

Original Article



Textbook Outcome of Delta-Shaped Anastomosis in Minimally Invasive Distal Gastrectomy for Gastric Cancer in 4,505 Consecutive Patients

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ABSTRACT

Purpose: Textbook outcome is a comprehensive measure used to assess surgical quality and is increasingly being recognized as a valuable evaluation tool. Delta-shaped anastomosis (DA), an intracorporeal gastroduodenostomy, is a viable option for minimally invasive distal gastrectomy in patients with gastric cancer. This study aims to evaluate the surgical outcomes and calculate the textbook outcome of DA.

Materials and Methods: In this retrospective study, the records of 4,902 patients who underwent minimally invasive distal gastrectomy for DA between 2009 and 2020 were reviewed. The data were categorized into three phases to analyze the trends over time. Surgical outcomes, including the operation time, length of post-operative hospital stay, and complication rates, were assessed, and the textbook outcome was calculated.

Results: Among 4,505 patients, the textbook outcome is achieved in 3,736 (82.9%). Post-operative complications affect the textbook outcome the most significantly (91.9%). The highest textbook outcome is achieved in phase 2 (85.0%), which surpasses the rates of in phase 1 (81.7%) and phase 3 (82.3%). The post-operative complication rate within 30 d after surgery is 8.7%, and the rate of major complications exceeding the Clavien–Dindo classification grade 3 is 2.4%.

Conclusions: Based on the outcomes of a large dataset, DA can be considered safe and feasible for gastric cancer.

Keywords: Gastrectomy; Stomach neoplasms; Postoperative complications

INTRODUCTION

Gastric cancer is one of the most prevalent malignancies worldwide and the third leading cause of cancer-related deaths [1]. The standard treatment for most resectable gastric cancers is radical surgery [2,3], and recent key studies indicate that minimally invasive distal gastrectomy, which typically involves the laparoscopic approach, provides equivalent oncologic outcomes and better early post-operative results than open surgery [4-9].

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Conflict of Interest

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

Author Contributions

Conceptualization: L.I.S.; Data curation: O.S.G., L.S., S.B.O.; Formal analysis: O.S.G.; Funding acquisition: L.I.S.; Investigation: O.S.G., L.S., S.B.O., L.I.S.; Methodology: O.S.G., K.C.S., M.S.H., G.C.S., K.B.S., Y.M.W., Y.J.H., L.I.S.; Supervision: K.C.S., L.I.S.; Writing - original draft: O.S.G., L.I.S.; Writing - review & editing: O.S.G., L.I.S.

Billroth I anastomosis is a reconstruction method used after distal gastrectomy and offers several advantages over other methods, including simplicity with a single anastomosis, physiological food passage, better absorption of nutrients via the proximal small intestine, and minimal risk of internal hernia or afferent/efferent loop syndrome. Since the introduction of delta-shaped anastomosis (DA), which is an intracorporeal gastroduodenostomy using endoscopic linear staplers [10], researchers have evaluated its safety and compared its surgical outcomes with those of other reconstruction techniques or extracorporeal Billroth 1 methods [11-18]. However, shortcomings, such as a relatively small patient cohort size and inadequate long-term results, limit the clinical application of DA-related procedures. More importantly, the individual interpretation of conventional parameters commonly used to assess surgical quality does not provide comprehensive information regarding quality measures across different periods and hospitals.

Textbook outcome (TO) has been proposed as an important tool for measuring treatment quality after major surgery, including post-operative complications, mortality, and readmission. Recently, it has been considered a surrogate oncological parameter [19]. This can provide more composite outcomes, which can optimally reflect the quality of surgical care, instead of using any single parameter. Similarly, this concept has been introduced in gastric-cancer surgery to facilitate clinical-performance evaluation among different institutions and treatment methods [20]. Most previous studies pertaining to TO have been conducted in Western countries, where the proportion of patients with advanced tumors requiring neoadjuvant treatment and the incidence of open surgery are much higher than those in East Asia, a region characterized by diagnosis at an earlier stage and more frequent upfront surgeries via a minimally invasive approach [21-24]. Consequently, the TO from Western data emphasizes the overall treatment result instead of the surgery result. This has resulted in a significant gap in the literature regarding patients with gastric cancer in high-incidence countries.

