Int J Colorectal Dis (2012) 27:497–505
DOI 10.1007/s00384-011-1333-2

ORIGINAL ARTICLE

Impact of fat obesity on laparoscopic total mesorectal excision: more reliable indicator than body mass index

Jeonghyun Kang · Song-Ee Baek · Taehyung Kim · Hyuk Hur · Byung Soh Min · Joon Seok Lim · Nam Kyu Kim · Kang Young Lee

Accepted: 20 October 2011 / Published online: 9 November 2011

Abstract

Background The aim of this study was to evaluate the impact of visceral fat obesity (VFO) on early surgical and oncologic outcomes of laparoscopic total mesorectal excision (LTME) for rectal cancer.

Patients and Methods Between June 2003 and June 2009, a total of 142 patients who had undergone LTME were included. Patients were divided into the obese group (OG) and the non-obese group (NOG) according to BMI and visceral fat area (VFA). Obesity was defined by BMI ≥25 kg/m² or VFA ≥130 cm².

Results There were 37 (26.0%) and 29 (20.4%) obese patients according to BMI and VFA, respectively. The OG, defined by both VFA and BMI, had a significantly longer operative time. The VFO group experienced more frequent conversion to laparotomy (17.2% vs. 5.0%; $P=0.047$) and significantly higher blood loss during surgery (205.8±257.0 mL vs. 102.5±219.9 mL; $P=0.031$), whereas there was no significant difference when defined by BMI. Time to first flatus was significantly longer in the VFO group compared with the NOG (mean 3.5 days vs. 2.7 days; $P=0.046$), whereas it was not significantly different when classified by BMI. Regarding oncologic parameters, the VFO group had a significantly higher number of patients from whom less than 12 total lymph nodes were retrieved (65.5% vs. 34.5%; $P=0.002$); however, there was no difference between the two groups defined by BMI.

Conclusion VFO is proven to be a more reliable predictive factor than BMI in estimating early surgical outcomes for patients who underwent LTME. VFO is associated with fewer numbers of retrieved lymph nodes.

Keywords Obesity · Visceral fat · Body mass index · Rectal neoplasm · Total mesorectal excision

Introduction

As laparoscopic surgery has been penetrated rapidly in the management of colon cancer based on evidence of oncologic safety and advantages of short-term surgical outcomes, it has been also tried for treatment of rectal cancer because of the potential benefits of a minimally invasive approach [1–3]. However, laparoscopic rectal surgery has been regarded as a challenging procedure. A high conversion rate or a considerable rate of circumferential resection margin involvement in a well-designed multicenter clinical trial might reflect the technical complexity of laparoscopic rectal surgery [2]. Postoperative complications delayed patient recovery. Even worse, conversion or anastomotic leakage has been proven to be

J. Kang · T. Kim · H. Hur · B. S. Min · N. K. Kim · K. Y. Lee (✉)
Department of Surgery, Yonsei University Health System,
Yonsei University College of Medicine,
250 Seongsanno, Seodaemun-gu,
Seoul, Korea 120-752
e-mail: kylee117@yuhs.ac

S.-E. Baek · J. S. Lim
Department of Diagnostic Radiology, Yonsei University Health System, Yonsei University College of Medicine,
Seoul, Korea

associated with poor prognosis [3–5]. For this reason, proper patient selection for laparoscopic rectal surgery would be important in efforts to obtain better outcomes.

Obesity has been known as a contributing factor to technical difficulties in the performance of surgery and in postoperative morbidities in colorectal cancer surgery [6]. An excessive amount of visceral fat could be an obstacle to finding and keeping the exact dissection plane during the procedure, especially in the laparoscopic approach [7, 8]. Moreover, the number of retrieved lymph nodes could be affected by obesity [9, 10]. Body mass index (BMI) has been used to define obesity. In western studies, a BMI over 30 kg/m^2 is usually defined as obese using the World Health Organization (WHO) classification [7, 11]. However, because the average BMI might be different according to geography [12, 13], the definition of obesity by BMI differs among various ethnic groups in that obesity in Japan is adequately specified as BMI≥ 25 kg/m^2 by the Japan Society for the Study of Obesity [14]. Furthermore, it has been reported that BMI was not always consistent with visceral fat area [12, 14]. Visceral fat has been proposed as an alternative to BMI for a more accurate prediction of surgical complexity and morbidity in the management of colon cancer with laparoscopic technique [15, 16]. In laparoscopic rectal cancer surgery, precise prediction of obesity would be valuable in the determination of the high-risk group for technical difficulty, which could result in the optimization of minimally invasive techniques. However, the significance of visceral fat in surgical outcomes after laparoscopic rectal resection remains inconclusive since there are few reports on the impact of visceral fat obesity (VFO) on surgical morbidity and oncologic outcomes [17].

The aim of this study was to investigate the impact of VFO on early postoperative outcomes and pathological parameters in laparoscopic rectal cancer surgery.

