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Original Article

Safety and Efficacy of Reduced-Port Versus Conventional Laparoscopic Distal Gastrectomy for Early Gastric Cancer: A Multicenter, Randomized, Non-inferiority Trial (KLASS-12)

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ABSTRACT

Purpose: This trial (KLASS-12) compares the efficacy and safety of reduced-port laparoscopic gastrectomy (RPLG) versus conventional 5-port laparoscopic gastrectomy (CPLG) for early gastric cancer (EGC).

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

Author Contributions
Conceptualization: L.H.H.; Data curation: K.H.I., S.H., H.H., L.C.M., A.S.H., P.D.J., S.Y.S., J.O., S.S.Y., J.M.R., P.Y.S., K.D.W., S.J.H., L.Y., P.J.H., P.S.H., L.S., K.S.H., H.S.H., K.J.W., L.H.H.; Formal analysis: S.H., L.H.H.; Investigation: K.H.I., S.H., H.H., L.C.M., A.S.H., P.D.J., S.Y.S., J.O., S.S.Y., J.M.R., P.Y.S., K.D.W., S.J.H., L.Y., P.J.H., P.S.H., L.S., K.S.H., H.S.H.,

Materials and Methods: This multicenter, open-label, randomized controlled trial enrolled patients diagnosed with gastric adenocarcinoma (T1N0M0) at 15 university hospitals in Korea. Participants underwent RPLG or CPLG with at least D1+ lymph node dissection. The primary aim of this study was to verify the non-inferiority of RPLG to CPLG in terms of postoperative 30-day complications.
Results: From May 2022 to October 2023, 348 patients were randomly assigned to the RPLG and CPLG groups, with 174 patients in each group. After applying the exclusion criteria, 164 and 166 patients from the RPLG and CPLG groups, respectively, were analyzed. Complication rates were 10.4% and 9.2% for the RPLG and CPLG groups, in the intention-to-treat (ITT) population, and 10.4% vs. 7.2% in the per-protocol (PP) population. The risk difference was 0.012 (95% confidence interval [CI], −0.051 to 0.075) in the ITT population and 0.031 (95% CI, −0.030 to 0.093) in the PP population. These findings verified the non-inferiority of RPLG to CPLG, with a 10% margin. Additionally, the pain score on postoperative day 5 was significantly lower in the RPLG group (1.6% vs. 1.8%; P=0.028). The 2 groups showed no significant differences in the lymph node yield, conversion rate, or length of hospital stay. RPLG was not an independent risk factor for complications.
Conclusions: RPLG is a feasible and safe alternative for patients with EGC, and its short-term outcomes are not inferior to those of CPLG.

Trial Registration: Clinical Research Information Service Identifier: KCT0006935

Keywords: Minimally invasive surgical procedures; Stomach neoplasms; Laparoscopy; Gastrectomy

INTRODUCTION

The incidence of early gastric cancer (EGC) has notably increased with advances in endoscopic screening, and a 2019 nationwide survey in Korea indicated that 63.6% of gastric cancer cases are at an early stage [1,2]. Such EGCs frequently allow for curative resection, with more than 95% of patients achieving long-term survival [3]. Consequently, research has increasingly focused on enhancing survival rates and improving the quality of life of patients after surgery [4].

Laparoscopic gastrectomy is a widely accepted treatment modality for gastric cancer and has been validated as safe in various randomized controlled trials (RCTs) [5-8]. It not only offers cosmetic benefits but also reduces postoperative pain, thereby facilitating quicker recovery [5,6,9]. Although conventional 5-port laparoscopic gastrectomy (CPLG) is the standard procedure, a growing body of research has highlighted various aspects of reduced-port laparoscopic gastrectomy (RPLG). This method uses fewer ports to maximize the benefits of a minimally invasive surgery [10-15]. Comparative studies between RPLG and CPLG in patients with gastric cancer have shown no significant differences in intraoperative blood loss, postoperative complications, or lymph node (LN) retrieval [10,12]. These results suggest that RPLG is a viable option that does not compromise surgical safety or oncological outcomes [11,13,14].

Despite these encouraging findings, most existing studies on RPLG are retrospective, presenting risks of selection bias and variations in surgical timing that could affect outcomes. Prospective studies are essential to assess the safety and utility of RPLG accurately. Therefore,

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the Korean Laparoendoscopic Gastrointestinal Surgery Study Group (KLASS) has initiated a phase 3 multicenter RCT, KLASS-12, to explore the surgical feasibility of RPLG and to confirm its non-inferiority to CPLG in terms of postoperative complications.

MATERIALS AND METHODS

Study design and participants

KLASS-12 was designed as a phase 3, multicenter, open-label, non-inferiority, prospective RCT conducted by 21 gastric surgeons at 15 university hospitals across the Republic of Korea. The study protocol was approved by the Institutional Review Boards (IRBs) (IRB No. KC21EIDT0905) of Seoul St. Mary's Hospital, Yonsei University Severance Hospital, Ajou University Hospital, Korea University Ansan Hospital, Seoul National University Bundang Hospital, Ulsan University Hospital, Chonnam National University Hwasun Hospital, Dankook University Hospital, Ewha Womans University Hospital, Gyeongsang National University Hospital, Korea university Anam Hospital, Uijeongbu Eulji Medical Center, Jeonbuk National University Hospital, Seoul National University Hospital, Pusan National University Yangsan Hospital, Chung-Ang University Hospital, and all patients provided written informed consent.

For this RCT, we included patients diagnosed with gastric adenocarcinoma through preoperative endoscopic biopsy, aged between 20 and 85 years, and clinically staged as T1N0M0 by preoperative endoscopy or endoscopic ultrasound and abdominal computed tomography, in accordance with the 8th American Joint Committee on Cancer gastric cancer staging system [16]. Candidates were required to be scheduled to undergo laparoscopic distal gastrectomy (LDG) with at least D1 + LN dissection and were deemed eligible for curative surgery. Additionally, the participants were required to have signed an informed consent form prior to enrollment.

Comprehensive exclusion criteria were applied to ensure the safety and specificity of the study outcomes. Patients were excluded if they had a history of abdominal surgery other than appendectomy, laparoscopic cholecystectomy, or cesarean section; were expected to require combined resection (excluding cholecystectomy); had received chemotherapy or radiotherapy for newly diagnosed gastric cancer prior to surgery; were diagnosed with another primary malignancy within the past 5 years (excluding those cured of basal cell carcinoma of the skin or in situ cervical cancer); were vulnerable individuals, including those with impaired decision-making capacity, pregnant women, or those planning pregnancy; or had participated in another clinical trial within the past 6 months or were currently participating.

Randomization

Randomization was conducted preoperatively using a computer-based system that assigned patients sequentially to one of 2 groups, starting with the lowest number upon registration. This randomization was centrally managed by the leading research institution (Seoul St. Mary's Hospital), and stratification was applied at each participating institution to ensure 1:1 allocation between the RPLG and CPLG groups, facilitating competitive enrollment. Owing to the nature of this study, blinding of the surgical approach to either the surgeon or patient was not possible; therefore, the trial proceeded as an open-label study. Participants who were unable to undergo surgery within 30 days of registration were considered as dropouts.

