Research Square

Preprints are preliminary reports that have not undergone peer review.
They should not be considered conclusive, used to inform clinical practice,
or referenced by the media as validated information.

Short-term Outcomes of Robotic versus Laparoscopic Distal Gastrectomy with Billroth I Reconstruction in Patients with Obesity and Gastric Cancer: A Retrospective Cohort Study at a Single High-Volume Center

Eihab Munshi
University of Jeddah
Sung Eun Oh
Samsung Medical Center, Sungkyunkwan University School of Medicine
Min-Gew Choi
Samsung Medical Center, Sungkyunkwan University School of Medicine
Jun Ho Lee
Samsung Medical Center, Sungkyunkwan University School of Medicine
Tae Sung Sohn
Samsung Medical Center, Sungkyunkwan University School of Medicine
Jae Moon Bae
Samsung Medical Center, Sungkyunkwan University School of Medicine
Ji Yeong An
ugids@naver.com

Samsung Medical Center, Sungkyunkwan University School of Medicine

Research Article

Keywords:

Posted Date: November 18th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-11446315/v1

License: This work is licensed under a Creative Commons Attribution 4.0 International License.
Read Full License

Additional Declarations: No competing interests reported.

Comparison of Short-term Outcomes after Robotic versus Laparoscopic Distal Gastrectomy with Billroth I Reconstruction in Patients with Obesity and Gastric Cancer: A Retrospective Cohort Study.

Eihab Munshi[1,2†‡], Sung Eun Oh[2†], Min-Gew Choi[2], Jun Ho Lee[2], Tae Sung Sohn[2], Jae Moon Bae[2], Ji Yeong An[2*]

[1]Department of Surgery, University of Jeddah, Jeddah, Saudi Arabia

[2]Department of Surgery, Samsung Medical Center, Sungkyunkwan University School of Medicine, Seoul, Korea

[*]To whom correspondence should be addressed. E-mail: jar319.an@samsung.com (J.Y.A.)

[†]Eihab Munshi and Sung Eun Oh contributed equally to this work and share first authorship.

[‡]Current affiliation : Department of Surgery, University of Jeddah, Jeddah, Saudi Arabia

E-mail address:

Eihab Munshi: eihab.munshi@gmail.com

Sung Eun Oh: ohsungeun228@gmail.com

Min-Gew Choi: mingew.choi@samsung.com

Jun Ho Lee: gsjunholee@gmail.com

Tae Sung Sohn: ts.sohn@samsung.com

Jae Moon Bae: jmoon.bae@samsung.com

Ji Yeong An: ugids@naver.com

Corresponding address: Ji Yeong An, MD, PhD

Department of Surgery, Samsung Medical Center, Sungkyunkwan University School of Medicine, 81 Irwon-ro, Gangnam-gu, Seoul 06351, Korea

E-mail: ugids@naver.com; Tel: 82-2-3410-0884; Fax: 82-2-3410-6981

Background:

Surgical management in patients with obesity and gastric cancer is inherently challenging due to increased technical difficulty and postoperative morbidity. While laparoscopic distal gastrectomy with Billroth I reconstruction (LDG-BI) is widely adopted, the role of robotic distal gastrectomy with Billroth I reconstruction (RDG-BI) in this population remains less well defined. This study compared short-term surgical outcomes between RDG-BI and LDG-BI in patients with obesity and gastric cancer.

Methods:

This retrospective cohort study included patients with histologically confirmed gastric cancer and BMI ≥25 kg/m² who underwent RDG-BI or LDG-BI at a single high-volume center between 2015 and 2023. Perioperative outcomes and clinically significant 30-day postoperative complications were compared between groups. Multivariable logistic regression was used to identify factors associated with postoperative complications.

Results:

A total of 391 patients were included (RDG-BI: 156, LDG-BI: 235). Operative time was longer in the RDG-BI group than in the LDG-BI group (151.3 vs. 138.1 minutes, $p < 0.001$), whereas estimated intraoperative blood loss did not differ significantly. BMI showed a weak but significant positive correlation with operative time in both groups (LDG-BI: $r = 0.214$, $p < 0.001$; RDG-BI: $r = 0.216$, $p = 0.007$). The number of retrieved lymph nodes was higher with RDG-BI (36 vs. 34, $p = 0.041$). All postoperative complication rates were comparable between the RDG-BI and LDG-BI groups (5.8% vs. 4.3%, $p = 0.632$), with no significant difference in clinically significant complications (Clavien-Dindo grade ≥III; 1.3% vs. 2.1%, $p = 0.707$). All anastomotic leaks occurred in the LDG-BI group, although this difference was not statistically significant. In multivariable analysis, higher BMI and advanced pathological

stage, but not surgical approach, were independently associated with postoperative complications.

Conclusion:

RDG-BI demonstrated comparable rates of clinically significant postoperative complications to LDG-BI in patients with obesity and gastric cancer. The directional trend towards fewer anastomotic leaks in the robotic group warrants further investigation in prospective studies. Although RDG-BI was associated with longer operative time, the relationship between BMI and operative duration was similar in both surgical approaches. These findings suggest that RDG-BI is a safe and feasible alternative to LDG-BI in this population, while potential differences in specific complications, such as anastomotic leakage, require validation in larger studies.

Introduction

Gastric cancer remains a significant global health challenge, with an estimated 1 million new cases and nearly 800 thousand deaths annually worldwide. Despite declining incidence and mortality rates in recent decades, it still ranks as the third leading cause of cancer-related mortality globally (1). Prompt diagnosis of gastric cancer at an early stage can enhance the prognosis and enable surgical resection as a potentially curative treatment option (2). However, the management of gastric cancer in patients with obesity adds unique challenges, whether it is defined according to the Korean Society for the Study of Obesity or by the World Health Organization (WHO), as excess body weight has been linked to increased postoperative complications and poorer surgical outcomes (3,4). As obesity becomes more prevalent globally, addressing this challenge has become increasingly important.