In this study, we aim to assess the quality of surgical outcomes based on TO and the risk factors for post-operative complications by analyzing data acquired from more than 4,500 patients with gastric cancer who were consecutively treated with minimally invasive distal gastrectomy using DA.

MATERIALS AND METHODS

Patients

This retrospective study adhered to the guidelines of the Declaration of Helsinki and was approved by the Institutional Review Board (IRB) of the Asan Medical Center, Seoul, Korea (IRB No. 2022-1545). We retrospectively reviewed the electronic medical records of 4,902 patients who underwent minimally invasive distal gastrectomy with DA between 2009 and 2020. In this cohort, 397 patients with a history of malignancy (n=295), those who were lost to follow-up (n=80), and those with non-adenocarcinoma histology on the final pathology (n=28) were excluded. Notably, some patients were included in more than one category. Additionally, to assess the changes in surgical outcomes and quality over time, the patient group was categorized into 3 distinct phases: phase 1 (2009–2013), phase 2 (2013–2016), and phase 3 (2017–2020).

Data acquisition

Medical records were examined to determine the patients' demographic characteristics, including their age at surgery, sex, body mass index (BMI), American Society of Anesthesiologists (ASA) score, and Charlson Comorbidity Index (CCI) score.

The tumor location, tumor differentiation, tumor size, number of metastatic and harvested lymph nodes, proximal/distal margin length, and pathological stage were assessed. Based on the histological findings, well-differentiated and moderately differentiated tubular adenocarcinomas and papillary adenocarcinomas were categorized as differentiated tumors, whereas the others were classified as undifferentiated. The invasion depth and nodal staging were determined based on the 8th edition of the American Joint Committee on Cancer.

Additionally, the type of minimally invasive surgery (laparoscopic vs. robotic), extent of lymph-node dissection, curability, operative time, and length of post-operative hospital stay were assessed. The extent of lymph-node dissection was determined in accordance with the Gastric Cancer Treatment Guidelines [2,3].

Post-operative complications were defined as any adverse events occurring within 30 days after surgery, in addition to complications that occurred during surgery. The morbidity severity was categorized based on the Clavien–Dindo classification (CDC) [25]. Complications of grade 3 or higher that required surgical, endoscopic, or radiological intervention were designated as major complications. Several complications that occurred in the patients were counted individually.

TO

Ten measures related to treatment quality were evaluated to assess TO success. TO was considered to have been achieved when all listed criteria were satisfied. Curative resection was determined based on the surgeon's assessment to achieve radical resection during surgery, whereas tumor-negative resection margins were evaluated using the final pathological report. Severe complications were considered adverse events with a CDC grade of >2. Reintervention included any radiological, endoscopic, or surgical treatment performed under local or general anesthesia. Prolonged post-operative days were defined as hospital stays exceeding 21 days. Mortality was defined as death within 30 days of surgery. Readmission was defined as admission due to surgery-related causes within 30 days of surgery at any hospital.

Statistical analysis

Continuous variables are presented as mean (\pm standard deviation), whereas categorical variables are presented as numbers (percentages). To assess the significance of changes in characteristics across the three phases, we analyzed continuous variables using the analysis of variance or the Kruskal–Wallis test, whereas categorical variables were examined using the χ^2 test or Fisher's exact test. Univariate and multivariate logistic regression analyses were conducted to identify the risk factors for complications. The significance of the differences in TOs was evaluated by performing a comparison across phases using the χ^2 test. The five-year overall survival (OS) and disease-free survival (DFS) rates were calculated using the Kaplan–Meier curves. Additionally, the survival differences across the different phases were compared using the log-rank test. P-values less than 0.05 were considered statistically significant for all statistical tests. Statistical analyses were performed using R version 4.3.2 (R Foundation for Statistical Computing, Vienna, Austria) and the IBM SPSS Statistics software (version 22.0; IBM Corp., Armonk, NY, USA).

RESULTS

Clinicopathologic characteristics of patients receiving minimally invasive distal gastrectomy with DA

A total of 4,505 patients who underwent DA were analyzed. The mean age at operation was 58.5 years, and 2,737 (60.8%) patients were men. Cases with an ASA score of 2 and a CCI score of 5 or higher were the most common. Tumors were located in the antrum or pylorus in 2,711 patients (60.2%), and 58.9% had undifferentiated histology. The mean tumor size was 2.9 cm, and the percentages of metastatic and harvested lymph nodes were 0.4 and 33.1, respectively. More than 90% of the patients had stage I gastric cancer. Compared with the initial patient group in phase 1, the most recent group (phase 3) included significantly older patients and those with higher ASA and CCI scores (**Table 1**).

