

Is There any Role of Visceral Fat Area for Predicting Difficulty of Laparoscopic Gastrectomy for Gastric Cancer?

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Purpose: Obesity is associated with morbidity following gastric cancer surgery, but whether obesity influences morbidity after laparoscopic gastrectomy (LG) remains controversial. The present study evaluated whether body mass index (BMI) and visceral fat area (VFA) predict postoperative complications.

Materials and Methods: A total of 217 consecutive patients who had undergone LG for gastric cancer between May 2003 and December 2005 were included in the present study. We divided the patients into two groups ('before learning curve' and 'after learning curve') based on the learning curve effect of the surgeon. Each of these groups was sub-classified according to BMI (<25 kg/m² and ≥25 kg/m²) and VFA (<100 cm² and ≥100 cm²). Surgical outcomes, including operative time, quantity of blood loss, and postoperative complications, were compared between BMI and VFA subgroups.

Results: The mean operative time, length of hospital stay, and complication rate were significantly higher in the before learning curve group than in the after learning curve group. In the subgroup analysis, complication rate and length of hospital stay did not differ according to BMI or VFA; however, for the before learning curve group, mean operative time and blood loss were significantly higher in the high VFA subgroup than in the low VFA subgroup (P=0.047 and P=0.028, respectively).

Conclusions: VFA may be a better predictive marker than BMI for selecting candidates for LG, which may help to get a better surgical outcome for inexperienced surgeons.

Key Words: Stomach neoplasms; Laparoscopic; Gastrectomy; Obesity; Intra-abdominal fat

Introduction

Laparoscopic gastrectomy (LG) is accepted as the primary treatment for early gastric cancer in Eastern Asia. Many studies have reported that LG has several clinical advantages over open gastrectomy, including reduced blood loss and postoperative pain, faster bowel recovery, and better short-term quality of life.¹⁻⁵ A recent large-scale, multicenter, retrospective study

showed that long-term results are comparable between LG and open gastrectomy. Therefore, LG may be indicated for a variety of situations, including advanced cancer, remnant gastric cancer, extremely elderly patients, and obese patients.⁶⁻⁹

Performing LG on obese patients with gastric cancer is a challenging issue. Because obesity is a well-known risk factor for postoperative complications and makes appropriate radical lymphadenectomy difficult, some surgeons recommend against using the laparoscopic procedure for gastric cancer in obese patients.¹⁰ Recently, several studies have suggested that LG is safe and has clinical advantages over open gastrectomy,^{7,11-13} but the impact of obesity on LG remains controversial.

Body mass index (BMI) is a simple and commonly used tool to assess obesity. However, BMI may not reflect the amount of

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intra-abdominal fat, which makes the laparoscopic procedure more difficult. Several studies have reported that visceral fat is associated with longer operative time, greater intraoperative blood loss, and is a significant predictor of postoperative complications.¹⁴⁻¹⁷ However, few reports have investigated the impact of visceral fat on LG, and no study has investigated the relationship between visceral fat and surgeon experience with LG.

This study evaluated whether visceral fat area (VFA) and surgeon experience were associated with postoperative complications and surgical outcomes in patients with gastric cancer.

Materials and Methods

1. Patients

A total of 217 consecutive patients underwent LG by a single surgeon between May 2003 and December 2005 at Ajou University Hospital. Of these, 25 patients were excluded because measurement of abdominal fat area was technically impossible due to the poor quality of the computed tomography (CT) images, which were scanned from films imported from another hospital. The remaining 192 patients were included and analyzed for the present study.

We previously reported that the 50th case was the approximate cut-off for determining surgeon experience with the LG procedure based on the moving average method.¹⁸ Thus, we divided the patients into 'before learning curve' and 'after learning curve' groups by the 50th case. Each of these groups was classified into two subgroups based on previous studies: BMI-L and BMI-H were defined as BMI < 25 kg/m² and ≥ 25 kg/m², respectively; and VFA-L and VFA-H were defined as VFA < 100 cm² and ≥ 100 cm², respectively.^{10,13,17} Surgical outcomes, including operative time, blood loss, and postoperative complications, were compared between BMI and VFA subgroups.

