

Short-term outcomes depending on type of oesophagojejunostomy in laparoscopic total gastrectomy for gastric cancer: retrospective study based on a Korean Nationwide Survey for Gastric Cancer in 2019

Gun Kang¹, Jiyeon Kim² and Ju-Hee Lee^{1,3,*} 

¹Department of Surgery, Hanyang University Hospital, Seoul, Republic of Korea

²Department of Pre-Medicine, College of Medicine, and Biostatistics Laboratory, Medical Research Collaborating Center (MRCC), Hanyang University, Seoul, Republic of Korea

³Department of Surgery, Hanyang University, College of Medicine, Seoul, Republic of Korea

*Correspondence to: Ju-Hee Lee, Department of Surgery, College of Medicine, Hanyang University, 222 Wangsimni-ro, Seongdong-gu, Seoul, Republic of Korea (e-mail: leehu79@gmail.com)

Abstract

Background: The study aimed to assess postoperative complication rates of different oesophagojejunostomy (EJ) techniques used in laparoscopic total gastrectomy for gastric cancer.

Methods: A total of 1155 patients who underwent laparoscopic total gastrectomy were retrospectively selected from the data obtained from the Korean Nationwide Survey for gastric cancer in 2019. Morbidity rate was compared between patients who received intracorporeal or extracorporeal EJ using linear or circular staplers during laparoscopic total gastrectomy. The variables of the groups were balanced using the inverse probability of treatment weighting.

Results: Seven hundred and seventy-three patients received intracorporeal EJ using a linear stapler (IL), 137 received intracorporeal EJ using a circular stapler (IC), 134 received extracorporeal EJ using a linear stapler (EL) and 111 received extracorporeal EJ using a circular stapler (EC). The overall complication rates were lower in the extracorporeal group (EL: 13.4% versus EC: 12.6%) compared to the intracorporeal group (IL: 22.6% versus IC: 17.5%) ($P = 0.006$). Fewer major complications were observed in the extracorporeal group (EL: 1.4% versus EC: 1.8%) compared to the intracorporeal group (IL: 9.4% versus IC: 7.3%) ($P = 0.004$). There was no significant difference in EJ-related complications between the groups ($P = 0.418$ in EJ leakage and $P = 0.474$ in EJ stricture). Multivariable analysis showed that the IL method correlated with more overall and major complications than the extracorporeal method.

Conclusion: The results of this study suggest that despite its widespread use, the IL method is a challenging procedure with higher complication rates than the extracorporeal method. Further high-quality studies are required to confirm the results.

Introduction

Gastric cancer remains the fifth most common cancer and the third leading cause of cancer-related deaths worldwide¹. Laparoscopic surgery has provided an alternative approach for treating gastric cancer. With the development of laparoscopic surgical techniques, the scope of laparoscopic gastrectomy is gradually expanding. Although laparoscopic total gastrectomy (LTG) is increasingly being performed², oesophagojejunostomy (EJ) is still considered a difficult procedure. Globally, surgeons seem to be struggling with establishing the proper method of EJ after LTG^{3–9}.

In total open gastrectomy, EJ with a circular stapler is the standard technique. Indeed, the authors prefer this method, even in laparoscopic surgery (intracorporeally), owing to previous research results¹⁰. However, the implementation of intracorporeal EJ with a circular stapler (IC) seems to be related to anastomosis stenosis according to some studies¹¹. Therefore, further studies are needed to determine the optimal anastomosis method.

According to the published nationwide survey data of the Korean Gastric Cancer Association (KGCA), LTG was performed in 1211 patients in 68 hospitals in 2019². In most cases, Roux-en-Y EJ was performed as a reconstruction, but various EJ techniques were performed depending on the surgical approach used (intracorporeal or extracorporeal) and whether the stapler used was circular or linear. The purpose of this study was to compare complications and short-term results of each anastomosis technique and to propose an appropriate anastomosis method after LTG using a large-scale nationwide data set.

Materials and methods

Patients and data extraction

Patients ($n = 1212$) who underwent LTG in 2019 were selected from a nationwide survey database of the KGCA. The KGCA has been conducting nationwide retrospective surveys for gastric cancer

Received: December 13, 2023. Revised: June 10, 2024. Accepted: September 16, 2024

© The Author(s) 2024. Published by Oxford University Press on behalf of BJS Foundation Ltd.

This is an Open Access article distributed under the terms of the Creative Commons Attribution License (<https://creativecommons.org/licenses/by/4.0/>), which permits unrestricted reuse, distribution, and reproduction in any medium, provided the original work is properly cited.

every 5 years since 1995 and the results have been published regularly^{2,12,13}. All institutions registered with the KGCA were invited to participate in this survey via email and chose to participate voluntarily. Designated representatives of the institutions were responsible for gathering and submitting data from their respective institutions, as well as correcting any inaccuracies or omissions in the data. The Information Committee of the KGCA was tasked with reviewing the collected data and identifying any inaccuracies or omissions. The survey comprised 54 questions, including those relating to patient demographics, past medical history, pathological findings, operative methods and surgical outcomes. Patient demographics included age, sex, hospital volume, BMI, ASA physical status classification, history of previous abdominal surgery or gastrectomy, and co-morbidities. Co-morbidity variables included diabetes mellitus, hypertension, liver disease, tuberculosis, heart disease, chronic renal failure, chronic obstructive pulmonary disease, cerebrovascular accident and others. The number of co-morbidities was categorized as 0–1 or 2 or more.

