

Delta-shaped anastomosis, a good substitute for conventional Billroth I technique with comparable long-term functional outcome in totally laparoscopic distal gastrectomy

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Abstract

Background Delta-shaped anastomosis (DA) is a new Billroth I reconstruction technique using only a laparoscopic linear stapler under a totally laparoscopic approach. The present study compared the outcomes of DA with those of laparoscopic conventional Billroth I anastomosis (cBIA).

Methods A total of 138 and 100 patients with gastric cancer who underwent laparoscopic distal gastrectomy with DA and cBIA, respectively, were selected. Clinicopathological data and short- and long-term outcomes were compared between the two groups.

Results The mean operating time in the DA group was similar to that in the cBIA group. Short-term outcomes, such as bowel function recovery, morbidity, and mortality, did not differ between the DA and cBIA groups. There were no significant differences in the 5-year disease-free and overall survival rates between the two groups. All nutritional indices (body weight change, albumin level, transferrin level, and total lymphocyte count) were similar between the two groups with the exception of a few points in the early follow-up period. Endoscopic evaluation using the Residual food, Gastritis, Bile reflux classification revealed relatively better gastritis findings in the DA group despite worse bile reflux for 5 postoperative years. The

food amount was significantly larger in the DA group for 2 postoperative years.

Conclusions The outcomes of DA were comparable to those of cBIA. DA is a recommendable reconstruction method, especially in totally laparoscopic distal gastrectomy.

Keywords Billroth I operation · Gastrectomy · Laparoscopic surgery · Outcome assessment · Stomach neoplasm

Laparoscopic surgery has become a standard approach in the treatment of early gastric cancer, and advancement of less invasive techniques is ongoing [1, 2]. To remove the mini-laparotomy scar created by extracorporeal anastomosis in laparoscopy-assisted distal gastrectomy (LADG), intracorporeal anastomosis is currently adopted and gives rise to totally laparoscopic distal gastrectomy (TLDG) [3–6]. The delta-shaped anastomosis (DA) is a new method of intracorporeal Billroth I reconstruction that was designed and published by Kanaya et al. in 2002 [7]. In contrast to conventional Billroth I reconstruction by end-to-end or side-to-end anastomosis using a circular stapler, DA is intracorporeally completed by side-to-side (functional end-to-end) gastroduodenostomy with only laparoscopic linear staplers. Because the DA procedure is relatively simple, it can be performed easily by even an inexperienced gastric cancer surgeon [8]. Therefore, the use of this technique in intracorporeal Billroth I reconstruction is increasing in Korea and Japan [9–13].

Several studies have demonstrated the short-term outcomes of DA [5, 6, 9–12]. However, there are no comparisons of the long-term outcomes of this anastomotic technique with those of other types of gastroduodenostomy [8]. Although there were a few reports for other techniques

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of laparoscopic gastroduodenostomy except conventional Billroth I anastomosis (cBIA) with a circular stapler in LADG, those reports were only initial experiences with small cases and had no long-term outcomes for their technique [14–17]. Accordingly, to evaluate the feasibility and usefulness of DA, the present study compared the short-term outcomes and long-term functional outcomes of DA and cBIA which is the most popular gastroduodenostomy technique at present.

Materials and methods

Patients and surgery

Of all patients with clinically early gastric cancer, 138 who underwent TLDG with DA and 100 who underwent LADG with cBIA at Catholic Medical Center between 2004 and 2011 were enrolled in the present study. All operations were performed by two gastric cancer specialists (K.J.J. and S.K.Y.). Two surgeons were contemporaries and had similar techniques and experience with laparoscopic surgery for gastric cancer.

Two operative techniques were carried out using five trocars. DA in TLDG was performed using only a laparoscopic linear stapler as mentioned in a previous report [5, 6]. cBIA in LADG was performed through a 4- to 5-cm right upper transverse mini-laparotomy incision after full mobilization of the stomach and lymph node dissection. The mobilized stomach was pulled out, and Billroth I gastroduodenostomy using a circular stapler was performed extracorporeally through this mini-laparotomy incision [18].

Data collection and questionnaire

Perioperative and operative details and pathological data of all enrolled patients were retrospectively collected from the gastric cancer registries of Catholic Medical Center. The pathological stage was classified according to the Seventh American Joint Cancer Committee (AJCC) TNM classification. The histological type was categorized as differentiated or undifferentiated. Poorly differentiated tubular adenocarcinoma, signet ring cell adenocarcinoma, and mucinous adenocarcinoma were assigned to the undifferentiated group.