2. Estimation of body fat compartments

Abdominal fat distribution was analyzed on preoperatively scanned CT images at the level of the umbilicus.^{10,13,17} Fatscan software (Extended Brilliance Workspace ver. 3.5; Philips, Best, Netherlands) was used to measure abdominal fat compartments. The adipose tissue was determined electronically by setting the attenuation values for a region of interest within the range of -190 to -30 Hounsfield units. The cross-sectional surface areas (cm²) including total fat area, subcutaneous fat area, and VFA were quantified automatically by the software.

3. Surgical technique

LG was performed with the patient in the supine position under general anesthesia. The operator and endoscopist stood on the right side of the patient, and the first assistant stood on the left side. Two 12 mm ports and three 5 mm ports were placed, and the pneumoperitoneum was maintained at 10 to 13 mmHg. A harmonic scalpel (LCS; Ethicon Endo-Surgery Inc., Cincinnati, OH, USA) was used for lymph node dissection. After radical lymphadenectomy, a mini-laparotomy was performed on the epigastric area, and specimen delivery and anastomosis were conducted via mini-laparotomy.

For reconstruction after LG, gastroduodenostomy was made using a circular stapler (Proximate CDH; Ethicon Endo-Surgery Inc.), and gastrojejunostomy was performed by hand sewing. After total gastrectomy, esophagojejunostomy was made using a circular stapler and jejunojejunostomy was performed 50 cm from the esophagojejunostomy by hand sewing.

4. Statistical analysis

All statistical analyses were performed using IBM SPSS version 20.0 (IBM Co., Armonk, NY, USA). The χ^2 test, Fisher's exact test, Student's t test, and Mann-Whitney U test were used for between-group comparisons. Linear regression with a coefficient of determination was used for correlations between BMI and abdominal fat area. The overall survival rates were estimated using Kaplan-Meier curves and compared using the log-rank test. A P-value < 0.05 was considered statistically significant.

Results

1. Patient characteristics

Patient characteristics and surgical outcomes are listed in Table 1. The two groups did not differ in age, sex, comorbidity, BMI, abdominal fat area, extent of surgery, reconstruction methods, or lymph node dissection. However, a greater proportion of individuals in the 'after learning curve' group reported previous history of abdominal surgery.

Regarding short-term surgical outcomes, 'before learning curve' group showed a longer mean operative time (235.7 vs. 184.3 minutes, P < 0.001), greater mean blood loss (383.5 vs. 278.2 ml, P = 0.017), and longer hospital stay (13.1 vs. 10.4 days, P = 0.003) than the 'after learning curve' group. The complication rate was significantly different between the two groups; in particular, wound problems occurred more frequently in the 'before

Table 1. Clinical and surgical outcomes according to surgeon experience

Variable	Before learning curve (n=43)	After learning curve (n=149)	P-value
Age (yr)	58.2±12.9	59.1±12.5	0.700
Sex			0.350
Male	31 (72.1)	96 (64.4)	
Female	12 (27.9)	53 (35.6)	
Comorbidity	13 (30.2)	62 (41.6)	0.178
Previous abdominal surgery	2 (4.7)	28 (18.8)	0.030
BMI (kg/m ²)	23.3±2.8	23.6±3.0	0.481
Total body fat area (cm ²)	223.7±102.3	240.1±110.9	0.384
SFA	123.7±70.3	135.5±74.2	0.354
VFA	99.8±50.9	104.6±56.8	0.623
Extent of surgery			0.531
Total gastrectomy	2 (4.7)	14 (9.4)	
Distal gastrectomy	41 (95.3)	135 (90.6)	
Reconstruction			0.178
Billroth I	16 (37.2)	43 (28.9)	
Billroth II	25 (58.1)	86 (57.7)	
Roux en Y	2 (4.7)	20 (13.4)	
Lymph node dissection			0.223
<D2	23 (53.5)	95 (63.8)	
≥D2	20 (46.5)	54 (36.2)	
Estimated blood loss (ml)	383.5±243.8	278.2±206.8	0.017
Operative time (min)	235.7±44.8	184.3±42.9	<0.001
Retrieved LN	29.1±13.9	27.6±9.1	0.517
Length of hospital stay (d)	13.1±5.2	10.4±5.0	0.003
Postoperative complication	17 (39.5)	18 (12.1)	<0.001
Wound	10 (23.3)	5 (3.4)	
Bleeding	1 (2.3)	4 (2.7)	
Intestinal obstruction	2 (4.7)	3 (2.0)	
Pulmonary	1 (1.3)	2 (1.3)	
Fluid collection	2 (4.7)	1 (0.7)	
Anastomotic leakage	1 (2.3)	1 (0.7)	
Other	0 (0)	2 (1.3)	