Postoperative complications were defined as any complication that occurred within 30 days of surgery. Postoperative complications were categorized into 14 types, including anastomotic leakage, anastomotic stricture, duodenal stump leakage, intra-abdominal bleeding, luminal bleeding, pancreatic fistula, intra-abdominal abscess, fluid collection, wound problem, mechanical ileus, pneumonia, cerebrovascular accident, cardiac disease and others, and the severity of postoperative complications was determined using the Clavien–Dindo classification¹⁴. Postoperative mortality was defined as death within 30 days of surgery or during hospitalization.

Patients ($n = 35$) with a history of neoadjuvant chemotherapy for gastric cancer and those who received a handsewn EJ procedure ($n = 3$) were excluded. A further 18 patients whose data on the extent of lymph node dissection and stages were unavailable were also excluded given that these factors were used for inverse probability of treatment weighting (IPTW) to balance patients' baseline characteristics between study groups. Of the remaining 1155 patients, 773 were treated using an intracorporeal EJ with a linear stapler (IL), 137 using an intracorporeal EJ with a circular stapler (IC), 134 using an extracorporeal EJ with a linear stapler (EL), and 111 using an extracorporeal EJ with a circular stapler (EC). This study was approved by the Institutional Review Board of Hanyang University Hospital (IRB no. 2023-09-012).

Statistical analysis

Statistical analyses were performed using SAS 9.4 (SAS Institute Inc., Cary, NC, USA) and R version 4.2.3 (R Foundation for Statistical Computing, Vienna, Austria). IPTW using propensity score-calculated weights was used to minimize the effect on the difference in confounding factors between the two groups and balance age, sex, extent of lymph node dissection and stages between study groups. All values are expressed as the mean (s.d.) or frequency (percentage). The χ^2 test, Fisher's exact test and one-way analysis of variance were used for comparisons between the groups. $P \leq 0.05$ was considered statistically significant. A logistic regression model was used for multivariable analysis to identify independent risk factors for complications, and odds ratios with 95% confidence intervals were calculated before and after IPTW. For the multivariable analysis, only variables with $P \leq 0.05$ from the univariable analysis were included.

Results

Patient demographics and postoperative outcomes

The baseline characteristics were compared between the IL, IC, EL and EC groups before and after weighting using the standardized differences approach, and values that were ± 0.1 of the standardized differences were denoted as well-balanced between the two groups (Table 1). Before adjustment, the mean age, hospital volume (<100 cases/year versus ≥ 100 cases/year), presence of previous abdominal operation history, surgical intent (curative versus palliative), extent of lymph node dissection and type of omentectomy (partial versus total) were statistically different between the groups. After IPTW, the hospital volume, presence of previous abdominal operation history and performance of combined surgery remained significantly different between the study groups.

The mean (s.d.) number of harvested lymph nodes was >40 in all study groups (IL: 42.74(22.81), IC: 45.15(20.09), EL: 41.77(23.75), EC: 48.50(24.64); $P = 0.053$ and 0.005 before and after IPTW respectively). The mean operating time ($P < 0.001$) and estimated blood loss ($P = 0.04$) were significantly different before IPTW, although the significance was lost after IPTW ($P = 0.139$ and 0.975 respectively). Additionally, there was no significant difference in the postoperative hospital stay between the study groups before and after IPTW (mean (s.d.) number of days 11.73(12.95) versus 10.83(10.25) versus 10.52(9.57) versus 10.24(6.63) in IL versus IC versus EL versus EC groups; $P = 0.5441$ and 0.314 before and after IPTW respectively).

Postoperative complications

The overall complication rates were significantly different between the groups before and after IPTW (IL: 22.6% versus IC: 17.5% versus EL: 13.4% versus EC: 12.6%; $P = 0.01$ and 0.006 before and after IPTW respectively). Major complication ($>$ grade IIIa) rates were also significantly different (IL: 9.4% versus IC: 7.3% versus EL: 1.5% versus EC: 1.8%; $P = 0.001$ and 0.004 before and after IPTW respectively). However, EJ-related complications (EJ leakage and stricture) were not significantly different between the groups before and after IPTW (5.6% versus 3.6% versus 3.0% versus 3.6% in IL versus IC versus EL versus EC groups; $P = 0.447$ and 0.614 before and after IPTW respectively). The incidence of EJ leakage did not differ significantly between the groups before and after IPTW (4.3% versus 2.2% versus 3.0% versus 1.8% in IL versus IC versus EL versus EC groups; $P = 0.527$ and 0.418 before and after IPTW respectively). With regard to EJ stricture rates, there were no significant differences between groups before and after IPTW (1.3% versus 1.5% versus 0% versus 1.8% in IL versus IC versus EL versus EC groups; $P = 0.519$ and 0.474 before and after IPTW respectively). Nine patients in the IL group died during hospitalization. After IPTW, there was no significant difference in mortality rates between the study groups ($P = 0.027$ and 0.244 before and after IPTW respectively).

