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Laparoscopic gastrectomy versus open gastrectomy for gastric cancer in patients with body mass index of 30 kg/m^2 or more

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Abstract

Background High body mass index (BMI) and high visceral fat area (VFA) are known to be a preoperative risk factor for laparoscopic gastrectomy (LG) for gastric cancer. However, the impact of obesity on LG still remains controversial. In the present study, we compared the operative outcomes of LG with those of OG in patients with BMI of 30 kg/m^2 or more.

Methods Seventy-seven patients who underwent distal or total gastrectomy for gastric cancer were enrolled. The patients were divided into two groups by approach method; an OG group ($n = 19$) and a LG group ($n = 62$). Aquarius iNtuition® program was used to measure VFA. The operation time, estimated blood loss, complication rate, the number of retrieved lymph nodes, and patient survival were compared between two groups.

Results The mean BMI and VFA were 31.6 kg/m^2 and 195.3 cm^2. The complication rate was 42.1 % in OG group and 14.5 % in LG group, respectively ($P = 0.010$). LG group showed less estimated blood loss ($P = 0.030$) and fast recovery of bowel movement ($P < 0.001$). However, there were no significant differences in operation time, the number of retrieved lymph nodes, and the length of hospital stay between two groups. In subgroup analysis, there was significant correlation between estimated blood loss and VFA ($R^2 = 0.113$, $P = 0.014$), but there was no correlation between operation time and VFA ($R^2 = 0.002$, $P = 0.734$). In stage I, the 5-year survival was not different between two groups ($P = 0.220$).

Conclusion LG showed better operative outcomes compared with OG, in terms of less estimated blood loss, fast recovery of bowel movement, and low complication rate, in patients with BMI of ≥ 30 kg/m^2 or more.

Keywords Gastric cancer · Laparoscopic gastrectomy · Obesity · Body mass index · Visceral fat area

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Gastric cancer is the fourth most common cancer and a major cause of cancer-related deaths worldwide [1]. Despite advances in multimodal approaches over the past decades, open gastrectomy (OG) plus radical lymphadenectomy remains the mainstay of treatment for resectable gastric cancer [2, 3]. Recently, laparoscopic gastrectomy (LG) has become an alternative option for the treatment of gastric cancer in Eastern Asia. Among the clinical advantages of LG are reduced postoperative pain, faster recovery after surgery, and fewer complications [4–7]. However, this emerging technique is not universal in Western countries because of the relatively low incidence of gastric cancer, the high proportion of patients diagnosed with advanced-stage disease, tumor location in the upper third of the stomach, and the higher rate of obesity, making laparoscopic lymphadenectomy more difficult [8, 9].

Obesity has become a serious health problem worldwide [10]. Defined by the World Health Organization (WHO) as a body mass index (BMI) $\geq$30 kg/m^2, the prevalence of obesity in the United States was reported to be 31.1 % [11]. Although the prevalence of obesity in Eastern Asia is lower than in Western countries, it is also increasing in Asian countries [12, 13]. Obesity is a risk factor for postoperative complications in patients undergoing gastric cancer surgery, with a higher BMI hampering regional lymph node (LN) dissection and representing an independent predictor of cancer recurrence [14–17].

Obesity has been considered as a contraindication for laparoscopic surgery because of technical difficulties and high conversion rates [18, 19]. As experience with laparoscopic methods increases, LG has shown greater promise in obese patients with gastric cancer. However, most of these studies were limited to patients with a BMI <30 kg/m^2. Moreover, to our knowledge, no study has compared LG with OG in patients with a high BMI ($\geq$30 kg/m^2); thus the impact of obesity on LG and the oncological safety of LG in obese patients remain unclear, hampering the extension of the laparoscopic approach in the treatment of gastric cancer. The present study was designed to compare operative outcomes of LG and OG in gastric cancer patients with a BMI $\geq$30 kg/m^2 to verify the feasibility and safety of LG in patients with a high BMI.

Materials and methods

This case–control retrospective study was based on a prospectively collected gastric cancer database. Some clinical information was also obtained retrospectively from electric medical records of the hospital. The study protocol was approved by the Institutional Review Board of our institution (protocol registration number B1310-222-106).

