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ORIGINAL SCIENTIFIC REPORT

Effect of Visceral Obesity on Surgical Outcomes of Patients Undergoing Laparoscopic Colorectal Surgery

Byung Kwan Park[1] · Ji Won Park[1,2,3] · Seung-Bum Ryoo[1] · Seung-Yong Jeong[1,2,3] · Kyu Joo Park[1,3] · Jae-Gahb Park[4]

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Abstract

Background Visceral obesity has been known to be more pathogenic than body mass index (BMI). There have been a few reports about the association between visceral obesity and surgical outcomes in laparoscopic surgery. The aim of this study was to evaluate the effect of visceral obesity on surgical outcomes undergoing laparoscopic colorectal surgery.

Methods Between January 2005 and December 2012, a total of 543 patients who underwent laparoscopic resection for colorectal cancer and had available computed tomography (CT) scans were included in this retrospective study. Visceral fat volumes (VFVs) were measured in preoperative CT scans from S1 to 12.5 cm above. Patients were divided into an obese group and a non-obese group according to VFV and BMI. Obesity was defined by VFV $\geq$1.92 dm^3 (75 % value of VFV) or BMI $\geq$25 kg/m^2.

Results There were 136 (25.0 %) and 150 (27.6 %) obese patients according to VFV and BMI, respectively. The high VFV group had a longer operative times (165.2 ± 84.4 vs. 146.1 ± 58.9 min; $P = 0.016$), higher blood loss during surgery (132.5 ± 144.8 vs. 98.3 ± 109.6 ml; $P = 0.012$), more frequent conversion to laparotomy (5.9 vs. 1.5 %; $P = 0.010$), and more frequent major complications (Dindo score $\geq$3; 11.0 vs. 4.7 %; $P = 0.008$), whereas there was no significant difference between the high and low BMI groups. High VFV was a significant independent risk factor for open conversion (odds ratio 4.964, 95 % confidence interval 1.336–18.438, $P = 0.017$).

Conclusions Visceral obesity can be a more clinically useful predictor than BMI in predicting surgical outcomes for laparoscopic colorectal cancer surgery.

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✉ Ji Won Park
sowisdom@gmail.com

[1] Department of Surgery, Seoul National University College of Medicine, 101 Daehak-Ro, Jongno-Gu, Seoul 110-744, Korea

[2] Cancer Research Institute, Seoul National University, Seoul, Korea

[3] Colorectal Cancer Center, Seoul National University Cancer Hospital, Seoul, Korea

[4] Center for Colorectal Cancer, National Cancer Center, Goyang, Korea

Introduction

Laparoscopic colorectal surgery has been established as a standard surgical treatment in the management of colorectal malignancies. Laparoscopic colorectal surgery has not only safe oncologic outcomes but also better early surgical outcomes, such as decreased postoperative pain and early rehabilitation [1–5]. However, conversion to open laparotomy during laparoscopic surgery is associated with greater morbidity [3, 6]. Male gender, extensive tumor spread, location in the rectum, body mass index (BMI), and emergent operation were shown as the risk factors for conversion [6–8]. Considering these risk factors, proper patient selection is important to maximize the surgical outcomes of laparoscopic colorectal surgery.

Generally, obesity has been considered a risk factor for postoperative morbidity after abdominal surgery. The association between obesity and surgical outcomes of laparoscopic colorectal surgery has been studied, but the results are controversial [5, 9–12]. Most studies focused on general obesity using BMI. However, visceral obesity has emerged as a more reliable factor than BMI as an indicator of obesity in Asians [13–18]. Visceral obesity is known to be more pathogenic than BMI. Waist circumference and visceral fat area have been used to evaluate visceral obesity [14, 19, 20]. Recently, the visceral fat volume (VFV) parameter has been introduced [21]. The aim of this study was to evaluate the effect of visceral volume on surgical outcomes patients who underwent laparoscopic colorectal surgery.

Patients and methods

Between January 2005 and December 2012, 889 consecutive patients who underwent laparoscopic surgery for colorectal adenocarcinoma at Seoul National University Hospital were retrospectively reviewed. Of these patients, 346 were excluded because of unavailable to calculate the computed tomography (CT) volumetry for the following reasons: 302 had CT scans from outside hospitals with inappropriate images to calculate the VFV, 39 patients had CT colonography, and 5 patients had no preoperative CT scans. Finally, 543 patients were included in this retrospective study. This study was approved by the Institutional Review Board of the Seoul National University Hospital, Korea.

