

## Original Article



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### Correspondence to

Taeil Son

Department of Surgery, Yonsei University  
College of Medicine, 50-1 Yonsei-ro  
Seodaemun-gu, Seoul 03722, Korea.  
E-mail: TISON@yuhs.ac

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### ORCID iDs

Jeong Ho Song

<https://orcid.org/0000-0002-2356-7152>

Taeil Son

<https://orcid.org/0000-0002-0327-5224>

Sejin Lee

<https://orcid.org/0000-0002-9634-8313>

Seohee Choi

<https://orcid.org/0000-0002-9384-8646>

Minah Cho

<https://orcid.org/0000-0003-3011-5813>

Yoo Min Kim

<https://orcid.org/0000-0002-5176-804X>

Hyoung-Il Kim

<https://orcid.org/0000-0002-6134-4523>

Woo Jin Hyung

<https://orcid.org/0000-0002-8593-9214>

<https://jgc-online.org>

# D2 Lymph Node Dissections during Reduced-port Robotic Distal Subtotal Gastrectomy and Conventional Laparoscopic Surgery Performed by a Single Surgeon in a High-volume Center: a Propensity Score-matched Analysis

Jeong Ho Song <sup>1,2</sup>, Taeil Son <sup>1,2</sup>, Sejin Lee <sup>1,2</sup>, Seohee Choi <sup>1,2</sup>,  
Minah Cho <sup>1,2</sup>, Yoo Min Kim <sup>1,2</sup>, Hyoung-Il Kim <sup>1,2</sup>, Woo Jin Hyung <sup>1,2</sup>

<sup>1</sup>Department of Surgery, Yonsei University College of Medicine, Seoul, Korea

<sup>2</sup>Gastric Cancer Center, Yonsei Cancer Center, Yonsei University Health System, Seoul, Korea

## ABSTRACT

**Purpose:** Various studies have indicated that reduced-port robotic gastrectomies are safe and feasible for treating patients with early gastric cancer. However, there have not been any comparative studies conducted that have evaluated patients with clinically advanced gastric cancer. Therefore, we aimed to compare the perioperative outcomes of D2 lymph node dissections during reduced-port robotic distal subtotal gastrectomies (RRDGs) and conventional 5-port laparoscopic distal subtotal gastrectomies (CLDGs).

**Materials and Methods:** We retrospectively evaluated 118 patients with clinically advanced gastric cancer who underwent minimally invasive distal subtotal gastrectomies with D2 lymph node dissections between February 2016 and November 2019. To evaluate the patient data, we performed a 1:1 propensity score matching (PSM) according to age, sex, body mass index, American Society of Anesthesiologists physical status classification score, and clinical T status. The short-term surgical outcomes were also compared between the two groups.

**Results:** The PSM identified 40 pairs of patients who underwent RRDG or CLDG. The RRDG group experienced a significantly longer operation time than the CLDG group ( $P < 0.001$ ), although the RRDG group had significantly less estimated blood loss ( $P = 0.034$ ). The number of retrieved extraperigastric lymph nodes in the RRDG group was significantly higher than that of the CLDG group ( $P = 0.008$ ). The rate of postoperative complications was not significantly different between the two groups ( $P = 0.115$ ).

**Conclusions:** D2 lymph node dissections can be safely performed during RRDGs and the perioperative outcomes appear to be comparable to those of conventional laparoscopic surgeries. Further studies are needed to compare long-term survival outcomes.

**Keywords:** Robotic surgical procedures; Gastrectomy; Stomach neoplasms; Lymphadenectomy

**Presentation**

This study was presented in August of 2020 at the Korea International Gastric Cancer Week (KINGCA) 2020 in Seoul, Korea.

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**Author Contributions**

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

**Conflict of Interest**

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

**INTRODUCTION**

Surgical resection with lymph node dissection is currently the primary treatment for non-metastatic gastric cancer [1,2], and laparoscopic surgery has become popular for treating early gastric cancer in recent decades [3,4]. Laparoscopic gastrectomies have several advantages over open surgeries, including less blood loss and pain, earlier bowel function recovery, shorter hospital stays, and better cosmetic results [5-7]. Advances in laparoscopic devices and techniques have led to reduced-port laparoscopic gastrectomies being considered feasible and safe [8-11]. Nevertheless, the technical challenges of this approach have created controversy regarding its actual advantages and limitations [12], and some surgeons are hesitant to perform reduced-port gastrectomies. Therefore, although laparoscopic surgery is currently being used for advanced gastric cancer [13], there are only a few reports from a small number of experienced surgeons regarding the use of reduced-port laparoscopic surgery for advanced gastric cancer [8,11,14].