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Quality control

For this trial, the participating surgeons were required to have performed at least 40 laparoscopic gastric cancer surgeries and conduct a minimum of 30 gastric cancer surgeries annually. For quality control, all surgeons were required to have experience of at least 10 cases of RPLG or had submitted one unedited RPLG video for review. The Trial's Steering Committee reviewed these videos and approved them on the basis of the demonstrated surgical proficiency and adherence to the standardized procedures.

Study endpoints

The primary endpoint of this study was to elucidate the non-inferiority of RPLG in comparison with CPLG in terms of postoperative 30-day complications, which were categorized into surgical and systemic complications (**Supplementary Table 1**). All complications were classified according to the Clavien–Dindo classification (CDC) [17,18]. Complications were categorized as surgical or systemic complications. Surgical complications included wound complications, fluid collection/abscesses, intraabdominal bleeding, intraluminal bleeding, anastomotic leakage, intestinal obstruction, ileus, stenosis, stasis, pancreatitis, cholecystitis, and idiopathic small-bowel perforation. Systemic complications included respiratory, cardiovascular, hepatic, renal, urinary, metabolic, gastrointestinal, and infectious complications.

Secondary endpoints included the number of LNs harvested, pain levels, rate of conversion from RPLG to CPLG or the open approach, and the postoperative hospital stay.

Surgical procedures and outcome measurement

In accordance with the Korean practice guidelines for gastric cancer, standard radical gastrectomy with at least D1 + LN dissection was performed, and D2 + LN dissection was performed as deemed necessary by the surgeon [19]. Choices regarding nasogastric tube insertion, reconstruction method, drainage tube placement, and the use of surgical instruments beyond the standard tools were left to the surgeon's discretion. Prophylactic antibiotics were administered within 30 minutes of induction of general anesthesia. In the RPLG group, the total number of ports, including the camera port, was limited to 2 or 3, whereas in the CPLG group, at least 5 ports were used. The placement of ports in both groups was determined by the surgeon. For the pathological examination, the LNs from the resected specimens were categorized by compartments. Patients showing signs of distant metastasis or major organ invasion during laparoscopic examination were excluded from the trial, and appropriate treatment was administered based on the surgeon's assessment.

Postoperative care was standardized across both groups, with dietary progression from fasting to sips of water, a liquid diet, and then a soft diet, based on the individual surgeons' judgments. Methods for prevention of venous thrombosis before and after surgery included intermittent pneumatic compression, elastic stockings, and anticoagulants, depending on the surgeon's discretion [20]. A standardized pain control protocol was not uniformly applied across all institutions. Instead, each institution followed its existing patient-controlled analgesia (PCA) device protocol, with additional analgesics administered at the surgeon's discretion.

Data collected included baseline patient information, such as age, sex, height, weight, past medical history, Eastern Cooperative Oncology Group (ECOG) performance status, comorbidities, surgical and medication history, and preoperative endoscopic submucosal dissection. Laboratory tests, such as complete blood count, measurement of C-reactive protein level, and blood chemistry analysis, were performed preoperatively, immediately after surgery, on postoperative days (POD) 1 and 3, and optionally on POD 5 [21].

The surgical details collected included the interval from incision to skin closure, number and placement of ports, extent of gastrectomy and LN dissection, reconstruction methods, extent of omentectomy, estimated blood loss (EBL), use and type of special instruments, number of assistants involved, and intraoperative complications. The timing of gas passage and the start of the liquid diet were assessed. The pain score (Wong-Baker Faces Pain Rating Scale) was assessed on POD 1, 3, and 5 [22]. On POD 30, the patients returned for an outpatient visit to check for mortality and its causes, complications, reasons for rehospitalization, weight, ECOG status changes, and final pathology results.

Statistical analysis

This study was designed to verify the non-inferiority of the incidence of short-term complications in RPLG in comparison with that in CPLG. Previous reports indicated that the complication rates for RPLG and CPLG were similar at approximately 15% [6,9,11,13,15,23]. Since no prospective randomized study on reduced-port surgery (RPS) for gastric cancer exists, a non-inferiority margin of 10% was established on the basis of the results of previous KLASS trials and multiple expert discussions conducted by the KLASS-12 trial committee. The hypothesis of this study was that the complication rate of RPLG is within the non-inferiority margin of comparison with the complication rate of CPLG. Considering the follow-up compliance and dropout rate, if an additional 10% of patients were enrolled, the planned sample size would be 174 participants per group, totaling 348 participants. This provided a power of 80% to reject the null hypothesis, with a significance level of less than 0.05.

We defined 2 distinct populations for our analysis. The intent-to-treat (ITT) population included all randomized patients, except those who met the post-randomization exclusion criteria. The per-protocol (PP) population excluded patients who deviated from the initial treatment plan, such as those requiring additional port insertion for 4-port surgery, those undergoing surgeries other than LDG, and those undergoing combined resections other than cholecystectomy. Both populations were analyzed to assess patient demographics and surgical outcomes. Statistical comparisons between groups were performed using Student's t-test, χ^2 test, and Fisher's exact test. Multivariate analysis was conducted using binary logistic regression to identify the independent risk factors for postoperative complications. Statistical significance was set at $P<0.05$.

All statistical analyses were performed using the SPSS software (version 24; SPSS Inc., Chicago, IL, USA) for Windows. This trial was registered with the Clinical Research Information Service (Registration No. KCT0006935).

RESULTS

Patient enrollment and distribution

Fig. 1 shows the trial flowchart. Between May 25, 2022, and October 5, 2023, 348 patients were enrolled and randomly assigned to the groups. In the ITT population, one patient was excluded because of withdrawal of consent. In the PP population, 9 patients were excluded from the RPLG group: 7 patients required additional port insertion (4 for total gastrectomy and 3 for operative difficulties such as adhesion, obesity, or bleeding), 1 patient required