A complete list of the observed morbidities for all patients is shown in Table S1. Grade II complications were the most common complications in all study groups, although there was no significant difference in the incidence of grade I, II, IIIa, IIIb, IVa and V complications between the study groups after IPTW ($P = 0.845$ in grade I, $P = 0.599$ in grade II, $P = 0.061$ in grade IIIa, $P = 0.141$ in grade IIIb, $P = 0.129$ in grade IVa, and $P = 0.824$ in grade V; Table 2).

Table 1 Clinicopathological characteristics between study groups (n = 1155)

Character	Unadjusted				IPTW	
	Intracorporeal (n = 910)		Extracorporeal (n = 245)		P	Standardized difference
	IL (n = 773)	IC (n = 137)	EL (n = 134)	EC (n = 111)		
Age (years), mean(s.d.)	63.29(11.77)	64.77(10.98)	64.10(11.06)	60.77(11.67)	0.045*	0.187
Sex						
Male	549	94	103	75	0.354†	0.113
Female	224	43	31	36		
Hospital volume						
<100 cases	78 (10.1)	5 (3.7)	3 (2.2)	26 (23.4)	<0.001†	0.383
≥100 cases	695 (89.9)	132 (96.4)	131 (97.8)	85 (76.6)		
BMI (kg/m ²), mean(s.d.)	24.03(3.36)	23.58(2.93)	23.85(3.15)	24.23(3.16)	0.383*	0.113
ASA class					<0.001†	0.236
0–2	631 (83.3)	121 (88.3)	95 (70.9)	96 (86.5)		
≥3	127 (16.8)	16 (11.7)	39 (29.1)	15 (13.5)		
Co-morbidities						
0–1	538 (71.7)	53 (60.9)	83 (75.2)	78 (73.6)	0.125†	0.161
≥2	212 (28.3)	34 (39.1)	27 (24.8)	28 (26.4)		
Presence of previous operation history					0.030†	0.212
No	165 (21.9)	17 (19.5)	30 (27.5)	13 (11.7)		
Yes	590 (78.2)	70 (80.5)	79 (72.5)	98 (88.3)		
Previous gastrectomy					0.221‡	0.111
No	724 (95.9)	85 (97.7)	107 (98.2)	110 (99.1)		
Yes	31 (4.1)	2 (2.3)	2 (1.8)	1 (0.9)		
Surgical intent					<0.001†	0.141
Curative	753 (97.4)	136 (99.3)	134 (100.0)	108 (100.0)		
Palliative	20 (2.6)	1 (0.7)	–	–		
Combined operation					0.106†	0.137
No	695 (90.2)	125 (91.2)	118 (88.1)	92 (82.9)		
Yes	76 (9.8)	12 (8.8)	16 (11.9)	19 (17.2)		
Lymph node dissection					<0.001†	0.289
<D2	234 (30.3)	62 (45.3)	76 (56.7)	45 (40.5)		
≥D2	539 (69.8)	75 (54.7)	58 (43.3)	66 (59.5)		
Omentectomy					0.048†	0.121
Partial	461 (64.2)	65 (74.7)	95 (73.1)	79 (71.2)		
Total	257 (35.8)	22 (25.3)	35 (26.9)	32 (28.8)		
Stage					0.136†	0.233
I	133 (17.2)	26 (19.0)	34 (25.4)	15 (13.5)		
II	474 (61.3)	93 (67.9)	75 (56.0)	77 (69.4)		
III	145 (18.8)	15 (11.0)	23 (17.2)	16 (14.4)		
IV	21 (2.7)	3 (2.2)	2 (1.5)	3 (2.7)		
Overall complication	175 (22.6)	24 (17.5)	18 (13.4)	14 (12.6)	0.010†	0.151
Major complication (CD grade > 3)	72 (9.4)	10 (7.3)	2 (1.5)	2 (1.8)	0.001†	0.223
EJ related complications						
EJ leakage	43 (5.6)	5 (3.6)	4 (3.0)	4 (3.6)	0.447†	0.223
EJ stricture	33 (4.3)	3 (2.2)	4 (3.0)	2 (1.8)	0.527‡	0.081
Mortality	10 (1.3)	2 (1.5)	–	2 (1.8)	0.519‡	0.101
No. of harvested lymph nodes	9 (1.2)	–	–	–	0.027‡	0.078
Operation time (min), mean(s.d.)	42.74 (22.81)	45.15 (20.09)	41.77 (23.75)	48.50 (24.64)	0.053*	0.163
EBL (mL), mean(s.d.)	212.21 (98.84)	131.58 (140.87)	252.40 (70.95)	162.82 (138.42)	<0.001*	0.61
Hospital stay (days), mean(s.d.)	133.12 (182.43)	88.60 (103.21)	150.19 (128.51)	114.73 (113.64)	0.040*	0.265
	11.73 (12.95)	10.83 (10.25)	10.52(9.57)	10.24 (6.63)	0.441*	0.077