Patients and methods

Eligibility

Between June 2003 and June 2009, a total of 142 patients who underwent laparoscopic surgery with curative intent for adenocarcinoma located within 12 cm from the anal verge were included in the analysis. All included patients underwent abdomino-pelvic computed tomography (APCT) before surgery. No distant metastasis was observed at initial diagnosis. We excluded patients (1) who underwent laparoscopic abdomino-perineal resection or who underwent hand-sewn coloanal anastomosis, (2) for whom visceral fat area could not be calculated from the APCT in the workstation, and (3) who underwent combined resection, which meant that another part of an organ (e.g. gall bladder, ovary, uterus, seminal vesicle, and liver) was resected simultaneously with the main rectal resection.

Preoperative evaluation was performed using a combination of digital rectal examination, rigid sigmoidocopy, colonoscopy, chest X-ray examination, APCT, transrectal ultrasonography, and magnetic resonance imaging.

Surgical procedure

After pneumoperitoneum was accomplished using carbon dioxide, we used either a medial-to-lateral or a lateral-to-medial approach for dissection. The inferior mesenteric artery was ligated at the level of the root (high ligation technique). Splenic flexure mobilization was optional. Total mesorectal excision (TME) was performed for middle or low rectal cancers. TME included the complete removal of the mesorectum circumferentially and distally with dissection to the level of the levator ani muscle. After the dissection was completed, the rectum was transected with an endoscopic linear stapler. The specimen was extracted through a 5–6-cm-sized left lower abdominal incision or low pfannenstiel incision. End-to-end anastomosis was performed using the circular stapler. Air leakage test was performed to confirm anastomosis completeness. Diverting loop ileostomy was applied when assumed necessary by the surgeon depending on the anastomosis status in each patient. Pelvic drain was indwelled routinely [18].

Definitions of perioperative surgical outcomes and data collection

Open procedure was defined as performance of a conventional laparotomy, with an abdominal incision greater in size than that initially planned for specimen delivery [19]. Anastomotic leakage was diagnosed based on clinical signs or image studies. Clinical signs include abdominal pain or fever, discharge of pus or feces through the indwelling drain, local or generalized peritonitis, pus discharge through the anus, etc. Radiologic evaluation was performed to confirm clinical suspicion [18]. Pathologic variables and postoperative outcomes were extracted from our prospectively collected database.

Visceral fat area measurement

All included patients underwent preoperative APCT. A single cross-section image from APCT at the level of the L4–L5 intervertebral space was obtained (Fig. 1) [15, 16, 20–22]. Two experienced radiologists (SE Baek and JS Lim) reviewed all of the APCT studies and measured the total fat area, visceral fat area, and subcutaneous fat area.

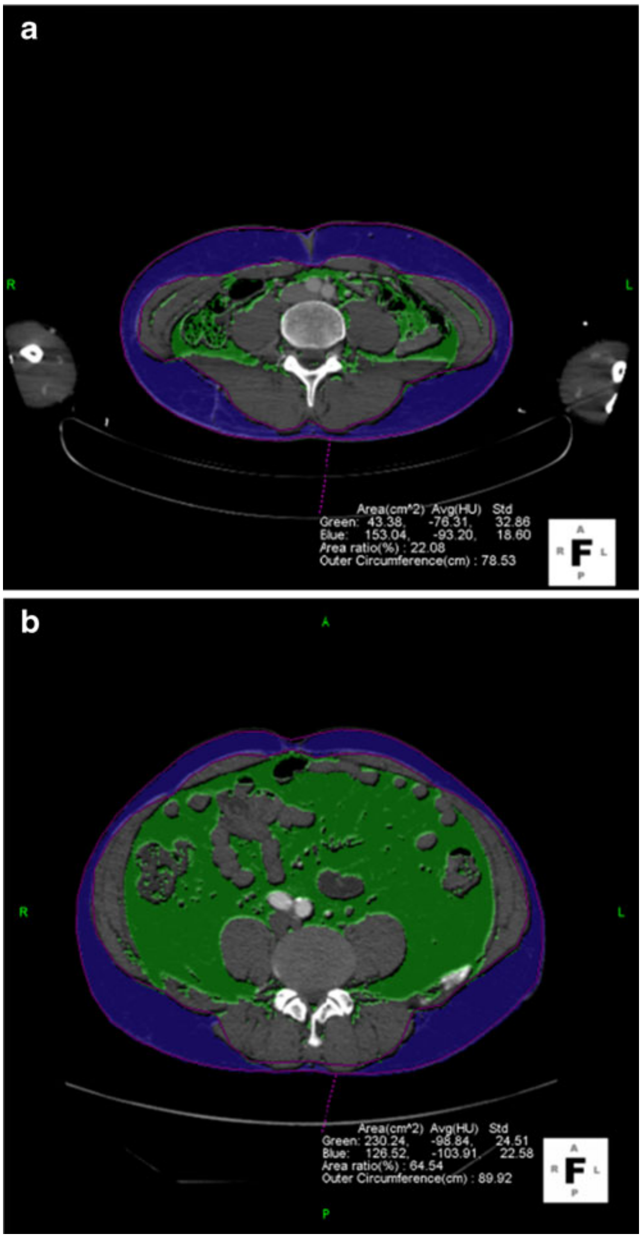

Fig. 1 Measurement of the visceral fat area. Visceral fat areas were obtained using abdomino-pelvic computed tomography and TeraRecon ™ software. Using one cross-sectional scan at the level of the L4–L5 intervertebral space, intraperitoneal tissue is defined by manually tracing its contour on the scan. The *green*-colored area is the manually measured visceral fat area and the *purple*-colored area is the subcutaneous fat area. In this picture, both patients have almost the same body mass index (**a** 24.79 kg/m^2; **b** 24.8 kg/m^2); however, the visceral fat area is significantly different (**a** 43.3 cm^2, **b** 230.2 cm^2)

For measurement of these parameters, the fat margin was manually traced, and calculation of the area was processed on a workstation using imaging software (Aquarius workstation; TeraRecon, San Mateo, CA, USA) (Fig. 1). Radiologists were not informed with regard to clinical data and pathologic results prior to measurement.