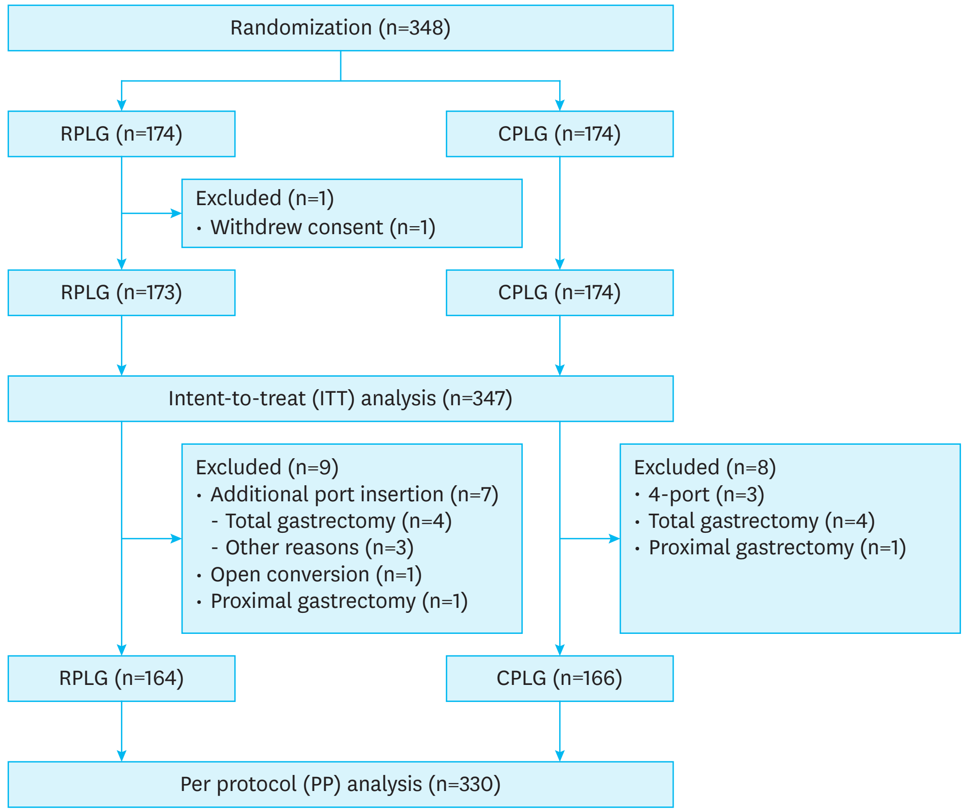

Fig. 1. Flow chart of patient enrollment, randomization, and population distribution.
RPLG = reduced-port laparoscopic gastrectomy; CPLG = conventional-port laparoscopic gastrectomy.

open conversion due to severe adhesion, and one patient underwent proximal gastrectomy without additional port insertion. In the CPLG group, 8 patients were excluded from the PP population: 3 patients underwent 4-port surgery, 4 patients underwent total gastrectomy, and 1 patient underwent proximal gastrectomy. Consequently, the PP population analysis included 164 and 166 patients from the RPLG and CPLG groups (**Fig. 1**).

Baseline characteristics

Table 1 shows the baseline characteristics of the patients, including their age, sex, body mass index (BMI), ECOG performance status, comorbidities, and preoperative characteristics. Overall, the 2 groups showed no significant differences in the baseline characteristics. However, the ITT population showed a higher incidence of steroid use history in the RPLG group, as well as differences in the circumferential location of the tumors. Nevertheless, these differences were not observed in the PP population (**Table 1**).

Information and quality of the surgeons and the institutions

In this multicenter study, which involved numerous surgeons with diverse levels of experience, we conducted an analysis to determine whether surgeon experience and hospital volume differed between the 2 groups. All surgeons had performed at least 40 cases of laparoscopic radical gastrectomy, and although experience with RPLG varied among surgeons, the 2 groups showed no differences in terms of surgeon expertise. Additionally, all participating institutions were tertiary care hospitals, and no differences in hospital scale were noted between the groups (**Supplementary Table 2**).

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Table 1. Baseline characteristics

Variables	Intention-to-treat population			Per-protocol population		
	RPLG (n=173)	CPLG (n=174)	P-value	RPLG (n=164)	CPLG (n=166)	P-value
Age (yr)	61.8±10.8	62.3±10.6	0.645	62.0±10.7	62.3±10.6	0.766
Sex			0.651			0.486
Male	116 (67.1)	112 (64.4)		112 (68.3)	107 (64.5)	
Female	57 (32.9)	62 (35.6)		52 (31.7)	59 (35.5)	
BMI (kg/m^2)	24.0±3.0	23.9±3.5	0.937	23.9±2.9	23.8±3.5	0.726
ECOG score			0.335			0.308
0	144 (83.2)	147 (84.5)		137 (83.5)	141 (84.9)	
1	26 (15)	27 (15.5)		24 (14.6)	25 (15.1)	
2	3 (1.7)	0 (0)		3 (1.8)	0 (0)	
Comorbidity						
Hypertension	74 (42.8)	75 (43.1)	1.000	71 (43.3)	72 (43.4)	1.000
Diabetes	33 (19.1)	39 (22.4)	0.508	31 (18.9)	37 (22.3)	0.497
Cardiovascular	17 (9.8)	16 (9.2)	0.857	17 (10.4)	16 (9.6)	0.856
Pulmonary	9 (5.2)	9 (5.2)	1.000	7 (4.3)	8 (4.8)	1.000
Hepatic	9 (5.2)	8 (4.6)	0.810	9 (5.5)	6 (3.6)	0.442
Renal	5 (2.9)	3 (1.7)	0.502	4 (2.4)	3 (1.8)	0.722
Cerebral	10 (5.8)	7 (4.0)	0.469	8 (4.9)	7 (4.2)	0.798
Other malignancy	3 (1.7)	5 (2.9)	0.723	3 (1.8)	5 (3.0)	0.723
Others	43 (24.9)	34 (19.5)	0.247	41 (25.0)	33 (19.9)	0.292
Medication history						
Antiplatelets or anticoagulants	26 (15.0)	21 (12.1)	0.437	25 (15.2)	21 (12.7)	0.528
Steroids	5 (2.9)	0 (0)	0.030	4 (2.4)	0 (0)	0.060
No. of tumors on EGD			0.612			1.000
1	170 (98.3)	168 (96.6)		161 (98.2)	161 (97.0)	
2	3 (1.7)	5 (2.9)		3 (1.8)	4 (2.4)	
3	0 (0)	1 (0.6)		0 (0)	1 (0.6)	
Tumor size on EGD (cm)	2.0±0.9	2.1±1.1	0.715	2.0±0.9	2.1±1.1	0.746
Location (longitudinal) on EGD			0.330			0.401
Upper third	8 (4.6)	4 (2.3)		8 (4.9)	4 (2.4)	
Middle third	30 (17.3)	38 (21.8)		28 (17.1)	34 (20.5)	
Lower third	135 (78)	132 (75.9)		128 (78.0)	128 (77.1)	
Location (circumferential) on EGD			0.044			0.087
LC	47 (27.2)	67 (38.5)		43 (26.2)	61 (36.7)	
GC	48 (27.7)	41 (23.6)		46 (28.0)	41 (24.7)	
AW	30 (17.3)	35 (20.1)		29 (17.7)	33 (19.9)	
PW	48 (27.7)	31 (17.8)		46 (28.0)	31 (18.7)	
Gross type			0.783			0.867
I	5 (2.9)	5 (2.9)		5 (3.0)	5 (3.0)	
IIa	43 (24.9)	55 (31.6)		42 (25.6)	52 (31.3)	
IIb	35 (20.2)	34 (19.5)		30 (18.3)	31 (18.7)	
IIc	75 (43.4)	64 (36.8)		72 (43.9)	62 (37.3)	
III	10 (5.8)	11 (6.3)		10 (6.1)	11 (6.6)	
Others	5 (2.9)	5 (2.9)		5 (3.0)	5 (3.0)	
Histology			0.108			0.100
Differentiated	95 (54.9)	80 (46.0)		91 (55.5)	77 (46.4)	
Undifferentiated	78 (45.1)	94 (54.0)		73 (44.5)	89 (53.6)	
Previous ESD	24 (13.9)	17 (9.8)	0.249	23 (14.0)	17 (10.2)	0.315
Interval from ESD to surgery (days)	29.8±9.5	37.6±27.9	0.209	30.1±9.5	37.6±27.9	0.236

Values are presented as number (%) or mean ± standard deviation.
RPLG = reduced-port laparoscopic gastrectomy; CPLG = conventional-port laparoscopic gastrectomy; BMI = body mass index; ECOG = Eastern Cooperative Oncology Group; EGD = esophagogastroduodenoscopy; LC = lesser curvature; GC = greater curvature; AW = anterior wall; PW = posterior wall; ESD = endoscopic submucosal dissection.