Laparoscopic-assisted gastrectomy was first reported in 1994, when Kitano introduced the technique (5). It has become the standard treatment for early gastric cancer due to its postoperative advantages over conventional open gastrectomy (6). However, there are drawbacks to laparoscopic-assisted surgery, including limitations in forceps movement and increased fatigue during lengthy procedures. Robotic surgical techniques have emerged as a promising alternative to conventional laparoscopic gastrectomy, offering improved visualization, enhanced dexterity, and potentially superior short-term patient outcomes (7). Robotic-assisted surgery may be particularly advantageous for patients with obesity, as the improved precision and control afforded by the robotic platform could help mitigate the technical difficulties posed by excess body weight during the surgical procedure (8).

In this study, we aim to compare the 30-day postoperative complication rates between RDG-BI and LDG-BI in patients with obesity and gastric cancer. We address the knowledge gap by testing the null hypothesis that there is no difference in 30-day postoperative complications between the robotic and laparoscopic approaches.

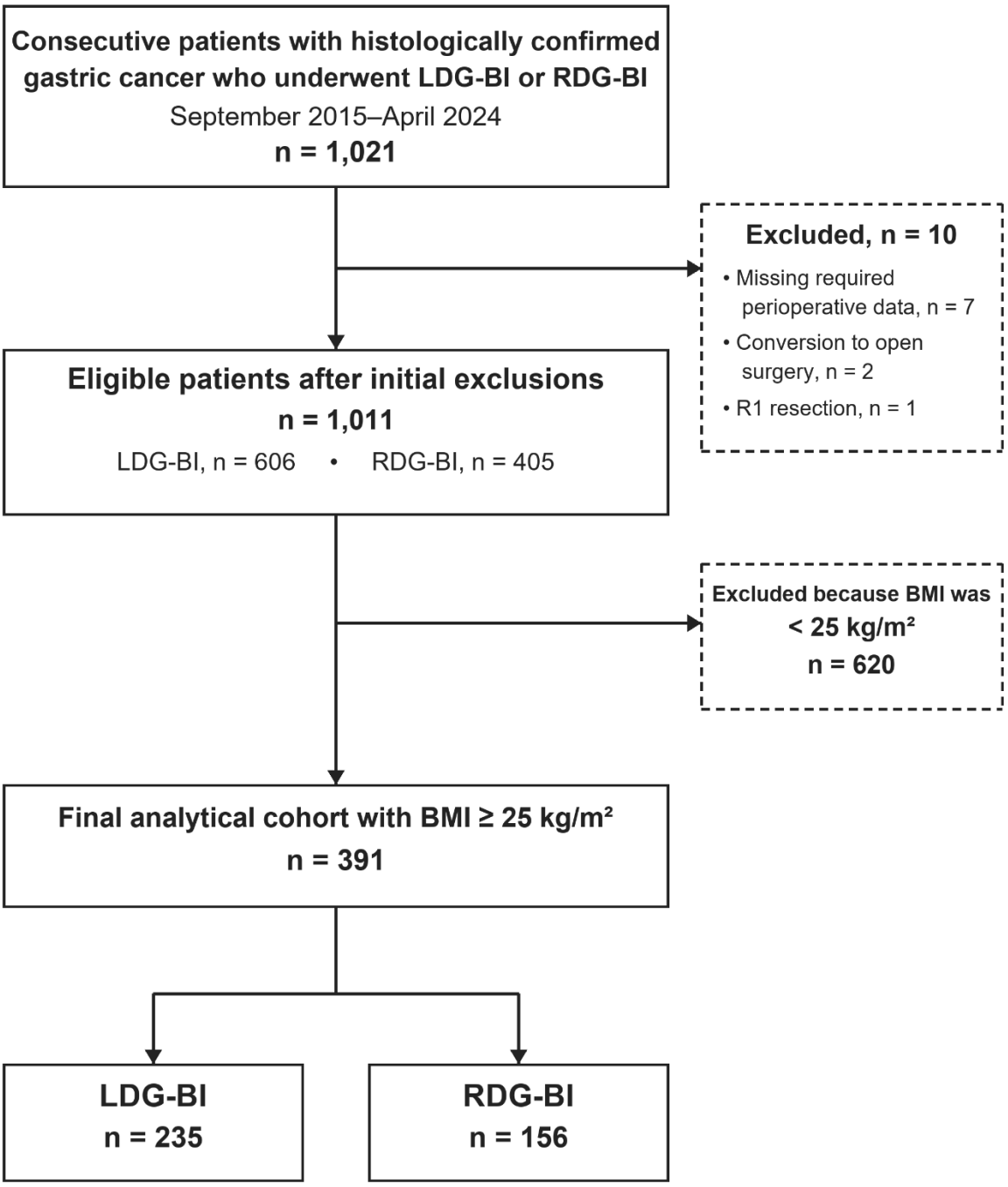
Patients and methods

Study design and setting

This retrospective cohort study was conducted at Samsung Medical Center, Seoul, Korea. The study cohort comprised consecutive patients with histologically confirmed gastric cancer who underwent LDG-BI or RDG-BI reconstruction performed by a single surgeon between September 2015 and April 2024. Data were obtained retrospectively from the institutional electronic medical records database. This study was reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guideline for cohort studies.

Study population

Obesity was defined as a body mass index (BMI) ≥25 kg/m² according to the Korean Society for the Study of Obesity criteria (9). The source cohort consisted of patients who underwent curative distal gastrectomy with Billroth I reconstruction and D1+ or D2 lymphadenectomy for histologically confirmed gastric cancer. Patients with missing perioperative data (n = 7), conversion to open surgery (n = 2), or R1 resection (n = 1) were excluded. Patients with a BMI <25 kg/m² (n = 620) were subsequently excluded, leaving a final study population of 391 patients, including 235 who underwent LDG-BI and 156 who underwent RDG-BI. The patient selection process is summarized in Figure 1.