Definition of obesity

VFA ≥130 cm^2 was defined as VFO and BMI ≥25 kg/m^2 was defined as BMI obesity (BO). This threshold value was adapted from the previous study [16]. Patients were divided into the obese and the non-obese group according to BMI and VFA and early surgical and oncologic parameters were compared.

Statistical analysis

All statistical analyses were performed using SPSS software, version 12.0 (SPSS, Chicago, IL, USA). Categorical variables were analyzed using chi-square or Fisher's exact test, and continuous variables were analyzed using Student's *t*-test. All variables associated with open conversion or less than 12 examined lymph nodes, with $p<0.25$ in univariate analysis, were entered into multivariate analysis using logistic regression analysis. Disease-free survival (DFS) was defined from the date of surgery to the date of detection of recurrence, last follow-up, or death. Differences in survival between groups were compared using the Kaplan–Meier method and tested with the log-rank test. A p value of <0.05 was considered to indicate significance.

Results

Demographics

A total of 37 (26.0%) patients were categorized as obese patients by BMI, whereas 29 (20.4%) patients were grouped as obese patients by VFA. Incidence of cardiovascular disease was significantly higher in the obese group using either definition. The VFO group was associated with older age and a higher rate of American Society of Anesthesiologist (ASA) grade more than 2. There was no difference in other parameters between the obese and the non-obese group in either definition (Table 1).

Surgical outcomes

Compared with the non-obese group, the obese group, defined by both VFA and BMI, had a significantly longer operative time. The VFO group experienced significantly higher blood loss during surgery (205.8±257.0 mL vs. 102.5±219.9 mL; $p=0.031$), whereas there was no difference when defined by BMI. Time to the first flatus in the VFO was significantly longer compared with that of the non-obese group (mean 3.5 days vs. 2.7 days; $p=0.046$), whereas it was not significantly different when classified by BMI. However, the difference did not last in other following parameters such as day to oral intake or hospital stay (Table 2).

Table 1 Clinicopathological characteristics according to BMI and visceral fat

	BMI (kg/m²)			Visceral fat (cm²)		
	<25, *N*=105 (%)	≥25, *N*=37 (%)	*P*	<130, *N*=113 (%)	≥130, *N*=29 (%)	*P*
Gender						
Male	67 (63.8)	22 (59.5)		73 (64.6)	16 (55.2)	
Female	38 (36.2)	15 (40.5)	0.638	40 (35.4)	13 (44.8)	0.349
Age(mean ± SD) (year)	62.4±10.9	61.8±10.4	0.782	60.9±10.6	67.5±9.6	0.003
Comorbidity						
Cardiovascular	35 (33.3)	22 (59.5)	0.005	39 (34.5)	18 (62.1)	0.007
Endocrine	22 (21.0)	10 (27.0)	0.447	22 (19.5)	10 (34.5)	0.084
PAS	20 (19.0)	8 (21.6)	0.735	22 (19.5)	6 (20.7)	0.883
ASA grade						
1	76 (72.4)	24 (64.9)		84 (74.3)	16 (55.2)	
≥2	29 (27.6)	13 (35.1)	0.389	29 (25.7)	13 (44.8)	0.044
Tumor height (cm)	8.5±2.4	8.2±2.8	0.635	8.3±2.4	9.0±2.6	0.180
Tumor size (cm)						
≤5	77 (73.3)	26 (70.3)	0.720	83 (73.5)	20 (69.0)	0.629
Preoperative CRT	9 (8.6)	0 (0)	0.112[a]	9 (8.0)	0 (0)	0.204[a]
Depth of invasion						
pCR or T1 or T2	44 (41.9)	14 (37.8)		50 (44.2)	8 (27.6)	
T3 or T4	61 (58.1)	23 (62.2)	0.665	63 (55.8)	21 (72.4)	0.103
LN group						
LN (−)	63 (60.0)	25 (67.6)		71 (62.8)	17 (58.6)	
LN (+)	42 (40.0)	12 (32.4)	0.415	42 (37.2)	12 (41.4)	0.677
No. of retrieved LNs	15.5±9.5	15.9±9.3	0.801	16.4±9.3	12.5±9.4	0.046
No. of <12 LNs	42 (40.0)	16 (43.2)	0.730	39 (34.5)	19 (65.5)	0.002

SD standard deviation, *PAS* previous abdominal surgery history, *ASA* American Society of Anesthesiologist, *pCR* pathological complete response, *LN* lymph node, *CRT* chemoradiotherapy

[a]Fisher's exact test

The VFO group experienced more frequent conversion to laparotomy (17.2% vs. 5.3%; $p=0.047$) (Table 3).