Surgical outcomes and complications

Most patients underwent total laparoscopic surgery with D1+ or D2 lymph-node dissection, and R0 resection was achieved in 99.8% of the cases. The mean operative time was 133.2 minutes, and the mean hospital stay after surgery was 6.5 days (**Table 2**). In the phase-3 group, the proportion of patients who underwent limited lymphadenectomy was the smallest, and the hospital stay was the shortest.

Nine patients experienced adverse events during surgery, including significant bleeding (n=5), bowel injury (n=1), cardiac complications (n=1), pulmonary complications (n=1), and drug-induced anaphylaxis (n=1) (**Table 3**). A total of 394 patients (8.7%) had post-operative complications; among them, 108 experienced major complications greater than CDC grade 3. Intra-abdominal bleeding was the most common complication (n=26), followed by anastomotic stricture (n=23), fluid accumulation (n=20), anastomotic leakage (n=18), and luminal bleeding (n=10) (**Supplementary Table 1**).

Risk factors affecting surgical complication

Univariate analysis show that age ≥ 60 years, male sex, BMI ≥ 25 kg/m², higher ASA and CCI scores, advanced T-stage, and longer operative times were significantly associated with surgical complications. In the multivariate analysis, male sex, higher BMI, and higher CCI scores were independent risk factors (**Table 4**).

TO assessment

Ten variables related to gastrectomy quality were evaluated, and the frequency of achievement for each parameter is presented as a bar graph (**Fig. 1**). Additionally, the cumulative rate of satisfying the preceding variables is depicted as a line graph. A total of 82.9% of the patients achieved TOs (black line), with phase-specific values of 81.7% for phase 1 (orange), 85.0% for phase 2 (green), and 82.3% for phase 3 (blue). Post-operative complications greater than CDC grade 2 were the main cause hindering the achievement of TO across all periods (9.0%), followed by the requirement for reintervention or operation (3.0%) and readmission (2.2%) (**Table 5**).

Next, we compared the patient characteristics between the TO and non-TO groups (**Supplementary Table 2**). The aforementioned factors affecting complications, such as older age, male sex, higher BMI, higher CCI scores, advanced T-stage, and longer operative times, were significantly associated with a lower probability of achieving TO (**Supplementary Table 3**).

Textbook Outcome in Gastric Cancer
Table 1. Clinicopathologic characteristics of patients who received delta-shaped anastomosis

