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Operation duration and adrenal gland size, but not BMI, are correlated with complication rate for posterior retroperitoneoscopic adrenalectomy for benign diseases

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ABSTRACT

Background: We sought to determine whether obesity is correlated with complications after posterior retroperitoneoscopic adrenalectomy for benign diseases and to develop surrogate markers of abdominal fat in preoperative computed tomography.

Methods: We conducted a retrospective chart review of all patients who had undergone posterior retroperitoneoscopic adrenalectomy and preoperative computed tomography between January 1, 2008 and December 31, 2015. The cross-sectional components of fat assessed by computed tomography included total fat area, subcutaneous fat area, retroperitoneal fat area, and peritoneal fat area. The patients were grouped into 2 categories according to the absence or presence of a postoperative complication (the no-complications group and the complications group, respectively).

Results: Of 116 study patients, 20 patients (17%) had a postoperative complication. Operations of greater duration and smaller adrenal gland size were significantly correlated with complications both in univariate and multivariate analyses. Body mass index, total fat area, subcutaneous fat area, retroperitoneal fat area, peritoneal fat area, and distance of skin to muscle (in axial and sagittal images) correlated with complications in univariate analysis but not in multivariate analysis. In the no-complications group, the removed adrenal gland was larger than that removed in the complications group (6 vs 4 cm, respectively, $P = .001$), whereas the complications group had a greater operative duration (139 vs 104 min, respectively, $P = .001$) and a greater duration of hospital stay (3 days vs 1 day, respectively, $P = .001$).

Conclusion: In this study, operations of greater duration and smaller adrenal gland size were better predictors of complications after posterior retroperitoneoscopic adrenalectomy for benign disease than measures of obesity, including body mass index.

Introduction

Transabdominal laparoscopic adrenalectomy (LA), first described in 1992, was shown to be superior to the open approach in terms of morbidity, complications, hospital stay, and postoperative pain and hence quickly became the gold standard.[1,2] The widespread use of laparoscopic procedures and technologic advances led to the development of the posterior retroperitoneoscopic adrenalectomy (PRA), first described in 1995,[3] which is performed with the patient in the prone, jackknife position. The PRA approach was popularized by Walz et al[4] who demonstrated safety, decreased operative times, and rapid patient recovery.[4–6] These results were later confirmed by several studies that demonstrated the safety and benefits of the PRA approach.[7–16]

In general, obesity is considered to be a major factor in the degree of technical difficulty encountered during laparoscopic abdominal surgery, although the effect on operative outcome is still controversial.[17–21] Some researchers have reported that among patients who underwent LA, obesity had no influence on short-term outcome, and complications did not differ between obese and nonobese patients; other studies, however, found a substantial increase in intraoperative and postoperative complications among obese individuals undergoing LA.[22–28] Zonca et al reported in 2015

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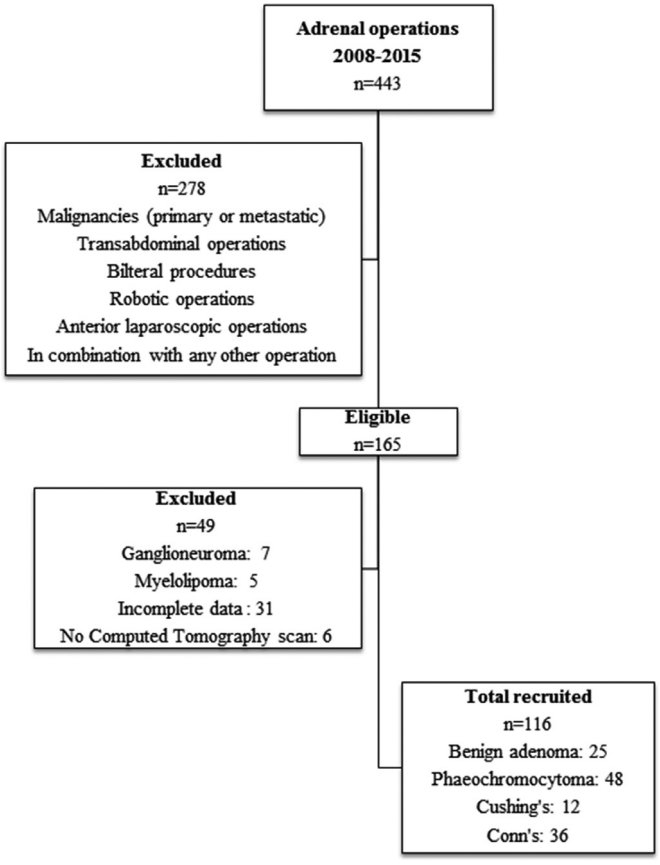

Fig. 1. Flowchart of patients included in the study.

that obese patients who underwent PRA had a greater operative duration, 30-day postoperative morbidity, and hospital stay than did nonobese patients.[29]

Adipose tissue in the abdomen has various components, including visceral fat, subcutaneous fat, and retroperitoneal fat. Previous studies have reported that visceral obesity is a more accurate marker for the degree of technical difficulty encountered in LA and nephrectomy than increased body mass index (BMI).[17,30] Retroperitoneal fat has been shown to be a more useful parameter than BMI for predicting operative outcomes after LA.[31,32] Measuring the various components of fat, especially retroperitoneal fat, has been reported infrequently in the literature and has consisted of using the "Polygonal Lasso Tool" to create regions of interest.[31,32] To our knowledge, the exact effects of the various components of fat on operative outcomes after PRA had not been investigated previously.