Multivariate analysis revealed that a previous abdominal surgery history and VFO were independent predictors of open conversion (hazard ratio 6.3; 95% CI 1.7–23.6, $p=0.006$; hazard ratio 4.0; 95% CI 1.0–15.5, $p=0.041$, respectively) (Table 5).

Postoperative recovery

One postoperative mortality occurred during the study. Although the patient showed good recovery of gastrointestinal function, she failed to extubate several times and died due to pulmonary problems on postoperative day 49. Overall morbidity rate was 23.2%. Regarding

Table 2 Comparison of operative outcomes and early recovery parameters between groups according to BMI and visceral fat obesity

	BMI (kg/m²)			Visceral fat (cm²)		
	<25, *N*=105 (%)	≥25, *N*=37 (%)	*P*	<130, *N*=113 (%)	≥130, N=29 (%)	*P*
Diverting loop ileostomy	19 (18.1)	11 (29.7)	0.136	25 (22.1)	5 (17.2)	0.566
Operative time (min)	252.6±83.1	289.8±76.8	0.018	254.1±79.8	294.3±88.3	0.019
Blood loss (ml)	121.5± 235.1	129.7± 221.3	0.853	102.5± 219.9	205.8± 257.0	0.031
DRM (cm)	2.4±2.0	2.0±1.3	0.286	2.3±2.0	2.3±1.3	0.990
CRM positive	9 (8.6)	2 (5.4)	0.728[a]	9 (8.0)	2 (6.9)	1.0[a]
VAS at POD #1	3.2±1.6	3.5±1.7	0.313	3.4±1.6	3.1±1.7	0.377
Days to first flatus	2.8±1.9	3.1±2.1	0.457	2.7±1.8	3.5±2.3	0.046
Days to oral intake	4.4±2.1	4.4±2.1	0.989	4.3±2.0	4.8±2.3	0.271
Length of hospital stay (day)	11.8±8.0	11.5±5.4	0.825	11.5±7.7	12.5±6.2	0.497

DRM distal resection margin, *CRM* circumferential resection margin, *VAS* visual analogue scale, *POD* post-operative day

[a]Fisher's exact test

Table 3 Reasons for conversion to open laparotomy

	BMI (kg/m^2)		Visceral fat (cm^2)		
Reasons for conversion	< 25, N=105 (%)	≥ 25, N=37 (%)	< 130, N=113 (%)	≥ 130, N=29 (%)	P
Severe adhesions	2	1	2	1	
Bowel distension	1	1	1	1	
Bulky or fixed tumor	2	0	2	0	
Bowel edema due to previous radiation therapy	0	1	0	1	
Unable to find EMR site	0	1	1	0	
EEA Stapler misfire	1	0	0	1	
Ureter injury	1	0	0	1	
Total	7 (6.7)	4 (10.8)	6 (5.3)	5 (17.2)	0.047[a]

EMR endoscopic mucosal resection, *EEA* end-to-end anastomosis

[a] Fisher's exact test

operation-related morbidities, there was no significant difference between obese and non-obese patients using either definition (Table 4).

Early oncologic outcomes

Regarding oncological parameters, significantly more patients in the VFO group had less than 12 retrieved lymph nodes (65.5% vs. 34.5%; p=0.002); however, there was no difference between obese and non-obese groups defined by BMI. Multivariate analysis revealed that a tumor size of less than 5 cm, (y)pT stage(pCR or pT1 or pT2), and VFO were independent predictors of inadequate lymph node retrieval (less than 12 retrieved lymph nodes) (Table 5).

Long-term follow-up results

All patients with diverting loop ileostomy underwent ileostomy repair within several months after the initial surgery (median 6, range 2–11 months). After a median follow-up period of 31.4 months (range 1.6–90.4 months), there was no significant difference of 3-year DFS between the obese group and the non-obese group as defined by BMI and VFA (3-year DFS: 82.5% in patients with BMI< 25 kg/m^2 vs. 76.9% in patients with BMI≥25 kg/m^2, p= 0.390; 82.5% in patients with VFA<130 cm^2 vs. 74.4% in patients with VFA≥130 cm^2, p=0.262) (Fig. 2).

Discussion

The impact of VFO on early surgical or oncological outcomes in patients who have undergone laparoscopic rectal surgery remains controversial. This study shows that VFO can predict technical difficulties in laparoscopic rectal resection more accurately than BMI in terms of increased conversion rate, increased blood loss during surgery, and delayed bowel function recovery. With regard to oncologic outcomes, VFO is associated with a higher proportion of less than 12 retrieved lymph nodes.