Values are presented as mean±standard deviation or number (%). BMI = body mass index; SFA = subcutaneous fat area; VFA = visceral fat area; LN = lymph node.

learning curve' group.

2. Correlation between body mass index and body fat compartments

Fig. 1 shows the correlations between BMI and body fat compartments. BMI and total fat area were significantly correlated ($R^2=0.805$, $P<0.0001$) and had a higher correlation ef-

iciency than BMI and VFA ($R^2=0.686$, $P<0.0001$).

3. Subgroup analysis according to body mass index and visceral fat area

To evaluate the impact of BMI and VFA on surgical outcomes, we performed subgroup analysis on each of the group (Table 2).

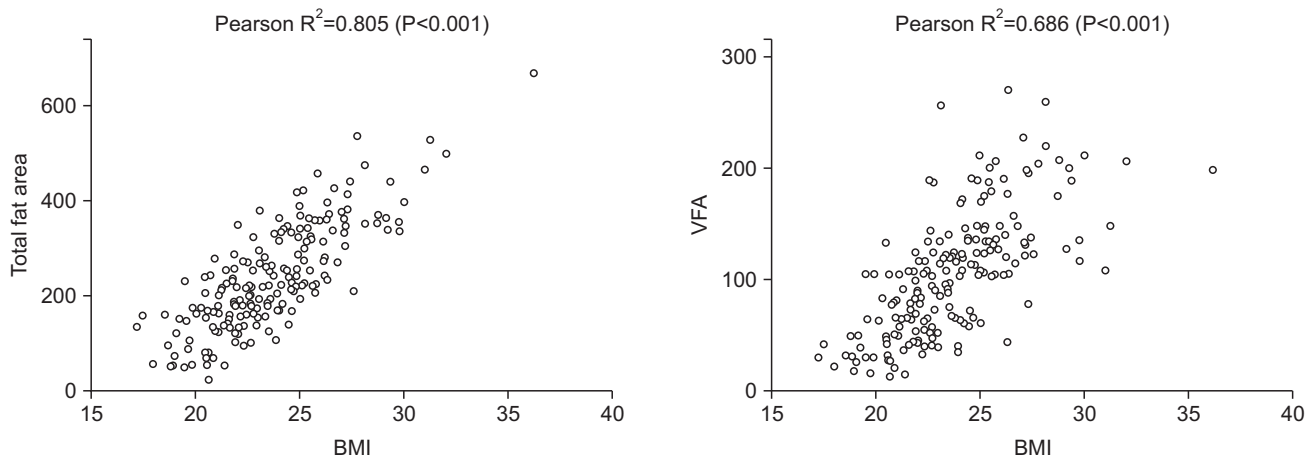


Fig. 1. Correlation between body mass index (BMI) and visceral fat area (VFA). The correlation efficiency was lower between BMI and VFA than between BMI and total fat area.