The aims of this study were to determine whether obesity is correlated with complications associated with PRA performed in our institution for benign diseases and to identify surrogate markers of abdominal fat on preoperative computed tomography (CT), which can assist in surgical planning.

Methods

This study was approved by the institutional review board at our institution (study number PA15-0951). The patient population was identified by a search of prospectively collected data in the Endocrine Surgery Database between January 1, 2008 and December 31, 2015. We included all patients who had undergone PRA in our department and had available preoperative abdominal CT imaging for review. The exclusion criteria are shown in Fig. 1 and include, among others, patients with adrenal malignancy, those with incomplete records, and those without a preoperative abdominal CT. Myelolipomas and ganglioneuromas were excluded because of small number of these cases.

Clinical information was obtained from the patient database and, when necessary, supplemented with data obtained directly from institutional medical records. Extracted data included demographic information (sex, age, and BMI), presenting symptomatology, type of operation, nursing notes, imaging studies, histopathologic results, complications (duration of operation, blood loss, and conversion to open surgery), and follow-up details (outcome of PRA, etc.).

Operative technique

All operations were performed by 1 of 5 experienced endocrine surgeons in our department who are proficient in the PRA technique. All PRAs were performed according to a previously described standardized technique.[10,33] In our center, patients are not eligible for a PRA if there is any concern or uncertainty of adrenal malignancy, large tumor size (although no absolute cutoff size, we generally use ~8 cm), and patient characteristics that are restricting the PRA approach (ie, inability to tolerate positioning, prior retroperitoneal operations/scarring)[36,37].

Technique for evaluating cross-sectional areas of fat on CT

The amounts of total fat area (TFA), subcutaneous fat area (SFA), retroperitoneal fat area (RFA), and peritoneal fat area (PFA) were measured by helical CT. These measurements were assessed by cross-sectional areas at the axial CT level of the adrenal lesion of interest. The TFA was considered to be distributed into 3 portions: the SFA, the RFA, and the PFA. The TFA was determined by a CT attenuation window (−180 to 0 Hounsfield Units) using a CT workstation (GE Advantage Windows; Fig. 2). The SFAs and RFAs were delineated manually; the PFA was considered to be the remainder (ie, TFA minus SFA plus RFA).

The axial anterior–posterior distances of skin surface to muscle and skin surface to the near and far aspects of the adrenal lesion were evaluated on the same axial CT section as mentioned previously (Fig. 2). The sagittal distances of skin surface to muscle were evaluated along the linear trajectory inferior to the twelfth rib in the sagittal CT plane of the adrenal lesion (Fig. 2).

The patients were grouped into 2 categories according to the presence of postoperative complications (the complications group) or the absence of these complications (the no-complications group); complications included postoperative bleeding, wound infection, atelectasis (defined as a delay in discharge owing to the presence of otherwise unexplained fever or the need for pulmonary physiotherapy or temporary supplemental oxygen), pneumothorax, need for reoperation, and need for antibiotics (Supplementary Table 1).

Statistical analysis

Demographic and clinical characteristics were summarized. Data are reported as the median and range. Differences between groups were compared with chi-squared and Fisher exact tests. Associations of continuous variables between groups were assessed by the nonparametric Mann-Whitney test. A multivariable logistic regression analysis was performed to determine the independent risk factors for complications. The selection of the variables to be included in this model was based on the statistical significance of the correlation in the univariate analysis, and the variables were entered in the model in a single step using the enter method.