The volumetry program with the automated assessment of body fat from CT data was used [22]. Preoperative CT images, which were 2.5–5 mm thickness images, were exported to DICOM files for evaluation. The volumetry program imported the DICOM files and calculated VFV from S1 to 12.5 cm above in a method that has been described in previous studies (Fig. 1) [21, 23]. Patients were divided into an obese group and a non-obese group according to VFV and BMI. Because there is no absolute cut-off value for VFV, we categorized the patients into dichotomized groups at the 75 % value of VFV as suggested in a previous study [24]. For BMI, 25 kg/m^2 was used as a cut-off value according to the categories proposed by the International Obesity Task Force, IOTF (World Health Organization, WHO, International Association for the Study of Obesity, IOTF (2000), The Asia–Pacific perspective redefining obesity and its treatment. Health Communications, Sydney) [25].

As a standardized procedure, laparoscopic colorectal surgery was performed. In general, five trocars were inserted (two or three 5-mm trocars, one 11-mm trocar, and one or two 12-mm trocars). A 30° angled scope was inserted through an 11-mm umbilical trocar. During mobilization of the colon or rectum, the root of the vessel was ligated laparoscopically. The specimen was extracted through an extended incision of the port in the umbilicus or the perineum. The anastomosis was performed with a circular stapler intracorporeally or two linear staplers extracorporeally.

Demographic data included the following: age, gender, BMI, American Society of Anesthesiologist (ASA) class, the presence of comorbidities, social behaviors, previous laparotomy history, tumor location, curative resection, neoadjuvant chemoradiotherapy, operation type, combined resection, and tumor stage. Surgical outcomes included conversion, intraoperative event, transfusion, operative time, estimated blood loss, harvested lymph nodes, complications over 30 postoperative days, length of postoperative hospital stay, and readmission rate. The definition of intraoperative event was any event that occurred unexpectedly, and open conversion was defined as any additional laparotomy than that initially planned for specimen removal or anastomosis [26]. A postoperative complication was defined as any deviation from the normal postoperative course required specific medical or surgical treatment according to Dindo's classification [27], and a major complication was defined as a serious condition, which was more than Dindo score III [10]. Postoperative ileus was defined as any condition requiring diet regression or reinsertion of a nasogastric tube. Deep organ infection was defined as any intra-abdominal fluid collection requiring percutaneous drainage. Anastomotic leakage was defined as changes to feces in a surgical drain that requires discontinuation of the diet and/or a surgical procedure. Surgical outcomes were compared between the obese and the non-obese groups.

Data are presented as the number of patients and percentages or as the mean with standard deviation. Depending on the nature of the data, χ^2 test, Fisher's exact test, Student's t test, or Mann–Whitney U test was used for comparisons. Intraclass correlation coefficients between observers were calculated in a randomly selected subsample of 54 (10 %) patients. Binary logistic regression analysis was used in a multivariable analysis to determine the risk factors for open conversion. Statistical analysis was performed using SPSS software, version 19.0 (SPSS, Chicago, IL). A two-tailed P value <0.05 was the criterion for statistical significance.

Results

The mean VFV of the patients was 1.51 ± 0.67 dm^3, and the mean BMI was 23.51 ± 2.86 kg/m^2 (Table 1). The intraclass correlation coefficient between observers for