BMI, body mass index; LDG-BI, laparoscopic distal gastrectomy with Billroth I reconstruction; RDG-BI, robotic distal gastrectomy with Billroth I reconstruction.

Figure 1. A flowchart of the included cohorts.

Surgical procedures

The choice of robotic or laparoscopic approach was determined according to institutional practice and surgeon-patient decision-making during the study period. Both RDG-BI and LDG-BI followed the same oncologic principles, including distal gastrectomy, lymphadenectomy based on tumor stage, and Billroth I reconstruction with a delta-shaped gastroduodenostomy. LDG-BI was performed using conventional laparoscopic instruments.

RDG-BI was performed using the da Vinci Si or Xi Surgical System (Intuitive Surgical, Sunnyvale, CA, USA) with four robotic arms (Figure 2). Instrument configuration included Cadiere forceps (Arm 1), a Harmonic scalpel (Harmonic ACE®, Arm 2), a 3D camera (Arm 3), and a fenestrated Maryland bipolar forceps (Arm 4). An additional laparoscopic port assisted the procedure by facilitating retraction and providing access to surgical gauze, sutures, and the endoscopic stapler. The surgical steps were standardized across both robotic and laparoscopic procedures.

The following steps were performed in sequence: omentectomy and perigastric lymph node dissection, mobilization of the distal stomach and duodenum, duodenal transection distal to the pylorus using a linear Tri-stapler (Signia™ linear stapler), and completion of suprapancreatic lymph node dissection. The stomach was then transected proximally while ensuring an adequate resection margin from the tumor, defined as a 2-cm margin for early gastric cancer and a 3-5 cm margin for locally advanced tumors. The specimen was extracted using an Endo Catch bag through an extended laparoscopic port site measuring approximately 3-4 cm. Resection margins were assessed by frozen-section analysis to confirm negative margins.

Billroth I reconstruction was performed using a delta-shaped anastomosis, as described by Noshiro et al. (10). Briefly, small gastrotomy and duodenostomy openings were created on

the inferior aspect of each stump. The duodenal stump and gastrotomy site were then aligned, and a side-to-side anastomosis was performed through the posterior walls of the stomach and duodenum using a linear stapler. The common entry hole was closed with two additional stapler firings. The anastomosis was reinforced with 5–6 interrupted 3-0 Vicryl sutures. In all cases, a closed-suction drain was placed in the subhepatic space near the anastomotic site.

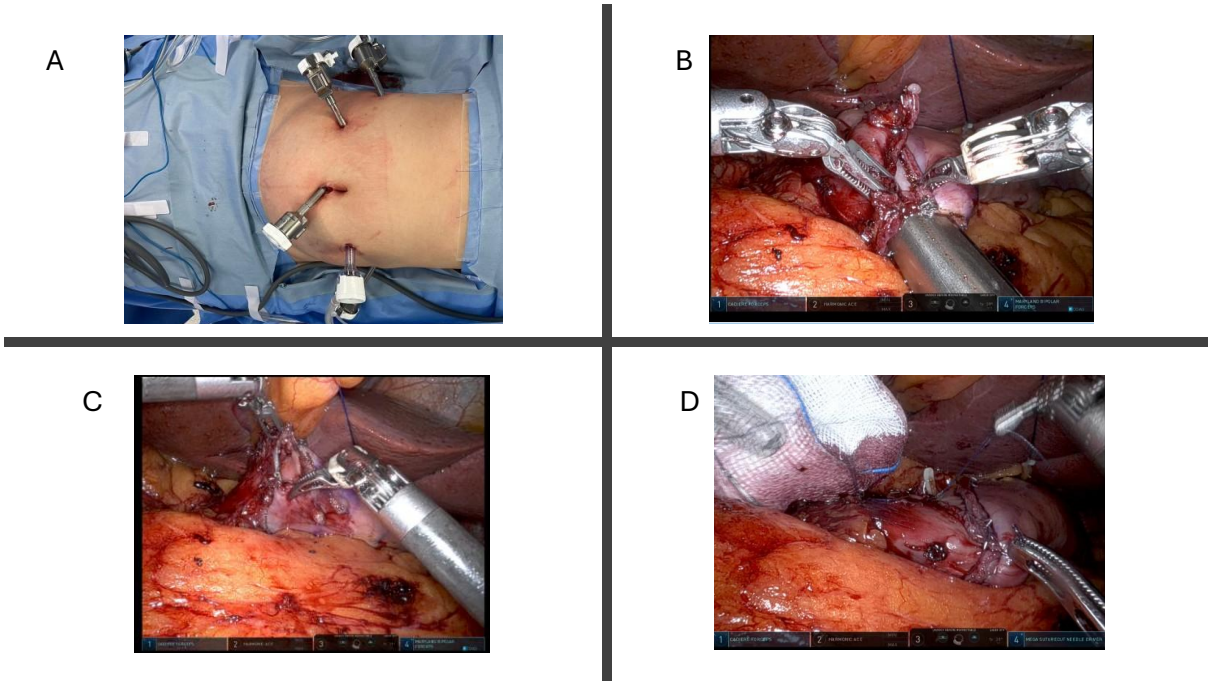


Figure 2. Robotic distal gastrectomy with Billroth I reconstruction for distal gastric cancer. (A) Port site. (B) Creation of the gastroduodenal anastomosis by a linear stapler through the posterior walls. (C) Adjusting the entry opening for closure with a linear stapler. (D) Delta-shaped anastomosis was created and interrupted, and Vicryl sutures were placed for reinforcement.

