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Preoperative Radiological Evaluation of Visceral Obesity: A Potential Tool for the Prediction of Anastomotic Leak after Laparoscopic Resection for Rectal Cancer

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Abstract

Background: Visceral obesity has been evaluated as a predictive factor for the surgical difficulty of laparoscopic total mesorectal excision of rectal cancer, with conflicting results. Few reports have assessed this concept in a Western population, with a higher prevalence of obesity.

Objective: This retrospective cohort study evaluated the impact of visceral obesity on surgical difficulty and postoperative oncological outcomes. All patients from 2003 through 2014 who had laparoscopic lower anterior rectal cancer resection were included. Incidence of anastomotic leak 90 days post-surgery, operative time, completeness of resection, and locoregional recurrence were the outcomes evaluated.

Results: Among the 139 patients included in our analysis, mean BMI was 27.4 ± 5.2 kg/m^2. Anastomotic leaks were observed in 24 patients (17%). Successful surgical resection was achieved in 87% of patients (94/108). After a median follow-up of 73.6 months (interquartile range 51.9; 96.3), 12 patients (9%) experienced locoregional recurrences. The 5-year overall survival was 81% (103/127). Total Fat Area (TFA) (odds ratio 1.007, 95% CI 1.001-1.014, p=0.006) and Mesorectal Area (MA) (odds ratio1.063, 95% CI 1.004-1.125, p=0.028) were associated with an increased risk of anastomotic leak in multivariate analysis. Three radiological measures were associated with an increased operative time: Intrapelvic Area (IPA)/MA (p<0.001), Mesorectal Fat Area (MFA) (p<0.001), and the ratio of Visceral Fat Area (VFA) to Subcutaneous Fat Area (SFA) (p=0.042). No radiological measures showed a predictive value for the outcomes of successful resection, locoregional recurrence, or 5-year overall survival.

Conclusion: An increase in MA or TFA was associated with an increased risk of anastomotic leak. IPA/MA, MFA and VFA/SFA were significantly associated with increased risk of prolonged operative time. Visceral obesity was not associated with worse oncological outcomes.

Keywords: Rectal cancer; Surgical difficulty; Recurrence; Anastomotic leak

Introduction

For the management of rectal cancer, laparoscopic Total Mesorectal Excision (TME) has similar oncologic outcomes as the open approach, while also being associated with improved postoperative recovery [1,2]. However, in some patients, laparoscopic mesorectal dissection can be technically difficult to perform, especially in male patients with a narrow pelvis, bulky mesorectum, or lower rectal lesion [3-6]. Predicting surgical difficulty from preoperative evaluations remains challenging.

Body Mass Index (BMI) has been studied for its association with unfavorable postoperative evolution with conflicting results [7-12]. A recent study by Verduin et al. suggested, however, that the association of BMI with anastomotic leak after colon cancer resection is attributable to the levels of visceral fat [13]. Many previous reports have assessed the impact of Visceral Obesity (VO) on surgical difficulty in Asian populations [9,10,14-19]. Few studies have evaluated the influence of VO in Western populations, however, and Western populations tend to have higher BMIs with lower body fat percentages [20,21]. Our aim was to evaluate the influence of intra-abdominal and pelvic adipose deposition, as determined in preoperative imaging studies, on perioperative and

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oncological outcomes following laparoscopic rectal cancer resection in a North American cohort.

Materials and Methods

Study design and patients

All patients who had a rectal cancer resection from 2003 through 2014 performed by the colorectal unit at Centre Hospitalier Universitaire (CHU) de Quebecat Laval University were evaluated. Patients were included in the study if TME was performed laparoscopically and if pelvic Magnetic Resonance Imaging (MRI) and abdominal Computed Tomography (CT) scans performed 6 months or less before surgery were available for analysis. Patients were excluded from analysis if they were younger than 18 years of age or if they had an open resection, an abdominoperineal resection, or a multivisceral resection. The requirement for informed consent was waived after the study protocol was approved by the ethics committee of the Centre Hospitalier Universitaire de Québec-Université Laval.