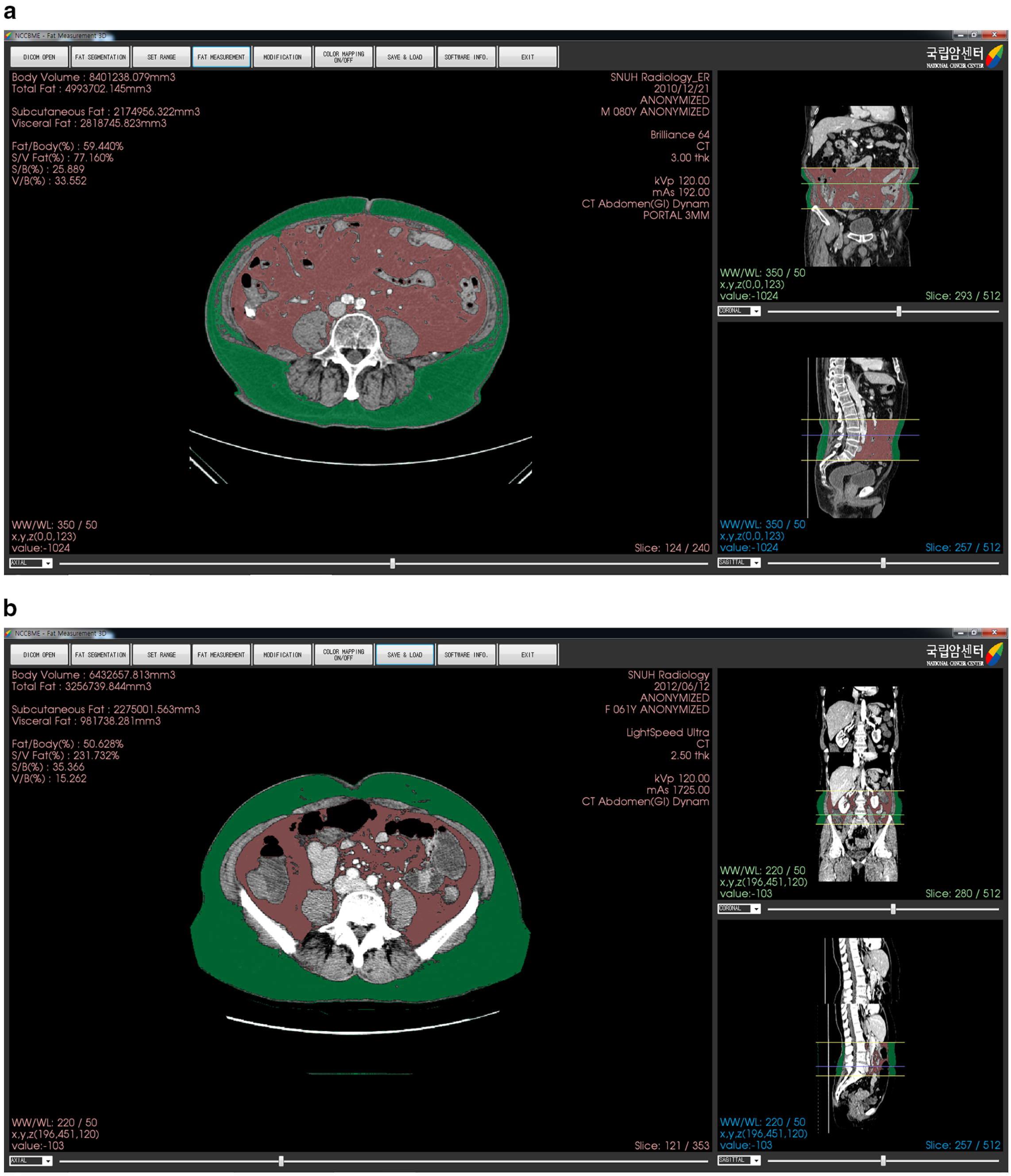

Fig. 1 The volumetry program calculated VFV from S1 to 12.5 cm above using DICOM files [**a** 80 years old man whose VFV was 2.82 dm^3 (high VFV) but BMI was 24.3 kg/m^2 (non-obese), **b** 61 years old woman whose VFV was 0.98 dm^3 (low VFV) but BMI was 28.4 kg/m^2 (obese)]

VFV was 0.998 ($P < 0.001$). The 75 % value of VFV was 1.92 dm^3, which was defined as the cut-off value. The clinicopathological characteristics of the patients according to the VFV and BMI are presented in Table 2. There was no significant difference in the clinicopathological characteristics except age, gender, BMI, underlying disease, and tumor location between the high and low VFV groups. There was no significant difference in the

Table 1 Visceral fat volume and body mass index (BMI) of patients

Variables	Visceral fat volume (dm^3)	BMI (kg/m^2)
Mean (SD)	1.51 (0.67)	23.51 (2.86)
Median	1.44	23.22
Minimum	0.14	16.49
Maximum	3.94	38.73
Interquartile range (IQR)	1.07–1.92	21.62–25.30