Data collection and variables

Demographic, clinical, operative, pathological, and postoperative data were collected retrospectively from electronic medical records. Baseline variables included age, sex, body mass index (BMI), American Society of Anesthesiologists physical status classification, clinical stage, and relevant clinicopathological characteristics. Operative variables included surgical approach, operative time, estimated blood loss, extent of lymphadenectomy, number

of lymph nodes retrieved, and number of suprapancreatic lymph nodes retrieved. Pathological stage was classified according to the eighth edition of the American Joint Committee on Cancer staging system. Postoperative recovery variables included time to first flatus, time to oral intake, postoperative length of hospital stay, and postoperative complications within 30 days after surgery.

Study endpoints

The primary endpoint was the occurrence of clinically significant postoperative complications within 30 days after surgery, defined as Clavien-Dindo grade III or higher. Secondary endpoints included operative time, estimated intraoperative blood loss, number of retrieved lymph nodes, number of retrieved suprapancreatic lymph nodes, time to first flatus, time to oral intake, postoperative length of hospital stay, anastomosis-related complications, and 30-day mortality. The association between BMI and operative time was evaluated as an exploratory endpoint.

Ethical approval

This study was approved by the Institutional Review Board of Samsung Medical Center, Seoul, Korea (SMC 2025-04-133). The requirement for informed consent was waived because of the retrospective nature of the study. All patient data were anonymized before analysis, and the study was conducted in accordance with the principles of the Declaration of Helsinki.

Statistical analysis

Continuous variables were assessed for distribution and summarized as mean ± standard deviation. Continuous variables were compared between the RDG-BI and LDG-BI groups using Student’s t-test or the Mann-Whitney U test, depending on data distribution.

Categorical variables were summarized as numbers and percentages and compared using the chi-square test or Fisher's exact test, as appropriate.

The linear association between BMI and operative time was evaluated using correlation analysis. Multivariable regression analysis was performed to assess whether the relationship between BMI and operative time differed according to surgical approach by including an interaction term between BMI and surgical approach. Multivariable logistic regression was used to identify factors associated with postoperative complications. Clinically relevant covariates identified on univariate analysis ($p < 0.05$) were entered into the multivariable logistic regression model. Results were expressed as odds ratios (OR) with 95% confidence intervals (CI). All statistical tests were two-sided, and p-values <0.05 were considered statistically significant.

Results

Clinicopathological Characteristics

The clinicopathological characteristics of the RDG-BI and LDG-BI groups are summarized in Table 1. The groups differed significantly in age and ASA physical status classification. Patients in the RDG-BI group were younger than those in the LDG-BI group (56.7 ± 9.9 vs. 61.8 ± 11.3 years, $p < 0.001$). ASA score also differed significantly between groups ($p = 0.005$), with fewer patients classified as ASA III in the RDG-BI group than in the LDG-BI group. Sex distribution, BMI, pT classification, pN classification, and pathological stage did not differ significantly between groups.

Table 1. Clinicopathological characteristics of the groups.

Characteristics	Laparoscopic (n = 235)	Robotic (n = 156)	P value
Age, yrs, mean±SD	61.8±11.3	56.7±9.9	**<0.001**
Male, sex, n (%)	155 (66.0)	105 (67.3)	0.782
Body mass index, mean±SD	27.2±2.3	27.5±2.3	0.177

ASA score, n (%)			**0.005**
I	43 (18.3)	36 (23.1)	
II	165 (70.2)	116 (74.4)	
III	27 (11.5)	4 (2.6)	
pT classification, n (%)			0.167*
T1	214 (91.1)	131 (84.0)	
T2	10 (4.3)	11 (7.1)	
T3	9 (3.8)	10 (6.4)	
T4a	2 (0.9)	4 (2.6)	
pN classification, n (%)			0.360*
N0	203 (86.4)	134 (85.9)	
N1	23 (9.8)	11 (7.1)	
N2	7 (3.0)	7 (4.5)	
N3a	2 (0.9)	4 (2.6)	
Pathological stage, n (%)			0.119*
I	211 (89.8)	131 (84.0)	
II	22 (9.4)	20 (12.8)	
III	2 (0.9)	5 (3.2)	

*Fisher's exact test.

Surgical and postoperative outcomes

Surgical and postoperative outcomes are summarized in Table 2. Operative time was significantly longer in the RDG-BI group than in the LDG-BI group (151.3 ± 31.9 vs. 138.1 ± 34.9 min, $p < 0.001$). Estimated intraoperative blood loss, time to first flatus, and postoperative length of hospital stay did not differ significantly between groups. The RDG-BI group had a significantly higher number of retrieved lymph nodes than the LDG-BI group (36 ± 12 vs. 34 ± 11, $p = 0.041$), whereas the number of retrieved suprapancreatic lymph nodes was similar between groups.

Table 2. Surgical and postoperative outcomes

Characteristics	Laparoscopic (n=235)	Robotic (n=156)	P value
Operative time, min, mean±SD	138.1±34.9	151.3±31.9	**<0.001**
Estimated intraoperative blood loss, mL, mean±SD	67.5±52.7	60.4±41.1	0.158
Retrieved lymph nodes, mean±SD	34±11	36±12	**0.041**
Retrieved supra pancreatic lymph nodes, mean±SD	12±5	13±5	0.279
Time to first flatus, d, mean±SD	3.6±0.7	3.5±0.7	0.709
Postoperative length of stay, d, mean±SD	7.0±3.6	6.9±2.1	0.756

BMI Association with Operative Time

A positive correlation between BMI and operation time was identified in both surgical groups (Table 3). In the LDG-BI group, the Pearson correlation coefficient was $r = 0.214$ ($p = 0.001$); in the RDG-BI group, $r = 0.216$ ($p = 0.007$). Clinically, this translated into an increase in operative time of approximately 3.2 minutes per 1 kg/m² increase in BMI for the LDG-BI group and 3.0 minutes for the RDG-BI group. Furthermore, a multivariable regression analysis confirmed that the interaction between BMI and surgical approach on operative time was not statistically significant (interaction $p = 0.863$), indicating that BMI influenced operative time to a similar degree in both modalities. Figure 3 illustrates these relationships using scatter plots and linear trendlines.