Characteristics	Phase 1 (n=1,161)	Phase 2 (n=1,343)	Phase 3 (n=2,001)	Total (n=4,505)	P-value
Age (yr)	57.3±11.2	57.7±11.5	59.8±11.4	58.5±11.5	<0.001
Sex					0.224
Male	715 (61.6)	790 (58.8)	1,232 (61.6)	2,737 (60.8)	
Female	446 (38.4)	553 (41.2)	769 (38.4)	1,768 (39.2)	
BMI (kg/m ²)	24.0±3.1	24.0±3.1	24.2±3.1	24.1±3.1	0.134
ASA score					<0.001
1	220 (18.9)	350 (26.1)	295 (14.7)	865 (19.2)	
2	924 (79.6)	951 (70.8)	1,556 (77.8)	3,431 (76.2)	
3	14 (1.2)	41 (3.1)	147 (7.5)	202 (4.5)	
≥4	3 (0.3)	1 (0.0)	3 (0.0)	7 (0.1)	
CCI score					<0.001
2	215 (18.5)	264 (19.7)	280 (14.0)	759 (16.8)	
3	281 (24.2)	274 (20.4)	379 (18.9)	934 (20.7)	
4	218 (18.8)	283 (21.1)	438 (21.9)	939 (20.8)	
≥5	447 (38.5)	522 (38.8)	904 (45.2)	1,873 (41.7)	
Location					<0.001
Antrum/pylorus	942 (81.1)	808 (60.2)	961 (48.1)	2,711 (60.2)	
Body	219 (18.9)	535 (39.8)	1,040 (51.9)	1,794 (39.8)	
Differentiation					<0.001
Differentiated	501 (43.2)	554 (41.3)	788 (39.4)	1,843 (40.9)	
Undifferentiated	652 (56.3)	787 (58.6)	1,212 (60.5)	2,651 (58.9)	
Undescribed	8 (0.7)	2 (0.1)	1 (0.1)	10 (0.2)	
Size (cm)	3.1±1.8	2.8±4.1	2.9±3.5	2.9±3.4	<0.001
Metastatic LN	0.5±2.1	0.5±3.3	0.3±1.6	0.4±2.3	0.940
Harvested LN	35.6±12.5	34.2±12.6	31.0±11.5	33.1±12.3	<0.001
PRM (cm)	3.7±2.2	3.9±2.4	4.1±2.6	3.9±2.4	0.035
DRM (cm)	5.3±3.0	5.1±2.7	5.4±3.0	5.3±2.9	0.038
T stage					0.215
T1	1,020 (87.9)	1,189 (88.6)	1,757 (87.9)	3,966 (88.1)	
T2	87 (7.5)	95 (7.1)	137 (6.8)	319 (7.1)	
T3	33 (2.8)	49 (3.6)	77 (3.8)	159 (3.5)	
T4a	21 (1.8)	10 (0.7)	29 (1.5)	60 (1.3)	
N stage					0.439
N0	1,020 (87.9)	1,183 (88.0)	1,750 (87.5)	3,953 (87.8)	
N1	79 (6.8)	99 (7.4)	152 (7.6)	330 (7.3)	
N2	37 (3.2)	45 (3.4)	76 (3.8)	158 (3.5)	
N3a	19 (1.6)	13 (1.0)	19 (0.9)	51 (1.1)	
N3b	6 (0.5)	3 (0.2)	4 (0.2)	13 (0.3)	
TNM stage					0.740
IA	938 (80.9)	1,097 (81.6)	1,613 (80.6)	3,648 (81.0)	
IB	113 (9.7)	131 (9.8)	186 (9.3)	430 (9.5)	
IIA	49 (4.2)	54 (4.0)	102 (5.1)	205 (4.6)	
IIB	34 (2.9)	33 (2.5)	57 (2.8)	124 (2.8)	
IIIA	14 (1.2)	17 (1.3)	28 (1.4)	59 (1.3)	
IIIB	8 (0.7)	10 (0.7)	11 (0.6)	29 (0.6)	
IIIC	5 (0.4)	1 (0.1)	3 (0.2)	9 (0.2)	
Adjuvant chemotherapy					0.662
Yes	79 (6.8)	83 (6.2)	139 (6.9)	301 (6.7)	
No	1,082 (93.2)	1,260 (93.8)	1,862 (93.3)	4,204 (93.3)	
Neoadjuvant chemotherapy					NA
No	1,161 (100.0)	1,343 (100.0)	2,001 (100.0)	4,505 (100.0)	

Values are expressed as mean ± standard deviation or number (%).

ASA = American Society of Anesthesiologists; CCI = Charlson Comorbidity Index; LN lymph node; PRM = proximal resection margin; DRM = distal resection margin; TNM = tumor, node, metastasis; NA = not applicable.

Table 2. Surgical outcomes of patients who received delta-shaped anastomosis

Surgical outcomes	Phase 1 (n=1,161)	Phase 2 (n=1,343)	Phase 3 (n=2,001)	Total (n=4,505)	P-value
Type of minimally invasive surgery					
Laparoscopic	1,161 (100.0)	1,343 (100.0)	1,685 (93.1)	4,367 (96.9)	
Robotic	0 (0.0)	0 (0.0)	138 (6.9)	138 (3.1)	
Extent of LN dissection					0.054
≤D1	15 (1.3)	11 (0.8)	10 (0.5)	36 (0.8)	
≥D1+	1,146 (98.7)	1,332 (99.2)	1,991 (99.5)	4,469 (99.2)	
Curability					0.922
R0	1,158 (99.7)	1,341 (99.8)	1,996 (99.7)	4,498 (99.8)	
R1	2 (0.2)	1 (0.1)	4 (0.2)	6 (0.1)	
R2	1 (0.1)	1 (0.1)	1 (0.1)	3 (0.1)	
Operation time (min)	134.6±36.6	128.3±29.9	135.5±37.6	133.2±35.3	<0.001
Hospital stays after surgery (days)	6.7±3.1	6.6±3.2	6.2±4.7	6.5±3.9	<0.001

Values are expressed as the mean ± standard deviation or number (%).