Table 2 Clinicopathologic characteristics of patients

	Low VFV (*n* = 407)	High VFV (*n* = 136)	*P* value	Low BMI[a] (*n* = 390)	High BMI[a] (*n* = 150)	*P* value
Age (SD), years	61.9 (10.8)	66.4 (8.5)	<0.001	62.8 (10.7)	63.5 (9.5)	0.491
Male gender	205 (50.4 %)	106 (77.9 %)	<0.001	229 (58.7 %)	79 (52.7 %)	0.203
BMI[a]			<0.001			N/A
<25	333 (82.2 %)	57 (42.2 %)		–	–	
≥25	72 (17.8 %)	78 (57.8 %)		–	–	
VFV			N/A			<0.001
Low VFV	–	–		333 (85.4 %)	72 (48.0 %)	
High VFV	–	–		57 (14.6 %)	78 (52.0 %)	
ASA class[b] ≥3	10 (2.5 %)	5 (3.7 %)	0.544[c]	13 (3.4 %)	2 (1.3 %)	0.254[c]
Presence of comorbidities[d]	190 (46.8 %)	87 (64.0 %)	0.001	180 (46.2 %)	96 (64.0 %)	<0.001
Smoking history[d]	51 (12.6 %)	21 (15.4 %)	0.392	55 (14.1 %)	17 (11.3 %)	0.396
Alcohol history	98 (24.1 %)	37 (27.2 %)	0.465	98 (25.1 %)	37 (24.7 %)	0.912
Previous laparotomy history	44 (10.8 %)	14 (10.3 %)	0.866	37 (9.5 %)	21 (14.0 %)	0.129
Location			0.001			0.100
Colon	252 (61.9 %)	105 (77.2 %)		249 (63.8 %)	107 (71.3 %)	
Rectum	155 (38.1 %)	31 (22.8 %)		141 (36.2 %)	43 (28.7 %)	
Curative resection	400 (98.3 %)	130 (95.6 %)	0.101[c]	382 (97.9 %)	145 (96.7 %)	0.364[c]
Neoadjuvant chemoradiotherapy	42 (10.3 %)	9 (6.6 %)	0.200	36 (9.2 %)	13 (8.7 %)	0.838
Operation types			0.433			0.375
RHC	78 (19.2 %)	23 (16.9 %)		74 (19.0 %)	27 (18.0 %)	
LHC	17 (4.2 %)	2 (1.5 %)		17 (4.4 %)	2 (1.3 %)	
AR	304 (74.7 %)	108 (79.4 %)		291 (74.6 %)	118 (78.7 %)	
Others	8 (2.0 %)	3 (2.2 %)		8 (2.1 %)	3 (2.0 %)	
TPC	1	0		0	1	
APR	7	2		7	2	
Hartmann's procedure	0	1		1	0	
Combined resection[e]	73 (17.9 %)	36 (26.5 %)	0.031	76 (19.5 %)	32 (21.3 %)	0.631
T stages			0.036			
T0,is	40 (9.8 %)	4 (2.9 %)		36 (9.2 %)	7 (4.7 %)	0.201
T1,2	138 (33.9 %)	47 (34.6 %)		130 (33.3 %)	55 (36.7 %)	
T3,4	229 (56.3 %)	85 (62.5 %)		224 (57.4 %)	88 (58.7 %)	
N stages			0.318			0.571
N0	256 (62.9 %)	92 (67.6 %)		252 (64.6 %)	93 (62.0 %)	
N1,2	151 (37.1 %)	44 (32.4 %)		138 (35.4 %)	57 (38.0 %)	
M stages			0.192			0.778
M0	384 (94.3 %)	124 (91.2 %)		364 (93.3 %)	141 (94.0 %)	
M1	23 (5.7 %)	12 (8.8 %)		26 (6.7 %)	9 (6.0 %)	

VFV visceral fat volume, *BMI* body mass index, *SD* standard deviation, *ASA* American Society of Anesthesiologists, *RHC* right hemicolectomy, *LHC* left hemicolectomy, *AR* anterior resection, *TPC* total proctocolectomy, *APR* abdominoperineal resection

[a] Three patients were missing data

[b] Eight patients were missing data

[c] Fisher's exact test

[d] One patient was missing data

[e] Include laparoscopic liver resection, hysterectomy, oophorectomy, cholecystectomy, appendectomy