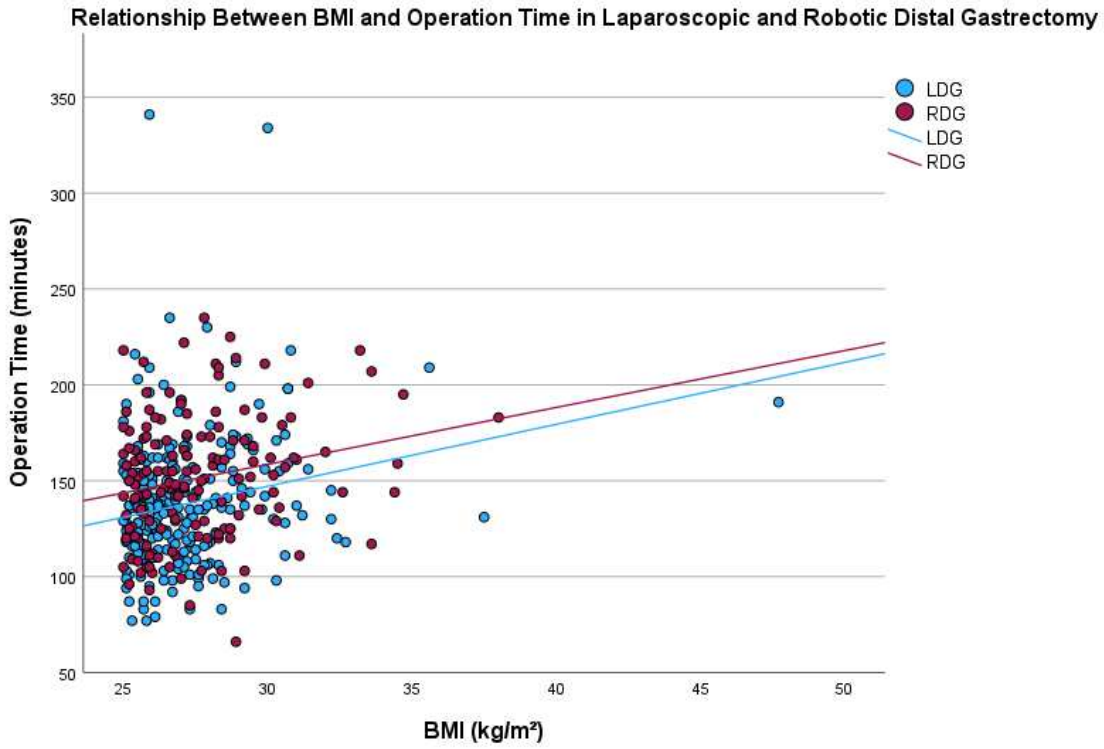


Figure 3. The scatter plot shows the relationship between body mass index (BMI) and operation time for the LDG and RDG groups. Linear regression lines with 95% confidence intervals are drawn.

Table 3. The correlation of BMI to operative time

Group	BMI (Mean ± SD)	Operation Time (Mean ± SD (min))	Pearson r	p-value
LDG (n= 235)	27.22 ± 2.31	138.13 ± 34.90	0.214	**0.001**
RDG (n= 156)	27.55 ± 2.32	151.26 ± 31.90	0.216	**0.007**

Postoperative Complications and Complications across BMI categories

Thirty-day postoperative complications are summarized in Table 4. Overall, 19 patients (4.9%) experienced at least one complication, with comparable rates between the LDG-BI

and RDG-BI groups (4.3% vs. 5.8%, p=0.632). Clinically significant complications (Clavien-Dindo grade ≥III), the primary endpoint of this study, occurred in 7 patients (1.8%): 5 in the LDG-BI group (2.1%) and 2 in the RDG-BI group (1.3%), with no statistically significant difference between groups (p=0.707). The distribution of these major complications was comparable across obesity classes (p>0.05 for all). Grade IIIa complications occurred in 4 LDG-BI patients (1.7%) and 2 RDG-BI patients (1.3%), comprising three anastomotic leaks and one fluid collection in the LDG-BI group, and one anastomotic stricture and one wound-related complication in the RDG-BI group. One grade IIIb complication (intraluminal bleeding) was observed exclusively in the LDG-BI group. No 30-day mortality occurred in either group.

Minor surgical complications (Clavien-Dindo grade I–II) occurred in 4 RDG-BI patients (2.6%) and none in the LDG-BI group, comprising two cases of ileus/obstruction and two fluid collections (p=0.025). Minor medical complications were similarly rare and evenly distributed, occurring in 5 LDG-BI patients (2.1%) and 3 RDG-BI patients (1.9%; p=1.000), and included pneumonia, diarrhea, and elevated CRP levels.

Table 4. Thirty-day postoperative complications.

Postoperative complications, No. (%)	**LDG-BI (n = 235)**	**RDG-BI (n = 156)**	***P* value**
All postoperative complications	10 (4.3)	9 (5.8)	0.632
Clinically significant complications (CD ≥III)	5 (2.1)	2 (1.3)	0.707
BMI obesity class I (25-29.9 kg/m²)	3 (1.3)	1 (0.6)	1.000
BMI obesity class II (30-34.9 kg/m²)	1 (0.4)	1 (0.6)	1.000
BMI obesity class ≥ III (≥ 35 kg/m²)	1 (0.4)	0	1.000
Grade IIIa	4 (1.7)	2 (1.3)	1.000
Wound-related	0 (0.0)	1 (0.6)	
Fluid collection	1 (0.4)	0 (0.0)	
Anastomotic leakage	3 (1.3)	0 (0.0)	

Anastomotic stricture	0 (0.0)	1 (0.6)	
Grade IIIb	1 (0.4)	0 (0.0)	1.000
Bleeding (intra-, extraluminal)	1 (0.4)	0 (0.0)	
Surgical complications (CD grade I–II)	0 (0.0)	4 (2.6)	0.025
Ileus/obstruction	0 (0.0)	2 (1.3)	
Fluid collection	0 (0.0)	2 (1.3)	
Medical complications (CD grade I–II)	5 (2.1)	3 (1.9)	1.000
Pneumonia	2 (0.9)	0 (0.0)	
Diarrhea	1 (0.4)	3 (1.9)	
Elevated CRP	2 (0.9)	0 (0.0)	
Mortality	0 (0.0)	0 (0.0)	

Data are presented as n (%). All p-values were calculated using Fisher's exact test. CD = Clavien-Dindo classification.