Regular follow-up programs were conducted according to the standard protocol (every 3 and 6 months for advanced and early gastric cancer, respectively, for the first 3 years; every 12 months thereafter) and included the determination of tumor marker levels and nutritional indices including the albumin level, transferrin level, total lymphocyte count (TLC), abdominal imaging, and

endoscopic examination. Endoscopic findings of the remnant stomach were annually evaluated using the RGB (Residual food, Gastritis, Bile reflux) classification [19], and the findings were simultaneously reviewed by two expert endoscopists. If there was a disagreement in the findings, they discussed the case and arrived at a consensus.

Functional outcomes were assessed with a questionnaire in the outpatient clinic. The questionnaire comprised (1) the food amount, (2) postgastrectomy syndromes, and (3) diet-related gastrointestinal symptoms. The food amounts at postoperative 3, 6, and 9 months and 1 and 2 years were measured in terms of the percentage of the preoperative amount. Postgastrectomy syndrome, including dumping syndrome, bile reflux gastritis, and delayed gastric emptying, was evaluated using the 5-point Likert scale. In addition, dumping syndrome was assessed according to the presence of two types of symptom: gastrointestinal and cardiovascular. The degree of patient satisfaction related to eating problems was estimated at postoperative 1, 3, and 5 years according to the modified Visick grading system [20, 21].

The mean follow-up period for the 238 enrolled patients was 46.0 ± 28.1 months. Survival rates were repeatedly determined using the registration data of the Korea National Statistical Office and the patients' medical records.

This study was approved by the Institutional Review Board of the Ethics Committee of the College of Medicine, The Catholic University of Korea (XC13RIMI00390).

Statistical analysis

Differences between the two groups were analyzed using the *t* test for continuous variables and the χ^2 test or Fisher's exact test for categorical variables. Survival analysis was performed using the Kaplan–Meier method with a log-rank test for univariate analysis. Statistical analyses were performed with SPSS ver. 13.0 software (SPSS, Inc., Chicago, IL, USA). Values of $P < 0.05$ were considered to indicate significance.

Results

The DA group contained more male patients, older patients, and patients with a higher body mass index (BMI) than the cBIA group. However, there was no difference in Eastern Cooperative Oncology Group (ECOG) performance scores or comorbidities between the two groups (Table 1).

The operative details are provided in Table 2. There was no case of open conversion in either group and the extent of

Table 1 Comparison of patients' characteristics

Characteristic	DA (<i>n</i> = 138)	cBIA (<i>n</i> = 100)	<i>P</i> value
Age, mean (years ± SD)	62.4 ± 9.7	56.0 ± 11.2	<0.001
Sex, <i>n</i> (%)			
Male	87 (63.0)	47 (47.0)	0.014
Female	51 (37.0)	53 (53.0)	
BMI, mean (kg/m ² ± SD)	24.2 ± 3.1	22.6 ± 2.0	<0.001
ECOG, <i>n</i> (%)			
0	122 (88.4)	89 (89.0)	1.000
1	15 (10.9)	10 (10.0)	
2	1 (0.7)	1 (1.0)	
Comorbidity, <i>n</i> (%)			
Cardiovascular	49 (35.5)	26 (26.0)	0.119
Diabetes	30 (21.7)	14 (14.0)	0.129
Pulmonary	3 (2.2)	4 (4.0)	0.458
Renal	1 (0.7)	0 (0.0)	1.000
Hepatic	3 (2.2)	1 (1.0)	0.641
Others	5 (3.6)	5 (5.0)	0.746

Table 2 Comparison of operative details

Characteristic	DA (<i>n</i> = 138)	cBIA (<i>n</i> = 100)	<i>P</i> value
Lymph node dissection, <i>n</i> (%)			
D1+	66 (47.8)	41 (41.0)	0.296
D2 or over	72 (52.2)	59 (59.0)	
Combined resection, <i>n</i> (%)			
Gall bladder	5 (3.6)	4 (4.0)	1.000
Wedge of stomach (GIST)	1 (0.7)	0 (0.0)	
Operating time, mean (min ± SD)	220.4 ± 70.5	220.5 ± 64.7	0.997
Estimated blood loss, mean (ml ± SD)	99.8 ± 99.0	133.3 ± 152.1	0.041
Blood transfusion, units of PRC, <i>n</i> (%)			
0	111 (93.3)	88 (88.0)	0.401
1	2 (1.7)	2 (2.0)	
2	6 (5.0)	9 (9.0)	
5	0 (0.0)	1 (1.0)	

lymph node dissection was not different between two groups. The blood loss volume was higher in cBIA. However, the mean operating time was nearly identical and the blood transfusion volume was similar between the two groups. Although one 0.5-cm gastrointestinal stromal tumor (GIST) of the upper third was co-resected in the DA group, this case was not excluded from the present analysis because the risk stratification for GIST is very low and the

operating time of wedge resection is similar to that of cholecystectomy.