Robotic surgery is believed to overcome the limitations of laparoscopic surgery based on improved ergonomics and the use of three-dimensional visualization and wristed instruments without tremors [15]. Furthermore, compared to laparoscopic surgeries, robotic gastrectomies for gastric cancer are associated with less blood loss, more retrieved lymph nodes, and similar survival and perioperative outcomes [15-17].

Only a few initial reports have indicated that reduced-port gastrectomies using the da Vinci robotic surgical system are feasible and safe [18-20]. Thus, it is important to determine whether reduced-port robotic distal subtotal gastrectomies (RRDGs) with D2 lymph node dissections can be used for patients with clinically advanced gastric cancer and if the outcomes are comparable to those of conventional 5-port laparoscopic distal subtotal gastrectomies (CLDGs). As we are not aware of any related studies, we aimed to compare the short-term surgical outcomes resulting from RRDGs and CLDGs among patients with advanced gastric cancer.

**MATERIALS AND METHODS****Patients**

We retrospectively reviewed data from a prospectively maintained database of patients with gastric cancer who underwent gastrectomies between February 2016 and November 2019. All the procedures were performed by a single surgeon at a single tertiary center. Prior to this study, the surgeon had experience performing 100 laparoscopic gastrectomies, 28 open gastrectomies, 14 conventional port robotic gastrectomies, but no reduced-port laparoscopic or robotic gastrectomies. The minimally invasive surgeries, including the robotic or laparoscopic procedures, were usually performed for patients with serosa-negative gastric cancer, with or without limited involvement of the perigastric lymph nodes. In the case of patients with tumors exposed to the gastric serosa, the choice minimally invasive surgery to perform was made according to the patient's request. Prior to the surgeries, each of these patients were provided a detailed explanation of both the robotic and laparoscopic surgical techniques, after which they were allowed to choose the type of surgery they preferred through written informed consent. Patients who underwent open surgeries, total gastrectomies, proximal gastrectomies, and less than D2 lymph node dissections were excluded from the study. We ultimately identified 118 patients who underwent minimally

invasive distal subtotal gastrectomies with D2 lymph node dissections, including 40 patients who underwent RRDGs and 78 patients who underwent CLDGs. The study's retrospective protocol was approved by the institutional review board of Severance Hospital, Yonsei University Health System (4-2020-0766).

### Operative procedures

All robotic surgeries were performed using the da Vinci Si or Xi Surgical Systems (Intuitive Surgical, Sunnyvale, CA, USA). For the RRDG procedures, an overturned Single-Site® port (Intuitive Surgical) was inserted below the umbilicus to accommodate curved Cadiere forceps, a camera, and an assistant port. Two additional ports were placed on each side of the abdomen. Ultrasonic shears were inserted into the right side, and Maryland bipolar forceps were inserted into the left side. In preparation for docking, the first robotic arm was equipped with the ultrasonic shears, the second arm was equipped with the Cadiere forceps, the third arm was equipped with the camera, and the fourth arm was equipped with the Maryland forceps (Fig. 1). The surgeon controlled the first robotic arm with his left hand and the second and fourth robotic arms with his right hand. Details regarding the RRDG operating procedures have been reported previously [19].

The CLDG procedures were performed using five ports: a 12 mm camera port immediately below the umbilicus, two 12 mm ports on either side of the middle abdomen, and two additional 5 mm ports on either side of the upper abdomen.

The overall gastrectomy procedures, including the dissections and reconstructions, were similar between the two groups. The reconstructions were performed intracorporeally via gastroduodenostomies, gastrojejunostomies, or Roux-en-Y gastrojejunostomies. Tumor staging was defined according to the 8<sup>th</sup> edition of the American Joint Committee on Cancer staging system [21].

### Postoperative management

Both groups underwent the same postoperative management protocol. Prophylactic antibiotics were administered within 30 min before surgery and postoperative antibiotics were generally not used, except for patients with worsening symptoms and/or signs