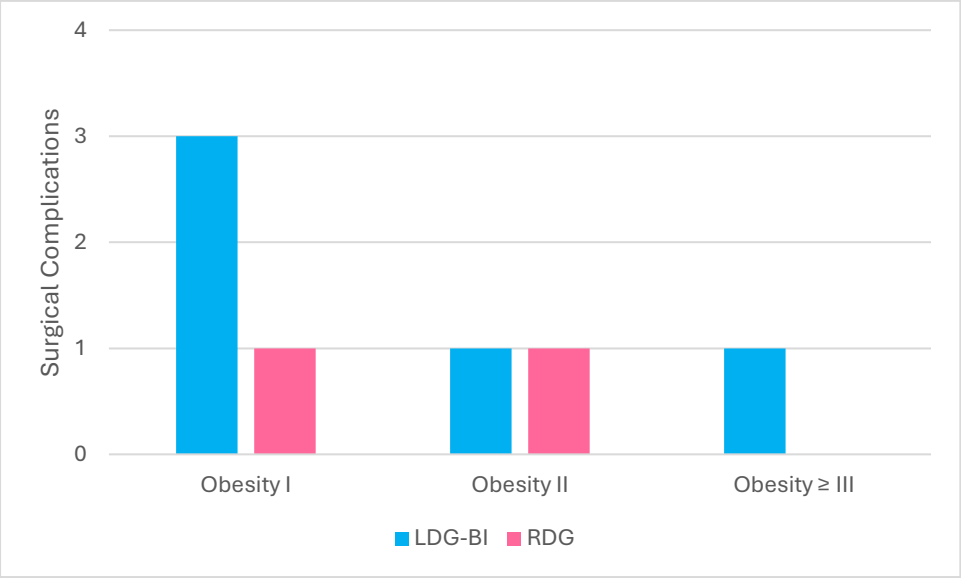


Figure 4. Distribution of clinically significant postoperative complications by BMI obesity class in the RDG-BI and LDG-BI groups

Risk Factors for Postoperative Complications

Univariate analysis identified BMI and pathological stage as significant risk factors for 30-day postoperative complications (Table 5). Patients with higher BMI had greater odds of

experiencing a complication (OR 1.24, 95% CI 1.08-1.42; p=0.002). Patients with pathological stage II had substantially higher odds compared with stage I (OR 6.02, 95% CI 2.19-16.52; p<0.001), while stage III vs. I comparison did not reach statistical significance. Robotic approach, age, sex, and ASA score were not significant predictors on univariate analysis.

Multivariable logistic regression, including BMI and pathological stage as covariates, confirmed both as independent risk factors. BMI remained independently associated with complications (OR 1.22, 95% CI 1.04-1.43; p=0.013), as did pathological stage II vs. I (OR 5.21, 95% CI 1.81-15.02; p=0.002); stage III vs. I did not achieve significance. Surgical approach (robotic vs. laparoscopic) was not a significant predictor in univariate analysis (OR 1.38, 95% CI 0.55-3.47; p=0.497) and was not included in the multivariable model.

Table 5. Risk factors for 30-day postoperative complications — univariate and multivariable logistic regression

Variables	**Univariate analysis**			**Multivariable analysis**		
	OR	**95% CI**	**P value**	**OR**	**95% CI**	**P value**
Robotic vs Laparoscopic approach	1.38	0.55-3.47	0.497			
Age, yrs	1.02	0.98-1.07	0.330			
Sex (Male vs Female)	0.68	0.27-1.73	0.418			
Body mass index	1.24	1.08-1.42	**0.002**	1.22	1.04-1.43	**0.013**
ASA score			0.095			
II vs I	1.87	0.41-8.46	0.418			
III vs I	5.70	0.99-32.92	0.052			
Pathological stage, n (%)			**0.002**			**0.005**

II vs I	6.02	2.19-16.52	**<0.001**	5.21	1.81-15.02	**0.002**
III vs I	5.02	0.56-45.29	0.151	5.71	0.62-52.52	0.124

Variables with $p < 0.10$ in univariate analysis (BMI and pathological stage) were included in the multivariable model. OR = odds ratio; CI = confidence interval

Discussion

This study affirms the safety and feasibility of RDG-BI in patients with obesity and gastric cancer by demonstrating that the rate of clinically significant postoperative complications (Clavien-Dindo grade ≥III) was comparable between the robotic and laparoscopic approaches In comparing surgical outcomes, while the robotic procedure had a longer operative time, it was associated with a higher number of retrieved lymph nodes, with no significant differences in estimated intraoperative blood loss, time to first flatus, or postoperative hospital stay. Two key insights emerged from this analysis: first, longer operative time was consistently driven by patient BMI rather than the surgical modality itself; and second, multivariable analysis identified higher BMI and advanced pathological stage, not the surgical approach, as independent predictors of postoperative complications.

The surgical management of gastric cancer in patients with obesity presents a distinct set of technical challenges that are known to increase the risk of postoperative complications. High visceral fat accumulation narrows the operative field, increases the risk of intraoperative bleeding, and complicates the fine dissection critical for both adequate lymphadenectomy and precise tumor margin delineation, all of which can contribute to longer operative times and higher morbidity (11,12). The robotic surgical platform, with its inherent technical advantages, is theoretically well-suited to mitigate these difficulties. The stable, high-definition three-dimensional visualization provides superior depth perception in a confined space, while the wristed instruments with tremor filtration allow for more precise dissection and suturing than is possible with conventional laparoscopic instruments (13). This study was

therefore designed to investigate whether these theoretical advantages translate into improved clinical outcomes in this specific, high-risk population.