LN = lymph node.

Table 3. Early complications in patients who received delta-shaped anastomosis

Variables	Phase 1 (n=1,161)	Phase 2 (n=1,343)	Phase 3 (n=2,001)	Total (n=4,505)	P-value
Intraoperative complication	2 (0.1)	1 (0.1)	6 (0.3)	9 (0.2)	0.199
Post-operative complication	113 (9.7)	119 (8.9)	162 (8.1)	394 (8.7)	0.276
CDC grade					
I	17 (1.5)	17 (1.3)	14 (0.7)	48 (1.1)	0.149
II	69 (5.9)	78 (5.8)	93 (4.6)	240 (5.3)	0.056
IIIa	16 (1.4)	9 (0.7)	35 (1.7)	60 (1.3)	0.009
IIIb	6 (0.5)	9 (0.7)	15 (0.7)	30 (0.7)	0.913
IVa	2 (0.2)	6 (0.4)	2 (0.1)	10 (0.2)	0.163
IVb	4 (0.3)	0 (0.0)	3 (0.1)	7 (0.2)	NaN
V	0 (0.0)	0 (0.0)	1 (0.0)	1 (0.0)	NaN

Values are expressed as the number (%).

CDC = Clavien–Dindo classification.

Survival outcomes

The 5-year OS and DFS rates were 95.0% and 92.8%, respectively. The survival rates were further analyzed based on tumor stage, and the results are presented in **Fig. 2A and B**. The OS rates were 97.1% for stage IA, 90.8% for stage IB, 86.3% for stage II, and 64.7% for stage III ($P<0.001$). The DFS rates were 95.2% for stage IA, 88.7% for stage IB, 82.3% for stage II, and 59.5% for stage III ($P<0.001$). Next, we investigated the prognostic impact of TO and discovered no survival difference based on the TO achievement between patients with stage II and III gastric cancer or in the entire cohort (**Fig. 2C and D**).

DISCUSSION

TO is a composite measure of clinicopathological parameters used to assess surgical performance and variations in individual hospitals, or to compare them between institutions. It is currently used to evaluate the effectiveness of treatments for several cancers [26–28]. Since its initial proposal by the Dutch Upper Gastrointestinal Cancer Audit for gastric cancer, Western studies have highlighted the prognostic importance of TO [20,22,23,29,30]. Based on previously published studies pertaining to TOs in gastric cancer, TO values ranging from 22.8% to 75% have been achieved [20,22,23,31]. However, despite the clinical implications, the application of TO has resulted in different surgical-outcome results in East Asian patients owing to the effect of pre-operative chemotherapy, a higher proportion of advanced tumors, and a significant amount of missing data. Therefore, we investigated surgery-specific TOs in

Table 4. Univariate and multivariate logistic-regression analyses for surgical complications in patients who received delta-shaped anastomosis

Variables	Univariate analysis			Multivariate analysis		
	OR	95% CI	P-value	OR	95% CI	P-value
Age			<0.001			0.162
<60 yr	1			1.000		
≥60 yr	1.671	1.354–2.061		1.207	0.927–1.571	
Sex			<0.001			0.003
Male	1			1.000		
Female	0.646	0.516–0.808		0.711	0.565–0.893	
BMI			0.001			0.007
<25 kg/m ²	1			1.000		
≥25 kg/m ²	1.441	1.000–1.776		1.339	1.083–1.656	
ASA score			0.003			0.942
1	1			1.000		
2	1.642	1.210–2.228		1.223	0.884–1.693	
≥3	1.974	1.176–3.311		1.021	0.582–1.791	
CCI score			<0.001			0.003
2	1			1.000		
3–5	1.609	1.133–2.284		1.307	0.893–1.914	
≥6	2.860	1.976–4.138		2.003	1.255–3.196	
T stage			0.016			0.074
T1	1			1.000		
T2–T4a	1.426	1.070–1.901		1.332	0.973–1.823	
N stage			0.085			0.496
N (-)	1			1.000		
N (+)	1.292	0.965–1.731		1.118	0.812–1.539	
Operation time			0.004			0.104
<130 min	1			1.000		
≥130 min	1.353	1.099–1.666		1.193	0.964–1.476	
Phases			0.276			
Phase 1	1					
Phase 2	0.893	0.682–1.169				
Phase 3	0.814	0.634–1.047				

OR = odds ratio; CI = confidence interval; BMI = body mass index; ASA = American Society of Anesthesiologists; CCI = Charlson Comorbidity Index.

a large patient cohort. To the best of our knowledge, this is the first study to evaluate the TO of DA in patients with gastric cancer.