Patients

Between May 2003 and December 2012, a total of 4,043 patients with gastric cancer underwent OG or LG at Seoul National University Bundang Hospital. The database was searched for patients with a BMI $\geq$30 kg/m^2. Of the 141 patients identified, 60 were excluded because they were preoperatively diagnosed with advanced-stage gastric cancer. The remaining 81 patients were divided into two groups, an OG group ($n = 19$) and an LG group ($n = 62$). The clinical characteristics of patients in the two groups were compared, including body shape index, operative outcomes, and survival.

Operative methods

All patients underwent subtotal or total gastrectomy with D1 + β or greater LN dissection by open or laparoscopic approaches. Bowel reconstruction after subtotal gastrectomy consisted of gastroduodenostomy, loop gastrojejunostomy, or Roux-en-Y gastrojejunostomy, whereas Roux-en-Y esophagojejunostomy was performed after total gastrectomy.

LG was performed with the patient in the supine position and using a five-port system (two 5 mm ports and three 12 mm ports). A 10 mm flexible laparoscope was used and the CO_2 pressure was maintained at 12–15 mmHg. An ultrasonically activated coagulating scalpel (Harmonic Scalpel, Ethicon EndoSurgery Inc., Cincinnati, OH, USA) and a LigaSure (Valleylab, Boulder, CO, USA) were used for radical lymphadenectomy. After completing lymphadenectomy, a mini-laparotomy was made on the epigastric area and used to retrieve the specimen and for anastomosis. Intracorporeal anastomoses were performed in five patients, three delta-shaped anastomoses and two loop gastrojejunostomies using linear staplers. After laparoscopic total gastrectomy, intracorporeal end-to-side esophagostomy was performed using a laparoscopic purse-string clamp (Lap-Jack, Eterne, Kyeonggi-do, South Korea) and a circular stapler. The procedure has been described in detail elsewhere. [20].

All cancers were staged according to the tumor node metastasis (TNM) classification system (7th edition) of the American Joint Committee on Cancer (AJCC).

Postoperative management after gastrectomy

Following surgery, the patients were managed by standardized protocols (clinical pathway) according to the procedures (distal or total gastrectomy), regardless of the approach method (open or laparoscopy). For patients who underwent distal gastrectomy, sips of water were allowed on the second postoperative day irrespective of flatus passage. A semi-fluid diet was administered on the third postoperative day and a semi-blend diet on the fourth postoperative day. The patients were discharged from the hospital on the fifth to sixth postoperative day. For patients who underwent total gastrectomy, sips of water were allowed on the third, a semi-fluid diet on the fourth, and a semi-blend diet on the fifth postoperative day. The laboratory examinations were routinely performed on the second, fifth, and seventh postoperative days. If the patients had any complication or other medical problems, the clinical pathway was terminated and they were excluded from the standardized protocol.

Measurement of visceral fat area

Visceral fat area (VFA) and subcutaneous fat area (SFA) were quantified on preoperatively scanned computed tomography (CT) images at the level of the umbilicus. The Aquarius iNtuition® program (TeraRecon, Inc., Foster City, CA) was used to measure the VFA and SFA. Adipose tissue was determined by the attenuation level within the range of −150 to −50 hounsfield units. The regions of visceral fat and of subcutaneous fat were defined by manually contoured areas along the body shape. After defining these regions, the VFA and SFA were calculated automatically by the software.

Statistical analysis

All statistical analyses were performed using SPSS version 18.0 (SPSS Inc., Chicago, IL, USA). The χ^2 test, Fisher's exact test, Student's t test, and Mann–Whitney U test were used for between-group comparisons, as appropriate. Linear regression with a coefficient of determination was used for correlations between the VFA and operative outcomes. The cumulative overall survival rates in patients with stage IA gastric cancer were estimated using Kaplan–Meier curves and compared using the log-rank test. A P value <0.05 was considered statistically significant.

Results

Patient characteristics

Of the 81 patients, 19 underwent OG and 62 underwent LG. The clinicopathological characteristics of the patients are summarized in Table 1. The mean ages of patients in these two groups were 58.3 and 60.5 years, respectively ($P = 0.524$), and their mean BMIs were 31.18 ± 0.97 and 31.80 ± 1.60 kg/m^2, respectively ($P = 0.110$). There were no significant between-group differences in the rates of comorbidity, previous abdominal surgery, tumor location, and Lauren classification.

