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Impact of visceral obesity on operative outcomes of laparoscopic nephrectomy: comparison between visceral fat area and body mass index

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Abstract

Background: Obesity has been considered as a risk factor influencing operative difficulty. It was reported that body mass index (BMI; kg/m^2) did not always properly reflect the degree of a patient's visceral fat. The purpose of this study is to retrospectively investigate the association of operative outcomes and obesity indices including visceral fat area (VFA; cm^2) and BMI in retroperitoneoscopic nephrectomy (RN).

Methods: We retrospectively reviewed consecutive 96 RN procedures performed from September 2016 to June 2020. We divided patients into BMI obese group (BMI ≥ 25, $n = 25$) and BMI normal group (BMI < 25, $n = 71$), VFA obese group (VFA ≥ 100, $n = 54$) and VFA normal group (VFA < 100, $n = 42$). Patient characteristics, operative and postoperative outcomes were compared between the two groups for each index of obesity.

Results: In two groups divided by BMI, the only specimen weight was significantly greater in the obese group (320 vs. 460 g, $p < 0.001$), whereas VFA obese group had longer insufflation time (165 vs. 182 min, $p = 0.028$), greater estimated blood loss (34 vs. 88 ml, $p = 0.003$) and greater specimen weight (255 vs. 437 g, $p < 0.001$) than VFA normal group. In a logistic regression analysis, high VFA value was a significant predictor for greater specimen weight and high VFA value and large size of renal tumor were significant predictors for greater blood loss. By contrast, BMI was not a significant predictor. Furthermore, in the case of non-obese patients (BMI < 25), VFA obese group had significantly longer insufflation time, greater estimated blood loss and greater specimen weight than normal group.

Conclusions: The present data suggest that VFA is a more useful parameter than BMI for predicting the operative difficulty associated with obesity, and VFA has a higher use value in non-obese patients (BMI < 25) than in obese patients (BMI ≥ 25).

Keywords: Obesity, Visceral fat area (VFA), Body mass index (BMI), Laparoscopic nephrectomy, Operative difficulty

1 Background

In recent years, the laparoscopic approach has been recognized as one of the standard surgical options for various urological disease conditions. At present, laparoscopic nephrectomy is well known as the standard surgical procedures due to their major advantages of shorter hospitalization time, faster return to normal activity and better cosmetic results.

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Meanwhile, obesity has been documented as a global epidemic in recent years, and its rapid increase has become a public health problem. Degree of obesity has been reported to be associated with increased difficulty of laparoscopic nephrectomy, as reflected by a trend toward longer operative times and more intraoperative complications [1, 2].

Although body mass index (BMI) is widely used as an index to assess adult obesity, BMI does not distinguish between fat and muscle weight or between visceral and subcutaneous fat. We hypothesized that visceral fat area (VFA) which were quantitatively measured on computed tomography (CT) images could reflect operative and postoperative factors better than BMI in obese Japanese patients. In the present study, we evaluated these indices of obesity as predictors of operative difficulty. To our knowledge, there are only few reports that evaluate the association between VFA and operative outcome on laparoscopic nephrectomy in obese Asian patients [3–6].

2 Methods

2.1 Data collection

We retrospectively reviewed consecutive 96 retroperitoneoscopic nephrectomy (RN) procedures performed at Shimane Prefectural Central Hospital from September 2016 to June 2020. All surgeries were performed by one senior urologist specializing in urologic laparoscopic surgeries. The indication of RN was suspected renal cell carcinoma in 42 cases, suspected renal pelvis and/or ureteral cancer in 43 cases and hydronephrosis and atrophic kidney in 11 cases. Radical nephrectomy, nephroureterectomy and simple nephrectomy were performed in 42, 43 and 11 cases, respectively. Medical records were reviewed and abstracted.

2.2 Research methods

Retroperitoneoscopic radical nephrectomy and nephroureterectomy were performed following the principles of oncological surgery, with wide margins and the inclusion of Gerota's fascia with all renal specimen. Retroperitoneal radical nephrectomy was performed fundamentally as described previously by Mita et al. [7]. In brief, four ports were placed in the retroperitoneal space in the kidney position. After the quadratus lumborum fascia had been identified, the laterocornal fascia and the posterior renal fascia were opened longitudinally. Blunt dissection was performed between the layers covering the perirenal fat and the renal fascia upward and medially to identify the renal artery and vein located at the renal hilum. First, the renal artery was dissected, followed by the renal vein. The medial layer of the posterior fascia was dissected from the anterior portion around the perirenal fat. The upper pole and medial aspect of the renal fascia were dissected from the fat tissue including the adrenal gland in cases where adrenalectomy was not included. The ureter was dissected, and then, the specimen was removed intact by creating a skin incision that extend the port wound and dividing the underlying muscle. Laparoscopic procedure of retroperitoneal nephroureterectomy was carried out fundamentally in the same way as for retroperitoneoscopic radical nephrectomy. Then, lower ureter dissection, bladder cuff resection and intact specimen removal are performed via the midline lower abdominal extraperitoneal approach in a lower lithotomy position. Retroperitoneal simple nephrectomy was performed fundamentally as retroperitoneoscopic radical nephrectomy. In case of firm adhesion and disappearance of the anatomical layers between the perirenal fat and peritoneum, we dissected the kidney at the renal capsule plane.

