group reported some cases of re-hospitalization after delta-shaped anastomosis due to obstructive symptoms [28]. These patients had edema and panniculitis at the anastomosis site, similarly to our experience of patients with obstruction after delta-shaped anastomosis. Transient edematous narrowing at the anastomosis site is associated with impaired circulation and excessive dissection of the duodenal tissue. Additionally, high food intake may affect food stasis. One study showed a significantly higher amount of food intake in the delta anastomosis group than in the conventional Billroth I group [10]. In delta-shaped anastomosis, the remaining part should be as large as possible to reduce traction tension. Larger remnant stomach and greater food intake may result in more food stasis [30].

Another important finding of this study was the worse QoL of the delta group observed at the initial postoperative period (no longer than three months). Many studies assessed QoL at six months postoperatively or later, without any significant difference between the Billroth I and Roux-en-Y groups [11,22,24,31]. However, in this study, QoL questionnaires were administered at one and three months postoperatively, and significant differences were identified between the two groups. Higher reflux symptoms and insomnia in the delta group may be related to food stasis, and patients with anastomotic edema and food stasis are more

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likely to experience reflux symptoms. Worse diarrhea symptoms in the delta group were also reported in a previous study [32]. In that study, the Post Gastrectomy Syndrome Assessment Scale (PGSAS)-45 was assessed one month after surgery, and high frequency of diarrhea was observed in the delta group. A wide anastomotic lumen and straightforward alignment from the esophagus to the duodenum could be associated with diarrhea.

Recently, some assessment tools for evaluating postgastrectomy symptoms and QoL have been developed and used in several clinical studies. PGSAS-45 is a questionnaire for the assessment of living status and QoL in postgastrectomy patients, developed by the Japanese Postgastrectomy Syndrome Working Party [33]. KOQUSS-40 is also a symptom-focused QoL questionnaire, developed by the KOrean QUality of life in Stomach cancer patients Study group (KOQUSS) [34]. The validity and reliability of KOQUSS-40 were proven in a validation study. These questionnaires are expected to better evaluate postgastrectomy symptoms and QoL, because they were developed for patients who underwent gastrectomy. Further studies are required to determine whether these questionnaires can more sensitively evaluate postgastrectomy symptoms and QoL compared to the sensitivity of the EORTC QLQ.

No significant differences in nutritional outcomes were observed between the two groups in this study. Consistent with that, many studies reported no significant differences in nutritional outcomes among Billroth I, Billroth II, and Roux-en-Y anastomoses [21-23,26]. Only a few studies reported less weight loss after Billroth I compared to those associated with other types of anastomoses [24,27]. Therefore, the anastomosis method probably has little effect on nutritional outcomes.

The present study had several limitations. First, this study was retrospectively performed using a single-center database, and anastomoses were based on the surgeons' preferences. Therefore, the proportion of surgeons that performed each type of anastomosis was not equal between the two groups, which might have affected the surgical outcomes. However, no significant difference in postoperative complications were observed between the two groups, and the differences of long-term functional outcomes might have been due to differences in anastomosis methods rather than differences in the surgeons' skills. Second, a considerable amount of data on nutritional parameters, endoscopic findings, and QoL at each time point was missing. In particular, ferritin and vitamin B12 levels were assessed in just 42% of all matched patients, and QoL data were collected from 35.6%–67.9% of all matched patients. Therefore, the results of ferritin, vitamin B12, and QoL should be carefully interpreted considering the limited data. Third, residual food is highly affected by fasting time. In general, the longer the fasting time, the lesser the residual food. We have no data on patients' fasting times before endoscopic evaluation, and residual food is not an absolute indicator for gastrointestinal motility function.

In conclusion, delta-shaped gastroduodenostomy and gastrojejunostomy had comparable postoperative complications, long-term nutritional status, and patient-reported outcomes. However, patients with delta-shaped anastomosis had more residual food with limited endoscopic evaluation and worse QoL in some subscales in the immediate postoperative period. For patients undergoing delta-shaped anastomosis, longer fasting time before endoscopic evaluation and symptom management during the initial postoperative period may be helpful.

https://doi.org/10.5230/jgc.2023.23.e35

jgc Journal of Gastric Cancer

SUPPLEMENTARY MATERIALS

Supplementary Fig. 1

European Organization for Research and Treatment of Cancer Quality of Life Questionnaire Core 30.

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Supplementary Fig. 2

European Organization for Research and Treatment of Cancer Quality of Life Questionnaire-STO22.