Of the 19 patients in the OG group, 15 (78.9 %) underwent subtotal gastrectomy and 4 (21.1 %) underwent total gastrectomy. In the LG group, 53 patients (85.5 %) underwent distal gastrectomy and nine (14.5 %) underwent total gastrectomy. The extent of LN dissection and reconstruction did not defer significantly in the two groups. Moreover, pathologic examination revealed no significant between-group differences in tumor depth and cancer stage.

Surgical outcomes: laparoscopic gastrectomy versus open gastrectomy

Short-term postoperative outcomes are shown in Table 2. Mean operation time was similar in the OG and LG groups (182.1 vs. 196.3 min; $P = 0.340$), but estimated blood loss was significantly higher in the OG group (163.5 mL vs. 105.4 mL; $P = 0.030$). The mean number of retrieved LNs was similar in these two groups (42.79 ± 14.93 vs.

Table 1 Clinicopathological characteristics

Variables	OG ($n = 19$)	LG ($n = 62$)	P value
Age (years)	58.3 ± 14.3	60.5 ± 12.1	0.524
Sex (M:F)	13:6	35:27	0.430
BMI (kg/m^2)	31.18 ± 0.97	31.80 ± 1.60	0.110
Comorbidity	8 (42.1 %)	32 (51.6 %)	0.601
Hypertension	6 (31.5 %)	22 (35.4 %)	
Diabetes mellitus	2 (10.5 %)	7 (11.2 %)	
Cardiovascular disease		7 (11.2 %)	
Liver disease		3 (4.8 %)	
Other	2 (10.5 %)	3 (4.8 %)	
Previous abdominal surgery			1.000
Present	2 (10.5 %)	9 (14.5 %)	
Tumor location			0.243
Upper	4 (21.1 %)	8 (12.9 %)	
Middle	3 (15.8 %)	12 (19.4 %)	
Lower	12 (63.1 %)	42 (67.7 %)	
Lauren classification			0.662
Intestinal	10 (52.6 %)	38 (61.3 %)	
Diffuse	8 (42.1 %)	20 (32.2 %)	
Mixed	1 (5.3 %)	4 (6.5 %)	
Type of surgery			0.491
Distal gastrectomy	15 (78.9 %)	53 (85.5 %)	
Total gastrectomy	4 (21.1 %)	9 (14.5 %)	
LN dissection			0.866
D1 + ß	10 (52.6 %)	34 (54.8 %)	
D2	9 (47.4 %)	28 (45.2 %)	
Reconstruction			0.769
Billroth I	11 (57.9 %)	30 (48.4 %)	
Billroth II	3 (15.8 %)	12 (19.4 %)	
Roux-en-Y	5 (26.3 %)	20 (32.2 %)	
Open conversion		4 (6.4 %)	
Depth of tumor			0.051
Mucosa	9 (47.2 %)	36 (58.1 %)	
Submucosa	1 (5.3 %)	15 (24.2 %)	
Proper muscle	3 (15.8 %)	6 (9.7 %)	
Subserosa	4 (21.1 %)	3 (4.8 %)	
Serosa exposure	2 (10.5 %)	2 (3.2 %)	
N classification			0.195
N0	12 (63.2 %)	53 (85.5 %)	
N1	3 (15.8 %)	4 (6. 5 %)	
N2	2 (10.5 %)	3 (4.8 %)	
N3	2 (10.5 %)	2(3.2 %)	
Pathologic Stage			0.110
IA	10 (52.6 %)	49 (79.1 %)	
IB	2 (10.5 %)	5 (8.1 %)	
IIA	2 (10.5 %)	2 (3.2 %)	
IIB	3 (15.8 %)	2 (3.2 %)	
IIIA		2(3.2 %)	

Table 1 continued

Variables	OG ($n = 19$)	LG ($n = 62$)	P value
IIIB	2 (10.5 %)	2 (3.2 %)	

Data were presented as number (%) or mean ± standard deviation

OG open gastrectomy, *LG* laparoscopic gastrectomy, *BMI* body mass index, *LN* lymph node