Operative details

Table 2 presents the data for operative details. Within the PP population, the use of 2-port and 3-port in the RPLG group was 23.2% and 76.8%, respectively. The usage rate of multi-channel ports was 42.1% in the RPLG group and 8.4% in the CPLG group (P<0.001).

Table 2. Operative details

Variables	Intention-to-treat population			Per-protocol population		
	RPLG (n=173)	CPLG (n=174)	P-value	RPLG (n=164)	CPLG (n=166)	P-value
No. of ports			<0.001			<0.001
2	38 (22.0)	0 (0.0)		38 (23.2)	0 (0.0)	
3	128 (74.0)	0 (0.0)		126 (76.8)	0 (0.0)	
4	1 (0.6)	3 (1.7)		-	-	
5	6 (3.5)	171 (98.3)		0 (0.0)	166 (100.0)	
Multi-channel port	71 (41.0)	15 (8.6)	<0.001	69 (42.1)	14 (8.4)	<0.001
Location of ports			<0.001			<0.001
Right side only	144 (83.2)	0 (0.0)		143 (87.2)	0 (0.0)	
Left side only	6 (3.5)	0 (0.0)		6 (3.7)	0 (0.0)	
Both sides	23 (13.3)	174 (100.0)		15 (9.1)	166 (100.0)	
Open conversion	1 (0.6)	0 (0.0)	0.499	-	-	
Extent of gastrectomy			1.000			
DG	168 (97.1)	169 (97.1)		164 (100)	166 (100)	
TG	4 (2.3)	4 (2.3)		-	-	
PG	1 (0.6)	1 (0.6)		-	-	
Extent of LN dissection			0.694			1.000
D1+	138 (79.8)	135 (77.6)		131 (79.9)	132 (79.5)	
D2 or more	35 (20.2)	39 (22.4)		33 (20.1)	34 (20.5)	
Reconstruction			0.980			0.967
B-I	38 (22.0)	38 (21.8)		37 (22.6)	38 (22.9)	
B-II	60 (34.7)	62 (35.6)		59 (36)	61 (36.7)	
B-II with Braun	26 (15.0)	22 (12.6)		25 (15.2)	22 (13.3)	
R-Y (including uncut R-Y)	44 (25.4)	47 (27.0)		43 (26.2)	45 (27.1)	
Others	5 (2.9)	5 (2.9)		-	-	
Direction of GJ anastomosis (except B-I)			0.755			0.751
Anti-peristaltic	106 (81.5)	104 (79.4)		104 (81.9)	102 (79.7)	
Iso-peristaltic	24 (18.5)	27 (20.6)		23 (18.1)	26 (20.3)	
Omentectomy			0.620			1.000
Partial	166 (96.0)	164 (94.3)		157 (95.7)	158 (95.2)	
Total	7 (4.0)	10 (5.7)		7 (4.3)	8 (4.8)	
Mesenteric defect closure	83 (48.0)	90 (51.7)	0.520	76 (46.3)	84 (50.6)	0.443
Entry hole closure			0.118			0.112
Hand sewing suture	118 (68.2)	104 (59.8)		110 (67.1)	97 (58.4)	
Stapler	55 (31.8)	70 (40.2)		54 (32.9)	69 (41.6)	
No. of staplers	5.4±1.1	5.4±1.3	0.639	5.3±1.1	5.4±1.3	0.546
OP time (min)	165.0±58.6	165.4±57.5	0.951	161.6±53.6	161.3±53.7	0.961
EBL (mL)	62.5±86.1	60.7±69.3	0.832	59.5±80.9	59.8±70.6	0.973
Special instruments	154 (89.0)	121 (69.5)	<0.001	148 (90.2)	114 (68.7)	<0.001
Articulating device	101 (58.4)	91 (52.3)	0.281	98 (59.8)	85 (51.2)	0.123
Mini-trocar	12 (6.9)	3 (1.7)	0.018	12 (7.3)	3 (1.8)	0.018
Intraabdominal retractor	86 (49.7)	32 (18.4)	<0.001	82 (50.0)	31 (18.7)	<0.001
Scope holder	17 (9.8)	13 (7.5)	0.452	17 (10.4)	13 (7.8)	0.450
Others	1 (0.6)	0 (0.0)	0.490	1 (0.6)	0 (0.0)	0.497
Intraoperative complication			0.247			0.748
No	170 (98.3)	173 (99.4)		163 (99.4)	165 (99.4)	
Major vessel injury	1 (0.6)	0 (0.0)		1 (0.6)	0 (0.0)	
Incomplete LN dissection	0 (0.0)	0 (0.0)		0 (0.0)	0 (0.0)	
Organ injury	2 (1.2)	0 (0.0)		0 (0.0)	0 (0.0)	
Others	0 (0.0)	1 (0.6)		0 (0.0)	1 (0.6)	
No. of assistants			<0.001			<0.001
No (solo surgery)	15 (8.7)	0 (0.0)		15 (9.1)	0 (0.0)	
1	129 (74.6)	54 (31.0)		123 (75.0)	50 (30.1)	
2 or more	29 (16.8)	120 (69.0)		26 (15.9)	116 (69.9)	

Values are presented as number (%) or mean ± standard deviation.
RPLG = reduced-port laparoscopic gastrectomy; CPLG = conventional-port laparoscopic gastrectomy; DG = distal gastrectomy; TG = total gastrectomy; PG = proximal gastrectomy; LN = lymph node; B-I = Billroth-I; B-II = Billroth-II; R-Y = Roux-en-Y; GJ = gastrojejunostomy; OP = operation; EBL = estimated blood loss.

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Regarding the location of ports, 87.2% of RPLG cases had ports only on the right side, and 9.1% had ports on both sides. The 2 groups showed no differences in the extent of LN dissection or the reconstruction method used. For Billroth-II with or without Braun reconstruction and Roux-en-Y (including uncut Roux-en-Y) reconstruction, gastrojejunostomies were predominantly performed in an anti-peristaltic fashion, accounting for approximately 80% of the cases in both groups. Since most patients had EGC, partial omentectomy was performed in approximately 95% of cases in both groups. Closure of the mesenteric defect was performed in approximately 50% of cases, with no significant difference between the groups. Closure of entry holes was performed using hand sewing in approximately 60% of cases, with no significant differences between the groups. Additionally, no significant differences in operation time and EBL were observed between the groups. Intraoperative complications occurred in one case in each group, with no significant differences observed.

Special instruments, particularly mini-trocars and intraabdominal retractors, were used more frequently in the RPLG group (90.2% vs. 68.7%, P<0.001). The usage rate of articulating instruments was slightly higher in the RPLG group, although the difference was not significant. Scope holders were not commonly used, but were similarly utilized in both groups. Intraoperative complications were rare in both groups. In the ITT population, the RPLG group showed one case of major vessel injury and 2 cases of organ injuries. The 2 cases of organ injuries involved the common bile duct and small bowel, each requiring additional trocar insertion. The CPLG group showed one case of ischemic change in the jejunal stump necessitating additional resection. All intraoperative complications were successfully managed without mortality or severe morbidity.