Table 2. Comparison of surgical outcomes after LG between BMI and VFA subgroups

Variable	BMI		P-value	VFA		P-value
	BMI-L	BMI-H		VFA-L	VFA-H	
Before learning curve						
No. of patient	30	13		20	23	
Extent of surgery			0.518			1.000
Total gastrectomy	1 (3.3)	1 (7.7)		1 (5.0)	1 (4.3)	
Distal gastrectomy	29 (96.7)	12 (92.3)		19 (95.0)	22 (95.7)	
Blood loss (ml)	223.0±277.0	376.9±231.5	0.109	189.5±263.7	352.2±256.9	0.047
Operation time (min)	227.8±45.6	253.8±38.8	0.080	219.8±44.8	249.6±40.9	0.028
Retrieved LN	29.4±10.2	28.4±20.5	0.859	30.0±11.4	28.4±15.9	0.701
Length of hospital stay (d)	13.1±5.4	13.1±5.1	0.988	12.1±5.8	13.9±4.7	0.240
Complication			0.559			0.223
None	19 (63.3)	7 (53.8)		14 (70.0)	12 (52.2)	
Yes	11 (36.7)	6 (46.2)		6 (30.0)	11 (47.8)	
After learning curve						
No. of patient	106	43		69	80	
Extent of surgery			0.352			0.393
Total gastrectomy	12 (11.3)	2 (4.7)		8 (11.6)	6 (7.5)	
Distal gastrectomy	94 (88.7)	41 (95.3)		61 (88.4)	74 (92.5)	
Blood loss (ml)	217.4±231.1	217.0±181.4	0.994	210.3±241.2	216.3±194.2	0.867
Operation time (min)	184.4±42.9	186.1±43.7	0.827	182.4±42.7	187.2±43.7	0.869
Retrieved LN	27.9±10.0	27.0±6.6	0.496	28.6±10.5	26.8±7.6	0.078
Length of hospital stay (d)	10.2±5.2	10.5±4.8	0.746	10.2±5.3	10.4±4.8	0.786
Complication			0.317			0.501
None	95 (89.6)	36 (83.7)		62 (89.9)	69 (86.3)	
Yes	11 (10.4)	7 (16.3)		7 (10.1)	11 (13.8)	

Values are presented as number only, number (%) or mean±standard deviation. LG = laparoscopic gastrectomy; BMI = body mass index; VFA = visceral fat area; BMI-L = BMI <25 kg/m²; BMI-H = BMI ≥25 kg/m²; VFA-L = VFA <100 cm²; VFA-H = VFA ≥100 cm²; LN = lymph node.