BMI and VFA were evaluated within 4 weeks before the operation. BMI was calculated as the ratio of weight (kg) divided by height (m^2). VFA (cm^2) was measured on the CT image at the umbilical level, using the Synapse® Vincent® volume analyzer system (Fujifilm, Tokyo, Japan). We defined fat tissue as tissue with a Hounsfield number between − 150 and − 50 [3]. The border of the intraabdominal cavity was outlined on the CT image, and VFA was then quantified using the Synapse® Vincent® volume analyzer system (Fig. 1).

In the Guidelines for the management of obesity disease issued by the Japan Society for the Study of Obesity [8], overall obesity is defined as BMI of ≥ 25 kg/m^2 and visceral fat accumulation is defined as VFA ≥ 100 cm^2. Therefore, we divided patients into BMI obese group (BMI ≥ 25, $n = 25$) and BMI normal group (BMI < 25, $n = 71$), VFA obese group (VFA ≥ 100, $n = 54$) and VFA

Fig. 1 Computed tomography revealing the degree of fat distribution. The white area within the drawn circle is the visceral fat area

normal group (VFA < 100, $n=42$). Patient characteristics, operative and postoperative outcomes were reviewed and compared between the two groups for each index of obesity. We regarded more than grade I of the Clavien–Dindo surgical complication grading system as morbidity.

This retrospective study was approved by the Institutional Review Board of Shimane Prefectural Central Hospital (R20-035 Shimane, Japan).

2.3 Statistical analysis

Statistical analysis was performed using the Student's *t* test for mean values and Pearson Chi-square test for proportions. Multivariate analysis was carried out using a logistic regression model. A p value of < 0.05 was regarded as statistically significant. All the statistical analyses were performed using EZR® (https://www.r-project.org/).

3 Results

Table 1 summarizes the demographic and preoperative factors. In two groups divided by BMI, there were no significant differences in age, gender distribution, diseased side, tumor size of renal tumor, number of renal vessels. Mean BMI values of the obese and normal groups were 28.1 and 21.8 kg/m^2, respectively. In two groups divided by VFA, there was significant difference only in gender distribution. Mean VFA values of the obese and normal groups were 156.0 and 57.8 cm^2, respectively. Both normal group and obese group divided by BMI or VFA had approximately same clinical characteristics.

The operative and postoperative outcomes are summarized in Table 2. In two groups divided by BMI, the specimen weight was significantly greater in the obese group (320 vs. 460 g, $p < 0.001$). On the other hands, VFA obese group had longer insufflation time (165 vs. 182 min, $p=0.028$), greater estimated blood loss (34 vs. 88 ml, $p=0.003$) and greater specimen weight (255 vs. 437 g, $p < 0.001$) than VFA normal group. In two groups divided by BMI or VFA, there were no statistically significant differences in the time to oral intake, time to ambulation and postoperative stay (Table 2).

Complications are shown in Table 3. In all cases, complication rate was 14 of the 96 cases (14.5%). These complications were consisted of peritoneal injury 7 (7.2%), renal vascular injury 3 (3.1%), renal capsule

Table 1 Demographics and preoperative factors of obese and normal groups classified by BMI or VFA

Variable	BMI normal	BMI obese	*p*	VFA normal	VFA obese	*p*
Pts	71	25		42	54	
Age, years (*r*; 43–96)	71.0 ± 10.6	70.8 ± 10.4	0.917	72.7 ± 11.4	69.7 ± 9.7	0.170
Gender, male/female	46/25	18/7	0.510	23/19	41/13	0.029
ASA-PS (*r*; 1–3)	2.2 ± 0.5	2.3 ± 0.5	0.429	2.2 ± 0.6	2.3 ± 0.5	0.519
Diseased side, right/left	31/40	10/15	0.750	19/23	22/32	0.658
Tumor size of renal tumor, mm (*r*; 15–81)	40.3 ± 18.4	41.1 ± 12.4	0.885	41.4 ± 18.0	40.1 ± 16.7	0.813
Renal arteries (*r*; 1–3)	1.3 ± 0.5	1.2 ± 0.4	0.539	1.2 ± 0.5	1.3 ± 0.5	0.740
Renal veins (*r*; 1–3)	1.1 ± 0.4	1.3 ± 0.4	0.057	1.1 ± 0.4	1.2 ± 0.4	0.551
BMI, kg/m^2 (*r*; 16.6–35.7)	21.8 ± 2.0	28.1 ± 2.7	< 0.001	–	–	–
VFA, cm^2 (*r*; 2.0–295.1)	–	–	–	57.8 ± 39.9	156.0 ± 42.2	< 0.001