Table 2 Short-term postoperative outcomes

Variables	OG ($n = 19$)	LG ($n = 62$)	P value
Operation time (min)	182.1 ± 65.5	196.3 ± 53.7	0.340
Estimated blood loss (mL)	163.5 ± 86.4	105.4 ± 98.7	0.030
Tumor size (cm)	5.91 ± 5.19	2.99 ± 1.56	0.035
Resection margin (cm)			
Proximal	6.01 ± 3.54	5.10 ± 2.55	0.344
Distal	7.17 ± 4.57	7.71 ± 4.67	0.919
Number of retrieved LNs	42.79 ± 14.93	47.55 ± 16. 39	0.262
Flatus passage (day)	4.9 ± 0.9	3.4 ± 0.8	<0.001
Time to soft diet (day)	4.9 ± 3.0	3.5 ± 1.1	0.049
Hospital stay (day)	9.3 ± 5.1	7.1 ± 4.3	0.069
Complications	8 (42.1 %)	9 (14.5 %)	0.010
Wound problem	2	2	
Pulmonary problem	2	2	
Ileus	2		
Anastomotic leakage	1	2	
Anastomotic stenosis		2	
Others	1	1	

Data were presented as number (%) or mean ± standard deviation

OG open gastrectomy, *LG* laparoscopic gastrectomy, *LNs* lymph nodes

47.55 ± 16.39, $P = 0.262$). Times to first flatus (4.9 vs. 3.4 days; $P < 0.001$) and soft diet (4.9 vs. 3.5 days; $P = 0.049$) were significantly longer, and the complication rate significantly higher (42.1 vs. 14.5 %; $P = 0.010$), in the OG group, but postoperative hospital stay did not differ significantly (9.3 vs. 7.1 days; $P = 0.069$).

Impact of visceral fat area on laparoscopic gastrectomy for gastric cancer

When the body shape indices of patients in the two groups were compared (Table 3), the mean VFA was similar in the OG and LG groups (186.3 vs. 198.1 cm^2, $P = 0.452$). Moreover, there were no significant between-group differences in anterior-posterior diameter, transverse diameter, and waist circumference. However, the SFA was significantly higher for the OG group than for the LG group (208.1 vs. 172.4 cm^2; $P = 0.015$).

Table 3 Comparison of body shape index between both groups

Variables	OG ($n = 19$)		LG ($n = 62$)		P value
	Mean	Range	Mean	Range	
BMI (kg/m^2)	31.1	30.0–33.7	31.8	30.0–37.2	0.110
APD (cm)	24.0	20.3–28.3	23.6	20.1–30.5	0.526
TD (cm)	36.6	32.5–40.8	36.7	32.8–43.6	0.859
Waist (cm)	97.0	88.6–107.0	98.0	87.1–115.0	0.535
SFA (cm^2)	208.1		172.4		0.015
Male	199.6	133–386	158.0	54–327	0.046
Female	226.6	182–291	191.0	124–252	0.089*
VFA (cm^2)	186.3		198.1		0.452
Male	202.6	132–279	222.2	142–404	0.302
Female	151.0	74–260	168.4	118–302	0.479*

BMI body mass index, *APD* anterior-posterior diameter, *TD* transverse diameter, *SFA* subcutaneous fat area, *VFA* visceral fat area

* Mann–Whitney U test

To investigate the effect of the VFA on the operative outcomes of LG, subgroup analysis was performed on 53 patients who underwent laparoscopic distal gastrectomy. The correlations between the VFA and operation time, estimated blood loss, and the number of retrieved LNs were analyzed. The VFA was significantly correlated with estimated blood loss ($R = 0.335$, $R^2 = 0.113$; $P = 0.014$), but not with operation time ($R = 0.048$, $R^2 = 0.002$; $P = 0.734$) or the number of retrieved LNs ($R = 0.054$, $R^2 = 0.003$; $P = 0.700$) (Fig. 1). The impact of the SFA was also analyzed, but no correlation was observed between the SFA and operation time ($R = 0.094$, $R^2 = 0.009$; $P = 0.504$) or estimated blood loss ($R = 0.103$, $R^2 = 0.011$; $P = 0.464$).

Overall survival

Patients in the OG and LG groups were followed up for a median 47.9 and 37.8 months, respectively ($P = 0.196$). Since the sample size was not sufficient to compare survival at each stage, overall survival was analyzed in patients with stage I tumors (Fig. 2). The 5-year survival rates of patients with stage I tumors that underwent OG and LG were similar (100 vs. 96. 7 %, $P = 0.230$). Four patients in the LG group died during the follow-up period, however, none showed evidence of cancer recurrence.