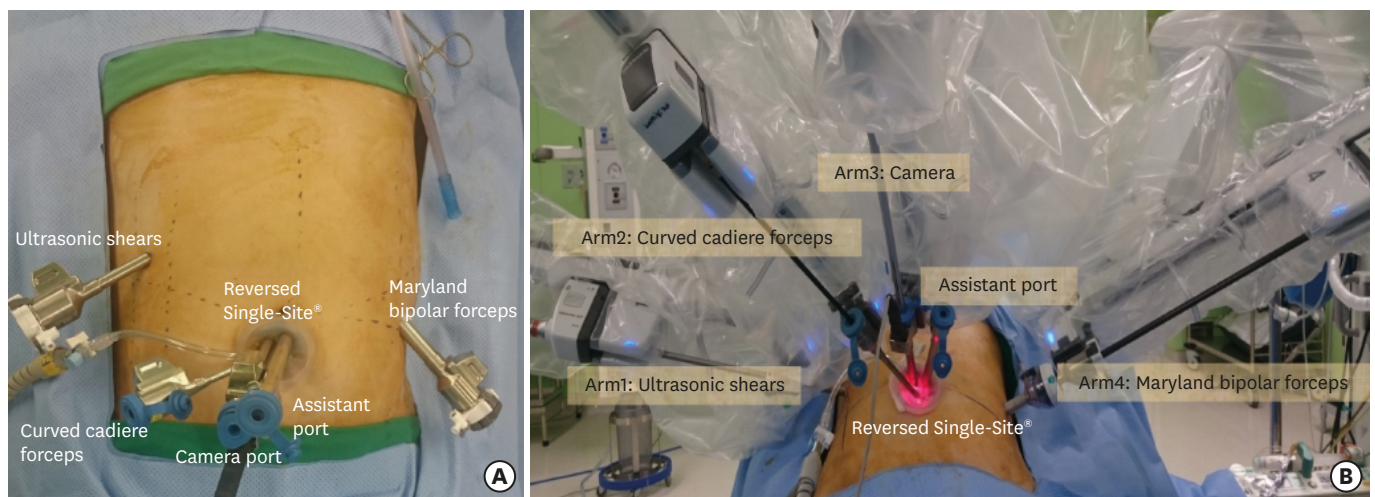


Fig. 1. Port placement. (A) The patient and port placement before docking. (B) The patient and port placement after docking.

of inflammation, including fever and leukocytosis, that developed  $\geq 3$  days after surgery. Nasogastric tubes were not routinely inserted, except for patients with obstructive lesions. Intravenous patient-controlled anesthesia was provided for postoperative pain control. Urinary catheters were routinely removed on postoperative day (POD) 1. The patients were allowed to start drinking water on POD 2, resume a liquid diet on POD 3, and begin eating soft foods on POD 4. Discharge was recommended on POD 5 if the patient's condition was tolerable.

### Measurements

The clinical characteristics of the two groups, including age, sex, body mass index (BMI), American Society of Anesthesiologists (ASA) physical status classification score, clinical T status, and clinical N status, were compared. Factors associated with operative outcomes and short-term postoperative recoveries were also compared. Lymph nodes were separated from the resected specimens according to the Japanese classification system definitions of the lymph node stations [3]. We also classified the lymph nodes as perigastric (lymph node stations 1–6) and extraperigastric (lymph node stations 7–14) and compared the numbers of lymph nodes for each station between the groups. Postoperative complications were defined as any deviation from the normal postoperative course until POD 90, and their severity was graded based on the Clavien-Dindo classification system [22]. Any additional treatments, other than the medications planned for use during the postoperative course, were defined as complications. We defined a postoperative fever, which was considered a complication, as a body temperature of 38°C or higher. Patients who were prescribed antipyretics or antibiotics were considered to have complications, regardless of whether they had a fever. Postoperative anemia was defined as a low hemoglobin level requiring transfusion or iron-supplying medication after surgery. Inflammatory markers, such as WBC counts and CRP levels, were obtained preoperatively, immediately after surgery (POD 0), and on PODs 1, 2, 3, and 5. The primary outcome of the study was postoperative complications. The secondary outcomes included estimated blood loss, operative time, length of hospital stay, and mean number of retrieved lymph nodes.

### Statistical analyses

The statistical analyses were performed using IBM SPSS software for Windows (version 25.0; IBM Corp., Armonk, NY, USA) and R software (version 3.3.3; R Foundation for Statistical Computing, Vienna, Austria). To reduce the influence of selection bias, we performed propensity score matching (PSM) using the MatchIt package in the R software and a 1:1 nearest-neighbor strategy. The covariates for the PSM were age, sex, BMI, ASA score, and clinical T status. The PSM identified 40 pairs of patients who underwent RRDGs or CLDGs, and their short-term surgical outcomes were compared using the chi-squared test and Fisher's exact test (for the categorical variables) or the Mann-Whitney test (for the continuous variables). Differences were considered statistically significant at P-values  $< 0.05$ .