Data are presented as mean ± standard deviation

ASA-PS American Society of Anesthesiologist-performance status, *BMI* body mass index, *VFA* visceral fat area

Table 2 Operative and postoperative data of obese and normal groups classified by BMI or VFA

Variable	BMI normal	BMI obese	*p*	VFA normal	VFA obese	*p*
Pts	71	25		42	54	
Insufflation time, min (*r*; 97–270)	172.6 ± 36.4	181.4 ± 34.1	0.304	165.9 ± 29.2	182.1 ± 39.2	0.028
Blood loss, ml (*r*; 0–500)	54.1 ± 72.4	93.9 ± 124.7	0.057	34.6 ± 27.8	88.3 ± 113.1	0.003
Specimen weight, g (*r*; 69–757)	320.3 ± 139.9	460.4 ± 154.0	< 0.001	255.5 ± 101.6	437.8 ± 144.1	< 0.001
Time to oral intake, days (*r*; 1.25–2.75)	1.7 ± 0.2	1.7 ± 0.3	0.911	1.7 ± 0.3	1.6 ± 0.3	0.408
Time to ambulation, days (*r*; 1–2)	1.0 ± 0.1	1.0 ± 0.2	0.428	1.0 ± 0.2	1.0 ± 0.0	0.114
Postoperative stay, days (*r*; 4–21)	9.8 ± 2.3	10.0 ± 3.3	0.824	10.3 ± 3.0	9.5 ± 2.2	0.170

Data are presented as mean ± standard deviation

BMI body mass index, *VFA* visceral fat area

Table 3 Comparison of complications between obese and normal groups classified by BMI or VFA

Variable	BMI normal	BMI obese	*p*	VFA normal	VFA obese	*p*
Pts	71	25		42	54	
Complications (%)	9 (12.8)	5 (19.2)	0.380	7 (16.6)	7 (12.9)	0.636
Peritoneal injury	6	1	0.461	5	2	0.125
Renal vascular injury	2	1	NA	1	2	NA
Renal capsule injury	0	1	NA	0	1	NA
Open conversion	0	1	NA	0	1	NA
Elevation of creatine kinase (CK)	0	1	NA	0	1	NA
Imperception of lower limb	1	0	NA	1	0	NA

Data are presented as cases

BMI body mass index, *VFA* visceral fat area, *NA* not available

injury 1 (1.0%), elevation of creatine kinase 1 (1.0%), imperception of lower limb 1 (1.0%). Only 1 of the 96 cases (1.0%) required conversion to open surgery because of difficulty in the setting of scope port due to thick abdominal wall. Renal vascular injuries included minor injuries to vessels. These three cases required no blood transfusion. The elevation of creatine kinase and imperception of lower limb were reversibly improved by conservative treatment. There were no complications required a second operation. In two groups divided by BMI or VFA, there were no statistically significant differences in complications (Table 3).

Because the variables used in this study might be interrelated, multivariate analysis was done using a logistic regression model. As shown in Table 4, in a logistic regression analysis, high VFA value was a significant predictor for greater specimen weight ($p < 0.001$) and high VFA value and large size of renal tumor were significant predictors for greater blood loss in RN ($p = 0.041$ and $p = 0.017$, respectively). By contrast, BMI was not a significant predictor.

4 Discussion

Obesity has been considered as a risk factor which influences operative difficulty and complications in several urological operations [9–11]. BMI has been used as one of the most reliable anthropometric indices of obesity [12]. Several studies have reported a correlation between operating time or blood loss and BMI in laparoscopic nephrectomy. In a series of retroperitoneoscopic radical nephrectomies in Japanese patients, Inoue et al. [13] reported that a BMI ≥ 25 was a risk factor for longer operating time and greater estimated blood loss than a BMI < 25 and Makiyama et al. [14] described that obese group (BMI ≥ 25) had significantly longer operation time and greater specimen weight compared to normal group (BMI < 25). In our institution, except for specimen weight, there was no statistically significant difference between the normal group and obese group dichotomized by BMI of 25 in any of the operative outcomes of RN.