There were no differences in most tumor characteristics, including TNM stage. The DA group had significantly more cases of differentiated histology and longer proximal margins (Table 3). The postoperative recovery in the DA

Table 3 Comparison of pathological characteristics

Characteristic	DA (<i>n</i> = 138)	cBIA (<i>n</i> = 100)	<i>P</i> value
Tumor size, mean (cm ± SD)	2.1 ± 1.1	2.0 ± 1.3	0.531
Tumor location, <i>n</i> (%)			
Middle	43 (31.2)	32 (32.0)	0.890
Lower	95 (68.8)	68 (68.0)	
Multiplicity, <i>n</i> (%)			
One	133 (96.4)	98 (98.0)	0.702
Multiple	5 (3.6)	2 (2.0)	
Histological type, <i>n</i> (%)			
Differentiated	94 (68.1)	55 (55.0)	0.039
Undifferentiated	44 (31.9)	45 (45.0)	
Lauren classification, <i>n</i> (%)			
Intestinal type	85 (61.6)	52 (52.0)	0.135
Diffuse type	32 (23.2)	35 (35.0)	
Mixed type	21 (15.2)	13 (13.0)	
Lymphatic invasion, <i>n</i> (%)			
No	107 (77.5)	87 (87.0)	0.063
Yes	31 (22.5)	13 (13.0)	
Vascular invasion, <i>n</i> (%)			
No	137 (99.3)	100 (100.0)	1.000
Yes	1 (0.7)	0 (0.0)	
Perineural invasion, <i>n</i> (%)			
No	130 (94.2)	95 (95.0)	0.789
Yes	8 (5.8)	5 (5.0)	
Proximal margin, mean (cm ± SD)	5.0 ± 2.7	4.2 ± 2.2	0.012
Harvested lymph node, mean (<i>n</i> ± SD)	38.3 ± 14.8	37.0 ± 13.4	0.481
Depth of invasion, <i>n</i> (%)			
T1	127 (92.0)	94 (94.0)	0.801
T2	10 (7.2)	5 (5.0)	
T3	1 (0.7)	1 (1.0)	
Lymph node metastasis, <i>n</i> (%)			
N0	119 (86.2)	90 (90.0)	0.705
N1	12 (8.7)	8 (8.0)	
N2	5 (3.6)	2 (2.0)	
N3	2 (1.4)	0 (0.0)	
Pathological stage (AJCC, 7th edition), <i>n</i> (%)			
I	128 (92.8)	96 (96.0)	0.545
II	8 (5.8)	4 (4.0)	
III	2 (1.4)	0 (0.0)	

Table 4 Comparison of the postoperative course

Outcomes	DA (<i>n</i> = 138)	cBIA (<i>n</i> = 100)	<i>P</i> value
Duration to flatus, mean (days ± SD)	2.7 ± 0.7	2.8 ± 0.7	0.108
Duration to soft diet, mean (days ± SD)	4.6 ± 1.3	4.9 ± 0.9	0.063
Duration of discharge, mean (days ± SD)	8.5 ± 5.1	7.8 ± 2.0	0.211
Morbidity ^a , <i>n</i> (%)	11 (8.0)	7 (7.0)	0.586
Pulmonary	1 (0.7)	0 (0.0)	
Luminal bleeding	1 (0.7)	0 (0.0)	
Anastomotic leakage	2 (1.4)	0 (0.0)	
Anastomotic stricture	2 (1.4)	4 (4.0)	
Ileus	2 (1.4)	1 (1.0)	
Pancreatitis	2 (1.4)	0 (0.0)	
Wound infection	1 (0.7)	2 (2.0)	
Mortality ^a , <i>n</i> (%)	1 (0.7)	0 (0.0)	1.000

^a Within 30 postoperative days

group, as shown in Table 4, was not different from that in the cBIA group.

The 5-year disease-free survival rate of the 138 patients who underwent DA was 97.4 %, which was identical to that of the 100 patients who underwent cBIA ($P = 0.603$) (Fig. 1A). In addition, the 5-year overall survival rate did not differ significantly between the DA and cBIA groups (92.6 vs. 95.6 %, respectively; $P = 0.136$) (Fig. 1B).