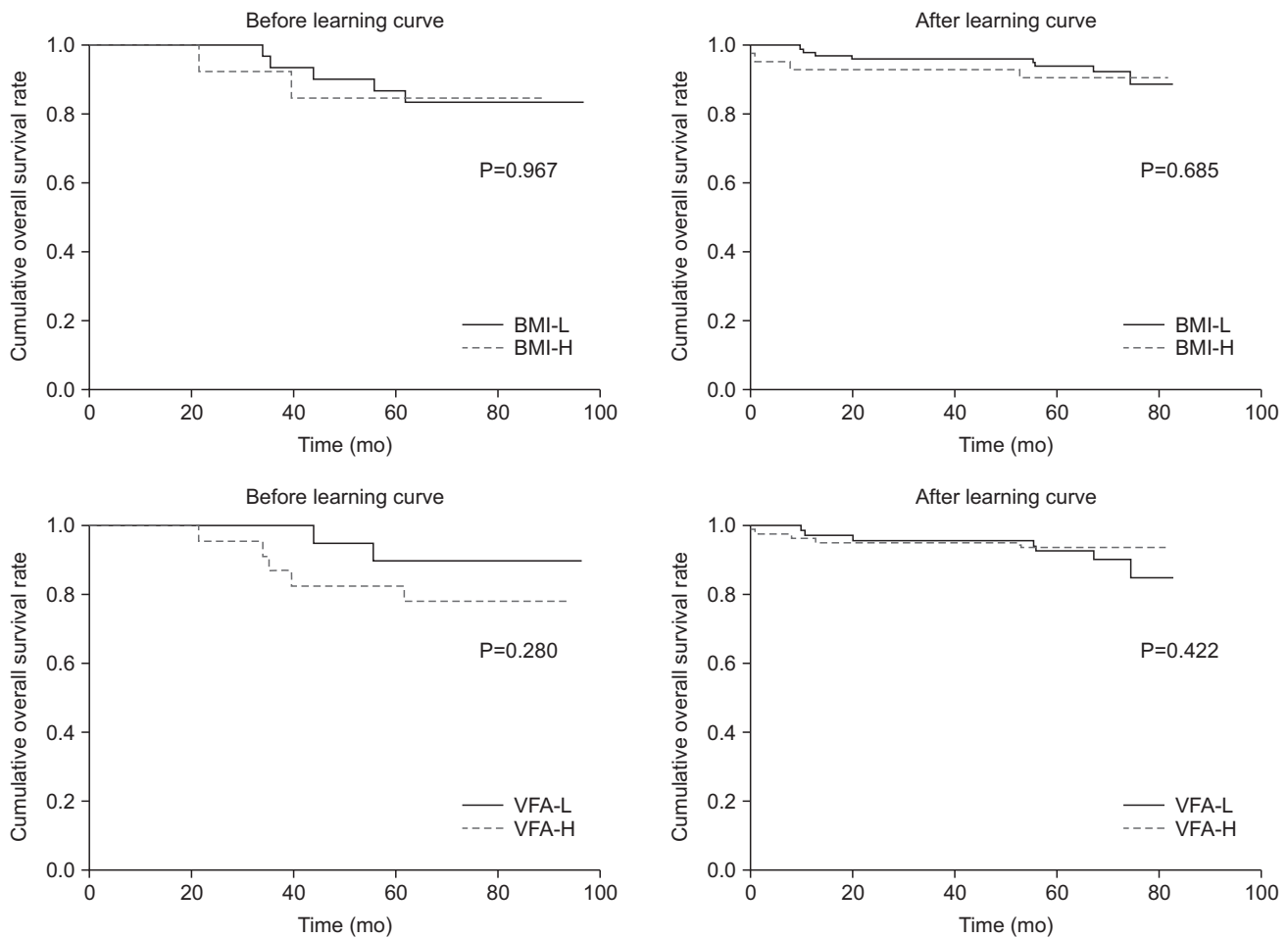


Fig. 2. Overall survival of patients according to obesity and surgeon experience. Although the difference was not statistically significant, the overall survival rate tended to be lower in patients with high visceral fat area (VFA) in the 'before learning curve' group. BMI = body mass index; BMI-H = BMI ≥ 25 kg/m²; VFA-L = VFA < 100 cm²; VFA-H = VFA ≥ 100 cm²

In 'before learning curve' group, the BMI-H subgroup tended to have greater blood loss, longer operative time, and higher complication rate, although these relationships were not statistically significant. However, the operative time was longer and blood loss was greater in the VFA-H group than in the VFA-L group (P=0.028 and P=0.047, respectively). Complication rates were not different among any of the subgroups.

In the 'after learning curve' group, no difference in surgical outcomes were observed between BMI and VFA subgroups.

4. Overall survival according to obesity status and surgeon experience

Overall survival is shown in Fig. 2. In the 'before learning curve' group, the 5-year overall survival was 86.7% and 84.6% in the BMI-L and BMI-H subgroups (P=0.967), and 90.0% and 82.6% in the VFA-L and VFA-H subgroups, respectively (P=0.280). In the 'after learning curve' group, the 5-year over-

all survival was 94.3% and 93.0% in the BMI-L and BMI-H subgroups (P=0.685), and 92.8% and 95.0% in the VFA-L and VFA-H subgroups, respectively (P=0.422).

Discussion

Obese population is increasing not only in Western countries but also in Eastern Asia.^{19,20} According to the Korean Society for the Study of Obesity, the prevalence of obesity (BMI ≥ 25 kg/m²) is over 30%, and the incidence of severe obesity is steadily increasing.²¹ Therefore, the number of obese patients who require surgery for gastric cancer will likely increase in the near future.