Simple regression analysis was used to fit data to a model that defines a functional relationship between 2 random variables, a dependent variable y (operation duration) and one independent

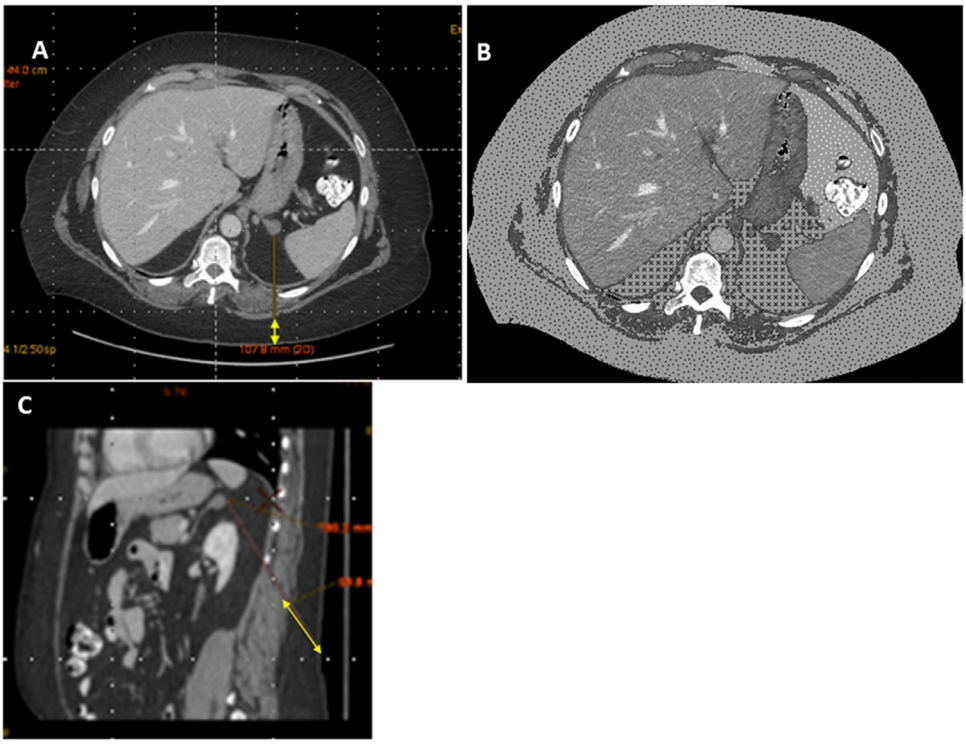

Fig. 2. Graphic representation of computed tomography imaging used to calculate the following: (*A*) yellow arrow represents the axial distance of skin to muscle (cm), (*B*) CS retroperitoneal fat area (cm^2), and (*C*) yellow arrow represents the sagittal distance of skin to muscle (cm).

Table 1
Correlation of risk of complications after a PRA with clinical and surgical-related variables.

		No complications($n = 96$)		Complications($n = 20$)		*P* value
		N	(%)	*n*	(%)	
Sex	Male	39	(41)	7	(35)	.803
	Female	57	(59)	13	(65)	
Ethnicity	White	74	(77)	17	(85)	.545
	Black	12	(13)	1	(5)	
	Asian	4	(4)	0		
	Hispanic	6	(6)	2	(10)	
BMI	0–25	24	(25)	0		.024
	25–30	24	(25)	7	(35)	
	30–35	27	(28)	4	(20)	
	>35	21	(22)	9	(45)	
Surgeon	1	26	(27)	7	(35)	.553
	2	48	(50)	7	(35)	
	3	13	(14)	2	(10)	
	4	4	(4)	2	(10)	
	5	5	(5)	2	(10)	
ASA score	2	21	(22)	1	(5)	.161
	3	73	(76)	19	(95)	
	4	2	(2)	0		
Clinical diagnosis	Adenoma	19	(20)	5	(25)	.946
	Pheochromocytoma	38	(40)	8	(40)	
	Cushing's	10	(10)	2	(10)	
	Conn's adenoma	29	(30)	5	(25)	
Laterality of operation	Right	46	(48)	7	(35)	.210
	Left	50	(52)	13	(65)	
Age at operation (years) (median, range)		50	(9–86)	52	(15–77)	.747
Time between CT and operation (days) (median, range)		3	(0.2–56)	6	(1–13)	.723
Weight of specimen (g) (median, range)		20	(3–140)	18	(5–40)	.206
Size of specimen (cm) (median, range)		6	(2–12)	4	(3–7)	.001
Operative duration (min) (median, range)		104	(46–281)	139	(66–316)	.001
Blood loss (mL) (median, range)		10	(2–1300)	24	(5–200)	.087
Duration of stay (days) (median, range)		1	(1–7)	3	(1–20)	.001
Follow-up (months) (median, range)		7	(1–90)	5	(1–89)	.130

PRA = posterior retroperitoneoscopic adrenalectomy; BMI = body mass index; ASA = American Society of Anesthesiologists; CT = computed tomography. $P < 0.05$ was considered statistically significant.

Table 2
Comparison of CT imaging–related variables between patients with and without perioperative complications.