Surgical procedure and follow-up

All laparoscopic TMEs were performed by surgeons who were fellowship trained in colorectal or minimally invasive surgery, assisted by surgical residents. Rectal resections were performed according to total mesorectal excision principles [22]. Either a stapled or a hand-sewn anastomosis was performed. The technique used for delayed coloanal anastomosis was described previously [23]. Routine water-soluble enema was performed before stoma closure.

A standard oncological follow-up was performed for all patients. Physical examination and carcinoembryonic antigen testing were performed every 3 to 6 months for the first 3 years, then every 6 months for the next 2 years. The first postoperative colonoscopy was performed 1 year after surgery or earlier if a complete preoperative endoscopic evaluation was not available. If normal, the next endoscopic evaluation was performed after 3 years, and then every 5 years. Postoperative CT scans were obtained every 6 to 12 months for the first 3 years, then every 12 months for the next 2 years.

Clinical data collection

All patients having a radical resection for rectal cancer during the study period were identified through medical records. Charts and imaging studies from patients meeting the inclusion criteria were reviewed. Demographic features at primary surgery and postoperative follow-up data from surgeons, hematologists, and radiation oncologists were collected from our data system. The original pathology report was used to assess the completeness of tumor resection. Reports of imaging studies (CT scan, MRI, or Positron Emission Tomography (PET) scans) performed at our center and other regional medical centers were consulted for postoperative complications and oncological recurrences. Patients or their families were contacted in 2018 to inquire about potential oncological recurrence and postoperative mortality. The last review of patient follow-up was performed in October 2021.

Radiological data collection

Radiological measurements were defined collaboratively by a radiologist and a colorectal surgeon. Following training on radiological data acquisition techniques, measurements at the umbilical level were performed by 2 medical students and 1 Post-Graduate Year-One (PGY-1) resident in diagnostic radiology. Using preoperative CT scans and the Syngo.via™ software (Version VB40, Siemens Healthcare GmbH, Erlangen, Germany), abdominal tissue composition was evaluated using the difference in Hounsfield Units (HU). Adipose tissue was defined as having an attenuation level ranging from -200 HU to -40 HU. Measurements were obtained at the umbilical level in planes perpendicular to the posterosuperior vertebral end plate of S1 (Figure 1A, 1B). Abdominal circumference was measured, and Total Fat Area (TFA) was defined as the area occupied by adipose tissue in the area manually traced to delineate the abdominal circumference (Figure 2A) [10,16,19]. Adipose tissue measured in the area delimited by the internal edge of the parietal peritoneum was defined as the Visceral Fat Area (VFA) [9,10,16-19]. Subcutaneous Fat Area (SFA) was obtained by subtracting VFA from TFA [17,19]. A ratio of VFA/SFA was then calculated using the IMPAX Software (Agfa HealthCare Inc., Version 6.7.0.3502).

Pelvic radiological evaluations were performed by the PGY-1 resident using T2-weighted images on preoperative MRI. On the axial plane at the level of the ischial tuberosities, Intrapelvic Area (IPA) was defined as the area delimited by the inner margin of the pelvic fascia (Figure 2B). The Mesorectal Area (MA) was delimited by the mesorectal fascia [3,14]. The Rectal Area (RA) was identified by the outer wall of the muscularis propria [3,14]. If the rectal tumor had transgressed the muscularis propria, the delimitation was continued along the prolongation of the outer wall of the rectum [3,14]. The anteroposterior and left-to-right mesorectal fat thickness were measured at this level [3]. The ratio of IPA/MA at the level of the ischial tuberosities was calculated to evaluate the potential interaction of pelvic fat tissue as compared with the mesorectal area. Finally, the Mesorectal Fat Area (MFA) was obtained by subtracting RA from MA [3,14].

All observers were blinded to postoperative outcomes. Study data were collected and managed using REDCap electronic data capture tools hosted at Université Laval [24,25]. All measurements were reviewed by a PGY-5 resident supervised by a radiologist for accurateness and quality control, and corrections were made when required. If more than one imaging study was available, the study closest to the surgery date was used for analysis.