Laparoscopic technique is emerging as an alternative option for the treatment of gastric cancer and is accepted as a standard treatment for early-stage gastric cancer. However, the impact of obesity on LG remains controversial. A few studies have reported that obesity does not increase surgical morbidities associated

with LG, whereas others show that a high BMI is a significant predictor of technical difficulties during LG and postoperative complication.^{11,12,22,23}

Recent research indicates that high VFA is a more accurate predictor of perioperative risk than high BMI in obese patients with gastric cancer.^{10,11,16} Excess visceral fat tissue may make it difficult to identify organs, vessels, and lymph nodes accurately, which may increase the difficulty of the laparoscopic procedure. However, BMI may not reflect accurately the amount of intra-abdominal fat because it is a simple calculation of body volume based on height and weight. In the present study, Fig. 1 shows that the correlation efficiency was high (Pearson $R^2=0.805$) between BMI and total fat area, but relatively low (Pearson $R^2=0.686$) between BMI and VFA. Moreover, blood loss and operative time were significantly higher in the VFA-H subgroup before learning curve, but these surgical outcomes were not significantly different between the BMI-L and BMI-H subgroups before or after learning curve. These results suggest that, VFA was a better predictor of laparoscopic procedure difficulty than BMI in obese patients.

Obesity did not increase postoperative morbidity after LG, but the complication rate tended to be higher in the BMI-H and VFA-H subgroups than in the BMI-L and VFA-L subgroups. For example, the complication rate in the VFA-H subgroup before learning curve (47.8%) was 1.5 times that of the VFA-L subgroup (30.0%). However, because the sample size in the 'before learning curve' group was small a large sample size from a multicenter study is needed to confirm this result.

To our knowledge, the present study was the first to evaluate the contribution of VFA and surgeon experience for predicting postoperative outcomes in LG procedures. Although several reports on the impact of VFA or surgeons experience on the surgical outcome after LG have been published, no study has investigated the relationship between visceral fat and surgeon experience with LG.^{10,14-17,24,25} Thus, we hypothesized that high VFA would affect surgical outcomes more for an inexperienced laparoscopic surgeon. Our data showed that blood loss and operative time did not differ between VFA subgroups after learning curve but significantly differed in VFA-H subgroup before learning curve, suggesting that the excess visceral fat may have influenced the LG technique of the inexperienced surgeon more than the experienced surgeon. Therefore, surgeons who have performed fewer than 50 LG procedures in patients with gastric cancer should check VFA rather than BMI to select appropriate

candidates for the procedure, and thereby reduce the risk of an unsatisfactory surgical outcome.

In the present study, we evaluated survival according to obesity index and surgeon experience whether the short-term outcomes of this study affect long-term survival. The overall survival rate seems to be lower in patients with high VFA in the 'before learning curve' group, but the difference was not statistically significant ($P=0.280$). Recently, a study evaluating the impact of obesity on surgical outcome and prognosis in patients with gastric cancer reported similar results.²⁶ This study divided the patients according to BMI class and VFA quartile. Although the third quartile (VFA, 103~150 cm²) showed a 1.513 hazard ratio compared with the fourth quartile (VF > 150 cm²) in the univariate analysis, the overall survival was not significantly different according to BMI class or VFA quartile. Therefore, further investigations are needed to clarify the impact of BMI or VFA on long-term survival after LG for gastric cancer.

Our study had some limitations. First, the study was retrospectively designed and confined to a single center and one surgeon's experience. Second, we excluded 25 patients from the present study due to the poor quality of scanned CT images, which may have created a selection bias. Further retrospective studies are needed to confirm the impact of VFA on surgical outcomes of LG for inexperienced surgeons.

In conclusion, the present study demonstrated that excess visceral fat accumulation was associated with technical difficulties for surgeons who have performed fewer than 50 cases of LG for gastric cancer. Therefore, VFA may be a better predictive marker than BMI for selecting candidates for LG and therefore helping to get a better surgical outcome for inexperienced surgeons.

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Conflicts of Interest

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

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