The changes in body weight at postoperative 1, 3, and 5 years compared with the preoperative body weight did not differ between the two groups at each time point (1 year, $P = 0.479$; 3 years, $P = 0.598$; and 5 years,

$P = 0.674$). Of the nutritional indices including the albumin level, transferrin level, and TLC, only three values (albumin at 3 years and TLC at 1 and 3 years) had statistical significance ($P = 0.033$, $P = 0.037$, and $P = 0.040$, respectively) (Fig. 2).

In the endoscopic evaluation of the remnant stomach using the RGB classification, there were no differences in the residual food amount throughout the 5-year follow-up, and only a decreasing trend in the DA group between 3 and 5 years was observed. Although the degree and extent of gastritis at 1 year postoperatively were significantly more severe in the cBIA group ($P < 0.001$ and $P = 0.003$, respectively) and the degree of gastritis in the cBIA group was significantly worse than that in the DA group at 3 years ($P = 0.034$), the extent of gastritis did not differ significantly between cBIA and DA groups after 3 years, and there were no differences in either the degree or extent at 5 years. Bile reflux was significantly more frequent in the DA group than in the cBIA group at all time points (1 year, $P < 0.001$; 3 years, $P = 0.001$; and 5 years, $P = 0.009$) (Fig. 3).

The food amount, which was measured until the second postoperative year, was significantly larger in the DA group than in the cBIA at all time points ($P < 0.001$). Patients in the DA group ate more than 50 % of their preoperative amount at 3 months and nearly 100 % at 2 years. However, patients in the cBIA group ate about 65 % of their preoperative amount at 2 years (Fig. 4). There was no significant difference in the severity of postgastrectomy syndrome according to the 5-point Likert scale between the two groups (Fig. 5). The degree of satisfaction related to eating problems in the two groups, which was presented by the modified Visick grading score,

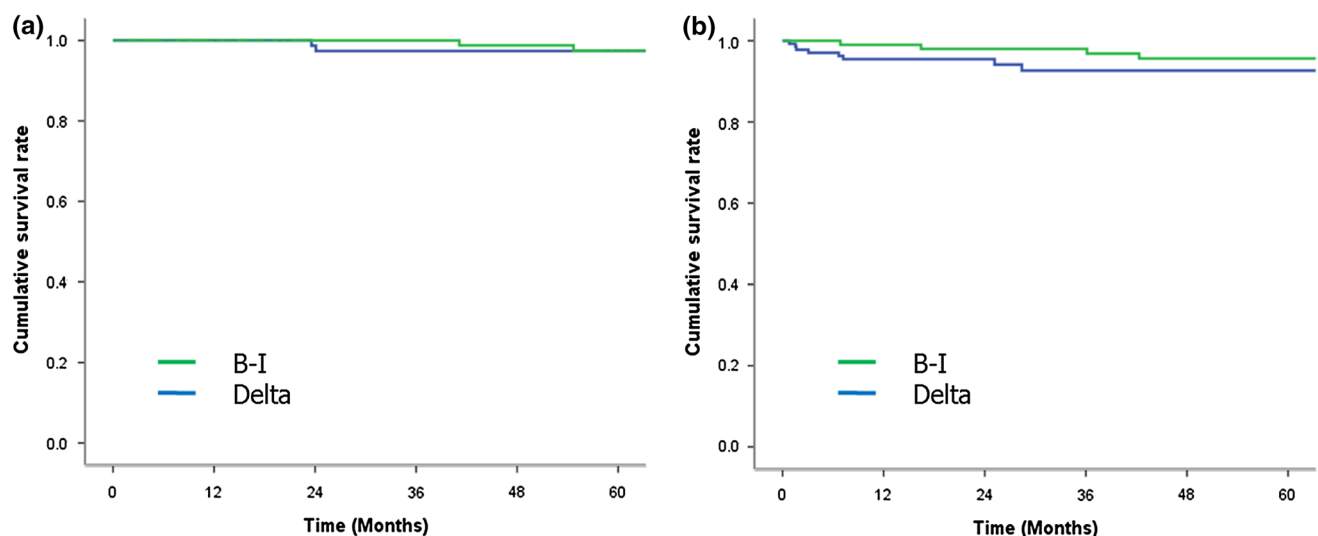


Fig. 1 Comparison of 5-year survival rates between patients with delta-shaped anastomosis (DA) and conventional Billroth I anastomosis (cBIA). **A** Disease-free survival ($P = 0.603$) and **B** overall survival ($P = 0.136$)