Obesity has been known to influence surgical outcomes in open colorectal surgery [6]. With respect to laparoscopic

Table 4 Comparison of operation-related morbidity and mortality between BMI and visceral fat obesity

	BMI (kg/m^2)			Visceral fat (cm^2)		
	<25, N=105 (%)	≥25, N=37 (%)	P	<130, N=113 (%)	≥130, N=29 (%)	P
Postoperative mortality	1 (1.0)	0 (0)	1.0[a]	0 (0)	1 (3.4)	0.204[a]
Complications						
Anastomotic leakage	9 (8.6)	3 (8.1)	1.0[a]	8 (7.1)	4 (13.8)	0.266[a]
SSI(Superficial)	0 (0)	2 (5.4)	0.067[a]	1 (0.9)	1 (3.4)	0.368[a]
Intrapelvic abscess	2 (1.9)	1 (2.7)	1.0[a]	2 (1.8)	1 (3.4)	0.499[a]
Intestinal obstruction	5 (4.8)	0 (0)	0.327[a]	5 (4.4)	0 (0)	0.583[a]
Voiding difficulty	4 (3.8)	2 (5.4)	0.651[a]	5 (4.4)	1 (3.4)	1.0[a]
Others	4 (3.8)	0 (0)	0.573[a]	3 (2.7)	1 (3.4)	1.0[a]
Overall	24 (22.9)	9 (24.3)	0.856	25 (22.1)	8 (27.6)	0.534

SSI surgical site infection

[a]Fisher's exact test

Table 5 Multivariate analysis of surgical outcomes

Dependent variables	Predictive factors	*P*	HR	95% CI
Open conversion	PAS	0.006	6.3	1.7–23.6
	VF≥130 cm^2	0.041	4.0	1.0–15.5
< 12 retrieved LNs	Tumor size≤5 cm	0.001	9.5	2.6–33.9
	pCR or pT1 or pT2	0.010	3.1	1.3–7.4
	VF≥130 cm^2	<0.001	9.2	2.9–29.2
	Preoperative chemoradiotherapy	0.051	5.0	0.9–25.7

HR hazard ratio, *CI* confidence interval, *PAS* previous abdominal surgery history, *VF* visceral fat, *LN* lymph node, *pCR* pathological complete response

colorectal surgery, the impact of obesity on surgical outcomes is inconclusive yet. Some reports have stated that obesity is associated with prolonged operation time, greater risk of postoperative complications, and higher conversion rate [7, 23]. In contrast, other studies have insisted that obesity did not adversely influence postsurgical outcome [11, 24]. In these studies, obesity was determined by BMI since BMI has been accepted as a determinant of obesity due to its simplicity. It has been advocated that most of the technical difficulties during laparoscopic resection originated from limited exposure or difficult dissection due to an excessive amount of visceral fat [7, 8]. It has been reported that BMI was not always consistent with the visceral fat area [12, 14]. Therefore, several studies have attempted to define obesity using visceral fat area. In laparoscopic colorectal surgery, determination of obesity with visceral fat area was reported as a more precise parameter for the prediction of postoperative complications than BMI [15–17]. In the current study, operation time in the obese group, regardless of the method of determination, was significantly longer than that of the non-obese group. However, it could be found only in the VFO group, not in the BMI obese group, that prolonged operation time was associated with an increased amount of blood loss and significant delay of bowel function recovery. Tumor infiltration/fixation, obesity, and adhesion have been known as the most common reasons for conversion in laparoscopic rectal surgery [3]. In this study, it was confirmed that a previous abdominal surgical history and obesity defined by visceral fat area were independent predictors of open conversion in multivariate analysis. However, there was no significant increase in conversion rate in the obese group defined by BMI. These results strongly indicate that visceral fat obesity was a more reliable factor than BMI in the prediction of surgical complexity in laparoscopic rectal resection.