Values are n (%) unless otherwise indicated. CD, Clavien–Dindo; EBL, estimated blood loss; EC, extracorporeal oesophagojejunostomy with a circular stapler; EJ, oesophagojejunostomy; EL, extracorporeal oesophagojejunostomy with linear staplers; IC, intracorporeal oesophagojejunostomy with a circular stapler; IL, intracorporeal oesophagojejunostomy with linear staplers; IPTW, inverse probability of treatment weighting; *ANOVA; †chi-square test; ‡Fisher's exact test.

Risk factors associated with postoperative morbidity

Risk factors associated with overall complications, major complications and EJ-related complications were evaluated. Variables associated with the occurrence of overall complications in univariate analysis were as follows: age >70 years ($P < 0.001$), hospital volume <100 cases ($P = 0.008$), co-morbidity ≥ 2 ($P = 0.042$), type of reconstruction ($P = 0.01$), history of previous abdominal surgery ($P = 0.03$), operation time ≥ 240 min ($P < 0.001$)

and stages ($P < 0.001$) (Table 2). Multivariable analysis showed that age >70 years, type of reconstruction (IL group versus EL or EC group), history of previous abdominal surgery and longer operation time (>240 min) were predictable risk factors for the occurrence of overall complications both before and after IPTW (Table 3).

Next, variables associated with major complications were analysed. Univariate analysis showed that age >70 years ($P < 0.001$), male sex ($P = 0.013$), hospital volume <100 cases ($P = 0.029$),

Table 2 Risk factors related to morbidity in patients who underwent laparoscopic total gastrectomy

Variables	No. patients (n = 1155)	Overall complications		Major complications		EJ complications	
		n (%)	P	n (%)	P	n (%)	P
Age (years)			<0.001*		<0.001*		0.516*
≤70	768	130 (16.9)		43 (5.6)		35 (4.6)	
>70	387	101 (26.1)		43 (11.2)		21 (5.4)	
Sex			0.206*		0.013*		0.205*
Male	821	172 (21.0)		71 (8.7)		44 (5.4)	
Female	334	59 (17.57)		15 (4.5)		12 (3.6)	
BMI (kg/m²)			0.233*		0.388*		0.461*
<25	734	139 (19.0)		51 (7.0)		33 (4.5)	
≥25	421	92 (21.9)		35 (8.4)		23 (5.5)	
Hospital volume			0.008*		0.029*		0.034*
<100 cases	112	33 (29.5)		14 (12.7)		10 (8.9)	
≥100 cases	1043	198 (19.0)		72 (7.0)		46 (4.4)	
Presence of co-morbidities			0.042*		0.313*		0.936*
0–1	751	147 (19.6)		54 (7.2)		39 (5.2)	
≥2	301	76 (25.3)		27 (9.1)		16 (5.3)	
Combined operation			0.130*		0.488*		0.381*
None	1030	200 (19.4)		75 (7.3)		52 (5.1)	
Yes	123	31 (25.2)		11 (9.1)		4 (3.3)	
Type of reconstruction			0.010*		0.001*		0.447*
IL	773	175 (22.6)		72 (9.4)		43 (5.6)	
IC	137	24 (17.5)		10 (7.3)		5 (3.7)	
EL	134	18 (13.4)		2 (1.5)		4 (3.0)	
EC	111	14 (12.6)		2 (1.8)		4 (3.6)	
Previous abdominal surgery			0.030*		0.617*		0.426*
None	837	164 (20.0)		62 (7.5)		41 (4.9)	
Yes	225	59 (26.2)		19 (8.5)		14 (6.2)	
Lymph node dissection			0.603*		0.177*		0.824*
<D2	429	80 (19.2)		25 (6.1)		21 (5.0)	
D2	742	151 (20.5)		61 (8.3)		35 (4.7)	
Surgical intent			0.282†		1.000†		0.620†
Curative	1131	229 (20.3)		85 (7.6)		56 (5.0)	
Palliative	21	2 (9.5)		1 (4.8)		-	
Omentectomy			0.162*		0.453*		0.073*
Partial	700	147 (21.0)		22 (6.4)		11 (3.2)	
Total	346	60 (17.3)		53 (7.7)		40 (5.7)	
Operation time (min)			<0.001*		0.025*		0.035*
≤240	711	120 (16.9)		43 (6.1)		27 (3.8)	
>240	444	111 (25.0)		43 (9.7)		29 (6.3)	
Stages			<0.001*		0.051*		0.478*
I	208	48 (23.1)		45 (6.3)		13 (6.3)	
II	719	122 (17.0)		20 (9.6)		33 (4.6)	
III	199	58 (29.2)		21 (10.6)		10 (5.0)	
IV	29	3 (10.3)		-		-	

EC, extracorporeal circular stapler; EJ, oesophagojejunostomy; EL, extracorporeal linear stapler; IC, intracorporeal circular stapler; IL, intracorporeal linear stapler; *chi-square test, †Fisher's exact test.