The finding of comparable rates of all postoperative complications between the two groups is consistent with the current body of high-level evidence. A recent, large-scale meta-analysis by Yu et al., which included patients with obesity, reported no significant difference in overall postoperative complications between robotic and laparoscopic gastrectomy (OR 0.99, p=0.98) (8). This is further corroborated by Qiu et al. in a large multicentre study of patients with obesity undergoing either distal or total gastrectomy, which similarly found no significant difference in overall complications (14). Furthermore, the complication rates observed in our cohort are notably lower than those reported by Qiu et al. (5.8% vs. 13.8% in the robotic group), which may reflect the benefits of a high-volume center and extensive single-surgeon experience (14). Although the between-groups difference in clinically significant complications, CD grade ≥III events, did not reach statistical significance, the directional trend is consistent with evidence suggesting a potential advantage of the robotic platform in reducing severe complications in patients with obesity.

Stratification by complication severity revealed a clinically relevant finding. The absence of anastomotic leaks in the RDG-BI group, compared with three cases in the LDG-BI group, did not reach statistical significance given the low event rate; however, its clinical importance is supported by a recent meta-analysis from Yang et al., which demonstrated that robotic surgery was associated with a significantly lower anastomotic leak rate in patients with high visceral obesity (OR 4.09, p=0.001) (15). This aligns with the findings of Komatsu et al., who also reported a significant reduction in clinically significant complications (CD ≥IIIa) in their overweight robotic cohort (0% vs. 8.8%, p=0.01) (11). Taking together, this evidence suggests that the technical advantages of the robotic platform are not merely theoretical but

may translate into a clinically meaningful reduction in procedure-specific complications, such as anastomotic leaks, particularly in patients with visceral obesity.

A consistent finding in the literature, and a frequent criticism of the robotic platform, is that RDG has a longer operative time than LDG. Our study was no exception, with a mean operative time for RDG-BI that was approximately 13 minutes longer. This finding is consistent with meta-analyses and is confirmed in overweight populations and patients with obesity across multiple studies (8,13,14,16). However, our analysis adds a new perspective to this well-established observation. We demonstrated a weak but significant positive correlation between BMI and operative time in both groups, with no significant interaction between BMI and surgical approach. This indicates that the incremental effect of excess adiposity on operative duration is a consistent, modality-independent phenomenon. This contrasts with the findings of Matsui et al., who reported that BMI affected operative time only in the laparoscopic group (17). The discrepancy is likely explained by procedural efficiency: their median robotic operative time exceeded 350 minutes, more than double that of our cohort, and such a prolonged baseline duration may have masked the more subtle, incremental contribution of BMI. Our data, therefore, help clarify the debate: the issue is not simply that the robotic approach is slower, but that patient-related factors are a key underlying variable that must be accounted for when comparing the two techniques.

The multivariable analysis identified higher BMI and advanced pathological stage as independent predictors of postoperative complications, while surgical approach was not a significant predictor on univariate analysis. The role of obesity as a risk factor is multifactorial, attributed to a chronic pro-inflammatory state that impairs wound healing and to the technical difficulties imposed by high visceral adiposity (17,18). The literature corroborates our finding; Roh et al. similarly identified a high BMI as an independent risk factor for severe complications (OR 2.56) (19). By confirming that the primary determinants

of morbidity are patient-related rather than modality-related, our results support the view that both RDG-BI and LDG-BI can be considered safe options in this population, with appropriate patient selection and perioperative optimization remaining the central focus.

This study has several strengths. First, it focuses on a well-defined and technically challenging cohort—patients with obesity undergoing a standardized procedure—which reduces the variability inherent in studies that mix different reconstruction types or operative approaches. Second, all procedures were performed by a single experienced surgeon at a high-volume center, minimizing the confounding effects of the learning curve and institutional variation. Third, postoperative complications were graded using the validated Clavien-Dindo classification, with a pre-specified primary endpoint threshold (CD ≥III), providing an objective and reproducible measure of surgical morbidity.

Several limitations must be acknowledged. Retrospective design is the primary constraint, as it introduces the potential for selection bias and limits causal inference. As a single-center study using an Asian obesity threshold (BMI ≥25 kg/m²), the findings may have limited generalizability to Western populations where a higher threshold (BMI ≥30 kg/m²) is standard. The study is also restricted to short-term perioperative outcomes, and long-term oncologic results were not assessed. Furthermore, the multivariable logistic regression model is constrained by the relatively small number of outcome events, yielding an events-per-variable ratio below the conventional threshold of 10; the estimated odds ratios should therefore be interpreted with appropriate caution. The non-significant result for pathological stage III vs. I likely reflect insufficient statistical power in this subgroup rather than a true absence of effect. Finally, the low overall rate of clinically significant complications (1.8%), while indicative of high-quality surgical care, limited the power to detect significant between-group differences in specific outcomes, including anastomotic leaks.

In conclusion, this study provides further evidence that RDG-BI is a safe and feasible option for the surgical management of gastric cancer in patients with obesity, with clinically significant complication rates comparable to the established laparoscopic approach. For surgeons, the decision between these two advanced techniques should not rest on operative time alone; the potential of the robotic platform to reduce severe, procedure-specific complications such as anastomotic leaks in this high-risk population warrant consideration. Validation through a prospective, multicenter randomized controlled trial remains necessary to confirm these safety benefits, assess long-term oncologic outcomes, and stratify results by obesity class.