Study outcomes

The primary outcome was the incidence of anastomotic leak 90 days post-surgery, defined as an intestinal wall defect with secondary communication with the extraluminal compartments confirmed either clinically, endoscopically, or radiologically [26]. A secondary outcome, which was used as a surrogate for surgical difficulty, was a prolonged operative time, defined as ≥ 75^{th} percentile of operative times for this cohort, which corresponded to ≥ 290 min.

To assess the potential impact of radiological measures on postoperative oncological evolution, the completeness of surgical resection was also evaluated as a secondary outcome, and was defined using the criteria proposed in the ACOSOG Z6051 randomized clinical trial [27]. A composite outcome of successful resection, defined as a complete or nearly complete total mesorectal excision, a negative Circumferential Resection Margin (CRM) and a negative distal resection margin (both defined as adenocarcinoma at ≥ 1 mm), was also assessed [28]. Another secondary outcome was the incidence of locoregional recurrence during the entire follow-up period. Recurrence was defined as a pelvic mass progressing in size on successive radiological evaluations. Pathological confirmation following a biopsy or surgical resection was also considered a recurrence. Five-year Overall Survival (OS) was evaluated as a final secondary outcome.

Statistical analysis

Continuous data were presented as either mean with standard deviation or in median with Interquartile Range (IQR) depending on the normality of the data distribution. Categorical data were presented as proportions.

For categorical outcomes, multivariate logistic regression analyses were performed to assess potential risk factors. For the outcome of locoregional recurrence, a multivariate Cox regression was used. In addition to the radiological measures of interest, relevant clinical covariables were evaluated for their confounding effect on the outcomes assessed. Odds Ratios (OR) or Hazard Ratios (HR) with 95% Confidence Intervals (CI) was calculated as appropriate. For locoregional recurrence, the date of the last clinical, radiological, or endoscopic assessment was used as the end of the period at-risk for recurrence.

For all regression a model, a stepwise selection process was performed, with a p-value ≤ 0.15 stated as the inclusion criterion for the multivariate analysis. A p-value ≤ 0.05 was considered significant. Finally, exploratory analyses were performed using receiver-operating-characteristic curves with Youden's index to establish optimal cut-point values for continuous radiological variables that met the statistical significance threshold. Bivariate logistic analyses assessing these new dichotomous variables were used to produce ORs with improved clinical significance. Statistical analyses were performed using SAS University Edition (© 2012-2020, SAS Institute Inc., Cary, NC, USA).

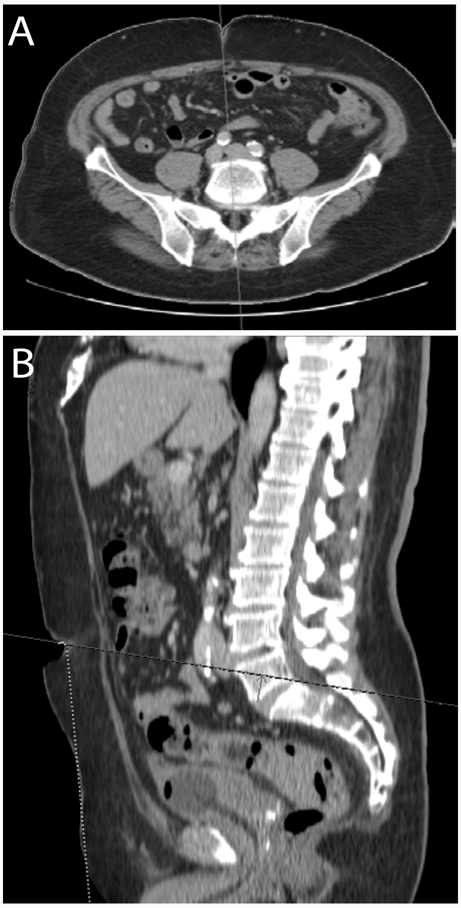

Figure 1: Anatomical landmarks for radiological measurements obtained at the umbilical level through the posterosuperior aspect of the vertebral end plate of S1. A) Axial plane. B) Sagittal plane.