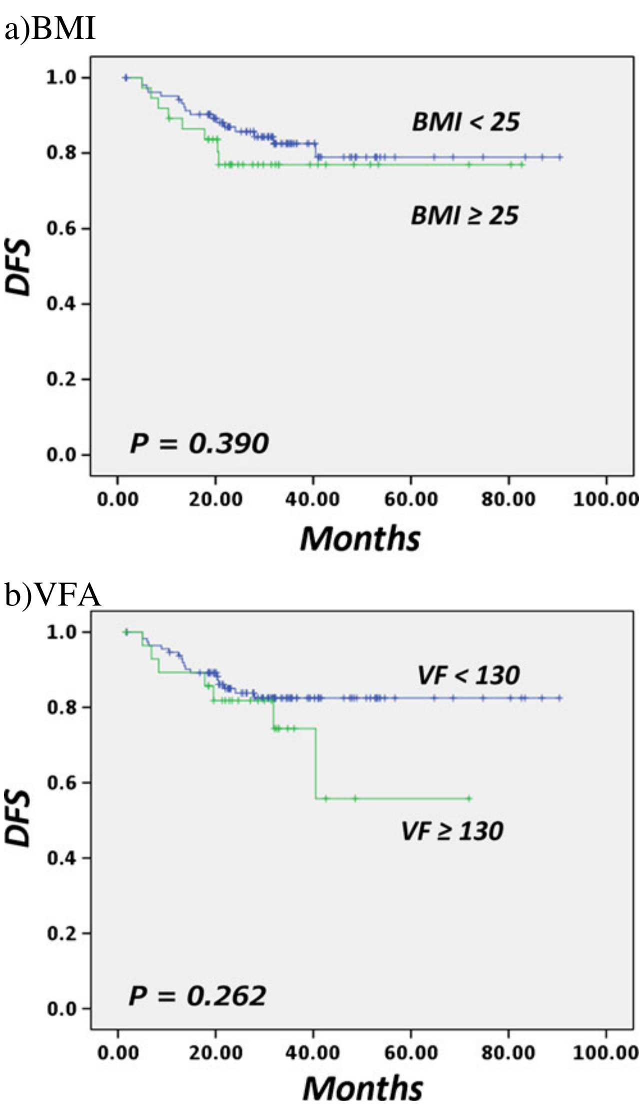

Fig. 2 Comparison of disease-free survival between obese group and non-obese group using either definition. **a** Three-year DFS: 82.5% in patients with BMI<25 kg/m^2 vs. 76.9% in patients with BMI≥25 kg/m^2, p=0.390. **b** Three-year DFS: 82.5% in patients with VFA<130 cm^2 vs. 74.4% in patients with VFA≥130 cm^2, p=0.262

In terms of postoperative complications, surgical morbidity after laparoscopic sigmoidectomy was reported to be significantly increased in the VFO group compared with the non-obese group [16]. Increased morbidity was derived mainly from different rates of wound infection between the obese group and the non-obese group [16]. Our study did not show any significant difference in overall morbidity rate between the obese and the non-obese groups. Also, the individual complication rate, including wound infection and anastomotic leakage, did not differ between the two groups. In our institute, when keeping the right surgical plane in the usual manner was difficult during the laparoscopic approach, conversion to open surgery without delay was indicated. For this reason, VFO would not result in increased morbidity but in an increased rate of conversion to open surgery.

Increased conversion rate and decreased number of retrieved lymph nodes have been found to be associated with VFO in our study. Conversion to open surgery is not only a reflection of surgical complexity but is also regarded as a cause of poor prognosis [3, 4]. Adverse impacts of conversion, such as delayed patient recovery in early postoperative periods or poor oncologic outcomes, may emphasize the need for adequate patient selection in laparoscopic surgery. Therefore, a history of previous abdominal surgery and VFO rather than BMI should be taken into account in patient selection, especially during the early learning curve periods when performing laparoscopic rectal surgery.

In management of colorectal cancer, an adequate number of retrieved lymph node is important for accurate tumor staging and patient prognosis [25, 26]. Higher BMI has been reported as an obstacle to the performance of proper lymph node dissection and was an independent predictor of disease recurrence in T2/T3 gastric cancers [9]. However, the association of retrieved lymph node numbers with obesity was not clearly identified in colorectal cancer. In the current study, VFO patients had a smaller mean number of retrieved lymph nodes and a higher proportion of less than 12 examined lymph nodes. Additionally, VFO was proven as an independent risk factor for inadequate number of retrieved lymph nodes in multivariate analysis. In contrast, using BMI, there was no difference in the mean numbers of retrieved lymph nodes or in the proportion of inadequate lymph node retrieval between obese and non-obese patients. Various factors are known to affect the number of retrieved lymph nodes in rectal cancer surgery [25, 27]. It has been reported that the most significant reduction of mean retrieved lymph node numbers in rectal cancer was observed in obese patients with short specimen length [10]. However, in our series, no significant difference in specimen length was observed between the groups (data not shown). In another point of view, VFO “per se” might act as an obstacle to a thorough search for lymph nodes. During lymph node detection in pathologic examination, it has been well established that the presence of fat tissue makes lymph node discovery difficult, especially in rectal cancer [28]. Recently, another interesting experimental result showed that visceral fat accumulation caused atrophy of mesenteric lymph nodes by inducing T-cell activation-mediated apoptosis in obese mice [29]. Though direct application of this result to humans may be inappropriate, further investigation will be needed.

In the present study, straight end-to-end anastomosis was the preferred method. It was reported that colonic J-pouch (CJP) reconstruction increased reservoir function and provided better short-term functional results than straight anastomosis [30, 31]. CJP reconstruction after TME has become the preferred method in the west. However, in the long-term follow-up, stool evacuation problems were reported, requiring digital evacuation or the use of laxatives [32]. Besides, CJP reconstruction needs a more extensive dissection in order to completely take down the splenic flexure for tension-free anastomosis and could cause difficulty in secure anastomosis because of a bulky colonic J-pouch [31, 33]. For these reasons, all of the enrolled patients in this study underwent straight end-to-end anastomosis.

It should be mentioned that this study has the limitation of defining obesity using BMI. According to WHO classification, obesity by BMI is defined as over 30 kg/m^2, while BMI over 25 kg/m^2 is defined as overweight. However, due to the diversity of mean BMI according to geography, the definition of obesity by BMI is inevitably different among various ethnic groups [12]. Asian populations may have greater visceral adiposity; however, BMI is relatively lower than in non-Asian populations [14]. The percentage of the population with BMI over 30 kg/m ^{2} is no more than 2.0–3.0% in Japan [34]. In our study group, only 3.5% of the enrolled patients are equivalent to the definition of obesity by BMI. For this reason, obesity by BMI would be defined with the cutoff value of 25 kg/m^2 in studies with Asian populations [15–17]. Even though our definition of obesity is not relevant to regions of higher BMI, we thought that the contradictive impact of BMI on surgical outcomes for laparoscopic rectal surgery originated mainly from the fact that BMI could not adequately reflect visceral fat adiposity. To determine more reliable parameters presenting visceral fat adiposity, the impact of visceral fat in the field of surgery such as gastric or colorectal operation has been discussed mainly in Asian populations [15–17, 35, 36]. According to previous results on the impact of visceral fat on surgical outcomes, including ours, visceral fat obesity may be a useful tool for prediction of difficulties in general surgery. However, to clarify the conclusion, further studies, especially after including more patients with higher BMI, are warranted.