References

1. Global cancer statistics 2018: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries [Internet]. [cited 2025 Jan 25]. Available from: https://acsjournals-onlinelibrary-wiley-com.libproxy.samsunghospital.com/doi/epdf/10.3322/caac.21492 doi:10.3322/caac.21492

2. Yada T, Yokoi C, Uemura N. The Current State of Diagnosis and Treatment for Early Gastric Cancer. Diagn Ther Endosc. 2013 Feb 28;2013:1–9. doi:10.1155/2013/241320

3. Wu XS, Wu WG, Li ML, Yang JH, Ding QC, Zhang L, et al. Impact of being overweight on the surgical outcomes of patients with gastric cancer: A meta-analysis. World J Gastroenterol. 2013 Jul 28;19(28):4596–606. doi:10.3748/wjg.v19.i27.4596

4. Struecker B, Biebl M, Dadras M, Chopra S, Denecke C, Spenke J, et al. The Impact of Obesity on Outcomes Following Resection for Gastric Cancer. Dig Surg. 2017;34(2):133–41. doi:10.1159/000449043

5. Kitano S, Iso Y, Moriyama M, Sugimachi K. Laparoscopy-assisted Billroth I gastrectomy. Surg Laparosc Endosc. 1994 Apr;4(2):146–8. PubMed PMID: 8180768.

6. Tokunaga M, Kaito A, Sugita S, Watanabe M, Sunagawa H, Kinoshita T. Robotic gastrectomy for gastric cancer. Transl Gastroenterol Hepatol. 2017 Jun 2;2(6):57–57. doi:10.21037/tgh.2017.05.09

7. Aoyama T, Maezawa Y, Hashimoto I. Open, Laparoscopy-assisted, Robotic-assisted Distal Gastrectomy for Gastric Cancer: Evidence from Randomized Clinical Trials. Anticancer Res. 2024 Sep;44(9):3737–45. doi:10.21873/anticanres.17198

8. Yu X, Zhu L, Zhang Y, Feng Q. Robotic versus laparoscopic gastrectomy for gastric cancer in patients with obesity: systematic review and meta-analysis. Front Oncol. 2023 May 19;13:1158804. doi:10.3389/fonc.2023.1158804

9. Haam JH, Kim BT, Kim EM, Kwon H, Kang JH, Park JH, et al. Diagnosis of Obesity: 2022 Update of Clinical Practice Guidelines for Obesity by the Korean Society for the Study of Obesity. J Obes Metab Syndr. 2023 Jun 30;32(2):121–9. doi:10.7570/jomes23031

10. Noshiro H, Iwasaki H, Miyasaka Y, Kobayashi K, Masatsugu T, Akashi M, et al. An additional suture secures against pitfalls in delta-shaped gastroduodenostomy after laparoscopic distal gastrectomy. Gastric Cancer. 2011 Oct;14(4):385–9. doi:10.1007/s10120-011-0082-9

11. Komatsu M, Kinoshita T, Akimoto E, Yoshida M, Nagata H, Habu T, et al. Advantages of robotic gastrectomy for overweight patients with gastric cancer: a comparison study of robotic gastrectomy and conventional laparoscopic gastrectomy. Surg Today. 2023 Nov;53(11):1260–8. doi:10.1007/s00595-023-02681-1

12. Park JY, Ryu KW, Reim D, Eom BW, Yoon HM, Rho JY, et al. Robot-Assisted Gastrectomy for Early Gastric Cancer: Is It Beneficial in Viscerally Obese Patients Compared to Laparoscopic Gastrectomy? World J Surg. 2015 Jul;39(7):1789–97. doi:10.1007/s00268-015-2998-4

13. Lee J, Kim YM, Woo Y, Obama K, Noh SH, Hyung WJ. Robotic distal subtotal gastrectomy with D2 lymphadenectomy for gastric cancer patients with high body mass index: comparison with conventional laparoscopic distal subtotal gastrectomy with D2 lymphadenectomy. Surg Endosc. 2015 Nov;29(11):3251–60. doi:10.1007/s00464-015-4069-1

14. Qiu W wu, Huang ZN, Li TY, Zhang L, She JJ, Jia BQ, et al. Assessment of the safety and efficacy of robotic versus laparoscopic gastrectomy in overweight patients with gastric cancer: a large-scale multicenter cohort study. Surg Endosc. 2025 Sep;39(9):5841–53. doi:10.1007/s00464-025-11990-0

15. Yang LW, Bai XY, Jing GM. Systematic review and meta-analysis of short-term outcomes: robot-assisted versus laparoscopic surgery for gastric cancer patients with visceral obesity. J Robot Surg. 2024 Jun 4;18(1):238. doi:10.1007/s11701-024-02002-9

16. Sun T, Wang Y, Liu Y, Wang Z. Perioperative outcomes of robotic versus laparoscopic distal gastrectomy for gastric cancer: a meta-analysis of propensity score-matched studies and randomized controlled trials. BMC Surg. 2022 Dec 14;22(1):427. doi:10.1186/s12893-022-01881-9

17. Matsui K, Sakuramoto S, Furube T, Yoshizawa M, Toriumi T, Ebara G, et al. Clinical benefits including the postoperative inflammatory status of robot-assisted distal gastrectomy for gastric cancer compared with laparoscopic distal gastrectomy in patients with obesity. J Robot Surg. 2025 Apr 10;19(1):143. doi:10.1007/s11701-025-02296-3

18. Wei LH, Zheng HL, Xue Z, Xu BB, Zheng HH, Shen LL, et al. Robotic gastrectomy was reliable option for overweight patients with gastric cancer: a propensity score matching study. Surg Endosc. 2024 Jun;38(6):3156–66. doi:10.1007/s00464-024-10845-4

19. Roh CK, Choi S, Seo WJ, Cho M, Choi YY, Son T, et al. Comparison of surgical outcomes between integrated robotic and conventional laparoscopic surgery for distal gastrectomy: a propensity score matching analysis. Sci Rep. 2020 Jan 16;10(1):485. doi:10.1038/s41598-020-57413-z