## RESULTS

### Patient characteristics

The institutional database included 866 patients who underwent gastrectomies performed by a single surgeon. A total of 118 patients were determined to be eligible for the study after 748 patients were excluded because of open surgeries (n=169), total gastrectomies (n=92), proximal gastrectomies (n=43), or less than D2 lymph node dissections (n=444). The PSM ultimately identified 40 pairs of patients who underwent RRDGs or CLDGs (**Fig. 2**). Before

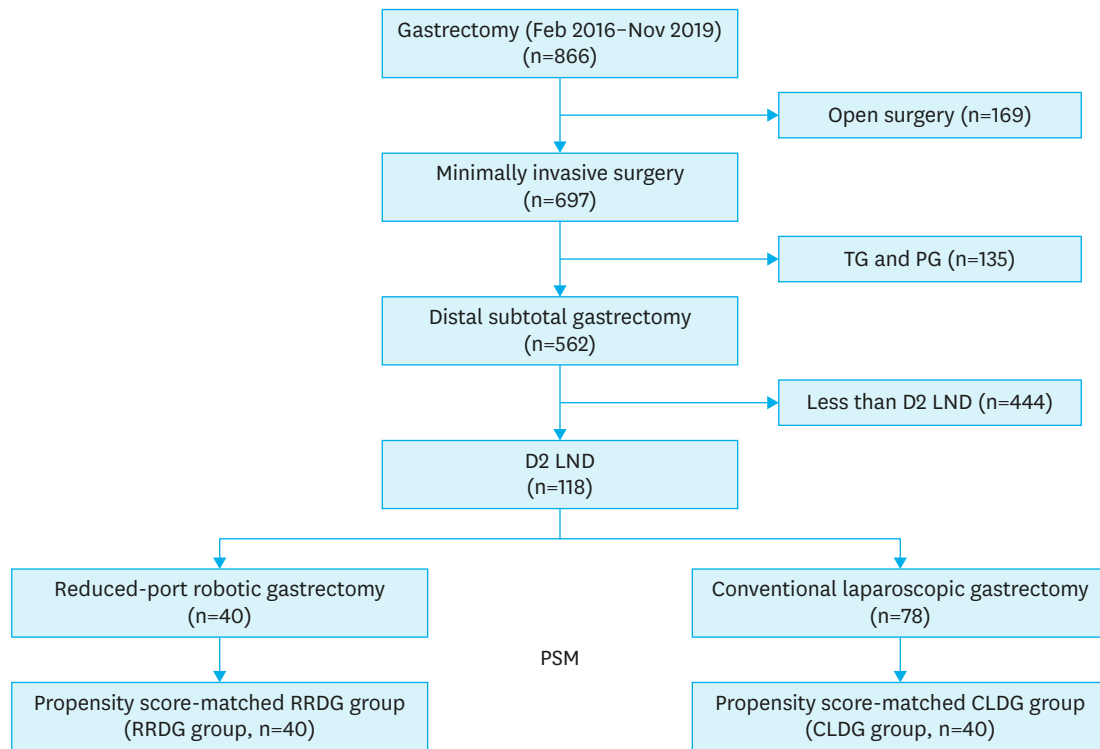


Fig. 2. Study flowchart.

TG = total gastrectomy; PG = proximal gastrectomy; LND = lymph node dissection; RRDG = reduced-port robotic distal subtotal gastrectomy; CLDG = conventional laparoscopic distal subtotal gastrectomy; PSM = propensity score matching.

the PSM, we determined that the CLDG group was significantly older ( $P=0.008$ ) and had a marginally higher BMI ( $P=0.096$ ) than the RRDG group. All the variables were well balanced between the RRDG and CLDG groups after the PSM (Table 1), however.

Table 1. Patient characteristics before and after the PSM

Variables	Pre-PSM			Post-PSM		
	RRDG (n=40)	CLDG (n=78)	P-value	RRDG (n=40)	CLDG (n=40)	P-value
Age (yr)	56.4±12.8	62.5±12.4	0.008	56.4±12.8	58.1±11.6	0.257
Sex			0.391			0.818
Male	24 (60)	53 (67.9)		24 (60)	25 (62.5)	
Female	16 (40)	25 (32.1)		16 (40)	15 (37.5)	
BMI (kg/m <sup>2</sup> )	22.7±2.8	23.4±3.0	0.096	22.7±2.8	22.8±2.8	0.392
ASA score			0.396			0.765
1	9 (22.5)	13 (16.7)		9 (22.5)	11 (27.5)	
2	22 (55)	36 (46.2)		22 (55)	18 (45)	
3	9 (22.5)	28 (35.9)		9 (22.5)	10 (25)	
4	0	1 (1.3)		0	1 (2.5)	
cT classification			0.452			1.000
T1	2 (5)	2 (2.6)		2 (5)	2 (5)	
T2	28 (70)	45 (57.7)		28 (70)	28 (70)	
T3	7 (17.5)	22 (28.2)		7 (17.5)	8 (17.5)	
T4	3 (7.5)	9 (11.5)		3 (7.5)	2 (5)	
cN classification			0.525			1.000
N0	26 (65)	46 (59.0)		26 (65)	26 (65)	
N1	14 (35)	32 (41.0)		14 (35)	14 (35)	

Data are shown as the mean±standard deviation or number (proportion).