In this study, we intended to investigate the usefulness of visceral fat obesity for prediction of surgical difficulties. For this purpose, the validity or feasibility of visceral fat measurement should be established. Visceral fat measurement with CT scan might be one of the reliable modalities for use in defining visceral fat obesity. It was reported that visceral fat areas from a single scan obtained at the level of the umbilicus (approximately at the level of L4 and L5) were highly correlated with the total visceral fat volume [20–22]. The visceral fat area was measured manually by a radiologist and then calculated mechanically by a computer system [15, 16]. It was a simple procedure, not a special technique; therefore, we believe that any radiologist could easily perform the VF measurement using CT imaging. However, it might take some time and require special software and equipment. These situations might be the limitation of using VFA in daily clinical work. In one study, waist circumference showed the closest relationship with VFA among convenient anthropometric parameters, such as BMI, waist circumference, waist/hip ratio, and waist/body height ratio [14]. As far as we know, no simple alternative parameter for VFA measurement has been definitely confirmed according to current evidence. This might be another issue for further evaluation. Besides, the cutoff value of 130 cm^2 for definition of visceral obesity in this study might be somewhat arbitrary. We expect that additional investigation on this subject could result in a more delicate or reliable parameter on the definition of visceral fat obesity.

In conclusion, VFO can be used as a more accurate predictor of surgical complexity than BMI. VFO should be taken into account especially during the early period of the learning curve when planning laparoscopic rectal resection. Additionally, VFO is associated with a smaller number of retrieved lymph nodes. Therefore, close pathologic inspection using a fat clearing method might be required for VFO patients after laparoscopic rectal surgery, although long-term oncologic impact of the small number of examined lymph nodes in these patients needs to be carefully investigated.

References

1. Clinical Outcomes of Surgical Therapy Study Group (2004) A comparison of laparoscopically assisted and open colectomy for colon cancer. N Engl J Med 350:2050–2059
2. Guillou PJ, Quirke P, Thorpe H, Walker J, Jayne DG, Smith AM et al (2005) Short-term endpoints of conventional versus laparoscopic-assisted surgery in patients with colorectal cancer (MRC CLASICC trial): multicentre, randomised controlled trial. Lancet 365:1718–1726
3. Poon JT, Law WL (2009) Laparoscopic resection for rectal cancer: a review. Ann Surg Oncol 16:3038–3047
4. Rottoli M, Bona S, Rosati R, Elmore U, Bianchi PP, Spinelli A et al (2009) Laparoscopic rectal resection for cancer: effects of conversion on short-term outcome and survival. Ann Surg Oncol 16:1279–1286
5. Ptok H, Marusch F, Meyer F, Schubert D, Gastinger I, Lippert H (2007) Impact of anastomotic leakage on oncological outcome after rectal cancer resection. Br J Surg 94:1548–1554
6. Gendall KA, Raniga S, Kennedy R, Frizelle FA (2007) The impact of obesity on outcome after major colorectal surgery. Dis Colon Rectum 50:2223–2237
7. Bege T, Lelong B, Francon D, Turrini O, Guiramand J, Delpero JR (2009) Impact of obesity on short-term results of laparoscopic rectal cancer resection. Surg Endosc 23:1460–1464
8. Rullier E, Sa Cunha A, Couderc P, Rullier A, Gontier R, Saric J (2003) Laparoscopic intersphincteric resection with coloplasty and coloanal anastomosis for mid and low rectal cancer. Br J Surg 90:445–451
9. Dhar DK, Kubota H, Tachibana M, Kotoh T, Tabara H, Masunaga R et al (2000) Body mass index determines the success of lymph node dissection and predicts the outcome of gastric carcinoma patients. Oncology 59:18–23
10. Gorog D, Nagy P, Peter A, Perner F (2003) Influence of obesity on lymph node recovery from rectal resection specimens. Pathol Oncol Res 9:180–183
11. Leroy J, Ananian P, Rubino F, Claudon B, Mutter D, Marescaux J (2005) The impact of obesity on technical feasibility and postoperative outcomes of laparoscopic left colectomy. Ann Surg 241:69–76
12. WHO expert consultation (2004) Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. Lancet 363:157–163
13. Zheng W, McLerran DF, Rolland B, Zhang X, Inoue M, Matsuo K et al (2011) Association between body-mass index and risk of death in more than 1 million Asians. N Engl J Med 364:719–729
14. Japan Society for the Study of Obesity (2002) New criteria for 'obesity disease' in Japan. Circ J 66:987–992
15. Seki Y, Ohue M, Sekimoto M, Takiguchi S, Takemasa I, Ikeda M et al (2007) Evaluation of the technical difficulty performing laparoscopic resection of a rectosigmoid carcinoma: visceral fat reflects technical difficulty more accurately than body mass index. Surg Endosc 21:929–934
16. Tsujinaka S, Konishi F, Kawamura YJ, Saito M, Tajima N, Tanaka O et al (2008) Visceral obesity predicts surgical outcomes after laparoscopic colectomy for sigmoid colon cancer. Dis Colon Rectum 51:1757–1765, discussion 1765–1757
17. Ishii Y, Hasegawa H, Nishibori H, Watanabe M, Kitajima M (2005) Impact of visceral obesity on surgical outcome after laparoscopic surgery for rectal cancer. Br J Surg 92:1261–1262
18. Kim JS, Cho SY, Min BS, Kim NK (2009) Risk factors for anastomotic leakage after laparoscopic intracorporeal colorectal anastomosis with a double stapling technique. J Am Coll Surg 209:694–701
19. Laurent C, Leblanc F, Bretagnol F, Capdepont M, Rullier E (2008) Long-term wound advantages of the laparoscopic approach in rectal cancer. Br J Surg 95:903–908
20. Sjostrom L, Kvist H, Cederblad A, Tylen U (1986) Determination of total adipose tissue and body fat in women by computed tomography, 40K, and tritium. Am J Physiol 250:E736–E745
21. Kvist H, Chowdhury B, Sjostrom L, Tylen U, Cederblad A (1988) Adipose tissue volume determination in males by computed tomography and 40K. Int J Obes 12:249–266
22. Yoshizumi T, Nakamura T, Yamane M, Islam AH, Menju M, Yamasaki K et al (1999) Abdominal fat: standardized technique for measurement at CT. Radiology 211:283–286
23. Schwandner O, Farke S, Schiedeck TH, Bruch HP (2004) Laparoscopic colorectal surgery in obese and nonobese patients: do differences in body mass indices lead to different outcomes? Surg Endosc 18:1452–1456
24. Tuech JJ, Regenet N, Hennekinne S, Pessaux P, Bergamaschi R, Arnaud JP (2001) Laparoscopic colectomy for sigmoid diverticulitis in obese and nonobese patients: a prospective comparative study. Surg Endosc 15:1427–1430
25. Tepper JE, O'Connell MJ, Niedzwiecki D, Hollis D, Compton C, Benson AB 3rd et al (2001) Impact of number of nodes retrieved on outcome in patients with rectal cancer. J Clin Oncol 19:157–163
26. Chang GJ, Rodriguez-Bigas MA, Skibber JM, Moyer VA (2007) Lymph node evaluation and survival after curative resection of colon cancer: systematic review. J Natl Cancer Inst 99:433–441
27. Mekenkamp LJ, van Krieken JH, Marijnen CA, van de Velde CJ, Nagtegaal ID (2009) Lymph node retrieval in rectal cancer is dependent on many factors—the role of the tumor, the patient, the surgeon, the radiotherapist, and the pathologist. Am J Surg Pathol 33:1547–1553