We discovered that post-operative complications were the most common factors for TO noncompliance, which is consistent with the findings of previous studies [21,30]. However, the incidence of both overall and severe complications in our study was lower than that reported in Western studies [20,22,23,30] and comparable to the results of laparoscopic distal gastrectomy in Asian randomized controlled trials (RCTs) (13.0%–16.6%) [4,6]; this might be due to a higher proportion of early cancer requiring less than D2 lymphadenectomy. As 88% of patients had early gastric cancer, the rates of curative resection and acquisition of tumor-negative resection margins did not significantly affect TO compliance, in contrast to the results of other studies [20,21]. Additionally, failure to obtain >15 lymph nodes during surgery was minimal, in contrast to other studies [20–22,30]. However, we could not demonstrate significantly better oncological outcomes in the TO group than in the non-TO group among patients with stage II or III disease. This might be due to the lower proportion of stage II or III patients and the insufficient incidence of complications, which impeded the achievement of significant prognostic differences. Moreover, the commencement of adjuvant chemotherapy within 8 weeks after surgery for most patients, despite morbidity, may be a contributing factor.

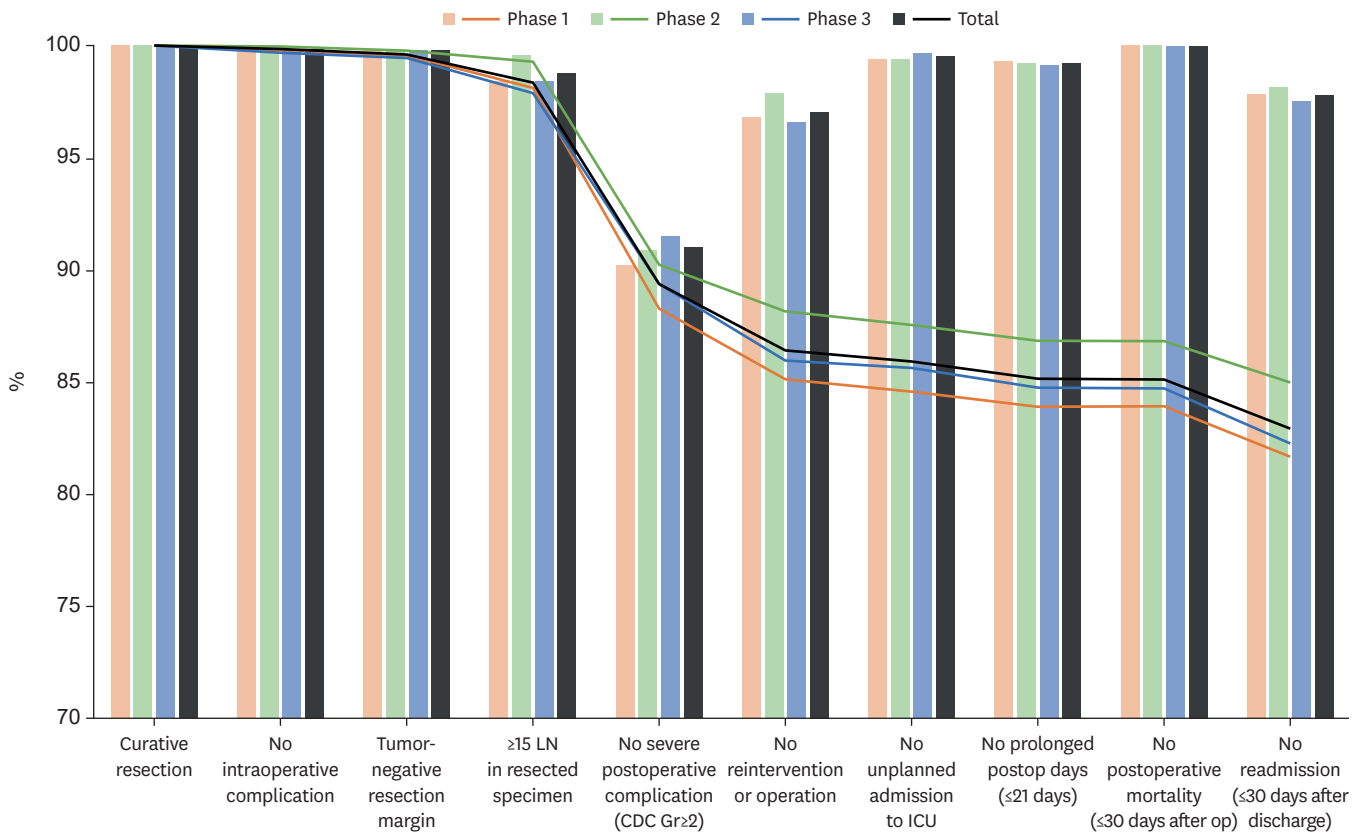


Fig. 1. Proportion of patients achieving textbook outcome and each quality metric after delta-shaped anastomosis. Textbook outcomes: 81.7% for phase 1 (orange), 85.0% for phase 2 (green), and 82.3% for phase 3 (blue). LN = lymph node; CDC = Clavien-Dindo classification; ICU = intensive care unit.