Table 3 Surgical outcomes according to visceral fat volume

	Low VFV ($n = 407$)	High VFV ($n = 136$)	P value
Conversion	6 (1.5 %)	8 (5.9 %)	0.010
Advanced disease	2	1	
Severe adhesion	3	3	
Bleeding	0	1	
Other organ injury	1	1	
Narrow pelvis	0	1	
Anatomical difficulty	0	1	
Intraoperative event	22 (5.4 %)	9 (6.6 %)	0.598
Bleeding	11	6	
Bowel injury	2	1	
Anastomotic leak	1	1	
Bowel color change	4	1	
Distal margin positive	2	0	
Others[a]	2	0	
Transfusion	6 (1.5 %)	6 (4.4 %)	0.083[b]
Operative time (SD), min	146.1 (58.9)	165.2 (84.4)	0.016[b]
Estimated blood loss (SD), ml	98.3 (109.6)	132.5 (144.8)	0.012[c]
Harvested lymph node (SD)	19.7 (10.2)	17.4 (8.4)	0.052[c]
Harvested lymph node (<12)	82 (20.6 %)	33 (25.0 %)	0.288
Postoperative complication	84 (20.6 %)	34 (25.0 %)	0.286[d]
Dindo I, II	65 (16.0 %)	19 (14.0 %)	0.786[d]
I	44	15	
II	21	4	
Dindo III, IV, IV	19 (4.7 %)	15 (11.0 %)	0.029
III	17	15	
IV	1	0	
V	1	0	
Postoperative hospital stay (SD), days	7.6 (4.3)	7.9 (4.7)	0.457[c]
Readmission	2 (0.5 %)	3 (2.2 %)	0.103[b]

VFV visceral fat volume, *SD* standard deviation

[a] Others include further resection for unidentified lesion

[b] Fisher's exact test

[c] Mann–Whitney *U* test

[d] Versus no complication

clinicopathological characteristics except underlying disease and VFV between the high and low BMI groups.

Table 3 shows the surgical outcomes according to the VFV. The conversion rate was significantly higher in the high visceral fat group than in the low visceral fat group (5.9 vs. 1.5 %, $P = 0.010$). Longer operative time (165.2 ± 84.4 vs. 146.1 ± 58.9, $P = 0.016$) and increased estimated blood loss (132.5 ± 144.8 vs. 98.3 ± 109.6, $P = 0.012$) were observed in the high VFV group. The rates of postoperative major complications (Dindo score ≥ 3) were significantly higher in the high VFV group than the low VFV group (11.0 vs. 4.7 %, $P = 0.029$), but the rates of overall postoperative complications were not significantly different between the two groups. Intraoperative event, harvested lymph nodes, mortality, postoperative hospital stay, and readmission rates were not significantly different between the groups. There were no significant differences in surgical outcomes between the high and low BMI groups (Table 4).

In the univariate analysis of the risk factors for open conversion, high visceral fat ($P = 0.010$), a history of previous laparotomy ($P = 0.011$) and combined operation ($P = 0.042$) were significantly associated with open conversion (Table 5). However, BMI was not associated with

Table 4 Surgical outcomes according to body mass index

	Non-obese (BMI <25 kg/m^2) (n = 390)	Obese (BMI ≥25 kg/m^2) (n = 150)	P value
Conversion	11 (2.8 %)	3 (2.0 %)	0.767
Advanced disease	3	0	
Severe adhesion	4	2	
Bleeding	1	0	
Other organ injury	2	0	
Narrow pelvis	1	0	
Anatomical difficulty	0	1	
Intraoperative event	21 (5.4 %)	9 (6.0 %)	0.780
Bleeding	12	5	
Bowel injury	2	1	
Anastomotic leak	0	2	
Bowel color change	4	1	
Distal margin positive	1	0	
Others[a]	2	0	
Transfusion	6 (1.5 %)	6 (4.0 %)	0.103[b]
Operative time (SD), min	146.6 (58.8)	160.0 (82.0)	0.070
Estimated blood loss (SD), ml	100.4 (108.8)	121.7 (144.1)	0.103[c]
Harvested lymph node (SD)	19.4 (10.1)	18.5 (9.0)	0.355
Harvested lymph node (<12)	80 (21.0 %)	33 (22.6 %)	0.688
Postoperative complication	84 (20.6 %)	34 (25.0 %)	0.907[d]
Dindo I, II	61 (15.6 %)	22 (14.7 %)	0.830[d]
I	42	17	
II	19	5	
Dindo III, IV, IV	23 (5.9 %)	11 (7.3 %)	0.809
III	22	10	
IV	1	0	
V	0	1	
Postoperative hospital stay (SD), day	7.8 (4.9)	7.3 (2.6)	0.487[c]
Readmission	4 (1.0 %)	1 (0.7 %)	1.000[b]