Results

During the study period, 569 patients had a resection for rectal cancer at our center (Figure 3). After exclusions, 139 adult patients who had a laparoscopic low anterior resection were included in our analysis. These patients were 65 ± 11 years old with a mean BMI of 27.4 ± 5.2 kg/m^2, and most were male (76%) (Table 1). Anastomotic leak was observed in 24 patients (17%) within 90 days of surgery (Table 2).

Pathological analysis indicated that positive distal margins were present in 3 patients (2%), and positive circumferential margins were observed in 4 patients (3%), (Table 3). TME was complete or near complete for 92% of the patients analyzed (98/107), and surgical resection was successful, as defined by the composite outcome, in 87% of patients (94/108). After a median postoperative follow-up of 73.6 months (IQR 51.9, 96.3), recurrence was observed in 36 patients (26%), with 12 locoregional recurrences (9%). The 5-year overall survival rate was 81% (103/127). The CT scans and MRIs used for radiological analysis (Table 4) were performed, respectively, at a median 44 days (IQR 16, 132) and 97 days (IQR 26, 134) before surgery.

For the primary outcome of anastomotic leak, TFA (OR: 1.007, 95% CI 1.001-1.014, p=0.006), MA (OR: 1.063, 95% CI 1.004-1.125, p=0.028), and creation of a reservoir were associated with an increased risk of leak in multivariate analysis (Table 5). In exploratory analysis, after dichotomization of the continuous radiological variables, both increased TFA (>159.5 cm^2, OR: 4.46, 95% CI 1.38-14.37, p=0.012) and increased MA (>43.39 cm^2, OR: 6.35, 95% CI 1.98-20.38, p=0.002)

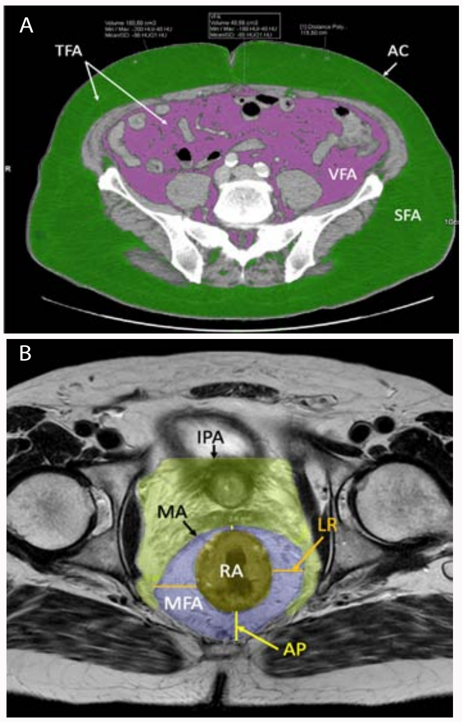

Figure 2: A) Radiological measurements at the umbilical level. B) Radiological measures at the level of the ischial tuberosities.
TFA: Total Fat Area; VFA: Visceral Fat Area; SFA: Subcutaneous Fat Area; AC: Abdominal Circumference; IPA: Intrapelvic Area; MA: Mesorectal Area; RA: Rectal Area; MFA: Mesorectal Fat Area; AP: Anteroposterior Mesorectal Fat Thickness; LR: Left-to-Right mesorectal Fat Thickness

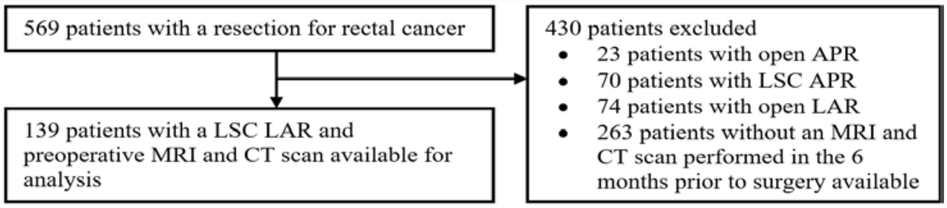

Figure 3: Flowchart detailing patients evaluated and included in the study.
APR: Abdominoperineal Resection; LSC: Laparoscopic; LAR: Lower Anterior Resection; MRI: Magnetic Resonance Imaging; CT: Computerized Tomography

Table 1: Patient demographics.