Table 5. Profile of textbook outcome features for delta-shaped anastomosis

Variable	Yes	No
Curative resection	4,505 (100.0)	0 (0.0)
No intraoperative complication	4,496 (99.8)	9 (0.2)
Tumor-negative resection margin	4,495 (99.8)	10 (0.2)
≥15 lymph nodes in resected specimen	4,451 (98.8)	54 (1.2)
No severe post-operative complication (CDC grade 2 or more)	4,099 (91.0)	406 (9.0)
No reintervention or reoperation	4,372 (97.0)	133 (3.0)
No unplanned admission to ICU	4,483 (99.5)	22 (0.5)
No prolonged post-operative days (21 days or longer)	4,470 (99.2)	35 (0.8)
No postoperative mortality (within 30 days after operation)	4,504 (99.9)	1 (0.1)
No readmission (within 30 days after discharge)	4,406 (97.8)	99 (2.2)
Textbook outcome	3,736 (82.9)	769 (17.1)

Values are expressed as the number (%).
 CDC = Clavien-Dindo classification; ICU = intensive care unit.

In this study, the early post-operative complication rate was 8.7%, which is comparable to those of other retrospective studies reporting DA in Asian groups (8.0%–13.3%) [13,16,17] and Asian RCT (13.0%–16.6%) [4,6]. Anastomosis-related complications, which are a significant concern in performing DA, were observed in less than 1% of the patients. This suggests that the proposed method is safe. The risk factors related to morbidity in other studies, such as male sex, higher BMI, and higher CCI scores, were reconfirmed. In particular, we reanalyzed the surgical results and TO by period as considerable factors