	No complications($n=96$)		Complications($n=20$)		*P* value
	Median	(Range)	Median	(Range)	
TFA*	29	(4–90)	45	(14–94)	.001
SFA*	15	(2–61)	23	(7–64)	.002
RFA*	4	(0.1–23)	7	(0.5–18)	.059
PFA*	7	(0.6–27)	11	(3–38)	.019
Skin to muscle distance (axial) (cm)	1.4	(0.3–4.3)	2.1	(0.9–4.6)	.003
Skin to muscle distance (sagittal) (cm)	1.7	(0.5–4.8)	2.4	(1.1–4.8)	.005

TFA = total fat area (cm^2); SFA = subcutaneous fat area (cm^2); RFA = retroperitoneal fat area (cm^2); PFA = peritoneal fat area(cm^2). *In cross-sectional imaging, $P < 0.05$ was considered statistically significant.

Table 3
Multivariate analysis of risk of complications.

	B	Wald	Exp(B)	95% CI	*P* value
Operative duration (min)	0.015	5.135	1.015	1.00–1.03	.023
Size of specimen (cm)	−0.946	12.609	0.388	0.23–0.65	<.001
BMI ()					
0–25 $n=24$		5.072			.167
25–30 $n=31$	20.287	0.0	646330344	0.0-	.998
30–35 $n=31$	18.104	0.0	72847524	0.0-	.998
>35 $n=X$	18.229	0.0	82523269	0.0-	.998
TFA*	219.299	0.101	1.739E+0.95	0.0-	.751
SFA*	−219.269	0.101	0.0	0.0-	.751
RFA*	−219.170	0.101	0.0	0.0-	.751
PFA*	−219.289	0.101	0.0	0.0-	.751
Skin to muscle distance (axial) (cm)	−0.118	0.908	0.888	0.70–1.13	.341
Skin to muscle distance (sagittal) (cm)	0.131	1.905	1.139	0.95–1.37	.167

BMI = body mass index; TFA = total fat area (cm^2); SFA = subcutaneous fat area (cm^2); RFA = retroperitoneal fat area (cm^2); PFA = peritoneal fat area(cm^2). *In cross-sectional imaging, CI = confidence intervals; $P < 0.05$ was considered statistically significant.

variable (fat components). The statistical package in IBM SPSS Statistics for Windows was used to perform linear regressions and to establish correlation coefficients. All statistical analyses were performed with use of IBM SPSS Statistics for Windows, Version 20.0 (IBM Corp., Armonk, NY).

Results

Figure 1 presents a flowchart of patients included in this study. Of the 443 patients who underwent adrenalectomy during the study period, 165 were eligible for the study, and after we applied additional inclusion/exclusion criteria, 116 patients were included in the study.

Overall, of the 116 study patients, 96 had no postoperative complications, and 20 had 1 or more complications (17%; Supplementary Table 1). The most common complication was pneumothorax (6 patients). There were no significant differences between the 2 groups with respect to the presence of comorbidities or the use of corticosteroids, tobacco, alcohol, warfarin, and antiplatelet and antihypertensive medications (Supplementary Table 2).

Table 1 compares the clinical characteristics between these 2 groups (the no-complications group and the complications group). Patients with a BMI >25 kg/m^2 had more complications than did patients with a BMI of 0–25 kg/m^2 ($P=.024$). There were no significant differences between the groups with respect to sex, ethnicity, the surgeon who performed the operation, American Society of Anesthesiologists score, laterality of operation, age at the date of operation, clinical diagnosis, and follow-up. The number of complications was not statistically different when we controlled for diagnosis ($P=.946$) or for the individual surgeon ($P=.553$).

Interestingly, in the no-complications group, the removed adrenal gland specimen was larger than that removed in the complications group (6 vs 4 cm, respectively, $P=.001$; Table 1). As anticipated, patients in the complications group, compared with those in the no-complications group, had a greater duration of operation (139 min vs 104 min, respectively, $P=.001$) and a greater duration of hospital stay (3 days vs 1 day, respectively; $P=.001$).

Table 2 compares CT measures of adiposity between the groups. On univariate analysis, the complications group had greater volumes for TFAs (cm^2), SFAs (cm^2), and PFAs (cm^2) ($P < .002$ each) whereas the RFAs (cm^2) approached significance ($P=.059$). Furthermore, the complications group had greater distances of skin to muscle on both axial and sagittal images ($P=.005$ each).

A multivariate logistic regression was performed to ascertain the effects of operative duration, size of the adrenal gland specimen, BMI, and CT measurements on the likelihood that complications would occur. The logistic regression model was statistically significant and explained 86% of complications. As seen in Table 3, operative duration was associated with greater likelihood of developing complications ($P=.023$), whereas the size of specimen was negatively associated with likelihood of developing complications ($P < .001$). BMI and CT measurements were not correlated to complications in the multivariate analysis.

Figure 3 shows the correlation between the cross-sectional measurements of the various components of adipose tissue (TFA, SFA, PFA, and RFA) and the categories of BMI (0–25, 25–30, 30–35, and >35). There was a statistical difference between all 4 components of adipose tissue and the BMI categories ($P < .001$ for all 4 variables).