PSM = propensity score matching; RRDG = reduced-port robotic distal subtotal gastrectomy; CLDG = conventional laparoscopic distal subtotal gastrectomy; BMI = body mass index; ASA = American Society of Anesthesiologists physical status classification.



**Table 2.** Perioperative outcomes before and after the PSM

Variables	Pre-PSM			Post-PSM		
	RRDG (n=40)	CLDG (n=78)	P-value	RRDG (n=40)	CLDG (n=40)	P-value
Anastomosis			0.501			0.784
B-I	24 (60)	38 (48.7)		24 (60)	22 (55.0)	
B-II	12 (30)	29 (37.2)		12 (30)	12 (30)	
Roux-en-Y	4 (10)	11 (14.1)		4 (10)	6 (15)	
Conversion	0	0		0	0	
Combined operation	1 (2.5)	5 (6.4)	0.662	1 (2.5)	3 (7.5)	0.615
Operation time, min	219.6±44.0	194.5±71.8	<0.001	219.6±44.0	181.3±63.9	<0.001
Estimated blood loss (mL)	70.2±103.1	100.5±98.1	0.001	70.2±103.1	99.0±117.7	0.034
Retrieved LNs	58.3±21.8	48.6±19.4	0.010	58.3±21.8	53.5±22.5	0.148
Complications			0.296			0.115
No	14 (35)	33 (42.3)		14 (35)	22 (55)	
I-II	25 (62.5)	45 (57.7)		25 (62.5)	18 (45)	
≥III	1 (2.5)	0		1 (2.5)	0	
Mortality	0	0		0	0	
First flatus (day)	3.1±0.7	3.3±0.9	0.140	3.1±0.7	3.4±1.1	0.164
Soft diet (day)	5.3±4.4	4.9±2.0	0.354	5.3±4.4	5.1±2.5	0.354
Hospital stay (day)	7.2±4.9	7.8±5.1	0.129	7.2±4.9	7.2±3.4	0.307

Data are shown as the mean±standard deviation or number (proportion).

PSM = propensity score matching; RRDG = reduced-port robotic distal subtotal gastrectomy; CLDG = conventional laparoscopic distal subtotal gastrectomy; LNs = lymph nodes.

### Perioperative outcomes

None of the patients required a change from the originally planned procedure to a multi-port robotic, laparoscopic, or open surgery. **Table 2** shows a comparison of the perioperative outcomes between the two groups. No significant differences were observed in terms of the type of anastomosis (P=0.784), combined resection of other organ (P=0.615), and number of retrieved lymph nodes (P=0.148). The RRDG group experienced a significantly longer mean operation time than the CLDG group (P<0.001), although the RRDG group also had significantly less estimated blood loss (P=0.034). No significant differences were observed between the two groups in terms of the time to first flatus (P=0.164), time to soft diet initiation (P=0.354), and length of hospital stay (P=0.307).