Discussion

Obesity is a challenging issue in the performance of laparoscopic surgery for gastric cancer. Since obesity was reported to be a risk factor for conversion to OG, obesity has been considered a relative contraindication for LG [18, 19]. Moreover, a high BMI was found to predict technical difficulties during

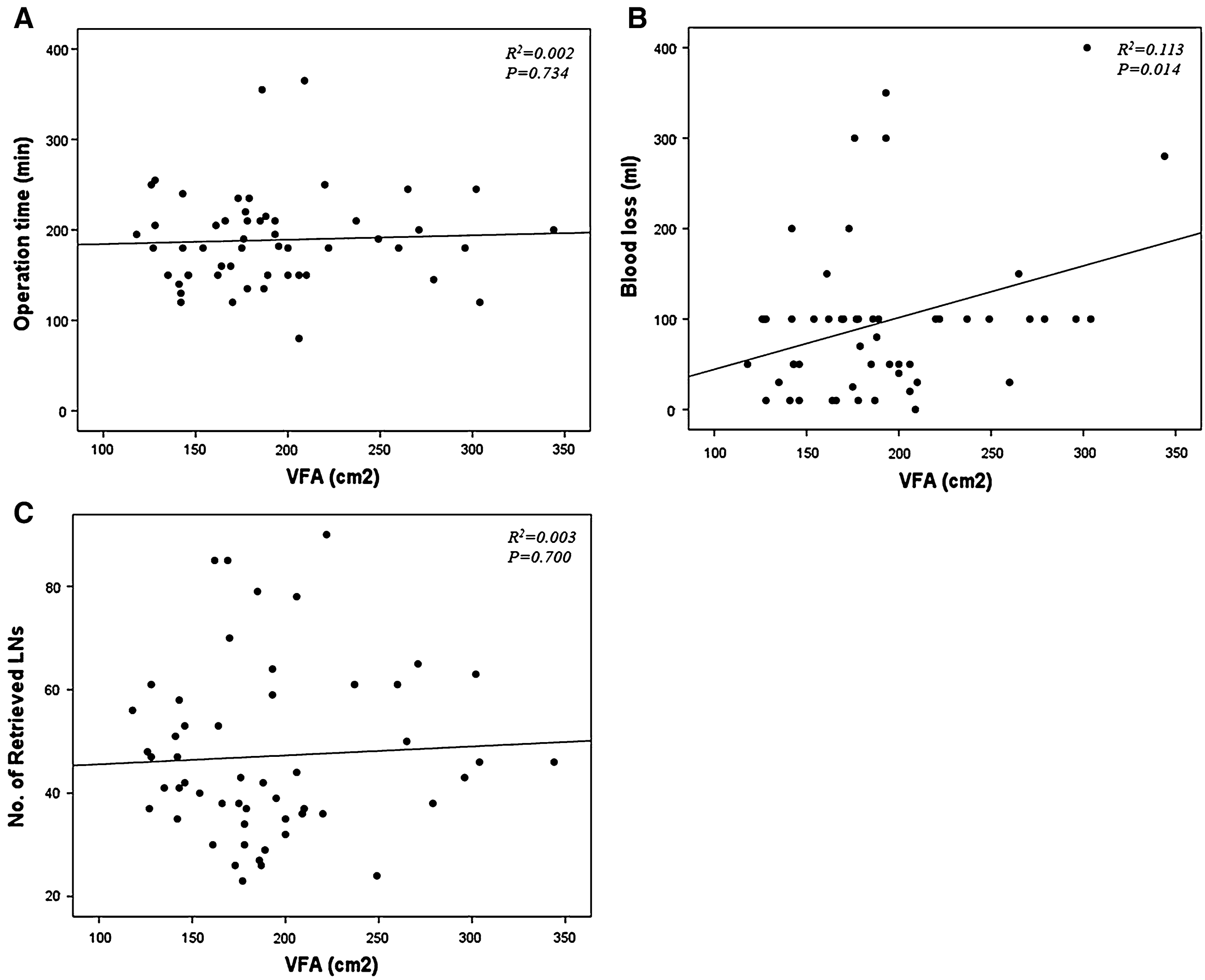

Fig. 1 Correlation between VFA and the operative outcomes in laparoscopic distal gastrectomy for gastric cancer. **a** Operation time and VFA. **b** Blood loss and VFA. **c** The number of retrieved lymph nodes and VFA

laparoscopic gastric surgery, as well as postoperative complications [21]. Conversely, several studies have reported that LG can be safely performed in obese patients with operative outcomes comparable to those of OG. For example, obesity was found to lengthen the operation time, but had no effect on the number of retrieved LNs or the rate of postoperative complications [22]. Another study found no significant differences between groups of obese and non-obese patients undergoing LG, with similar rates of major complications, number of retrieved LNs, and disease-free survival rates.