Table 3 Risk factors related to overall complications in patients who underwent laparoscopic total gastrectomy: multivariable analysis

Variables	Before IPTW			After IPTW		
	OR	95% c.i.	P	OR	95% c.i.	P
Age (>70 versus ≤70 years)	1.653	1.202,2.273	0.002	1.625	1.182,2.233	0.003
Hospital volume (<100 versus ≥100)	1.42	0.890,2.268	0.142	1.496	0.945,2.367	0.086
Presence of co-morbidity (≥2 versus 0–1)	1.18	0.844,1.650	0.332	1.175	0.840,1.643	0.346
Type of reconstruction						
IC versus IL	0.658	0.365,1.187	0.164	0.685	0.387,1.211	0.193
EL versus IL	0.551	0.317,0.959	0.035	0.495	0.284,0.864	0.013
EC versus IL	0.511	0.278,0.939	0.031	0.407	0.216,0.766	0.005
Previous abdominal surgery (yes versus no)	1.437	1.009,2.047	0.045	1.459	1.027,2.073	0.035
Operation time (>240 versus ≤240 min)	1.768	1.281,2.440	0.001	1.781	1.290,2.458	0.001
Stages						
II versus I	0.705	0.471,1.056	0.09	0.718	0.481,1.073	0.106
III versus I	1.164	0.726,1.867	0.528	1.236	0.772,1.981	0.378
IV versus I	0.322	0.091,1.139	0.079	0.273	0.068,1.097	0.067

EC, extracorporeal oesophagojejunostomy with a circular stapler; EL, extracorporeal oesophagojejunostomy with linear staplers; IC, intracorporeal oesophagojejunostomy with a circular stapler; IL, intracorporeal oesophagojejunostomy with linear staplers; IPTW, inverse probability of treatment weighting.

Table 4 Risk factors related to major complications in patients who underwent laparoscopic total gastrectomy: multivariable analysis

Variables	Before IPTW			After IPTW		
	OR	95% c.i.	P	OR	95% c.i.	P
Age (>70 versus ≤70 years)	1.927	1.226,3.030	0.005	1.832	1.168,2.871	0.008
Sex (male versus female)	1.89	1.056,3.382	0.032	1.691	0.962,2.971	0.068
Hospital volume (<100 versus ≥100)	1.699	0.892,3.233	0.107	1.642	0.868,3.106	0.127
Type of reconstruction						
IC versus IL	0.755	0.375,1.520	0.431	0.846	0.431,1.662	0.627
EL versus IL	0.123	0.029,0.513	0.004	0.24	0.080,0.718	0.011
EC versus IL	0.174	0.042,0.728	0.017	0.128	0.026,0.629	0.011
Operation time (>240 versus ≤240 min)	1.637	1.035,2.590	0.035	1.661	1.053,2.620	0.029

EC, extracorporeal oesophagojejunostomy with a circular stapler; EL, extracorporeal oesophagojejunostomy with linear staplers; IC, intracorporeal oesophagojejunostomy with a circular stapler; IL, intracorporeal oesophagojejunostomy with linear staplers; IPTW, inverse probability of treatment weighting.

Table 5 Risk factors related to oesophagojejunostomy-related complications in patients who underwent laparoscopic total gastrectomy: multivariable analysis

Variables	Before IPTW			After IPTW		
	OR	95% c.i.	P	OR	95% c.i.	P
Hospital volume (<100 versus ≥100)	1.893	0.916,3.908	0.085	1.786	0.888,3.594	0.104
Operation time (>240 versus ≤240 min)	1.654	0.958,2.857	0.071	1.766	1.035,3.014	0.037

IPTW, inverse probability of treatment weighting.

type of reconstruction ($P = 0.001$) and operation time ≥ 240 min ($P = 0.025$) were associated with the occurrence of major complications (Table 2). Before IPTW, age >70 years, male sex, type of reconstruction (IL group versus EL or EC group) and longer operation time (>240 min) were identified as independent risk factors associated with major complications in multivariable analysis (Table 4). After IPTW, the male factor lost statistical significance.

In univariable analysis, the occurrence of EJ-related complications was related to hospital volume <100 cases/year ($P = 0.034$) and operation time ≥ 240 min ($P = 0.035$) (Table 2). In multivariable analysis after IPTW, operation time ≥ 240 min was the only risk factor associated with EJ-related complications (Table 5). The type of reconstruction was not a predictor for EJ-related complications in univariable and multivariable analyses.