Characteristic	n (%)[1]
Age, mean ± SD, years	65 ± 11
BMI, mean ± SD, kg/m^2	27.4 ± 5.2
Normal weight (<25)	47 (34)
Overweight (25.0-29.9)	52 (37)
Obesity Class I (30.0-34.9)	30 (22)
Obesity Class II (35.0-39.9)	3 (2)
Obesity Class III (≥ 40)	7 (5)
Sex	
Male	105 (76)
Female	34 (24)
Charlson score, median (IQR)	2 (2; 3)
ASA score	
1	63 (45)
2	60 (43)
3	15 (11)
4	1 (1)
Clinical tumor stage	
cT1	5 (4)
cT2	42 (30)
cT3	90 (65)
cT4	2 (1)
Clinical nodal stage	
cN0	82 (59)
cN1	51 (37)
cN2	6 (4)
Distance from anal verge, median (IQR), cm	7 (5; 9)
Low rectum (0-5.0 cm)	50 (36)
Mid rectum (5.1-10 cm)	74 (53)
High rectum (>10 cm)	15 (11)
Neoadjuvant chemoradiotherapy	88 (63)

[1]Unless stated otherwise; ASA: American Society of Anesthesiologists; BMI: Body Mass Index; IQR: Interquartile Range; SD: Standard Deviation

were associated with an increased risk of anastomotic leak (Table 6).

For the outcome of prolonged operative time, four radiological measures were included in the multivariate regression model: IPA/MA (OR: 10.011, 95% CI 2.834-35.365, p<0.001), MFA (OR: 1.356, 95% CI 1.149-1.601, p<0.001), left-to-right mesorectal fat thickness (OR: 0.893, 95% CI 0.823-0.968, p=0.006), and VFA/SFA (OR: 3.704, 95% CI 1.049-13.072, p=0.042) (Table 5). The other variables that met the inclusion criteria and were significantly associated with prolonged operative time in the multivariate analysis were BMI (p<0.0001), male sex (p=0.005), and neoadjuvant chemoradiotherapy (p=0.030). In the exploratory analysis, increased VFA/SFA (>0.589, OR: 3.70, 95% CI 1.49-9.23, p=0.005) and MFA (>17.96 cm^2, OR: 2.90, 95% CI 1.11-7.61, p=0.031) were associated with a prolonged operative time (Table 6). None of the radiological measures showed a correlation with the three oncological outcomes assessed, as none of these measures were included in the multivariate models due to their lack of significance in the stepwise selection process (successful resection, 5-year overall survival, locoregional recurrence) (Table 5).

Table 2: Characteristics of laparoscopic lower anterior resection and surgical outcomes.

Characteristic	n (%)[1]
Conversion to laparotomy	10 (7)
Anastomosis technique	
Stapled	98 (71)
Delayed coloanal	26 (19)
Primary handsewn	15 (11)
Anastomosis with reservoir	
None - EEA	92 (66)
Baker type	41 (30)
Transverse Coloplasty pouch	6 (4)
Diverting ileostomy at primary surgery	99 (71)
Operative time, median (IQR), minutes	240 (200; 290)
Blood loss, median (IQR), mL	100 (50; 250)
Anastomotic leak[2]	24 (17)

[1]Unless stated otherwise; [2]Incidence proportion at 90 days post-surgery
IQR: Interquartile Range; EEA: End-to-End Anastomosis

Discussion

By assessing a myriad of radiologic measures indicative of VO in a North American cohort treated at a high-volume center, we found that increases in MA or TFA were associated with an increased risk of anastomotic leak after laparoscopic lower anterior resection of rectal cancer. Additionally, IPA/MA, MFA and VFA/SFA were significantly associated with increased risk of prolonged operative time. Visceral obesity was not associated with worse oncological outcomes.