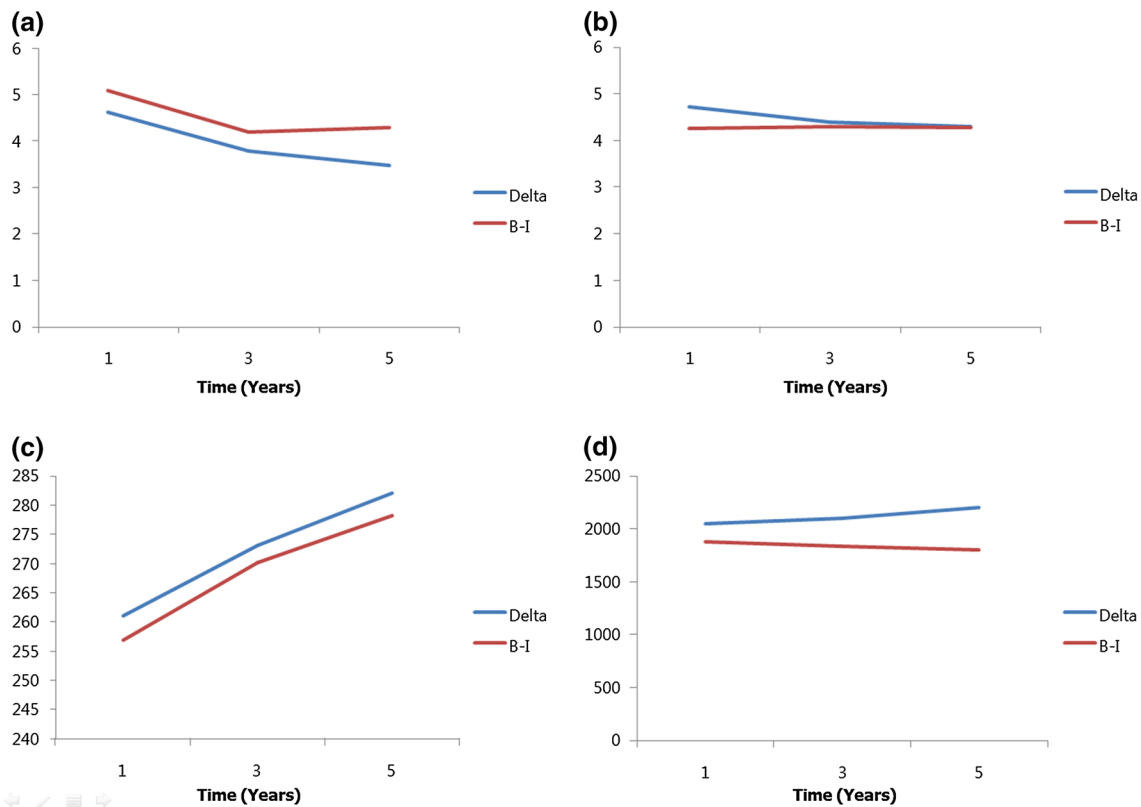


Fig. 2 Comparison of nutritional indices between the DA and cBIA groups at postoperative 1, 3, and 5 years. **A** Body weight change (kg) (1 year: 4.63 vs. 5.09, $P = 0.479$; 3 years: 3.79 vs. 4.20, $P = 0.598$; 5 years: 3.49 vs. 4.29, $P = 0.674$), **B** albumin (g/dl) (1 year: 4.73 vs. 4.26, $P = 0.216$; 3 years: 4.40 vs. 4.29, $P = 0.033$; 5 years, 4.29 vs.

4.28, $P = 0.868$), **C** transferrin (mg/dl) (1 year: 261.11 vs. 256.84, $P = 0.691$; 3 years: 273.10 vs. 270.24, $P = 0.870$; 5 years: 282.09 vs. 278.29, $P = 0.811$), and **D** total lymphocyte count ($10^3/\text{ml}$) (1 year: 2047.33 vs. 1880.01, $P = 0.037$; 3 years: 2102.74 vs. 1834.92, $P = 0.040$; 5 years: 2201.07 vs. 1800.59, $P = 0.102$)

was similar at the first postoperative year. However, at the fifth postoperative year, a significant difference was noted between the scores of 1.38 and 1.91 in the DA and cBIA groups, respectively ($P = 0.024$) (Fig. 6).