Discussion

In this study, the occurrences of overall, major and EJ-related complications were not significantly different between the IL and IC groups, or between the IC and extracorporeal anastomosis (EC or EL) groups. However, the incidence of overall and major complications was significantly higher in the IL group than in the extracorporeal anastomosis (EC or EL) groups. These results indicate that extracorporeal anastomosis seems to be safer and more feasible compared to IL anastomosis. Nevertheless, caution is needed in interpretation when considering the limitations of the data and changes in techniques over time. Moreover, no significant differences were observed in EJ-related complications among all types of anastomoses after LTG. Determining the appropriate method will require further discussion.

In the early period when laparoscopic surgery was introduced, extracorporeal anastomosis was widely performed. However, extracorporeal anastomosis is conducted in a limited working space with restricted vision, thus making the procedure difficult, especially in obese patients. The intracorporeal anastomosis

method was introduced with the hope of overcoming the difficulty of reconstruction, especially in obese patients. For distal gastrectomy, some studies have suggested that intracorporeal anastomosis is superior in terms of postoperative recovery^{15–17}, whereas others regard extracorporeal anastomosis to be better^{18,19}. Most studies have reported that the incidence of anastomosis-related complications is not significantly different between the procedures. Therefore, the Korean Laparoendoscopic Gastrointestinal Surgery study group (KLASS) 07 study was initiated to compare the procedures in terms of cosmesis, economics and patient's quality of life. This study is expected to confirm the optimal procedure after laparoscopic distal gastrectomy with regard to various aspects. The optimal anastomosis technique for LTG has also not yet been confirmed. Direct comparison of various methods is difficult because detailed techniques differ depending on individual surgeons, even for the same intracorporeal or extracorporeal anastomosis. A meta-analysis by Chen *et al.* showed that there were no significant differences in the operation time, estimated blood loss, time to first flatus, length of hospital stays, or overall and anastomosis-related complications between intracorporeal and extracorporeal EJ anastomosis²⁰. Another recent retrospective large-scale single-centre study from Korea reported that IL can be recommended as an appropriate procedure because of shorter operation time, fewer intraoperative anastomosis events and faster postoperative recovery compared to the EC method, although the complications were similar between the two groups²¹. Based on these research results, the intracorporeal method appears to be the preferred method for both partial and total gastrectomy, as shown in the KGCA-led nationwide survey 2019, which demonstrated a notable increase in the use of the intracorporeal method compared to the previous survey². In the present study, compared to extracorporeal anastomosis, intracorporeal anastomosis (especially the IL method) was found to be associated with increased rates of overall and major complications. Moreover, given the relatively recent multicentre data, this study can be considered more reliable than other

studies; however, the lack of important data makes it difficult to confirm the results. The present study lacks data on intraoperative events and surgeons' learning curves, both of which are closely related to postoperative complications but are difficult to investigate through the surveys. Randomized controlled studies balancing these factors are needed to determine the best technique.

EJ-related complication is the most important factor that determines which anastomosis method a surgeon will perform in total gastrectomy. The rate of EJ leakage after LTG is reported to range from 0.7% to 9.5%²². Most studies have shown no significant difference between anastomosis procedures during LTG in terms of EJ leakage^{7,9,11,23–25}. However, studies on EJ stenosis, especially between IL and IC methods, have reported slightly different opinions. According to two multicentre studies from Korea and Japan, stenosis of the intracorporeal EJ anastomosis was less frequent with the linear stapling technique than with the circular stapling technique^{11,23}. Yang *et al.* suggested that the use of an OrVil™ or a 21 mm circular stapler may be the cause of more frequent EJ stenosis in the IC group¹¹. Similarly, Murakami *et al.* speculated that the IL method may create a larger anastomosis than the IC reconstruction method, thereby lowering the incidence of anastomotic stenosis²³. In contrast, Kang *et al.* reported no significant difference in EJ-related complication rates between the IC and IL methods²⁵. They suggested that the reason for the lack of a difference in anastomosis stenosis between the methods is due to the use of a single circular stapling technique as the IC method. Several studies have found that this technique causes significantly lower rates of EJ stenosis compared to the hemi-double-stapling technique, which uses a linear stapler to create the oesophageal stump, causing the stapler line to overlap after the circular stapler is fired^{26,27}. In the present study, the rates of EJ-related complications were similar between the groups and the results did not change even when the EJ-related complications were subdivided into EJ leakage and stricture. Considering that patients who had undergone surgery relatively recently were also included, it seems that the IC technique is becoming more stable as the surgical society's experience accumulates. However, it is difficult to make a judgement based on these results alone, given that specific individual procedures were not surveyed. Additionally, another limitation is that EJ-related strictures were only analysed for 30 days after surgery, which was not a sufficient period of time to comprehensively evaluate long-term EJ-related strictures. Tumour location is also an important indicator to consider when deciding the EJ surgical technique. Because the IL method requires a longer oesophageal length for anastomosis, the IC method might be preferred when the tumour is located near or above the gastro-oesophageal junction. This may be one of the reasons why more complications are reported with the IC method than with the IL method in previous studies^{7,9,11,23}. However, presence or absence of oesophageal or gastro-oesophageal junction invasion was not separately surveyed in the present study. This is also an important consideration when interpreting the results.