Previous studies have evaluated the potential relationship between anastomotic leak and obesity. A 2021 systematic review with meta-analysis by Nugent and colleagues found a correlation between BMI and anastomotic leak occurrence following rectal anastomosis for cancer [29]. However, a retrospective analysis of 2,370 colon cancer resections led Verduin et al. to suggest that visceral fat rather than BMI was associated with anastomotic leak [13]. This correlation of VO with anastomotic leak has also been proposed in other reports [18,30]. This imparts a potential challenge in evaluating the influence of obesity on

Table 3: Tumor pathology and oncologic outcomes.

Characteristic	n (%)[1]
Pathological tumor stage	
pT0	27 (19)
pTis	1 (1)
pT1	11 (8)
pT2	39 (28)
pT3	60 (43)
pT4	1 (1)
Pathological nodal stage	
pN0	95 (68)
pN1	29 (21)
pN2	15 (11)
Number of lymph nodes harvested[2]	18 (13; 24)
Largest tumor dimension, median (IQR), cm	3.0 (2.0; 4.2)
Margins	
Positive distal margins	3 (2)
Positive circumferential margins[2]	4 (3)
Quality of total mesorectal excision[3]	
Complete	90 (84)
Near-complete	8 (8)
Incomplete	9 (8)
Composite outcome[4]	94 (87)
Adjuvant Chemotherapy	61 (44)
Recurrence	36 (26)
Locoregional recurrence	12 (9)
Distant recurrence	36 (26)
5-year overall survival[5]	103 (81)

[1]Unless stated otherwise; [2]missing data for 13 patients; [3]missing data for 32 patients; [4]defined as a complete or near-complete total mesorectal excision, a negative circumferential resection margin (>1 mm), and a negative distal resection margin (>1 mm), missing data for 31 patients; [5]missing data for 12 patients; IQR: Interquartile Range

Table 4: Radiological measurements[1].

Measure	mean ± SD
IPA, cm^2	88.4 ± 10.6
MA, cm^2	32.3 ± 8.4
RA, cm^2	11.2 ± 5.7
MFA, cm^2	21.1 ± 7.0
IPA/MA	2.93 ± 0.91
AP MFT, mm	18.8 ± 8.5
LR MFT, mm	36.8 ± 11.0
TFA, cm^2	96.4 ± 70.3
VFA, cm^2	36.9 ± 27.6
SFA, cm^2	59.6 ± 47.1
AC, cm	102.3 ± 10.1
VFA/SFA	0.70 ± 0.40

[1]Expressed as mean ± standard deviation

IPA: Intrapelvic Area; MA: Mesorectal Area; RA: Rectal Area; MFA: Mesorectal Fat Area; AP MFT: Antero Posterior Mesorectal Fat Thickness; LR MFT: Left-to-Right Mesorectal Fat Thickness; TFA: Total Fat Area; VFA: Visceral Fat Area; SFA: Subcutaneous Fat Area; AC: Abdominal Circumference

surgical outcomes, as obesity is not a homogenous phenomenon [31]. Because BMI does not reflect fat tissue distribution, VO may better indicate an intra-abdominal compartment that is more challenging for resection and predict surgical difficulty [8,10,17,31].

In our study, BMI and other known risk factors for anastomotic leak were not included in the multivariate analysis for this primary outcome due to a lack a statistical significance. Instead, our results suggest visceral adiposity as a risk factor for this postoperative complication, as two radiological measures of visceral adipose tissue deposition, MA and TFA, were associated with an increased risk of anastomotic leak. As MA increases, the space for mesorectal dissection may gradually decrease, which could result in more difficulty during the pelvic dissection phase of a TME. A larger TFA could also represent a more central distribution of adiposity as compared with gynecoid-type obesity, which may be associated with increased technical difficulty resulting in an increased risk for postoperative morbidities.