Although there are many manuscripts that evaluated the relationship between obesity and operative/postoperative factors, the conclusions are still unclear [13–15].

Table 4 Multivariate analysis for greater specimen weight and estimated blood loss

	Greater specimen weight			Greater estimated blood loss		
	Univariate	Multivariate		Univariate	Multivariate	
	p	OR (95% CI)	*p*	*p*	OR (95% CI)	*p*
Age (≥ 71 years)	0.999	–	–	0.695	–	–
Gender (Male)	0.217	–	–	0.333	––	–
ASA-PS (≥ 3)	0.996	–	–	0.870	–	–
Diseased side (Left)	0.143	–	–	0.563	–	–
Tumor size of renal tumor (≥ 42 mm)	0.057	–	–	0.018	6.20 (1.38–27.70)	0.017
VFA (≥ 100 cm^2)	< 0.001	8.26 (3.03–22.50)	< 0.001	0.001	6.86 (1.08–43.60)	0.041
BMI (≥ 25 kg/m^2)	0.004	2.10 (0.65–6.72)	0.213	0.006	1.51 (0.28–8.06)	0.627

ASA-PS American Society of Anesthesiologist-performance status, *BMI* body mass index, *VFA* visceral fat area, *OR* odds ratio, *CI* confidence interval

Because in those reports BMI is used as an index for obesity, which does not properly reflect the degree of a patient's visceral fat, the different conclusions might be presented [1]. Ode et al. [16] reported that BMI is poorly predictive of the degree of visceral fat in any body types, such as patients with increased percentage muscle. In addition, BMI may be inadequate as an index for evaluating obesity of Japanese people. Relatively few adult Japanese people are suited for the World Health Organization's definition of obesity (BMI greater than 30). The prevalence of BMI $\geq$ 30 in Japanese adults is quite low (3.5%) compared not only with western countries, but also with some Asian and other countries [8]. In this study, we defined the obese group as BMI greater than 25 in accordance with the Guidelines for the management of obesity disease issued by the Japan Society for the Study of Obesity [8] and there was little association between BMI and operative factors. Instead of BMI, VFA showed an association with operative factors, suggesting that VFA more adequately predicts the surgical difficulty than BMI, at least in Japanese patients. As mentioned above, BMI does not always properly reflect the degree of a patient's visceral fat because the distribution of fat tissue differs greatly between individuals [16]. Several studies suggested that there was significant association between VFA and operative factors, and VFA is a more useful parameter than BMI in predicting surgical outcomes of laparoscopic surgery [4, 6].

Previous studies also showed that Kumazawa et al. [3] investigated the association between indices of obesity and intraoperative factors in laparoscopic donor nephrectomy. Although patients in the fatty group categorized by VFA had significantly greater blood loss than those in the non-fatty group, there was no association between BMI and intraoperative factors. Zhai et al. [6] reported that high VFA was associated with increased surgical complexity, postoperative morbidity, postoperative stay in laparoscopic radical nephrectomy for renal cell carcinoma and may be superior to BMI. VFA obese group had a significant longer operation time, greater blood loss, more postoperative complications and longer postoperative stay than VFA normal group. In addition, Hagiwara et al. [4] showed that VFA obese group was significantly correlated with longer operating time, and the correlation coefficient of VFA was higher than that of BMI in laparoscopic radical nephrectomy. In multivariate analysis, it was shown that a high VFA was an independent risk factor for prolonged operating time, whereas BMI was not found to be a risk factor. They concluded that VFA had a greater impact than BMI on the complexity of laparoscopic radical nephrectomy. Even in this study, VFA seemed to be a more useful parameter than BMI for predicting the technical difficulty of performing a laparoscopic resection of kidney. In other words, in two groups divided by BMI, the only specimen weight was significantly greater in the obese group (320 vs. 460 g, $p < 0.001$), whereas VFA obese group had longer insufflation time (165 vs. 182 min, $p = 0.028$), greater estimated blood loss (34 vs. 88 ml, $p = 0.003$) and greater specimen weight (255 vs. 437 g, $p < 0.001$) than VFA normal group. Meanwhile, in two groups divided by BMI or VFA, there were no statistically significant differences in the time to oral intake, time to ambulation, postoperative stay and complication. Furthermore, in a logistic regression analysis, high VFA value was a significant predictor for greater specimen weight ($p < 0.001$) and high VFA value and large size of renal tumor were significant predictors for greater blood loss ($p = 0.041$ and $p = 0.017$, respectively). However, no significant predictors were found for prolonged insufflation time.