Regarding surgical assistance, 9.1% of the patients in the RPLG group underwent solo surgery, and 75% required only one assistant. In the CPLG group, none of the patients underwent solo surgery, and 30.1% of the surgeries involved only one assistant.

Results of pathological examinations

The results of pathological examinations are presented in **Table 3**. Although only patients clinically assessed as T1N0 were included in the study, 6.7% of the patients in the RPLG group and 12.6% of those in in the CPLG group had a tumor depth of T2 or higher (P=0.372). Additionally, LN metastasis was observed in 7.3% and 12.6% of the patients in the RPLG and CPLG groups, respectively (P=0.105). The pathological staging showed no significant differences between the 2 groups (P=0.169).

The overall number of retrieved LNs was similar between the groups (42.4 in the RPLG group vs. 42.8 in the CPLG group; P=0.839). Further analysis according to LN station, including perigastric and suprapancreatic LNs, showed no significant differences in the number of retrieved LNs across all stations (**Table 3**, **Fig. 2**).

Postoperative short-term outcomes and complications

The primary endpoint was the incidence of short-term postoperative complications. In the ITT population, the overall complication rates were 10.4% and 9.2% in the RPLG and CPLG groups, respectively, with no significant difference (P=0.722). Similarly, in the PP population, the rates were 10.4% and 7.2% in the RPLG and CPLG groups, again with no significant difference (P=0.337). For the non-inferiority test, risk differences and 95% confidence intervals (CIs) were analyzed. In the ITT population, the risk difference and 95% CI for overall complications were 0.012 and −0.051 to 0.075, respectively, and in the PP population,

Table 3. Results of pathological examinations

Variables	Intention-to-treat population			Per-protocol population		
	RPLG (n=173)	CPLG (n=174)	P-value	RPLG (n=164)	CPLG (n=166)	P-value
No. of tumors			0.104			0.104
1	171 (98.8)	166 (95.4)		162 (98.8)	158 (95.2)	
2	2 (1.2)	8 (4.6)		2 (1.2)	8 (4.8)	
Tumor size (cm)	2.3±1.2	2.5±1.4	0.250	2.3±1.2	2.4±1.4	0.523
Location (longitudinal)			0.554			0.095
Upper third	2 (1.2)	5 (2.9)		0 (0.0)	5 (3.0)	
Middle third	55 (31.8)	57 (32.8)		51 (31.1)	53 (31.9)	
Lower third	116 (67.1)	112 (64.4)		113 (68.9)	108 (65.1)	
Location (circumferential)			0.148			0.252
LC	55 (31.8)	74 (42.5)		51 (31.1)	68 (41.0)	
GC	45 (26.0)	36 (20.7)		43 (26.2)	36 (21.7)	
AW	27 (15.6)	29 (16.7)		26 (15.9)	27 (16.3)	
PW	46 (26.6)	35 (20.1)		44 (26.8)	35 (21.1)	
Gross type (EGC type)			0.191			0.417
I	1 (0.6)	2 (1.1)		1 (0.6)	2 (1.2)	
IIa	19 (11.0)	17 (9.8)		17 (10.4)	17 (10.2)	
IIb	58 (33.5)	39 (22.4)		54 (32.9)	38 (22.9)	
IIc	82 (47.4)	96 (55.2)		79 (48.2)	91 (54.8)	
III	6 (3.5)	7 (4.0)		6 (3.7)	7 (4.2)	
AGC	7 (4.0)	13 (7.5)		7 (4.3)	11 (6.6)	
Histology			0.198			0.271
Differentiated	91 (52.6)	79 (45.4)		86 (52.4)	76 (45.8)	
Undifferentiated	82 (47.4)	95 (54.6)		78 (47.6)	90 (54.2)	
PRM (cm)	4.6±3.0	4.1±2.7	0.132	4.6±2.9	4.1±2.7	0.133
DRM (cm)	6.5±3.8	6.3±3.5	0.671	6.4±3.8	6.3±3.5	0.724
T stage			0.297			0.372
T1a	98 (56.6)	95 (54.6)		93 (56.7)	90 (54.2)	
T1b	63 (36.4)	56 (32.2)		60 (36.6)	55 (33.1)	
T2	7 (4)	16 (9.2)		7 (4.3)	16 (9.6)	
T3	4 (2.3)	4 (2.3)		3 (1.8)	4 (2.4)	
T4a	1 (0.6)	3 (1.7)		1 (0.6)	1 (0.6)	
N stage			0.065			0.105
N0	161 (93.1)	151 (86.8)		152 (92.7)	145 (87.3)	
N1	10 (5.8)	11 (6.3)		10 (6.1)	10 (6.0)	
N2	1 (0.6)	6 (3.4)		1 (0.6)	5 (3.0)	
N3a	1 (0.6)	6 (3.4)		1 (0.6)	6 (3.6)	
TNM stage			0.087			0.169
I	164 (94.8)	157 (90.2)		156 (95.1)	151 (91.0)	
II	9 (5.2)	13 (7.5)		8 (4.9)	12 (7.2)	
III	0 (0.0)	4 (2.3)		0 (0.0)	3 (1.8)	
No. of retrieved LNs	42.7±17.8	43.4±17.3	0.727	42.4±18.0	42.8±17.0	0.839
Perigastric LNs	33.9±16.4	34.0±15.7	0.975	33.7±16.6	33.7±15.7	0.971
Suprapancreatic LNs	9.4±5.4	9.7±5.5	0.579	9.2±5.2	9.4±5.4	0.702
LNs #1	3.6±3.6	4.2±4.0	0.164	3.5±3.4	4.1±4.0	0.160
LNs #3	7.8±7.2	7.8±7.6	0.955	7.7±7.2	7.8±7.7	0.872
LNs #4sb	4.2±6.0	4.4±6.4	0.717	4.1±5.9	4.4±6.5	0.657
LNs #4d	7.2±6.4	6.4±5.4	0.229	7.2±6.3	6.2±5.4	0.148
LNs #5	1.5±1.8	1.5±2.1	0.977	1.4±1.8	1.4±2.0	0.808
LNs #6	5.1±3.4	5.0±3.4	0.760	5.2±3.4	4.9±3.3	0.476
LNs #7	4.9±3.3	4.9±3.1	0.849	4.9±3.3	4.9±3.2	0.929
LNs #8a	3.2±2.8	3.1±2.3	0.624	3.1±2.5	3.0±2.3	0.660
LNs #9	3.8±2.7	3.9±2.8	0.714	3.8±2.8	3.9±2.8	0.788
LNs #11p	2.4±2.3	2.9±2.5	0.092	2.4±2.3	2.8±2.5	0.171
LNs #12a	2.6±2.6	2.4±2.1	0.727	2.4±2.2	2.5±2.2	0.780
LNs #regional	2.1±2.1	2.7±1.6	0.370	1.9±1.5	2.5±1.6	0.253

Values are presented as number (%) or mean ± standard deviation.
RPLG = reduced-port laparoscopic gastrectomy; CPLG = conventional-port laparoscopic gastrectomy; LC = lesser curvature; GC = greater curvature; AW = anterior wall; PW = posterior wall; EGC = early gastric cancer; AGC = advanced gastric cancer; PRM = proximal resection margin; DRM = distal resection margin; TNM = tumor-nodes-metastasis; LN = lymph node.