The authors used a propensity score based on IPTW adjustment, which significantly reduces confounding bias and imbalance in covariates and thus potentially offers an estimation of treatment effect similar to that in randomized trials²⁸. It assigns weights to each observation based on the probability of receiving the treatment that was actually received, thereby balancing the distribution of covariates

between treatment groups. Using the entire cohort of 1155 patients, the IPTW approach increased the study power compared to matched-pairs analysis²⁹. The authors selected only variables (age, sex, extent of lymph node dissection and stages) that were strongly associated with the incidence of complications in gastric cancer rather than including all baseline variables. After IPTW adjustment, hospital volume, history of abdominal surgery and performance of combined operation remained as differences between the groups. Although these factors can influence the occurrence of complications, low hospital volume (<100 cases), history of abdominal surgery and performance of combined operation were not most frequent in the IL group, which had the highest rates of overall and major complications. Moreover, in multivariable analysis to further evaluate whether the type of reconstruction influences the complication rate, the IL method remained a significant risk factor.

In conclusion, the authors found that the IL method is a demanding procedure with a significant risk of complications compared to the extracorporeal EJ methods. However, considering that the EJ procedure has been transitioning to an intracorporeal method as investigated in this study, either the IL or IC method can be performed with no significant differences in overall, major and EJ-related complication rates. Although this study utilized previously collected data, which limited the ability to confirm certain factors, its significance lies in the inclusion of a considerable number of patients and efforts to minimize bias using IPTW. A well-designed randomized clinical trial is necessary to confirm the optimal anastomosis method for EJ in LTG.

Author contributions

Gun Kang (Conceptualization, Methodology, Writing—original draft, Writing—review & editing), Jiyeong Kim (Data curation, Formal analysis, Investigation, Methodology, Software, Validation, Visualization), and Juhee Lee (Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Resources, Supervision, Validation, Writing—original draft, Writing—review & editing)

Funding

This study was funded by the National Research Foundation of Korea (NRF) through a grant from the Korean government (MSIT) (No. 2022R1G1A1003210).

Acknowledgements

This study was supported by the nationwide survey project of the information committee of the Korean Gastric Cancer Association (study number: KGCA2023ICx).

Disclosure

The authors declare no conflict of interest.

Supplementary material

[Supplementary material](#) is available at *BJS Open* online.