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REFERENCES

1. Kim HH, Han SU, Kim MC, Kim W, Lee HJ, Ryu SW, et al. Effect of laparoscopic distal gastrectomy vs open distal gastrectomy on long-term survival among patients with stage I gastric cancer: the KLASS-01 randomized clinical trial. JAMA Oncol 2019;5:506-513.
PUBMED | CROSSREF
2. Hyung WJ, Yang HK, Park YK, Lee HJ, An JY, Kim W, et al. Long-term outcomes of laparoscopic distal gastrectomy for locally advanced gastric cancer: the KLASS-02-RCT randomized clinical trial. J Clin Oncol 2020;38:3304-3313.
PUBMED | CROSSREF
3. Kim TH, Kim IH, Kang SJ, Choi M, Kim BH, Eom BW, et al. Korean Practice Guidelines for Gastric Cancer 2022: an evidence-based, multidisciplinary approach. J Gastric Cancer 2023;23:3-106.
PUBMED | CROSSREF
4. Park SH, Kang MJ, Yun EH, Jung KW. Epidemiology of gastric cancer in Korea: trends in incidence and survival based on Korea Central Cancer Registry Data (1999-2019). J Gastric Cancer 2022;22:160-168.
PUBMED | CROSSREF
5. Information Committee of the Korean Gastric Cancer Association. Korean Gastric Cancer Association-led nationwide survey on surgically treated gastric cancers in 2019. J Gastric Cancer 2021;21:221-235.
PUBMED | CROSSREF
6. Kanaya S, Gomi T, Momoi H, Tamaki N, Isobe H, Katayama T, et al. Delta-shaped anastomosis in totally laparoscopic Billroth I gastrectomy: new technique of intraabdominal gastroduodenostomy. J Am Coll Surg 2002;195:284-287.
PUBMED | CROSSREF
7. Wang SY, Hong J, Hao HK. A comparative study of delta-shaped and conventional Billroth I anastomosis after laparoscopic distal gastrectomy for gastric cancer. Surg Endosc 2017;31:3191-3202.
PUBMED | CROSSREF
8. Watanabe Y, Watanabe M, Suehara N, Saimura M, Mizuuchi Y, Nishihara K, et al. Billroth-I reconstruction using an overlap method in totally laparoscopic distal gastrectomy: propensity score matched cohort study of short- and long-term outcomes compared with Roux-en-Y reconstruction. Surg Endosc 2019;33:3990-4002.
PUBMED | CROSSREF
9. Hu GY, Tao F, Ji KW, Wang W. Comparison of delta-shape anastomosis and extracorporeal Billroth I anastomosis after laparoscopic distal gastrectomy for gastric cancer: a systematic review with meta-analysis of short-term outcomes. PLoS One 2016;11:e0162720.
PUBMED | CROSSREF
10. Lee HH, Song KY, Lee JS, Park SM, Kim JJ. Delta-shaped anastomosis, a good substitute for conventional Billroth I technique with comparable long-term functional outcome in totally laparoscopic distal gastrectomy. Surg Endosc 2015;29:2545-2552.
PUBMED | CROSSREF