A linear regression was calculated to predict operative duration based on cross-section (CS) TFA (cm^2), CS SFA (cm^2), CS RFA (cm^2), CS PFA (cm^2) and BMI (Fig. 4). A regression equation was found for CS TFA, CS RFA, CS PFA, and BMI ($P < .001$ each) and approached significance for CS SFA ($P=.063$). Regression equations and confidence intervals are included in Fig. 4.

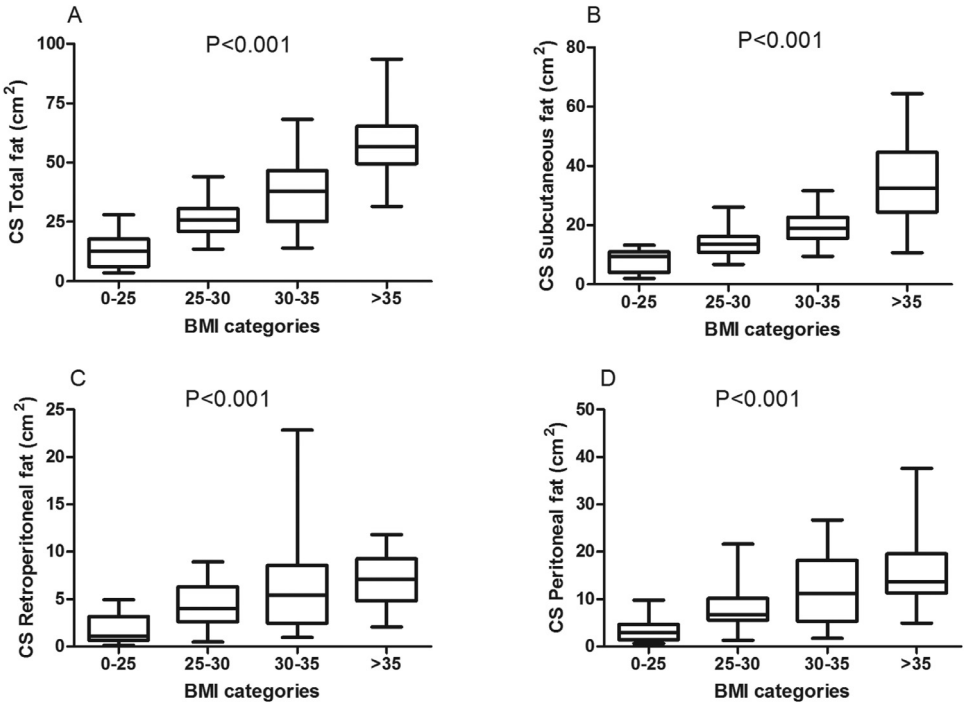

Fig. 3. Correlation between components of fat measured in cross-section (CS; cm^2) and body mass index categories; (*A*) CS total body fat (cm^2), (*B*) CS subcutaneous fat (cm^2), (*C*) CS retroperitoneal fat area (cm^2), and (*D*) CS peritoneal fat (cm^2).

Discussion

PRA has gained wide acceptance as a safe technique and is at least equal to LA in terms of operative outcomes.[8] PRA, however, is considered by many to be a more technically demanding operation because of the presumed unfamiliarity by general surgeons with the retroperitoneal space and because of the relatively small operating volume. Our study sought to investigate whether obesity is correlated with postoperative complications in patients undergoing PRA.

The presence of a high BMI was considered previously to be a contraindication to performing PRA.[4] The concern was that in the prone position, obese patients would experience compression of their retroperitoneum by their abdominal organs which would result in a very small operating space, even with insufflation pressures of up to 22 mm Hg.[4] With increasing experience with this new technique, however, there has been a paradigm shift, and now PRA is considered to be acceptable for obese patients as long as skin-to-retroperitoneal distances at the port sites do not exceed the length of the working port; it has been understood, however, that a greater risk of complications than usual may be anticipated in such patients.[10,29,34,35]

Our study demonstrated that patients with a BMI >25 kg/m^2 and 1 or more measures of components of abdominal fat (TFA, SFA, RFA, and potentially PFA) were univariate risk factors for complications; however, on multivariate analysis, we could not conclude that obesity (in whichever form we evaluated, ie, BMI, cross-sectional areas) was correlated with increased complications and, therefore, prior exclusions should likely be precautionary and not absolute contraindications in experienced hands. This is the first time, to our knowledge, that the relationship of these surrogate markers of obesity to complication rates has been reported. We also demonstrated that the various components of fat (SFA, RFA, and PFA) increased exponentially as BMI increased. Erbil et al have shown that RFA is a more useful parameter than BMI for predicting operative outcomes in LA, and our results suggest that future studies of the role of obesity in operative outcomes should include such direct measures of adiposity.[32]

Our study found that the distance between skin and muscle in both axial and sagittal images of the CT was correlated with the presence of complications in the univariate analysis. This distance in reality represents the amount of subcutaneous tissue that the trocars need to travel after insertion and is su*p*p*o*rted by the fact that the cross-sectional area of subcutaneous fat was also found to be statistically significant in the patients with a complication. A large amount of subcutaneous fat may predispose to wound infections and subcostal nerve injury, and if it results in increasing the time needed for dissection or makes dissection difficult, this could contribute to complications, such as pneumothorax, atelectasis, or bleeding. As such, this distance could be used potentially by the clinician as an indirect marker to predict the risk of postoperative complications.