BMI body mass index, *SD* standard deviation

[a] Others include further resection for unidentified lesion

[b] Fisher's exact test

[c] Mann–Whitney U test

[d] Versus no complication

open conversion. After adjusted with age, gender, BMI, and combined resection, high VFV (odds ratio 4.964, 95 % confidence interval 1.336–18.438, $P = 0.017$) and a history of previous laparotomy (odds ratio 8.071, 95 % confidence interval 2.184–29.832, $P = 0.002$) were independently significant risk factors for open conversion. And the rectal cancer (odds ratio 2.953, 95 % confidence interval 1.423–6.128, $P = 0.004$) and high VFV (odds ratio 3.336, 95 % confidence interval 1.426–7.806, $P = 0.005$) were significant risk factors for major complication (Dindo ≥3) after adjusting significant risk factors (Table 6, electronic supplement Table 1).

Discussion

Obesity itself increases postoperative morbidity because of other preexisting comorbid illness, and it can be a major factor in the increased difficulty of laparoscopic colorectal surgery [28]. These difficulties may be caused by the need to manipulate overly bulky mesenteries in obese patients, restriction in maneuvering of instruments in the working area, and obscure surgical views that are challenging for identifying adequate surgical planes and normal vasculature [10, 11, 19, 28]. For these reasons, laparoscopic colorectal surgery in obese patients requires more careful

Table 5 Analysis of risk factors for open conversion

	Univariate analysis			Multivariable analysis		
	No conversion ($n = 529$)	Conversion ($n = 14$)	P value	OR	95 % CI	P value
Age (SD), years	352 (97.2 %)	10 (2.8 %)	0.783	Reference	0.289–4.126	0.896
≥60 years	177 (97.8 %)	4 (2.2 %)		1.093		
<60 years						
Gender			0.278			
Male	301 (56.9 %)	10 (71.4 %)		Reference		
Female	228 (43.1 %)	4 (28.6 %)		1.703	0.408–7.105	0.465
BMI[a]			0.767			
<25	379 (72.1 %)	11 (78.6 %)		Reference		
≥25	147 (27.9 %)	3 (21.4 %)		3.733	0.854–16.328	0.080
ASA class[b]			0.292			
1 or 2	509 (97.3 %)	11 (91.7 %)				
3	14 (2.7 %)	1 (8.3 %)				
Presence of comorbidities[c]			0.318			
Yes	268 (50.8 %)	9 (64.3 %)		Reference		
No	260 (49.2 %)	5 (35.7 %)		1.584	0.451–5.560	0.473
Previous laparotomy			0.011			
No	476 (90.0 %)	9 (64.3 %)		Reference		
Yes	53 (10.0 %)	5 (35.7 %)		8.071	2.184–29.832	0.002
Smoking[c]			0.234			
Yes	72 (86.4 %)	0 (0.0 %)				
No	456 (13.6 %)	14 (100.0 %)				
Alcohol			0.352			
Yes	130 (75.4 %)	9 (64.3 %)				
No	399 (24.6 %)	5 (35.7 %)				
Location			0.400			
Colon	346 (65.4 %)	11 (78.6 %)				
Rectum	183 (34.6 %)	3 (21.4 %)				
Curative resection			0.291			
Curative	517 (97.7 %)	13 (92.9 %)				
Palliative	12 (2.3 %)	1 (7.1 %)				
Visceral fat			0.010			
Low VFV	401 (75.8 %)	6 (42.9 %)		Reference		
High VFV	128 (24.2 %)	8 (57.1 %)		4.964	1.336–18.438	0.017
Operation types			0.803			
RHC	99 (18.7 %)	2 (14.3 %)				
LHC	18 (3.4 %)	1 (7.1 %)				
AR, LAR	401 (75.8 %)	11 (78.6 %)				
Others[d]	11 (2.1 %)	0 (0.0 %)				
Combined resection			0.042			
No	426 (80.5 %)	8 (57.1 %)		Reference		
Yes	103 (19.5 %)	6 (42.9 %)		2.627	0.840–8.213	0.097