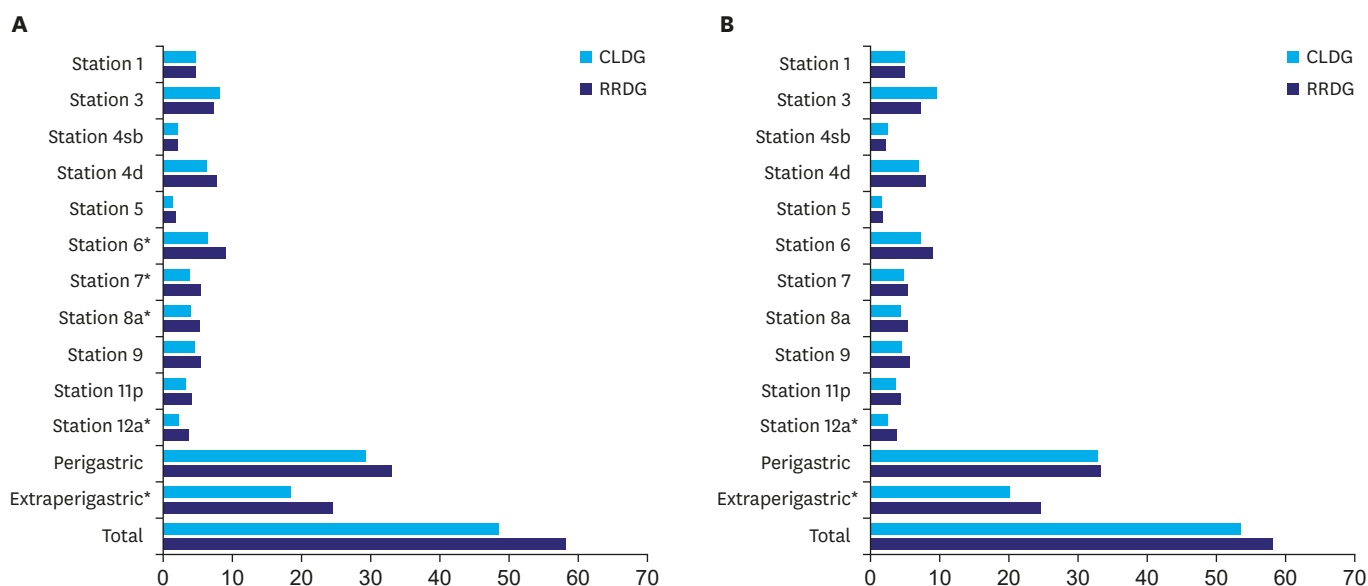
### Lymph node retrieval

The mean numbers of retrieved lymph nodes according to the lymph node station are shown in **Fig. 3**. Before the PSM, the RRDG group showed significantly more retrieved lymph nodes for stations 6 (P=0.002), 7 (P=0.025), 8a (P=0.021), and 12a (P<0.001). After the PSM, the RRDG group still showed significantly more retrieved lymph nodes for station 12a (P=0.001), as well as marginally higher numbers for stations 6 (P=0.073) and 8 (P=0.08). The RRDG group also showed a significantly higher number of extraperigastric lymph nodes (P=0.008), although there was no significant difference in the mean number of perigastric lymph nodes (P=0.459).

### Postoperative complications

A total of 26 of the 40 patients (65%) in the RRDG group, and 18 of the 40 patients (45%) in the CLDG group, experienced postoperative complications (**Table 3**). Both groups had patients who received antibiotics and recovered soon after a postoperative fever of unknown origin (RRDG: 17 patients, CLDG: 7 patients). The Clavien-Dindo grade I–II complications in the RRDG group included ileus (n=1), intra-abdominal fluid collection (n=3), pneumonia (n=1), upper respiratory tract infection (n=1), wound complications (n=1), and cardiac complications (n=1). The Clavien-Dindo grade I–II complications in the CLDG group included anemia (n=2), stasis (n=2), ileus (n=1), intra-abdominal fluid collection

Reduced-port Robotic D2 Gastrectomy



**Fig. 3.** The mean numbers of retrieved lymph nodes at each lymph node station (A) before and (B) after the PSM. PSM = propensity score matching; RRDG = reduced-port robotic distal subtotal gastrectomy; CLDG = conventional laparoscopic distal subtotal gastrectomy. \*P<0.05.

**Table 3.** Postoperative complications before and after the PSM

Variables	Pre-PSM		Post-PSM	
	RRDG (n=40)	CLDG (n=78)	RRDG (n=40)	CLDG (n=40)
Clavien-Dindo grade ≥III				
Intestinal obstruction	1	0	1	0
Clavien-Dindo grade I-II				
Fever	17	16	17	7
Anemia	0	3	0	2
Stasis	0	3	0	2
Ileus	1	4	1	1
Intra-abdominal fluid collection	3	4	3	1
Intra-luminal bleeding	0	1	0	1
Atelectasis	0	3	0	1
Pneumonia	1	2	1	0
Upper respiratory tract infection	1	0	1	0
Urinary tract infection	0	4	0	1
Voiding difficulty	0	4	0	1
Wound complication	1	0	1	0
Cardiac complication	1	1	1	1

PSM = propensity score matching; RRDG = reduced-port robotic distal subtotal gastrectomy; CLDG = conventional laparoscopic distal subtotal gastrectomy.

(n=1), intraluminal bleeding (n=1), atelectasis (n=1), urinary tract infection (n=1), voiding difficulty (n=1), and cardiac complications (n=1). One patient in the RRDG group required a reoperation because of an intestinal obstruction. Inflammatory markers, such as WBC counts and serum CRP levels, are provided in **Table 4**. After the PSM, the RRDG group showed significantly higher WBC counts than the CLDG group on PODs 2 and 3 (P=0.016 and P=0.032, respectively); however, the counts were similar on POD 5 (P=0.303). The CRP levels were statistically higher in the RRDG group than in the CLDG group on PODs 1 and 2 (P=0.010 and P=0.045, respectively), but there were no statistically significant differences between the groups after POD 3.