Our study has also demonstrated that smaller size adrenal tumors are a risk factor for the occurrence of complications. Although this result seems counterintuitive, we emphasize that the patients in this series were selected to undergo a minimally invasive operation, and therefore, the tumors were generally small to medium in size (median, 5.5 cm; range 1.1 to 12 cm). It is conceivable that the smaller tumors and their associated adrenal gland required a somewhat greater duration of time to identify and dissect within the retroperitoneal fat, and as such, required on average a greater operative time and predisposed to a greater rate of complications. Although we urge caution regarding overemphasis on the results of our multivariate analysis because of the relatively small number of complications in our population of a modest sample size and the challenges associated with the inclusion of multiple highly correlated measures of obesity/adiposity, it is interesting to note that both smaller adrenal size and greater operative times were more powerful predictors of risk of complications than any single measure of obesity, including BMI.

The regression equations for CS TFA, CS RFA, CS PFA, and BMI presented in this study have shown that it is possible to predict

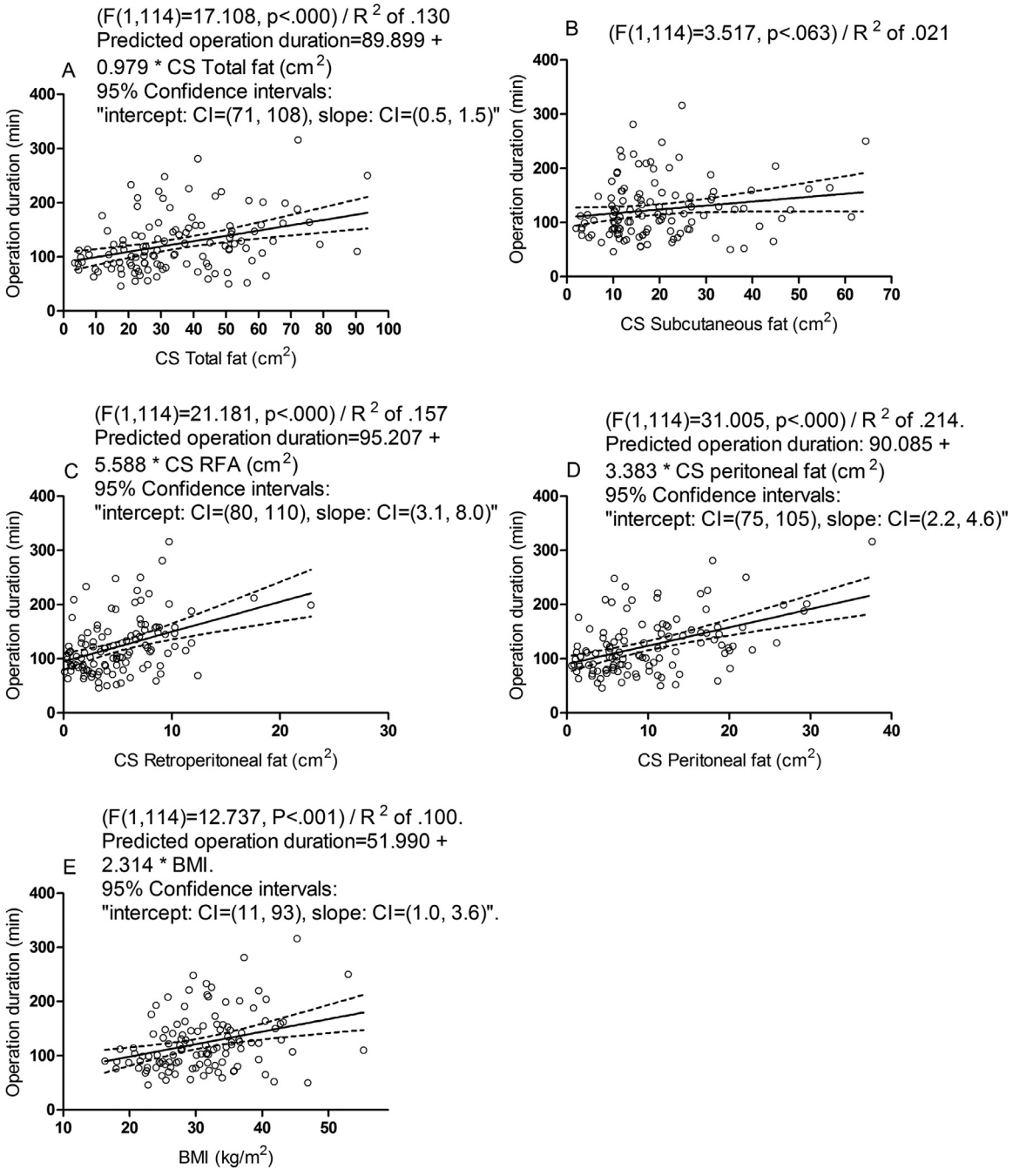

Fig. 4. Linear regression between operative duration and components of fat measured in cross-section (CS; cm^2) and body mass index categories; (*A*) CS total body fat (cm^2), (*B*) CS subcutaneous fat (cm^2), (*C*) CS retroperitoneal fat area (cm^2), (*D*) CS peritoneal fat (cm^2), and (E) BMI (kg/m^2).

the operative time before the actual operation. These formulas provide proof of correlation and could in theory be of use to the surgeon by optimizing the use of the operating list and allocating the appropriate time slots for each patient in a more patient-centered approach.

In an attempt to capture all major unintended morbidity associated with PRA in this patient population, we included a number of relatively minor complications. Even so, our study is limited by the relatively small number of events that occurred relative to the size of the population. Many of the complications that occurred (pneumothorax, atelectasis, subcostal nerve injury, and subcutaneous emphysema) have been reported to occur with some frequency after PRA.