A few studies have shown a correlation between prolonged operative time and adipose tissue deposition. Yamaoka et al. showed an association between a MFA of at least 26.0 cm^2 and prolonged operative time for the pelvic phase of laparoscopic TME [14]. Numerous studies have also observed a similar correlation of operative time with increased VFA [9,10,18,19,32]. In our study, several clinical and radiological variables showed a correlation with this secondary outcome. Both increased MFA, which is a measure of the adipose tissue within the mesorectal fascia around the rectum, and an increased VFA/SFA ratio, which indicates a higher proportion of intra-abdominal adipose tissue, were associated with an increased risk of a prolonged surgery. The association of prolonged operative time with an increased IPA/MA ratio could also be explained by increased pelvic area occupied by fat tissue for a given mesorectal size. Indeed, even though the prostate and the bladder are potentially included in the measurement of IPA, most of the remaining area is occupied by adipose tissue contained within the intrapelvic fascia. An increased IPA coupled with a smaller MA may indicate an increased proportion of pelvic adiposity located around the mesorectum in the surgical plane of pelvic dissection. This could increase the complexity of pelvic dissection, therefore increasing the operative time. BMI was also significantly associated with a prolonged operative time, however, and is easier to assess preoperatively. Therefore, careful evaluation is necessary to determine if radiological measures of VO provide information that could potentially improve patient care.

No radiological measures of adipose tissue composition were associated with unfavorable postoperative oncological evolution in our study. A correlation of VFA ≥ 100 cm^2 with incomplete mesorectal excision was previously reported by Chen et al. [9]. However, a composite outcome, rather than the quality of TME alone, was used in our study. Since it was recently proposed (2015), no similar studies assessing VO were found evaluating this composite outcome of successful resection. However, because the composite outcome used in our study was recently proposed (2015), no similar studies were found evaluating this outcome of successful resection. Regarding long-term oncological evolution, previous reports have shown conflicting results as to the influence of adipose deposition. After a median follow-up of 72 months, Yamamoto et al. found no association between VFA and recurrence-free survival or overall survival after colorectal surgery for cancer [17]. A similar conclusion was reached by Eckberg and colleagues after evaluating perirenal fat

Table 5: Multivariate analyses of primary and secondary outcomes.

Outcome	Parameters	Multivariate analysis	
Logistic Regression Analyses		**P-value[1]**	**OR (95% CI)**
Anastomotic leak	TFA	0.006	1.007 (1.001-1.014)
	Reservoirs	0.02	
	Baker type *vs.* EEA		0.442 (0.114-1.712)
	Transverse coloplasty *vs.* EEA		7.910 (1.282-48.797)
	MA	0.028	1.063 (1.004-1.125)
	Neoadjuvant Chemoradiotherapy	0.072	0.409 (0.151-1.103)
Prolonged operative time[2]	BMI	<0.001	1.277 (1.123-1.451)
	IPA/MA	<0.001	10.011 (2.834-35.365)
	MFA	<0.001	1.356 (1.149-1.601)
	Sex (male)	0.005	38.920 (2.996-505.521)
	LR MFT	0.006	0.893 (0.823-0.968)
	Neoadjuvant Chemoradiotherapy	0.03	4.041 (1.141-14.311)
	VFA/SFA	0.042	3.704 (1.049-13.072)
	Age	0.091	1.052 (0.992-1.115)
Composite outcome[3]	Sex (male)	0.027	0.277 (0.084-0.908)
5-year overall survival	Pathological nodal stage	0.001	
	pN1 *vs.* pN0		0.818 (0.237-2.824)
	pN2 *vs.* pN0		0.099 (0.030-0.333)
Cox Regression Analysis		**P-value[1]**	**HR (95% CI)**
Locoregional recurrence	Pathological nodal stage	0.011	
	pN1 *vs.* pN0		1.193 (0.222-6.407)
	pN2 *vs.* pN0		7.875 (1.960-31.631)
	Quality of total mesorectal excision	0.052	
	Near-complete *vs.* complete		1.000 (0.116-8.654)
	Incomplete *vs.* complete		5.612 (1.371-22.977)