**Table 4.** WBC counts and CRP levels before and after the PSM

Variables	Pre-PSM			Post-PSM		
	RRDG (n=40)	CLDG (n=78)	P-value	RRDG (n=40)	CLDG (n=40)	P-value
<b>WBC count (<math>\times 10^3/\text{mm}^3</math>)</b>						
Preop	6.76 $\pm$ 2.08	6.71 $\pm$ 2.08	0.417	6.76 $\pm$ 2.08	6.69 $\pm$ 2.30	0.491
POD #0	13.76 $\pm$ 3.73	13.07 $\pm$ 3.81	0.172	13.76 $\pm$ 3.73	13.19 $\pm$ 4.47	0.185
POD #1	10.08 $\pm$ 3.18	9.37 $\pm$ 2.70	0.184	10.08 $\pm$ 3.18	9.25 $\pm$ 2.90	0.182
POD #2	9.54 $\pm$ 3.26	8.44 $\pm$ 2.82	0.036	9.54 $\pm$ 3.26	8.06 $\pm$ 2.78	0.016
POD #3	7.56 $\pm$ 2.39	6.84 $\pm$ 2.41	0.043	7.56 $\pm$ 2.39	6.59 $\pm$ 2.45	0.032
POD #5	6.15 $\pm$ 1.59	6.20 $\pm$ 1.94	0.419	6.15 $\pm$ 1.59	6.02 $\pm$ 1.80	0.303
<b>CRP (mg/dL)</b>						
Preop	1.37 $\pm$ 1.70	1.35 $\pm$ 2.15	0.470	1.37 $\pm$ 1.70	0.94 $\pm$ 0.87	0.351
POD #0	2.16 $\pm$ 3.14	2.09 $\pm$ 4.71	0.264	2.16 $\pm$ 3.14	2.07 $\pm$ 5.87	0.219
POD #1	38.68 $\pm$ 20.03	32.70 $\pm$ 18.56	0.036	38.68 $\pm$ 20.03	30.20 $\pm$ 20.04	0.010
POD #2	92.07 $\pm$ 51.5	81.38 $\pm$ 46.13	0.132	92.07 $\pm$ 51.50	74.96 $\pm$ 48.82	0.045
POD #3	95.61 $\pm$ 56.79	92.41 $\pm$ 61.00	0.289	95.61 $\pm$ 56.79	83.94 $\pm$ 65.34	0.069
POD #5	63.03 $\pm$ 56.52	63.34 $\pm$ 44.66	0.359	63.03 $\pm$ 56.52	52.26 $\pm$ 39.11	0.182

Data are shown as the mean $\pm$ standard deviation.

PSM = propensity score matching; RRDG = reduced-port robotic distal subtotal gastrectomy; CLDG = conventional laparoscopic distal subtotal gastrectomy; WBC = white blood cell; POD = postoperative day; CRP = C-reactive protein.

## DISCUSSION

To the best of our knowledge, this is the first study to compare the short-term outcomes of D2 lymph node dissections among patients who underwent RRDG or CLDG. We did not identify any cases involving conversion or mortality, and the perioperative outcomes were comparable between the two groups.

Although robotic gastrectomies are becoming increasingly popular, few studies have described reduced-port robotic gastrectomies, and those that have were mainly intended to evaluate its safety and feasibility. Unlike the initial studies of patients with early gastric cancer [18,20], the current study involved patients with advanced gastric cancer that required a greater extent of lymph node dissection [3]. The D2 lymph node dissection for advanced gastric cancer procedure includes stations 11p and 12a, both of which are located behind major vessels and the pancreas. However, it is difficult to visualize the surgical field behind the pancreas and gain proper counter traction, which makes laparoscopic surgery difficult and often leads to fewer lymph nodes being retrieved. During robotic surgery, the articulated arms and steady camera enable the surgeon to operate in a stable environment [20,23]. These advantages also apply to reduced-port robotic surgery, which enabled greater extraperigastric lymph node retrieval in our study. The perigastric lymph nodes are resected along with the stomach, while the extraperigastric lymph nodes require additional dissections. Thus, the number of extraperigastric lymph nodes may differ between surgeons, institutions, and surgical methods. A previous study reported a greater number of extraperigastric lymph nodes resected in robotic surgery than in laparoscopic surgery; these results are in line with the results of the current study [24]. Previous reports have also indicated that robotic surgery is associated with less bleeding than laparoscopic surgery [16,25], and our findings involving D2 lymph node dissections with RRDG are in agreement with these results.