The strengths of this study include the strict inclusion criteria which allowed us to obtain a homogeneous cohort of patients with high-quality CTs that were individually reviewed and measured. The 2 diagnostic groups were similar in their basic demographics and comorbidities and, as expected, the complications group had a greater duration of stay than did patients with no complications. Future studies with a greater number of patients could explore the effect of morbid obesity on the rate of complications (we had only 13 patients with morbid obesity in this study).

This study has several limitations, including its retrospective nature and its single-institution design. Confirmation of our results awaits external validation and perhaps is best answered in a multi-institution collaborative. Also, the measurement of RFA has

an inherent risk of bias because this measurement is partly operator dependent owing to the lack of known automated software to perform such measurement. Operator variability was minimized by review of the CTs by multiple radiologists.

Conclusion

Multiple measures of obesity and adiposity (BMI, TFA, SFA, and PFA), along with operative duration and the size of the adrenal gland, were associated with PRA complications in univariate analysis but not in multivariate analysis. Excellent outcomes can be achieved by a PRA approach even in the obese patient. Operative duration and the size of the adrenal gland were independently correlated with complications in multivariate analysis. These results suggest that surgeons performing PRA for benign adrenal tumors paradoxically should take particular care when operating on patients with small tumors, especially in obese patients.

Conflicts of interest

The authors indicate that they have no conflicts of interest regarding the content of this article.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.surg.2018.09.004.