Data availability

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

References

- Bray F, Ferlay J, Soerjomataram I, Siegel RL, Torre LA, Jemal A. Global cancer statistics 2018: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. *CA Cancer J Clin* 2018;**68**:394–424
- 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
- Wang Z, Wei Y, Liu X, Li Z, Zhu G, Li Y et al. Application value of hand-sewn anastomosis in totally laparoscopic total gastrectomy for gastric cancer. *World J Surg Oncol* 2021;**19**:229
- Charalabopoulos A, Davakis S, Paraskeva P, Machairas N, Kapelouzou A, Kordzadeh A et al. Feasibility and short-term outcomes of three-dimensional hand-sewn esophago-jejunal anastomosis in completely laparoscopic total gastrectomy for cancer. *Cancers (Basel)* 2021;**13**:4709
- Wang Z, Liu X, Cheng Q, Wei Y, Li Z, Zhu G et al. Digestive tract reconstruction of laparoscopic total gastrectomy for gastric cancer: a comparison of the intracorporeal overlap, intracorporeal hand-sewn anastomosis, and extracorporeal anastomosis. *J Gastrointest Oncol* 2021;**12**:1031–1041
- Ushimaru Y, Omori T, Miyata H. A simple and safe T-shaped esophagojejunostomy for laparoscopic total gastrectomy. *J Gastrointest Surg* 2022;**26**:2019–2023
- Milone M, Elmore U, Manigrasso M, Vertaldi S, Aprea G, Servillo G et al. Circular versus linear stapling oesophagojejunostomy after laparoscopic total gastrectomy. A systematic review and meta-analysis. *Am J Surg* 2022;**223**:884–892
- Wei JP, Wang WD, Yang XS, Guo X, Li XH, Ji G. Comparing intracorporeal mechanical anastomosis vs. hand-sewn esophagojejunostomy after total laparoscopic gastrectomy for esophagogastric junction cancer: a single-center study. *World J Surg Oncol* 2023;**21**:12
- Guo Z, Deng C, Zhang Z, Liu Y, Qi H, Li X. Safety and effectiveness of overlap esophagojejunostomy in totally laparoscopic total gastrectomy for gastric cancer: a systematic review and meta-analysis. *Int J Surg* 2022;**102**:106684
- Park DJ, Lee JH, Lee MS, Lee HJ, Kim HH, Yang HK. Comparison of complications in end-to-side and side-to-side esophagojejunostomy after laparoscopy-assisted total gastrectomy for gastric cancer. *J Korean Soc Endosc Laparosc Surg* 2010;**13**:1–5
- Yang HK, Hyung WJ, Han SU, Lee YJ, Park JM, Cho GS et al. Comparison of surgical outcomes among different methods of esophagojejunostomy in laparoscopic total gastrectomy for clinical stage I proximal gastric cancer: results of a single-arm multicenter phase II clinical trial in Korea, KLASS 03. *Surg Endosc* 2021;**35**:1156–1163
- Information Committee of Korean Gastric Cancer Association. Korean Gastric Cancer Association nationwide survey on gastric cancer in 2014. *J Gastric Cancer* 2016;**16**:131–140
- Jeong O, Park YK. Clinicopathological features and surgical treatment of gastric cancer in South Korea: the results of 2009 nationwide survey on surgically treated gastric cancer patients. *J Gastric Cancer* 2011;**11**:69–77
- Dindo D, Demartines N, Clavien PA. Classification of surgical complications: a new proposal with evaluation in a cohort of 6336 patients and results of a survey. *Ann Surg* 2004;**240**:205–213
- Nishimura S, Oki E, Tsutsumi S, Tsuda Y, Sugiyama M, Nakashima Y et al. Clinical significance of totally laparoscopic distal gastrectomy: a comparison of short-term outcomes relative to open and laparoscopic-assisted distal gastrectomy. *Surg Laparosc Endosc Percutaneous Tech* 2016;**26**:372–376
- Jeong O, Jung MR, Park YK, Ryu SY. Safety and feasibility during the initial learning process of intracorporeal Billroth I (delta-shaped) anastomosis for laparoscopic distal gastrectomy. *Surg Endosc* 2015;**29**:1522–1529
- Zhang C, Xiao W, Chen K, Zhang Z, Du G, Jiang E et al. A new intracorporeal Billroth II stapled anastomosis technique in totally laparoscopic distal gastrectomy. *Surg Endosc* 2015;**29**:1636–1642
- Song KY, Park CH, Kang HC, Kim JJ, Park SM, Jun KH et al. Is totally laparoscopic gastrectomy less invasive than laparoscopy-assisted gastrectomy? A prospective, multicenter study. *J Gastrointest Surg* 2008;**12**:1015–1021
- Choi BS, Oh HK, Park SH, Park JM. Comparison of laparoscopy-assisted and totally laparoscopic distal gastrectomy: the short-term outcome at a low volume center. *J Gastric Cancer* 2013;**13**:44–50
- Chen K, Pan Y, Cai JQ, Wu D, Yan JF, Chen DW et al. Totally laparoscopic versus laparoscopy-assisted total gastrectomy for upper and middle gastric cancer: a single-unit experience of 253 cases with meta-analysis. *World J Surg Oncol* 2016;**14**:96
- Gong CS, Kim BS, Kim HS. Comparison of totally laparoscopic total gastrectomy using an endoscopic linear stapler with laparoscopy-assisted total gastrectomy using a circular stapler in patients with gastric cancer: a single-center experience. *World J Gastroenterol* 2017;**23**:8553–8561
- Inokuchi M, Otsuki S, Fujimori Y, Sato Y, Nakagawa M, Kojima K. Systematic review of anastomotic complications of esophagojejunostomy after laparoscopic total gastrectomy. *World J Gastroenterol* 2015;**21**:9656–9665
- Murakami K, Obama K, Tsunoda S, Hisamori S, Nishigori T, Hida K et al. Linear or circular stapler? A propensity score-matched, multicenter analysis of intracorporeal esophagojejunostomy following totally laparoscopic total gastrectomy. *Surg Endosc* 2020;**34**:5265–5273
- Park KB, Kim EY, Song KY. Esophagojejunal anastomosis after laparoscopic total gastrectomy for gastric cancer: circular versus linear stapling. *J Gastric Cancer* 2019;**19**:344–354
- Kang SH, Cho YS, Min SH, Park YS, Ahn SH, Park DJ et al. Intracorporeal esophagojejunostomy using a circular or a linear stapler in totally laparoscopic total gastrectomy: a propensity-matched analysis. *J Gastric Cancer* 2019;**19**:193–201
- Kosuga T, Hiki N, Nunobe S, Ohashi M, Kubota T, Kamiya S et al. Does the single-stapling technique for circular-stapled esophagojejunostomy reduce anastomotic complications after laparoscopic total gastrectomy? *Ann Surg Oncol* 2015;**22**:3606–3612
- Zuiki T, Hosoya Y, Kaneda Y, Kurashina K, Saito S, Ui T et al. Stenosis after use of the double-stapling technique for reconstruction after laparoscopy-assisted total gastrectomy. *Surg Endosc* 2013;**27**:3683–3689
- Lonjon G, Boutron I, Trinquart L, Ahmad N, Aim F, Nizard R et al. Comparison of treatment effect estimates from prospective nonrandomized studies with propensity score analysis and randomized controlled trials of surgical procedures. *Ann Surg* 2014;**259**:18–25
- Austin PC, Stuart EA. Moving towards best practice when using inverse probability of treatment weighting (IPTW) using the propensity score to estimate causal treatment effects in observational studies. *Stat Med* 2015;**34**:3661–3679