By the way, as shown in Table 5, among non-obese 71 patients (BMI < 25), 32 patients (45.1%) had visceral fat accumulation (VFA $\geq$ 100). In two groups divided by VFA in non-obese 71 patients, VFA obese group had longer insufflation time (164 vs. 183 min, $p = 0.025$), greater estimated blood loss (34 vs. 78 ml, $p = 0.009$) and greater specimen weight (246 vs. 413 g, $p < 0.001$) than VFA normal group. Considering that 88.0% of obese patients (BMI $\geq$ 25) had visceral fat accumulation (VFA $\geq$ 100) which was compatible with same proportion of previous report [17], VFA might be a more useful parameter in non-obese patients (BMI < 25) than in obese patients (BMI $\geq$ 25) for predicting the operative difficulty associated with obesity.

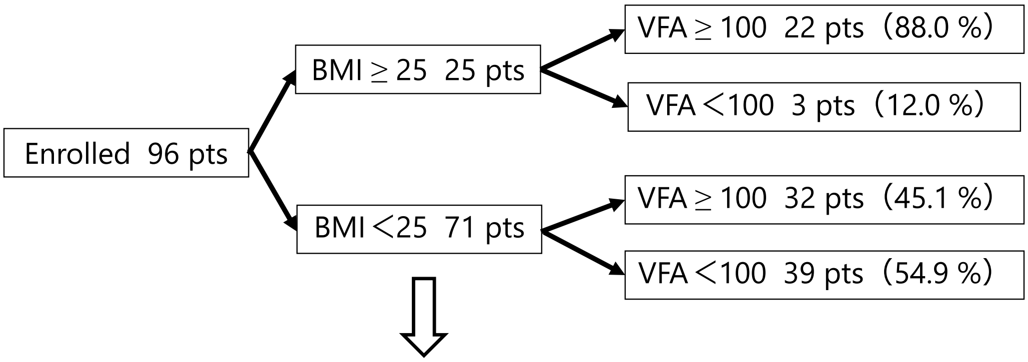
The higher risk of complications in obese compared to non-obese patients has been reported [9–11]. In unselected patients undergoing laparoscopic nephrectomy, there was an overall complication rate of 9.4–16% [13, 14, 18]. In our series, the complication rate was 14.5% (14 complications in 96 patients). In contrast, massively obese patients had a complication rate of 21–26% in laparoscopic urologic surgery [2, 19], and also among BMI obese group in our series, the complication rate was 19.2% which was higher than that of BMI normal group ($p = 0.380$).

Several limitations of this study should be acknowledged. It was performed in a retrospective manner. And unknown sources of bias may exist in the results. In addition, the relatively small sample size restricted analytic power.

5 Conclusions

The present data indicate that VFA is a more useful parameter than BMI for predicting the operative difficulty associated with obesity, and VFA has a higher use

Table 5 Operative data of obese and normal groups classified by VFA in non-obese patients (BMI < 25)



Variable	VFA normal	VFA obese	*p*
Pts (%)	39 (54.9)	32 (45.1)	
Insufflation time, min (*r*; 114–270)	164.0 ± 28.7	183.4 ± 42.2	0.025
Blood loss, ml (*r*; 0–450)	34.4 ± 28.5	78.8 ± 99.5	0.009
Specimen weight, g (*r*; 69–721)	246.1 ± 92.9	413.7 ± 133.9	< 0.001

Data are presented as mean ± standard deviation

BMI body mass index, *VFA* visceral fat area

value in non-obese patients (BMI < 25) than in obese patients (BMI ≥ 25).

Abbreviations

RN: Retroperitoneoscopic nephrectomy; BMI: Body mass index; VFA: Visceral fat area; ASA-PS: American Society of Anesthesiologist-performance status; OR: Odds ratio; CI: Confidence interval.

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Authors' contributions

TY, SO, TS, YK, KK were involved in the initial writing of the manuscript. YH provided major editing changes. TY, SO, TS, YK, KK, HY and YH participated in the surgical treatment. KK made the radiograph interpretation report on the basis of radiological image. HO made the pathological report of surgical specimen. HY and HS provided intellectual contributions to the content of the manuscript as well as editorial assistance. All authors read and approved the final manuscript.

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Availability of data and materials

The datasets used and analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

This retrospective study was approved by the Institutional Review Board of Shimane Prefectural Central Hospital (R20-035 Shimane, Japan).

Consent for publication

Informed consent was obtained from patients for publication of this manuscript.

Competing interests

The authors declared no potential conflicts of interest with respect to the authorship and/or publication of this article.

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