[1]Significance determined by Chi-squared test; [2]defined as ≥ 75th percentile of operative time; [3]defined as a complete or near-complete total mesorectal excision, a negative circumferential resection margin (>1 mm), and a negative distal resection margin (>1 mm)
OR: Odds Ratio; TFA: Total Fat Area; EEA: End-to-End Anastomosis; MA: Mesorectal Area; BMI: Body Mass Index; IPA: Intrapelvic Area; MFA: Mesorectal Fat Area; LR MFT: Left-to-Right Mesorectal Fat thickness; VFA: Visceral Fat Area; SFA: Subcutaneous Fat Area; HR: Hazard Ratio

Table 6: Bivariate logistic regression of anastomotic leak and prolonged operative time using optimal cut points.

Outcomes	Parameters	Multivariate analysis	
		P-value[1]	**OR (95% CI)**
Anastomotic leak	TFA (159.5cm^2)	0.012	4.46 (1.38-14.37)
	MA (43.39 cm^2)	0.002	6.35 (1.98-20.38)
Prolonged operative time[2]	MFA (17.96 cm^2)	0.031	2.90 (1.11-7.61)
	IPA/MA (3.928)	0.265	0.48 (0.13-1.75)
	LR MFT (36.2 mm)	0.2	0.60 (0.28-1.31)
	VFA/SFA (0.589)	0.005	3.70 (1.49-9.23)

[1]Significance determined by Chi-squared test; [2]defined as ≥ 75th percentile of operative time
OR: Odds Ratio; TFA: Total Fat Area; MA: Mesorectal Area; MFA: Mesorectal Fat Area; IPA: Intrapelvic Area; LR MFT: Left-to-Right Mesorectal Fat Thickness; VFA: Visceral Fat Area; SFA: Subcutaneous Fat Area

surface area as a surrogate for total visceral fat [33]. Recently, Fleming and colleagues observed an association between a high visceral-to-total-fat ratio and increased colon cancer recurrence and disease-specific mortality at 5 years [34]. Our results, however, suggest that VO does not affect oncological outcomes when rectal cancer surgery is performed by trained colorectal surgeons who perform a high-volume of rectal cancer resections.

Alternative surgical approaches might be considered to improve the management of patients in whom VO is considered a risk factor for anastomotic leak and prolonged operative time during laparoscopic rectal cancer resection. Robotic TME allows precise dissection in narrow pelvic spaces with improved imaging and ergonomics [14,35,36]. Robotic TME has shown promising results, with similar postoperative morbidities in obese and non-obese patients, as classified by BMI, following resection for colorectal cancer [37]. When compared with laparoscopic surgery for rectal cancer in obese patients, robotic surgery was associated with shorter hospital stays and a lower readmission rate but longer operative times [38]. Transanal TME may also make surgery less challenging, as it allows better visualization of the distal dissection plane especially in obese patients with a narrow pelvis [39]. The decision to choose these surgical approaches over a full laparoscopic surgery is based on a global evaluation of the patient's risk factors for increased surgical difficulty. Optimal cut-point values of VO, as presented in our analysis, could be used as an added criterion to improve this decision process.

One of the limitations of this study is its retrospective design. Pathological reports were often incomplete in the first few years of this study, and standardization of these reports was implemented during the study period. This limited the number of patients that were included in the analysis of successful resection. Another limitation is that due to the retrospective study design, total operative time was analyzed rather than pelvic dissection time, which may have better reflected technical challenges encountered during mesorectal dissection [6,14,40]. Additionally, the radiological software used was incompatible with imaging studies performed before 2008, which resulted in a loss of patients available for analysis.

Conclusion

In this study assessing the impact of VO on postoperative and oncological evolution, increased MA and TFA were associated with an increased risk of anastomotic leak, and IPA/MA, MFA, and VFA/SFA showed a statistically significant correlation with prolonged operative time. No radiological measures showed predictive value for the oncological outcomes of successful resection, locoregional recurrence, or 5-year overall survival. The added value of radiological measures for the prediction of prolonged operative time and postoperative complications in patients undergoing laparoscopic TME warrants further study.

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