Discussion

The present study is the first to compare the short- and long-term outcomes of DA with those of cBIA. The results of present study indicate that DA is not inferior to cBIA in terms of postoperative and functional outcomes during a long period of follow-up. Although intracorporeal anastomosis, which is essential in totally laparoscopic gastric cancer surgery, has the obvious advantage of minimizing the operative scar, there have been some concerns regarding technical difficulty, longer operation time because of the anastomosis, and higher costs from using a lot of stapling devices [6]. Our results provide strong evidence to alleviate these concerns with regard to intracorporeal anastomosis except for the cost problems. The mean anastomotic time of DA was 18.3 ± 16.0 min in the

present study (data not shown). This could be measured easily because DA was completed using a totally laparoscopic approach. On the other hand, the anastomotic time of cBIA was difficult to measure because it was performed by an extracorporeal approach. Therefore, the total operation time was compared instead of the anastomotic time. The mean operation time of DA was 220 min, which was almost identical to that of cBIA even though the mean BMI of the patients was significantly higher in DA group. These results suggest that totally intracorporeal Billroth I anastomosis is not a time-consuming procedure and a relatively short anastomotic time in DA group reflects the technical simplicity of DA. Moreover, it indicates the benefit of intracorporeal anastomosis technique in an obese patient [6], compared with that of extracorporeal anastomosis technique through a mini-laparotomy incision.

There were no significant differences between the groups in short-term outcomes, such as bowel function recovery, postoperative morbidity, and mortality. There was one case of mortality in the DA group; it was caused by complications of postoperative pancreatitis and had no relationship with the anastomosis technique. In terms of the

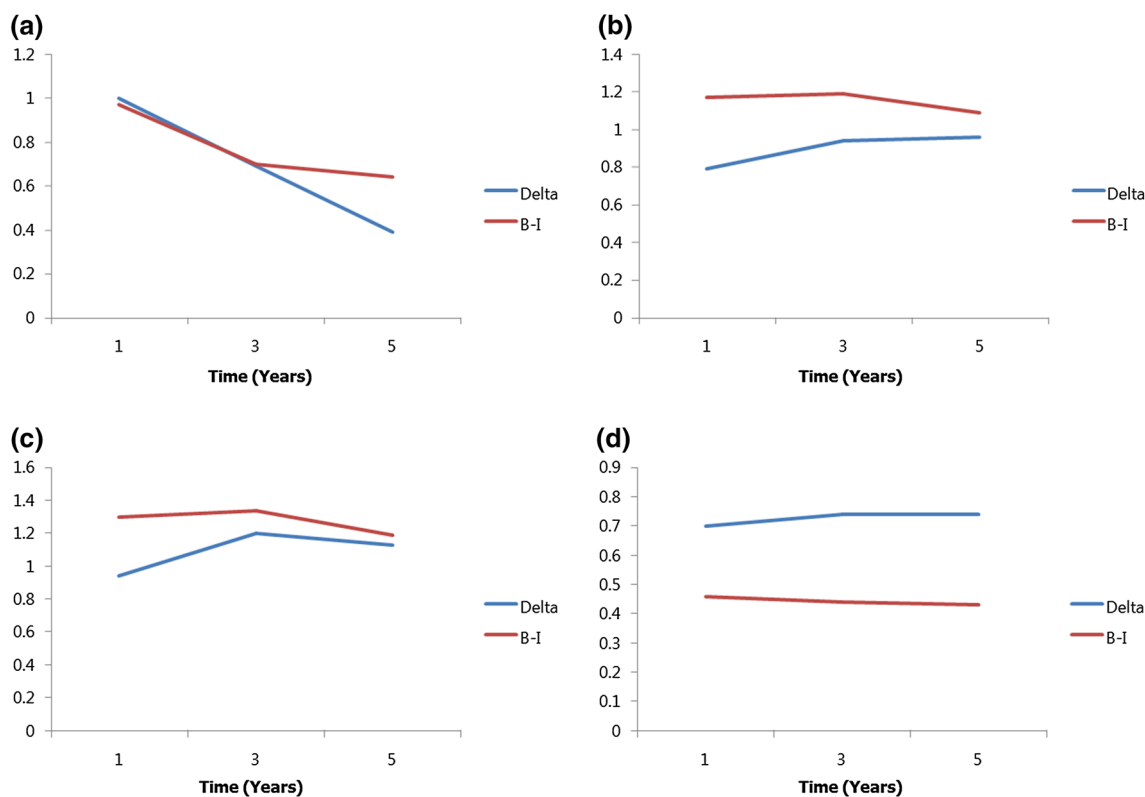


Fig. 3 Comparison of endoscopic findings of the remnant stomach between the DA and cBIA groups at postoperative 1, 3, and 5 years using the RGB (Residual food, Gastritis, Bile reflux) classification: **A** residual food (1 year: 1.00 vs. 0.97, $P = 0.847$; 3 years: 0.69 vs. 0.70, $P = 0.972$; 5 years: 0.39 vs. 0.64, $P = 0.321$), **B** gastritis (degree) (1 year: 0.79 vs. 1.17, $P < 0.001$; 3 years: 0.94 vs. 1.19,