SD standard deviation, *BMI* body mass index, *ASA* American Society of Anesthesiologists, *VFV* visceral fat volume, *RHC* right hemicolectomy, *LHC* left hemicolectomy, *AR* anterior resection

[a] Three patients were missing data

[b] Eight patients were missing data

[c] One patient was missing data

[d] Total proctocolectomy, abdominoperineal resection, Hartmann's procedure

Table 6 Analysis of risk factors for major complication (Dindo score ≥3)

	Univariate analysis			Multivariable analysis		
	Dindo <3 (*n* = 509)	Dindo ≥3 (*n* = 34)	*P* value	OR	95 % CI	*P* value
Age (SD), years			0.900			
≥60 years	339 (93.6 %)	23 (6.4 %)		Reference		
<60 years	170 (93.9 %)	11 (6.1 %)		1.402	0.624–3.151	0.413
Gender			0.850			
Male	291 (93.6 %)	20 (6.4 %)		Reference		
Female	218 (94.0 %)	14 (6.0 %)		1.233	0.568–2.676	0.596
BMI[a]			0.538			
≥25	139 (92.7 %)	23 (5.9 %)		Reference		
<25	367 (94.1 %)	11 (7.3 %)		1.321	0.562–3.106	0.524
ASA class[b]			0.246[c]			
1 or 2	488 (93.8 %)	32 (6.2 %)				
3	13 (86.7 %)	2 (13.3 %)				
Presence of comorbidities[d]			0.101			
No	253 (95.5 %)	12 (4.5 %)		Reference		
Yes	255 (92.1 %)	22 (7.9 %)		2.103	0.942–4.692	0.070
Previous laparotomy			0.077[c]			
No	458 (94.4 %)	27 (5.6 %)				
Yes	51 (87.9 %)	7 (12.1 %)				
Smoking[d]			0.603[c]			
Yes	439 (93.4 %)	31 (6.6 %)				
No	69 (95.8 %)	3 (4.2 %)				
Alcohol			0.552			
Yes	381 (93.4 %)	27 (6.6 %)				
No	128 (94.8 %)	7 (5.2 %)				
Location			0.018			
Colon	341 (95.5 %)	16 (4.5 %)		Reference		
Rectum	168 (90.3 %)	18 (9.7 %)		2.953	1.423–6.128	0.004
Curative resection			0.573[c]			
Curative	497 (93.8 %)	33 (6.2 %)				
Palliative	12 (92.3 %)	1 (7.7 %)				
Visceral fat			0.008			
Low VFV	388 (95.3 %)	19 (4.7 %)		Reference		
High VFV	121 (89.0 %)	15 (11.0 %)		3.336	1.426–7.806	0.005
Operation types			0.792			
RHC	96 (95.0 %)	5 (5.0 %)				
LHC	17 (89.5 %)	2 (10.5 %)				
AR, LAR	386 (93.7 %)	26 (6.3 %)				
Others[e]	10 (90.9 %)	1 (9.1 %)				
Combined resection			0.065			
No	411 (94.7 %)	23 (5.3 %)				
Yes	98 (89.9 %)	11 (10.1 %)				

SD standard deviation, *BMI* body mass index, *ASA* American Society of Anesthesiologists, *VFV* visceral fat volume, *RHC* right hemicolectomy, *LHC* left hemicolectomy, *AR* anterior resection

[a] Three patients were missing data

[b] Eight patients were missing data

[c] Fisher's exact test

[d] One patient was missing data

[e] Total proctocolectomy, abdominoperineal resection, Hartmann's procedure

effort and exhibits a higher open conversion rate. This study also showed that high VFV was associated with higher open conversion rate, longer operative time, and increased estimated blood loss undergoing laparoscopic colorectal cancer surgery. In a recent meta-analysis, the conversion rate varied from 1.1 to 18.0 % in non-obese patients and from 0 to 45.8 % in obese patients [29]; in another study, the visceral obese patients had a 4.1 times greater increased conversion risk [20]. However, intraoperative events, overall postoperative complication rate, postoperative hospital stay, and readmission rates were not different between the high and low VFV groups in this study, similar to other studies [13, 16, 21]. Laparoscopic colorectal surgery in visceral obese patients is a difficult and technically demanding procedure, but it is still safe and feasible when careful consideration regarding the possibility of conversion to open is employed and when meticulous postoperative care is accomplished by an experienced surgeon.