11. Park KB, Kwon OK, Yu W, Jang BC. Body composition changes after totally laparoscopic distal gastrectomy with delta-shaped anastomosis: a comparison with conventional Billroth I anastomosis. Surg Endosc 2016;30:4286-4293.
PUBMED | CROSSREF
12. Bosman FT, Carneiro F, Hruban RH, Theise ND. WHO Classification of Tumours of the Digestive System. WHO Classification of Tumours, 4th Edition. Volume 3. Geneva: World Health Organization; 2010.
13. Japanese Gastric Cancer Association. Japanese gastric cancer treatment guidelines 2018 (5th edition). Gastric Cancer 2021;24:1-21.
PUBMED | CROSSREF
14. Brierley JD, Gospodarowicz MK, Wittekind C. TNM classification of Malignant Tumours. Hoboken (NJ): John Wiley & Sons; 2017.
15. Clavien PA, Barkun J, de Oliveira ML, Vauthey JN, Dindo D, Schulick RD, et al. The Clavien-Dindo classification of surgical complications: five-year experience. Ann Surg 2009;250:187-196.
PUBMED | CROSSREF
16. Armstrong D, Bennett JR, Blum AL, Dent J, De Dombal FT, Galmiche JP, et al. The endoscopic assessment of esophagitis: a progress report on observer agreement. Gastroenterology 1996;111:85-92.
PUBMED | CROSSREF
17. Aaronson NK, Ahmedzai S, Bergman B, Bullinger M, Cull A, Duez NJ, et al. The European Organization for Research and Treatment of Cancer QLQ-C30: a quality-of-life instrument for use in international clinical trials in oncology. J Natl Cancer Inst 1993;85:365-376.
PUBMED | CROSSREF
18. Blazeby JM, Conroy T, Bottomley A, Vickery C, Arraras J, Sezer O, et al. Clinical and psychometric validation of a questionnaire module, the EORTC QLQ-STO 22, to assess quality of life in patients with gastric cancer. Eur J Cancer 2004;40:2260-2268.
PUBMED | CROSSREF
19. D'Agostino RB Jr. Propensity score methods for bias reduction in the comparison of a treatment to a non-randomized control group. Stat Med 1998;17:2265-2281.
PUBMED | CROSSREF
20. Cai Z, Zhou Y, Wang C, Yin Y, Yin Y, Shen C, et al. Optimal reconstruction methods after distal gastrectomy for gastric cancer: a systematic review and network meta-analysis. Medicine (Baltimore) 2018;97:e10823.
PUBMED | CROSSREF
21. Ishikawa M, Kitayama J, Kaizaki S, Nakayama H, Ishigami H, Fujii S, et al. Prospective randomized trial comparing Billroth I and Roux-en-Y procedures after distal gastrectomy for gastric carcinoma. World J Surg 2005;29:1415-1420.
PUBMED | CROSSREF
22. Lee MS, Ahn SH, Lee JH, Park DJ, Lee HJ, Kim HH, et al. What is the best reconstruction method after distal gastrectomy for gastric cancer? Surg Endosc 2012;26:1539-1547.
PUBMED | CROSSREF
23. Hirao M, Takiguchi S, Imamura H, Yamamoto K, Kurokawa Y, Fujita J, et al. Comparison of Billroth I and Roux-en-Y reconstruction after distal gastrectomy for gastric cancer: one-year postoperative effects assessed by a multi-institutional RCT. Ann Surg Oncol 2013;20:1591-1597.
PUBMED | CROSSREF
24. Nakamura M, Nakamori M, Ojima T, Iwahashi M, Horiuchi T, Kobayashi Y, et al. Randomized clinical trial comparing long-term quality of life for Billroth I versus Roux-en-Y reconstruction after distal gastrectomy for gastric cancer. Br J Surg 2016;103:337-347.
PUBMED | CROSSREF
25. Yang K, Zhang WH, Liu K, Chen XZ, Zhou ZG, Hu JK. Comparison of quality of life between Billroth-I and Roux-en-Y anastomosis after distal gastrectomy for gastric cancer: a randomized controlled trial. Sci Rep 2017;7:11245.
PUBMED | CROSSREF
26. Park JY, Kim YJ. Uncut Roux-en-Y reconstruction after laparoscopic distal gastrectomy can be a favorable method in terms of gastritis, bile reflux, and gastric residue. J Gastric Cancer 2014;14:229-237.
PUBMED | CROSSREF
27. Kim CH, Song KY, Park CH, Seo YJ, Park SM, Kim JJ. A comparison of outcomes of three reconstruction methods after laparoscopic distal gastrectomy. J Gastric Cancer 2015;15:46-52.
PUBMED | CROSSREF
28. Kitagami H, Morimoto M, Nozawa M, Nakamura K, Tanimura S, Murakawa K, et al. Evaluation of the delta-shaped anastomosis in laparoscopic distal gastrectomy: midterm results of a comparison with Roux-en-Y anastomosis. Surg Endosc 2014;28:2137-2144.
PUBMED | CROSSREF

29. Kanaya S, Kawamura Y, Kawada H, Iwasaki H, Gomi T, Satoh S, et al. The delta-shaped anastomosis in laparoscopic distal gastrectomy: analysis of the initial 100 consecutive procedures of intracorporeal gastroduodenostomy. Gastric Cancer 2011;14:365-371.
PUBMED | CROSSREF

30. Ahn JY, Jung HY, Bae SE, Jung JH, Choi JY, Kim MY, et al. Proper preparation to reduce endoscopic reexamination due to food residue after distal gastrectomy for gastric cancer. Surg Endosc 2013;27:910-917.
PUBMED | CROSSREF

31. So JB, Rao J, Wong AS, Chan YH, Pang NQ, Tay AY, et al. Roux-en-Y or Billroth II reconstruction after radical distal gastrectomy for gastric cancer: a multicenter randomized controlled trial. Ann Surg 2018;267:236-242.
PUBMED | CROSSREF

32. Hosoda K, Mieno H, Ema A, Ushiku H, Washio M, Song I, et al. Delta-shaped anastomosis vs circular stapler anastomosis after laparoscopic distal gastrectomy with Billroth I reconstruction: a randomized controlled trial. Asian J Endosc Surg 2020;13:301-310.
PUBMED | CROSSREF

33. Nakada K, Ikeda M, Takahashi M, Kinami S, Yoshida M, Uenosono Y, et al. Characteristics and clinical relevance of Postgastrectomy Syndrome Assessment Scale (PGSAS)-45: newly developed integrated questionnaires for assessment of living status and quality of life in postgastrectomy patients. Gastric Cancer 2015;18:147-158.
PUBMED | CROSSREF

34. Eom BW, Lee J, Lee IS, Son YG, Ryu KW, Kim SG, et al. Development and validation of a symptom-focused quality of life questionnaire (KOQUSS-40) for gastric cancer patients after gastrectomy. Cancer Res Treat 2021;53:763-772.
PUBMED | CROSSREF