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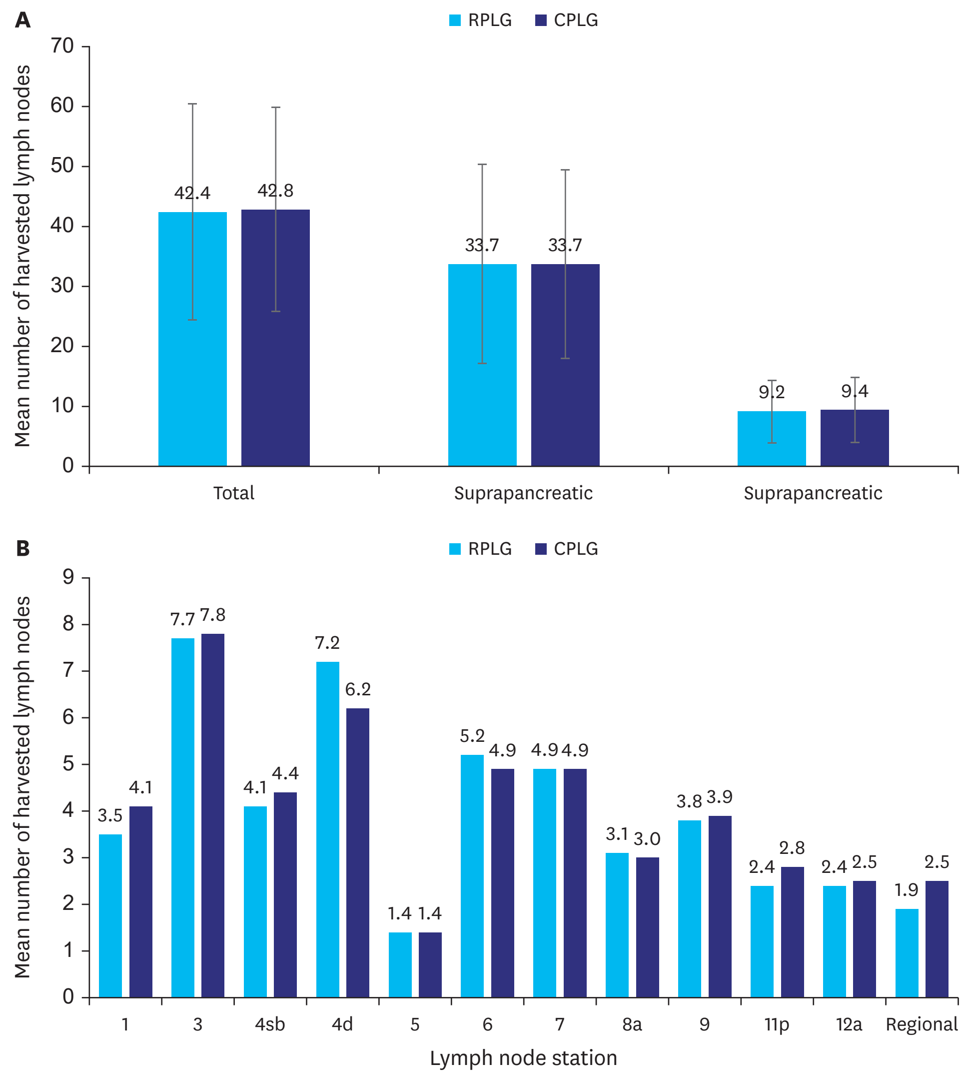

Fig. 2. Number of retrieved lymph nodes. The mean number of harvested lymph nodes is presented, and the findings show no significant differences between the groups. (A) Comparison of the total number of harvested lymph nodes in the 2 groups. The number of harvested lymph nodes was categorized into suprapancreatic and perigastric regions. (B) Comparison of the number of harvested lymph nodes in each station.
RPLG = reduced-port laparoscopic gastrectomy; CPLG = conventional-port laparoscopic gastrectomy.

they were 0.031 and −0.030 to 0.093, respectively. Therefore, since the 95% CI was within the non-inferiority margin of 0.1 for both the ITT and PP populations, our findings demonstrated the non-inferiority of RPLG to CPLG in terms of postoperative short-term complication rates (**Table 4**, **Fig. 3**).

No cases of mortality occurred during any of the surgeries. In the PP population, CDC grade 3 or higher complications occurred in 3.7% of the patients in the RPLG group and 3.0% of those in the CPLG group, with no significant difference (P=0.770). In terms of subgroup analysis, surgical complications, including wound complications, fluid collection, bleeding, anastomosis-related complications, and intestinal obstruction, occurred in 6.7% of the patients in the RPLG group and 5.4% of those in the CPLG group (P=0.652). Systemic complications (respiratory, cardiovascular, metabolic, and infectious) occurred in 4.3% and 1.8% of the patients in the RPLG and CPLG groups, respectively, with no significant difference (P=0.217) (**Table 4**).

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Table 4. Postoperative short-term outcomes (within 30 days postoperatively)