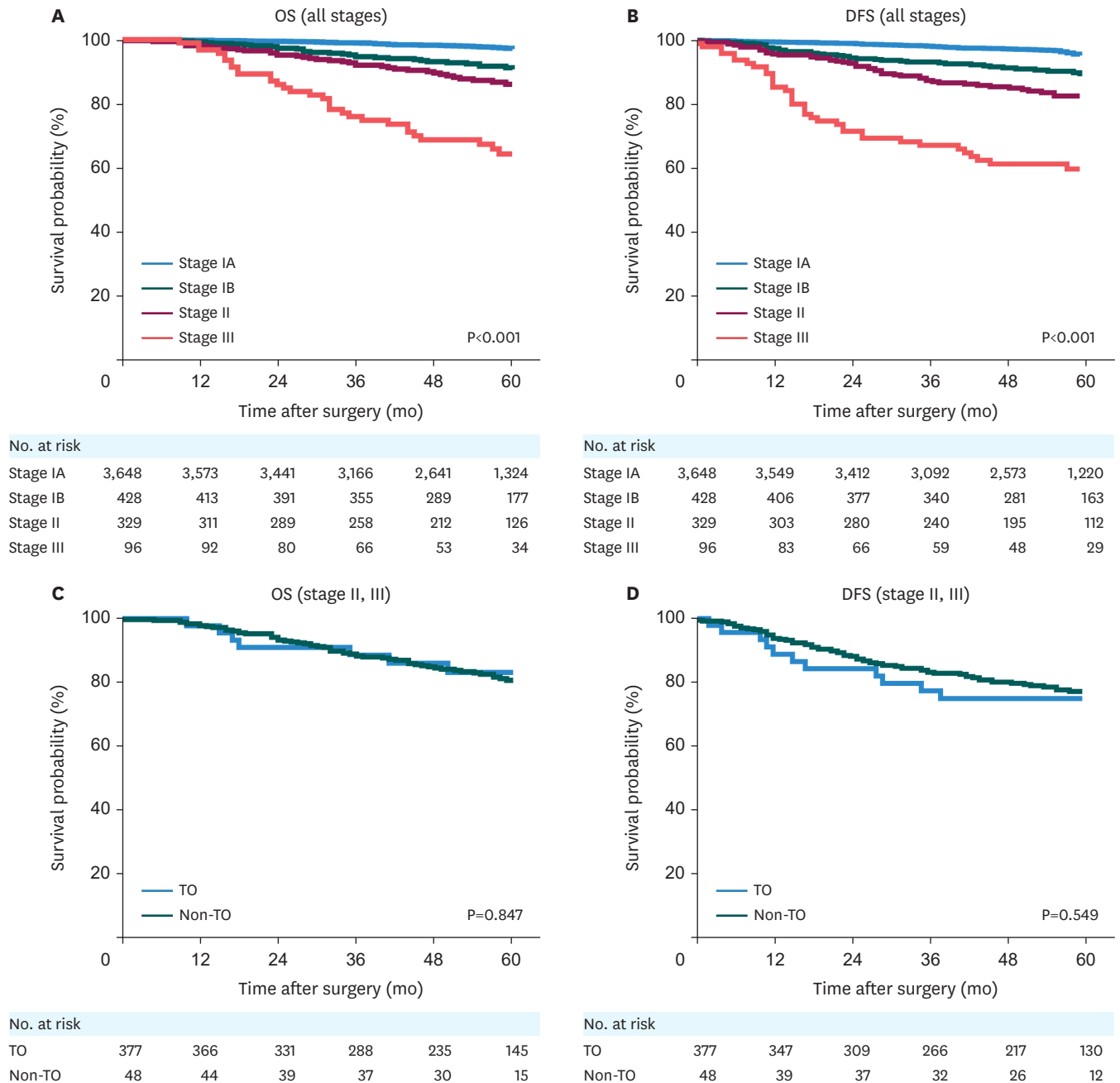


Fig. 2. Survival outcomes in patients who received minimally invasive distal gastrectomy with delta-shaped anastomosis. (A) OS (all stages), (B) DFS (all stages), (C) OS based on whether TO was achieved (stages II and III), and (D) DFS based on whether TO was achieved (stages II and III). OS = overall survival; DFS = disease-free survival; TO = textbook outcome.

affecting the outcomes remained, including changes in patient characteristics, the learning period of surgeons with insufficient experience, and the evolution of new technologies. Our results showed a recent increase in patient age and comorbidities, decreased morbidity, and shortened hospital stays after the introduction of a clinical pathway and early recovery after surgery. Meanwhile, the surgical outcomes were consistently favorable across the periods, thus highlighting the safety of DA in treating patients with gastric cancer.

This study presents some limitations. First, despite the large sample size, the patients were treated at a single institution, which restricts the generalizability of the study. Second, the study involves a retrospective design, which may have caused underestimated overall complications. Third, this study is not a comparative study that assesses the results of open surgery or other anastomotic methods after distal gastrectomy, which limits our ability to conclusively prove the safety of the procedure based on comparison with other methods. Finally, directly comparing our TO values with those of previously published studies based on different types of registries, including patients who underwent distal or total gastrectomy, open or laparoscopic surgery, and received neoadjuvant chemotherapy, is challenging. Hence, a multi-institutional prospective study is warranted. Nevertheless, our study is valuable because it provides a robust assessment based on TO, with a large patient cohort receiving the same anastomosis for more than 10 years and with minimal missing data. The high TO compliance rate suggests the safety and surgical quality of DA in patients with gastric cancer who require minimally invasive distal gastrectomy.

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SUPPLEMENTARY MATERIALS

Supplementary Table 1

Type of major complications in patients who received delta-shaped anastomosis

Supplementary Table 2

Comparison of characteristics based on achievement of TOs in patients who received delta-shaped anastomosis

Supplementary Table 3

Univariate and multivariate logistic regression analysis for achieving a textbook outcome in patients who underwent delta-shaped anastomosis

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