28. Cawthorn SJ, Gibbs NM, Marks CG (1986) Clearance technique for the detection of lymph nodes in colorectal cancer. Br J Surg 73:58–60
29. Kim CS, Lee SC, Kim YM, Kim BS, Choi HS, Kawada T et al (2008) Visceral fat accumulation induced by a high-fat diet causes the atrophy of mesenteric lymph nodes in obese mice. Obesity (Silver Spring) 16:1261–1269
30. Hida J, Yoshifuji T, Tokoro T, Inoue K, Matsuzaki T, Okuno K et al (2004) Comparison of long-term functional results of colonic J-pouch and straight anastomosis after low anterior resection for rectal cancer: a five-year follow-up. Dis Colon Rectum 47:1578–1585
31. Liang JT, Lai HS, Lee PH, Huang KC (2007) Comparison of functional and surgical outcomes of laparoscopic-assisted colonic J-pouch versus straight reconstruction after total mesorectal excision for lower rectal cancer. Ann Surg Oncol 14:1972–1979
32. Dehni N, Tiret E, Singland JD, Cunningham C, Schlegel RD, Guiguet M et al (1998) Long-term functional outcome after low anterior resection: comparison of low colorectal anastomosis and colonic J-pouch–anal anastomosis. Dis Colon Rectum 41:817–822, discussion 822–813
33. Wexner SD, Alabaz O (1998) Anastomotic integrity and function: role of the colonic J-pouch. Semin Surg Oncol 15:91–100
34. Yoshiike N, Matsumura Y, Zaman MM, Yamaguchi M (1998) Descriptive epidemiology of body mass index in Japanese adults in a representative sample from the National Nutrition Survey 1990–1994. Int J Obes Relat Metab Disord 22:684–687
35. Tanaka K, Miyashiro I, Yano M, Kishi K, Motoori M, Seki Y et al (2009) Accumulation of excess visceral fat is a risk factor for pancreatic fistula formation after total gastrectomy. Ann Surg Oncol 16:1520–1525
36. Kunisaki C, Makino H, Takagawa R, Sato K, Kawamata M, Kanazawa A et al (2009) Predictive factors for surgical complications of laparoscopy-assisted distal gastrectomy for gastric cancer. Surg Endosc 23:2085–2093