BMI is one of the well-established parameters for defining obesity because of its simplicity and convenience. However, BMI is not a reliable parameter across ethnic groups because the average BMI of Asian populations is lower than that of non-Asian populations [25]. According to the IOTF [30], the definition of obesity based on BMI in Asians is 25.0 kg/m^2, which is less than the cut-off of 30 kg/m^2 by WHO definition. Some authors have recommended that visceral obesity is a more useful and reliable parameter than BMI [13, 14, 16–20]. In this study, there were no significant differences regarding the surgical outcomes between the two groups classified based on a BMI of 25.0 kg/m^2.

To define visceral obesity, several parameters have been used, including waist circumference, waist–hip ratio, visceral fat surface area, or volume of visceral fat [13, 17, 18, 20]. A study suggested that other modalities, except VFV, do not permit accurate quantification of the abdominal adipose tissue depot and may be unrelated to the amount of visceral fat tissue [23]. The study suggested that quantifying abdominal adipose tissue using CT volumetry is a more accurate and reproducible technique and can depict age- and gender-related differences in visceral and subcutaneous abdominal adipose tissue deposition [23]. For these reasons, we used the volume of visceral fat for determining visceral obesity. Because most patients with colorectal cancer usually undergo preoperative CT scanning for preoperative metastatic evaluation, CT volumetry can be an available and useful tool for measuring visceral fat without further cost [21]. Nevertheless, there were few reports on the association between visceral obesity and surgical outcomes in laparoscopic colorectal surgery, based on VFV. VFV can be easily measured using the volumetry program automatically assessing body fat from CT DICOM data [22].

Only 14 (2.6 %) of patients were converted to open laparotomy in this study. Comparing with the western cohort (Cecchini et al.), the mean values of VFV were 2.2 ± 1.0 vs. 1.6 ± 0.7 dm^3 in male and 1.5 ± 0.9 vs. 1.3 ± 0.6 dm^3 in female, respectively. So the extremely low conversion rate might come from the relatively less obese population. However, the mean BMI of our cohort was not significantly different from that of other Asian cohort [6, 10]. After overcoming learning curve, our group had reached the stable rate of conversion. In a randomized clinical trial, our group showed the 1.2 % of conversion rate in laparoscopic rectal surgery [31]. And the rate of this study is comparable with other Asian study groups (7.7 % in Kang K et al. and 7.3 % in Yamamoto S et al.) [6, 13]. In this study, study population was not selected. We tried to apply laparoscopic resection regardless of the obesity. Finally, this study showed that visceral obesity can be a more risk factor for difficult laparoscopic surgery than BMI in Asian population.

In this study, previous laparotomy history was another significant risk factor for conversion. Historically, previous laparotomy history has been considered a contraindication for laparoscopic colectomy because of the potential to encounter adhesions intraoperatively that could lead to bleeding, organ damage, and bowel injury [32, 33]. Menzies et al. reported that 93 % patients with a previous laparotomy history had intra-abdominal adhesions on relaparotomy [34]. There are controversies regarding the relationship between the history of previous laparotomy and conversion to open surgery in laparoscopic colorectal surgery [28–30, 35, 36]. However, a recent large-scale study showed that previous laparotomy is no longer a contraindication [37].

The limitations of this study were its retrospective design and the fact that it involved a single institution and no definite cut-off value for defining obesity in the normal Asian population based on VFV. Prospective multicenter studies are needed for more solid results, especially in Western populations. However, this study had the advantage of evaluating the relationship between visceral obesity and surgical outcomes in laparoscopic colorectal surgery.

Conclusions

Visceral obesity can be a more clinically useful predictor than BMI in predicting surgical outcomes for laparoscopic colorectal cancer surgery. In visceral obese patients, significant higher open conversion rate and postoperative major complication were shown in this study. Before surgery, the careful considering of surgical plan should be established on visceral obese patients. During laparoscopic surgery, the operator always keeps in mind about the possibility of conversion or any unexpected event. After surgical procedure, expecting, careful, and meticulous postoperative care can guarantee the advantage of minimal invasive surgery to minimize the adverse surgical outcome.

Conflict of interest Drs. Byung Kwan Park, Ji Won Park, Seung-Bum Ryoo, Seung-Yong Jeong, Kyu Joo Park and Jae-Gahb Park have no conflicts of interest or financial ties to disclose.

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