$P = 0.034$; 5 years: 0.96 vs. 1.09, $P = 0.367$), **C** gastritis (extent) (1 year: 0.94 vs. 1.30, $P = 0.003$; 3 years: 1.20 vs. 1.34, $P = 0.359$; 5 years: 1.13 vs. 1.19, $P = 0.758$), and **D** bile reflux (1 year: 0.70 vs. 0.46, $P < 0.001$; 3 years: 0.74 vs. 0.44, $P = 0.001$; 5 years: 0.74 vs. 0.43, $P = 0.009$)

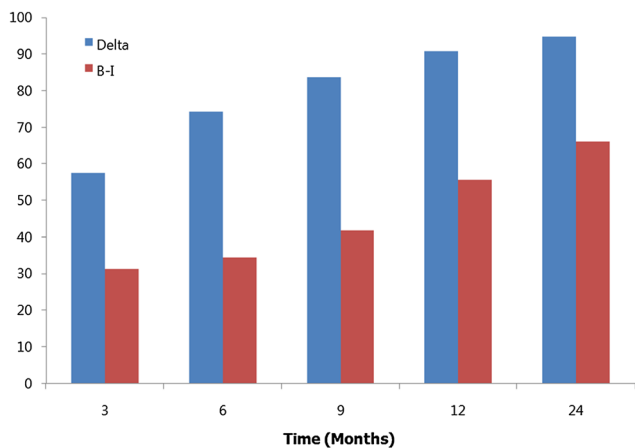


Fig. 4 Comparison of food amount between the DA and cBIA groups at postoperative 3 (57.53 vs. 31.38 %), 6 (74.37 vs. 34.38 %), 9 (83.67 vs. 41.69 %), 12 (90.89 vs. 55.69 %), and 24 months (94.75 vs. 66.15 %) (all, $P < 0.001$)

long-term survival outcome, while the 5-year disease-free survival rate in the DA group was identical to that in the cBIA group, the 5-year overall survival rate was somewhat lower in the DA group (without statistical significance).

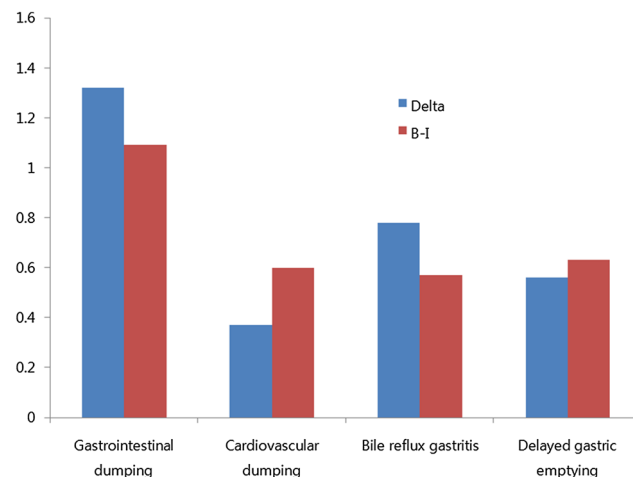


Fig. 5 Comparison of postgastroectomy syndromes between the DA and cBIA groups using the 5-point Likert scale: **A** dumping syndrome (gastrointestinal) (1.32 vs. 1.09, $P = 0.157$), **B** dumping syndrome (cardiovascular) (0.37 vs. 0.60, $P = 0.081$), **C** bile reflux gastritis (0.78 vs. 0.57, $P = 0.159$), and **D** delayed gastric emptying (0.56 vs. 0.63, $P = 0.557$)

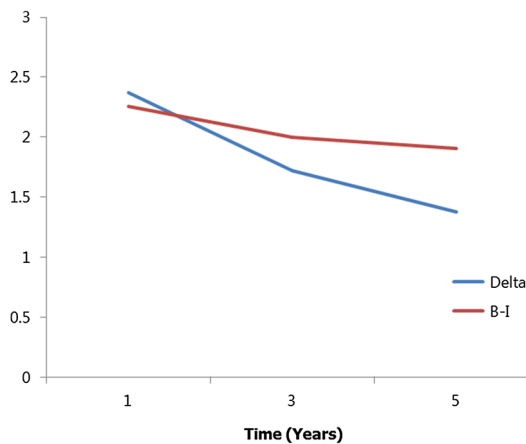


Fig. 6 Comparison of the degree of patient satisfaction related to eating problems between the DA and cBIA groups at postoperative 1 (2.37 vs. 2.26, $P = 0.353$), 3 (1.72 vs. 2.00, $P = 0.100$), and 5 years (1.38 vs. 1.91, $P = 0.024$) using the modified Visick grading score

Such results were thought to be a reflection of the DA group composition, which was characterized by older age and more stage II, III patients (also without statistical significance).