None of the patients in either of the groups experienced anastomotic problems or mortality, but a grade  $\geq 3$  complication (small bowel obstruction that required reoperation) was observed in 1 patient in the RRDG group. Although the RRDG group had more postoperative complications than the CLDG group, this difference was not statistically significant, and most of these complications involved a fever of unknown origin that was successfully



managed using antibiotics. Thus, the average postoperative recovery period for the RRDG group (7.2 days) was similar to that of the CLDG group. The longer operation times for the RRDG group were probably associated with more instances of fever, which is thought to have significantly increased the WBC counts and CRP levels in the RRDG group. However, these inflammatory markers were similar between the groups at the time of discharge, as were the average postoperative recovery periods.

A few studies have described D2 lymph node dissections during reduced-port laparoscopic distal subtotal gastrectomies [8,26]. According to these reports, the technique is feasible and safe, with similar perioperative outcomes, improved cosmesis, and comparable survival outcomes, relative to conventional laparoscopic surgery. However, during reduced-port laparoscopic procedures, collisions between the energy device, laparoscope, and other instruments can occur, because at least three people (the surgeon, assistant, and laparoscopist) must stand in the surgical field. Thus, substantial technical skill and experience is needed to avoid these collisions. Moreover, the presence of multiple devices and potential collisions can interfere with the surgical field of view and operator movements, which may lead to insufficient lymph node dissections and limit the choice of anastomosis technique. Robotic systems may help overcome these limitations, although there is still a perception that reduced-port robotic gastrectomies are technically challenging. Our findings indicate that RRDG provides comparable perioperative outcomes (relative to CLDG) for patients with advanced gastric cancer. We used an overturned Single-Site® port, plus two additional ports, which allowed for the insertion of a sufficient number of instruments, while still minimizing the likelihood of collisions. Thus, like conventional robotic surgery, the RRDG approach allowed for complete lymph node dissections, as well as all types of anastomosis, including gastroduodenostomies. Our procedure is also completely robotic and only requires one bedside assistant. Another advantage of this procedure is its short learning curve. We recently reported the learning curve for reduced-port robotic gastrectomies is approximately 21 cases, based on the operation times for an initial 100 consecutive cases, which included early and advanced gastric cancer [27]. The barrier to entry for the RRDG procedure is not very high, given that the learning curve for conventional laparoscopic gastrectomies requires 50 cases and that of reduced-port laparoscopic gastrectomies requires 30 to 50 cases, even for experienced laparoscopic surgeons.

The present study has several limitations that should be considered. First, this was a retrospective study, and it involved a small sample of patients who were treated by a single surgeon at a single center, although we used PSM to minimize the selection bias. Second, the surgeon's experience levels were different for the RRDG and CLDG procedures, as the surgeon had been performing laparoscopic gastrectomies for 4 years, while the RRDG cases with D2 lymph node dissections represented the surgeon's first 40 cases. Nonetheless, the perioperative outcomes of the RRDGs were not inferior to those of the CLDGs. Third, the control (CLDG) group did not include reduced-port laparoscopic distal subtotal gastrectomies or conventional robotic distal subtotal gastrectomies. Reduced-port robotic gastrectomies would be an excellent alternative, as reduced-port laparoscopic gastrectomies require advanced surgical skills and experience. However, since it is difficult to perform reduced-port laparoscopic gastrectomies, we only performed CLDGs for these patients and, therefore, cannot compare our results directly. Fourth, even with less blood loss and better retrieval of the extraperigastric lymph nodes, we failed to demonstrate superior patient-oriented outcomes. Additional studies, including those focusing on long-term survival, are needed. We did attempt, however, to identify if the indications for reduced-port surgery

could be extended to advanced gastric cancer, and it was meaningful that the results for the RRDG group were not inferior to those for the CLDG group. If the practicality of reduced-port laparoscopic surgery is in question for a given patient, this study could suggest another option for surgeons who hesitate to perform reduced-port surgeries due to technical difficulties. Finally, the possibility that near-infrared fluorescence-guided surgery affected the number of retrieved lymph nodes cannot be ruled out, and further studies with a larger number of patients are needed. Due to these limitations, there may be concerns regarding the generalization of the results of this study.

In conclusion, D2 lymph node dissections are safe and feasible when using a reduced-port robotic system for patients with clinically advanced cancer located at the distal to middle part of the stomach. Further studies are needed to clarify whether reduced-port RRDG provide advantages for long-term survival outcomes, however.

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