Variables	Intention-to-treat population			Per-protocol population		
	RPLG (n=173)	CPLG (n=174)	P-value	RPLG (n=164)	CPLG (n=166)	P-value
Complications			0.722			0.337
No	155 (89.6)	158 (90.8)		147 (89.6)	154 (92.8)	
Yes	18 (10.4)	16 (9.2)		17 (10.4)	12 (7.2)	
CDC grade			0.730			0.477
No	155 (89.6)	158 (90.8)		147 (89.6)	154 (92.8)	
CDC 1	1 (0.6)	3 (1.7)		1 (0.6)	2 (1.2)	
CDC 2	10 (5.8)	6 (3.4)		10 (6.1)	5 (3.0)	
CDC 3a	6 (3.5)	5 (2.9)		6 (3.7)	4 (2.4)	
CDC 3b	1 (0.6)	1 (0.6)		0 (0.0)	1 (0.6)	
CDC 4	0 (0.0)	1 (0.6)		0 (0.0)	0 (0.0)	
CDC 5	0 (0.0)	0 (0.0)		0 (0.0)	0 (0.0)	
Complications (CDC grade 3 or higher)	7 (4.0)	7 (4.0)	1.000	6 (3.7)	5 (3.0)	0.770
Mortality	0 (0.0)	0 (0.0)		0 (0.0)	0 (0.0)	
Surgical complications			1.000			0.652
No	161 (93.1)	162 (93.1)		153 (93.3)	157 (94.6)	
Yes	12 (6.9)	12 (6.9)		11 (6.7)	9 (5.4)	
Details of surgical complications						
Wound	2 (1.2)	1 (0.6)	0.623	2 (1.2)	1 (0.6)	0.622
Fluid collection or abscess	4 (2.3)	2 (1.1)	0.448	4 (2.4)	2 (1.2)	0.447
Intraabdominal bleeding	1 (0.6)	2 (1.1)	1.000	1 (0.6)	0 (0.0)	0.497
Intraluminal bleeding	1 (0.6)	1 (0.6)	1.000	1 (0.6)	1 (0.6)	1.000
Anastomosis or stump leakage	0 (0.0)	0 (0.0)				
Intestinal obstruction	0 (0.0)	0 (0.0)				
Ileus	3 (1.7)	4 (2.3)	1.000	2 (1.2)	2 (1.2)	1.000
Anastomosis stenosis	0 (0.0)	1 (0.6)	1.000	0 (0.0)	1 (0.6)	1.000
Stasis	1 (0.6)	2 (1.1)	1.000	1 (0.6)	2 (1.2)	1.000
Pancreatitis	0 (0.0)	0 (0.0)		0 (0.0)	0 (0.0)	
Cholecystitis	0 (0.0)	0 (0.0)		0 (0.0)	0 (0.0)	
Idiopathic intestinal perforation	0 (0.0)	0 (0.0)		0 (0.0)	0 (0.0)	
Others	0 (0.0)	0 (0.0)		0 (0.0)	0 (0.0)	
Systemic complications			0.379			0.217
No	166 (96)	170 (97.7)		157 (95.7)	163 (98.2)	
Yes	7 (4)	4 (2.3)		7 (4.3)	3 (1.8)	
Details of systemic complications						
Respiratory	2 (1.2)	2 (1.1)	1.000	2 (1.2)	1 (0.6)	0.622
Cardiovascular	0 (0.0)	1 (0.6)	1.000	0 (0.0)	1 (0.6)	1.000
Hepatic	1 (0.6)	0 (0.0)	0.499	1 (0.6)	0 (0.0)	0.497
Renal	0 (0.0)	0 (0.0)		0 (0.0)	0 (0.0)	
Urinary	1 (0.6)	0 (0.0)	0.499	1 (0.6)	0 (0.0)	0.497
Metabolic	2 (1.2)	0 (0.0)	0.248	2 (1.2)	0 (0.0)	0.246
Gastrointestinal	0 (0.0)	0 (0.0)		0 (0.0)	0 (0.0)	
Infectious	1 (0.6)	1 (0.6)	1.000	1 (0.6)	1 (0.6)	1.000
Others	3 (1.7)	0 (0.0)	0.123	3 (1.8)	0 (0.0)	0.122
Duration to flatus (days)	3.1±1.2	3.4±1.7	0.129	3.1±1.2	3.3±1.7	0.241
Duration to SOW (days)	1.2±0.9	1.3±2.1	0.482	1.1±0.8	1.1±0.8	0.479
Duration to diet (days)	2.6±1.3	2.8±2.4	0.382	2.6±1.3	2.6±1.3	0.833
Postoperative hospital stay (days)	6.3±2.7	6.5±3.6	0.469	6.2±2.6	6.2±2.4	0.921
Readmission	5 (2.9)	3 (1.7)	0.502	3 (1.8)	2 (1.2)	0.684
Duration to readmission from surgery	19.2±12.0	13.0±4.0	0.336	16.7±12.9	11.0±2.8	0.601
Duration to readmission from discharge	11.8±8.3	4.0±2.0	0.106	10.0±9.8	5.0±1.4	0.547
VAS score_POD #1	2.5±0.8	2.6±0.9	0.099	2.5±0.8	2.6±0.9	0.085
Patient number	173 (100)	173 (99.4)		164 (100)	166 (100)	
VAS score_POD #3	2.0±0.9	2.1±0.9	0.338	2.0±0.9	2.1±0.9	0.288
Patient number	173 (100.0)	173 (99.4)		164 (100.0)	166 (100.0)	
VAS score_POD #5	1.6±0.9	1.8±0.9	0.083	1.6±0.9	1.8±1.0	0.028
Patient number	134 (77.5)	133 (76.4)		126 (76.8)	126 (75.9)	
Weight change (%)	94.5±3.4	94.1±4.2	0.294	94.6±3.4	94.1±4.0	0.258
ECOG score increase	58 (33.5)	55 (31.6)	0.732	54 (32.9)	51 (30.7)	0.723

Values are presented as number (%) or mean ± standard deviation.
RPLG = reduced-port laparoscopic gastrectomy; CPLG = conventional-port laparoscopic gastrectomy; CDC = Clavien–Dindo classification; SOW = sips of water; VAS = visual analogue scale; POD = postoperative day; ECOG = Eastern Cooperative Oncology Group.

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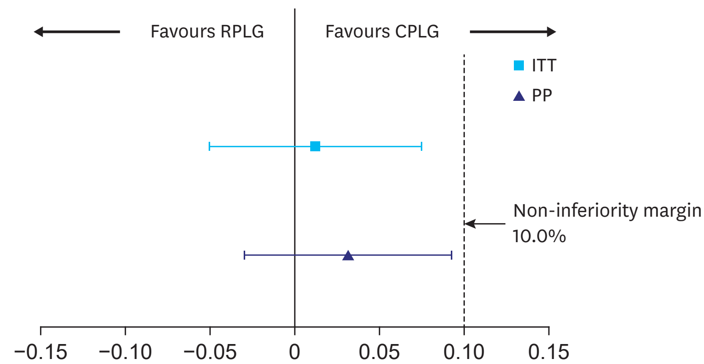

Population	Risk Difference	95% LCI	95% UCI
ITT	0.012	−0.051 (5.1%)	0.075 (7.5%)
PP	0.031	−0.030 (3.0%)	0.093 (9.3%)

Fig. 3. Demonstration of non-inferiority of RPLG to CPLG in terms of postoperative short-term complication rates. RPLG = reduced-port laparoscopic gastrectomy; CPLG = conventional-port laparoscopic gastrectomy; ITT = intention-to-treat; PP = per-protocol; LCI = lower confidence interval; UCI = upper confidence interval.

No differences were observed between the groups in terms of the duration to flatus, sips of water, oral diet initiation, or hospital stay. The readmission rates and durations were also similar between the groups. The pain scores measured on PODs 1 and 3 showed no significant differences between the groups (P=0.085 and P=0.288, respectively). On POD 5, pain scores were measured in approximately 75% of the patients, with the RPLG group reporting a significantly lower score (1.6 vs. 1.8, P=0.028) (**Table 4**).

Risk factors for the complications

Logistic regression analysis was used to identify independent risk factors for complications in the PP population. Female sex was found to be a protective factor against overall complications (odds ratio [OR], 0.259; CI, 0.087 to 0.770; P=0.015) (**Supplementary Table 3**). For CDC grade 3 or higher complications, shorter operation time (OR, 0.981; CI, 0.964 to 0.998; P=0.025) and EBL (OR, 1.007; CI, 1.001 to 1.013; P=0.016) were independent risk factors (**Supplementary Table 4**). RPLG was not identified as an independent risk factor for overall complications, CDC grade 3 or higher complications, or surgical complications (**Supplementary Tables 3-5**).

DISCUSSION

This phase 3 multicenter RCT aimed to validate the feasibility of RPLG in comparison with CPLG in terms of short-term complications. The primary endpoint was to demonstrate that the 30-day postoperative complication rate in RPLG was not inferior to that in CPLG. The complication rates were 10.4% and 9.2% in the RPLG and CPLG groups, respectively, in the ITT population, and 10.4% and 7.2% in the RPLG and CPLG groups, respectively, in the PP population. The risk difference and 95% CI were within the non-inferiority margin of 10%. Therefore, the primary endpoint of this study was achieved. The secondary endpoints included the number of harvested LNs, pain score, conversion rate to CPLG or the open approach, and postoperative hospital stay. The 2 groups showed no significant difference in the number of harvested LNs. Open conversion occurred in 0.6% of cases in the RPLG group, with no significant difference in comparison with the CPLG group. Conversion to CPLG occurred in 3.5% of RPLG cases, primarily due to total or proximal gastrectomy. Pain scores did not differ between the groups on POD 1 and 3; however, on day 5, the RPLG group showed a significantly lower score (1.6 vs. 1.8; P=0.028). The postoperative hospital stay did not differ between the groups. Therefore, the primary and secondary endpoints of this study validated the feasibility of RPLG.