In terms of long-term functional outcomes related to diet, nutritional status, and postgastrectomy symptoms, almost all parameters were very similar between the two groups except for some minor points. The food amounts which were estimated until 2 years after surgery were larger in DA group as shown in Fig. 4. Because the DA group obtained a significantly longer proximal margin and the tumor location did not differ between the two groups, the larger food intake in the DA group did not occur because of a large volume of the remnant stomach. DA is an oblique type reconstruction between the posterior wall of the remnant stomach body and the posterior–superior aspect of the duodenum, and it has wide lumen at the anastomotic site. Such structural alignment between the remnant stomach and the duodenum after DA, which is more straightforward from the esophagus to the duodenum than in cBIA, may permit more comfortable food intake (Fig. 7).

Both the degree and extent of gastritis in the cBIA group were worse than those in the DA group at 1 year postoperatively. However, with the passage of time, the gastritis in the cBIA group improved slightly, whereas that in the DA group somewhat worsened. Consequently, at 5 years postoperatively, there were no differences in either the degree or extent between the two groups. These results can be explained by the bile reflux in the DA group. Kanaya et al. [8], reported that bile reflux was observed endoscopically in 73.5 % of patients with DA. In the present study, the bile reflux in the DA group was more severe than that in the cBIA group throughout the 5-year postoperative

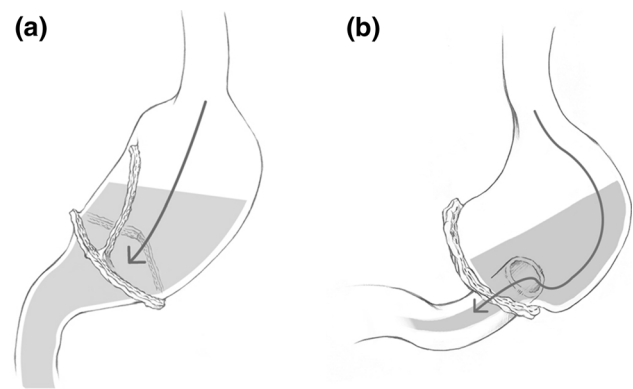


Fig. 7 Schematic illustrations of food passage according to anastomosis type. **A** Delta-shaped anastomosis and **B** conventional Billroth I anastomosis

period, and continuous exposure of the remnant stomach to bile might have aggravated the gastritis in the DA group. In the evaluation of postgastrectomy syndromes using the 5-point Likert scale, the DA group also showed higher values for bile reflux gastritis than did the cBIA group, but without statistical significance. This higher incidence of bile reflux in DA group may be due to the more straightforward structural alignment between the remnant stomach and the duodenum and wide anastomotic lumen in DA. The degree of patient satisfaction with resolution of eating problems according to the modified Visick grading score improved in both groups over time. However, the degree of improvement in the DA group was higher than that in the cBIA group, and the DA group had a significantly better score at 5 years postoperatively. The patients in the DA group took 90.89 % of their preoperative food amount at 1 year postoperatively and 94.75 % at 2 years. This increase in the food amount would have reduced the patients' stress related to postgastrectomy meals and induce a faster decline in the modified Visick grading score during the long-term follow-up period.

The present study had some limitations in terms of its comparative analysis setup. First, the DA group comprised relatively older and higher weight patients than did the cBIA group. However, the ECOG performance status and comorbidities, which have a marked influence on patient outcomes, did not differ between the two groups. In terms of the operative details, the cBIA group lost a somewhat larger volume of blood in the operative field. This result probably originated from mini-laparotomy and extracorporeal procedure, which was performed in the cBIA group. However, because the blood loss in both groups was less than 150 ml and the blood transfusion volume did not differ between the two groups, the significant difference in blood loss would not have affected the postoperative recovery.

In conclusion, DA is an innovative reconstruction technique with short- and long-term outcomes comparable to those of cBIA. DA not only has the advantage of a totally laparoscopic approach with a small scar, but also a similar operating time with a laparoscopy-assisted approach. The comparison of the postoperative course, including morbidity, revealed that DA and cBIA had similarly good outcomes. In addition, the more rapid recovery from the postgastrectomy diet among patients who underwent DA brought about increases in nutritional indices and patient satisfaction. DA is a recommendable reconstruction method, especially in totally laparoscopic gastric cancer surgery.

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