Several studies have analyzed the ability of the VFA to predict perioperative risks in patients undergoing gastrectomy for gastric cancer. Although increased fat content and large body shape affected the number of retrieved LNs and blood loss in patients undergoing conventional OG, they had little effect on patients undergoing LG [23]. A high VFA was associated with a longer operation time and a higher volume of intraoperative blood loss [24]. Moreover, the VFA may be more accurate than BMI in predicting postoperative complications [25, 26]. Most of these studies, however, involved East Asian patients and have limitations such as small sample size and different definitions of obesity (BMI $\geq$23 or 25 kg/m^2); thus the impact of obesity on LG still remains unclear.

This study evaluated surgical outcomes in obese patients, defined according to the WHO classification as BMI $\geq$30 kg/m^2, who underwent LG or OG for gastric cancer. Mean blood loss was lower, times to first flatus and soft diet shorter, and the complication rate lower in patients undergoing LG, but LG did not significantly increase operation time. Oncologic safety was similar, with no significant difference in the number of retrieved LNs and overall survival of patients with stage I tumors. In analyzing body shape indices and the impact of the VFA on operative outcomes,

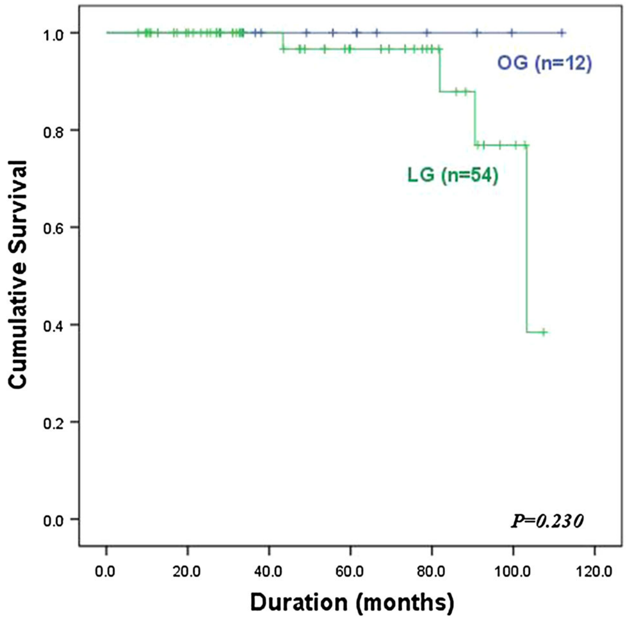

Fig. 2 Comparison of survival in patients with stage I

we found that the VFA was similar in the OG and LG groups and that the VFA did not affect operation time or number of retrieved LNs in laparoscopic distal gastrectomy.

This study had several limitations. It was retrospectively designed and confined to patients with preoperative early stage gastric cancer. Especially, the tumor size in the laparoscopy group was smaller than in the open group, and this difference was also identified in subgroup analysis (distal gastrectomy: 4.2 cm in OG vs. 2.9 cm in LG, $P = 0.048$; total gastrectomy: 11.3 cm in OG vs. 3.6 cm in LG, $P = 0.027$). This suggested that there was bias in selecting patients for laparoscopic surgery. In addition, the sample size of the OG group was small, which might influence the results. Therefore, our results has to be interpreted carefully and well-designed, large-scale randomized clinical trials are needed to confirm our results.

In conclusion, we found that LG yielded better operative outcomes than OG in patients with BMI ≥ 30 kg/m^2 undergoing surgery for gastric cancer, as shown by a reduction in estimated blood loss, faster recovery of bowel movement, and a lower complication rate. The VFA also correlated with estimated blood loss, but the oncological safety of LG was acceptable, as shown by the number of retrieved LNs and the survival of patients with stage I cancer. Overall, these results suggest that LG for gastric cancer is a feasible and safe procedure, even in patients with a high BMI.

Disclosures Drs. Sang-Yong Son, Do-Hyun Jung, Chang Min Lee, Sang-Hoon Ahn, Hye Seong Ahn, Do Joong Park, Hyung-Ho Kim have no conflict of interest or financial ties to disclose.

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