The use of RPS has been reported in many studies, particularly in gastric cancer surgery; the existing forms of RPS include reduced-port LDG for EGC and advanced gastric cancer as well as reduced-port total or proximal gastrectomy [10-15,23]. Recent multicenter retrospective studies have evaluated both short- and long-term outcomes of RPS [13]. Previous studies have reported the advantages of RPS, including its cosmetic effects, reduced pain, enhanced patient satisfaction, and reduced manpower requirements [11]. However, most of these studies were retrospective, highlighting the need for large-scale, multicenter RCTs. Further analysis of the benefits of RPS, as reported in previous studies, is warranted through subsequent analyses. Additionally, future studies should focus on standardizing procedures and defining specific criteria for patient selection to maximize the benefits of RPS. This prospective multicenter RCT provides robust evidence regarding the safety and efficacy of RPS, potentially influencing surgical guidelines and practices. This would ultimately contribute to improved patient outcomes and the broader adoption of minimally invasive approaches in gastric cancer surgery.

An extremely low or high BMI is generally considered a significant challenge in laparoscopic surgery, particularly for the application of RPS [24]. In this study, the 2 groups showed no significant difference in BMI. Additionally, the distribution of BMI was similar across both groups, with the BMI values of the patients ranging from 15.80 to 40.9. These findings suggest that RPLG can be performed regardless of BMI variations and may be applicable to a broad patient population (**Supplementary Fig. 1**).

Operative details, including port placement, reconstruction, and use of additional instruments, were at the discretion of each surgeon to ensure real-world applicability and patient safety [25]. Special instruments were defined as those not typically used in standard laparoscopic surgery, such as linear forceps, rigid or flexible scopes, energy devices, and laparoscopic staplers. Articulating devices are devices that can articulate within the abdominal cavity; the mini-trocar, with a diameter of 2 mm, was inserted directly into the abdomen [26,27]. An intraabdominal retractor, which was fixed within the abdomen and tied with sutures for external connections, was used for traction. Scope holders were used to secure and maneuver the laparoscopic scope at the desired angles in situations without a scopist [28]. These special instruments, which were used more frequently in the RPLG group (P<0.001), were deployed at the surgeon's discretion. In particular, the multi-channel port is indispensable in 2-port surgery and beneficial in 3-port surgery, facilitating the handling of traction and countertraction without an assistant [28]. This suggests that advancements in these instruments can support the progression toward even more minimally invasive surgeries [29].

Shortage of surgical personnel has become a critical issue. Labor costs constitute a substantial portion of medical expenses [30,31]. In this context, RPS offers the advantage of reducing the required surgical manpower. In our study, CPLG required 2 or more assistants in approximately 69% of the cases. In contrast, RPLG required 2 or more assistants in only approximately 16% of cases. Moreover, in approximately 9% of cases, the operator was able to perform surgery alone. Although we did not compare medical costs between the 2 groups, these findings suggest that RPLG could help alleviate the ongoing surgical workforce shortage, potentially reduce labor costs, and contribute to overall medical cost savings [11].

In addition to establishing the non-inferiority of RPLG as the primary endpoint, this study has several strengths that require acknowledgment. The first strength lies in the selection of qualified surgeons to conduct a multicenter RCT, allowing the collection of homogeneous data within an 18-month enrollment period without the introduction of new instruments or changes in protocol. Our analysis of both ITT and PP populations not only highlighted the effectiveness of RPLG but also reflected real-world data [32]. The second strength of the study is related to the results for the secondary endpoints, particularly the number of harvested LNs and pain scores. In gastric cancer surgery, the number of harvested LNs and safety margins typically represent short-term oncological outcomes [11]. No significant differences were observed between the 2 groups, with both groups averaging over 42 harvested LNs, indicating satisfactory results in comparison with previous reports [6,11,15]. The number of LNs harvested by station also showed no differences, affirming the short-term oncological feasibility of RPLG. In addition to cosmetic outcomes, reduced pain after surgery has been reported as a potential benefit in studies related to RPS [33,34]. In the PP population in this study, although the 2 groups showed no difference in pain scores on POD 1 and 3, the RPLG group showed a lower pain score on POD 5. Indeed, until POD 2 or 3, painkillers are usually administered aggressively using special methods, such as PCA; after that period, painkillers are not used as aggressively. This duration of painkiller use may have resulted in similar pain scores on POD 1 and 3 between the groups; therefore, the results showing a difference in pain scores on POD 5 reflect the reality of reduced postoperative pain with RPS.

Importantly, this study identified a shorter operation time as an independent risk factor for complications. This observation deviates from prior evidence suggesting that a shorter operative time reduces the risk of complications [35]. However, in the multivariate analysis, a shorter operation time increased the risk of severe complications, although the OR was 0.981, indicating a minor influence. The average operation times in this study were 165 minutes (ITT population) and 161 minutes (PP population), which were significantly shorter than those reported in other studies [36]. This could be due to quality control of the participating surgeons. Therefore, a further reduction in the already short operation time may be counterproductive. Thus, meticulous surgery with adequate time is more beneficial. Similar results were obtained in an analysis of surgeon quality control and outcomes in the KLASS-02 study [37].

However, the limitations of this study also require consideration. These limitations include the fact that the study was exclusively conducted in the Republic of Korea, where gastric cancer is prevalent. Thus, additional research is required to determine the applicability of its findings to Western countries. Additionally, the patient cohort was limited to patients with EGC, and the surgeries were limited to LDG, necessitating further research on its application in advanced gastric cancer and total or proximal gastrectomy. Although the long-term outcomes remain unverified, the sufficient number of harvested LNs substantiates the feasibility of short-term oncologic outcomes, raising positive expectations for long-term results. Ongoing follow-up of the study participants is essential for ascertaining long-term outcomes. Despite these limitations, this study holds substantial value as the world's first multicenter RCT to demonstrate the feasibility of using RPS for gastric cancer.

In patients with EGC, RPLG demonstrated non-inferiority to CPLG in terms of short-term complications. Additionally, RPLG was associated with favorable postoperative outcomes, such as reduced pain intensity, without compromising short-term oncological results, including the number of harvested LNs. Overall, these findings support RPLG as a feasible approach for improving short-term outcomes in EGC.

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SUPPLEMENTARY MATERIALS

Supplementary Table 1
Evaluation of postoperative morbidity

Supplementary Table 2
Information of surgeons and institutions

Supplementary Table 3
Risk factors for overall complications in the per-protocol population

Supplementary Table 4
Risk factors for overall complications Clavien-Dindo classification 3 or higher in the per-protocol population

Supplementary Table 5
Risk factors for surgical complications in the per-protocol population

Supplementary Fig. 1
Comparison of BMI between groups. (A) ITT population. (B) PP population.

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