References

1. Gagner M, Lacroix A, Bolte E. Laparoscopic adrenalectomy in Cushing's syndrome and pheochromocytoma. *N Engl J Med*. 1992;327:1033.
2. Schlinkert RT, van Heerden JA, Grant CS, Thompson GB, Segura JW. Laparoscopic left adrenalectomy for aldosteronoma: early Mayo Clinic experience. *Mayo Clin Proc*. 1995;70:844–846.
3. Mercan S, Seven R, Ozarmagan S, Tezelman S. Endoscopic retroperitoneal adrenalectomy. *Surgery*. 1995;118:1071–1075 discussion 5–6.
4. Walz MK, Peitgen K, Hoermann R, Giebler RM, Mann K, Eigler FW. Posterior retroperitoneoscopy as a new minimally invasive approach for adrenalectomy: results of 30 adrenalectomies in 27 patients. *World J Surg*. 1996;20:769–774.
5. Giebler RM, Walz MK, Peitgen K, Scherer RU. Hemodynamic changes after retroperitoneal CO2 insufflation for posterior retroperitoneoscopic adrenalectomy. *Anesth Analg*. 1996;82:827–831.
6. Walz MK, Alesina PF, Wenger FA, Deligiannis A, Szuczik E, Petersenn S, et al. Posterior retroperitoneoscopic adrenalectomy—results of 560 procedures in 520 patients. *Surgery*. 2006;140:943–948 discussion 8–50.
7. Constantinides VA, Christakis I, Touska P, Meeran K, Palazzo F. Retroperitoneoscopic or laparoscopic adrenalectomy? A single-centre UK experience. *Surg Endosc*. 2013;27:4147–4152.
8. Constantinides VA, Christakis I, Touska P, Palazzo FF. Systematic review and meta-analysis of retroperitoneoscopic versus laparoscopic adrenalectomy. *Br J Surg*. 2012;99:1639–1648.
9. Dickson PV, Alex GC, Grubbs EG, Ayala-Ramirez M, Jimenez C, Evans DB, et al. Posterior retroperitoneoscopic adrenalectomy is a safe and effective alternative to transabdominal laparoscopic adrenalectomy for pheochromocytoma. *Surgery*. 2011;150:452–458.
10. Dickson PV, Jimenez C, Chisholm GB, Kennamer DL, Ng C, Grubbs EG, et al. Posterior retroperitoneoscopic adrenalectomy: a contemporary American experience. *J Am Coll Surg*. 2011;212:659–665 discussion 65–7.
11. Perrier ND, Kennamer DL, Bao R, Jimenez C, Grubbs EG, Lee JE, et al. Posterior retroperitoneoscopic adrenalectomy: preferred technique for removal of benign tumors and isolated metastases. *Ann Surg*. 2008;248:666–674.
12. Evans DB, Perrier ND. On "Posterior retroperitoneoscopic adrenalectomy—results of 560 procedures in 520 patients.". *Surgery*. 2006;140:951–952.
13. Sho S, Yeh MW, Li N, Livhits MJ. Single-incision retroperitoneoscopic adrenalectomy: a North American experience. *Surg Endosc*. 2017;31:3014–3019.
14. Conzo G, Tartaglia E, Gambardella C, Esposito D, Sciascia V, Mauriello C, et al. Minimally invasive approach for adrenal lesions: systematic review of laparoscopic versus retroperitoneoscopic adrenalectomy and assessment of risk factors for complications. *Int J Surg*. 2016;28(Suppl 1):S118–S123.
15. Epelboym I, Digesu CS, Johnston MG, Chabot JA, Inabnet WB, Allendorf JD, et al. Expanding the indications for laparoscopic retroperitoneal adrenalectomy: experience with 81 resections. *J Surg Res*. 2014;187:496–501.
16. Nagesser SK, Kievit J, Hermans J, Krans HM, van de Velde CJ. The surgical approach to the adrenal gland: a comparison of the retroperitoneal and the transabdominal routes in 326 operations on 284 patients. *Jpn J Clin Oncol*. 2000;30:68–74.
17. Hagiwara M, Miyajima A, Hasegawa M, Jinzaki M, Kikuchi E, Nakagawa K, et al. Visceral obesity is a strong predictor of perioperative outcome in patients undergoing laparoscopic radical nephrectomy. *BJU Int*. 2012;110:E980–E984.
18. Seki Y, Ohue M, Sekimoto M, Takiguchi S, Takemasa I, Ikeda M, et al. 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*. 2007;21:929–934.
19. Yang T, Wei M, He Y, Deng X, Wang Z. Impact of visceral obesity on outcomes of laparoscopic colorectal surgery: a meta-analysis. *ANZ J Surg*. 2015;85:507–513.
20. Feder MT, Patel MB, Melman A, Ghavamian R, Hoenig DM. Comparison of open and laparoscopic nephrectomy in obese and nonobese patients: outcomes stratified by body mass index. *J Urol*. 2008;180:79–83.
21. Gong EM, Orvieto MA, Lyon MB, Lucioni A, Gerber GS, Shalhav AL. Analysis of impact of body mass index on outcomes of laparoscopic renal surgery. *Urology*. 2007;69:38–43.
22. Dancea HC, Obradovic V, Sartorius J, Woll N, Blansfield JA. Increased complication rate in obese patients undergoing laparoscopic adrenalectomy. *JSLS*. 2012;16:45–49.
23. Pedziwiatr M, Major P, Pisarska M, Natkaniec M, Godlewska M, Przeczek K, et al. Laparoscopic transperitoneal adrenalectomy in morbidly obese patients is not associated with worse short-term outcomes. *Int J Urol*. 2017;24:59–63.
24. Economopoulos KP, Phitayakorn R, Lubitz CC, Sadow PM, Parangi S, Stephen AE, et al. Should specific patient clinical characteristics discourage adrenal surgeons from performing laparoscopic transperitoneal adrenalectomy? *Surgery*. 2016;159:240–248.
25. Hu Q, Hang Z, Ho Y, Sun C, Xu K, Xia G, et al. Impact of obesity on perioperative outcomes of retroperitoneal laparoscopic adrenalectomy. *Urol Int*. 2015;95:361–366.
26. Hattori S, Miyajima A, Maeda T, Hasegawa M, Takeda T, Kosaka T, et al. Risk factors for perioperative complications of laparoscopic adrenalectomy including single-site surgery. *J Endourol*. 2012;26:1463–1467.
27. Kazaryan AM, Marangos IP, Rosok BI, Rosseland AR, Edwin B. Impact of body mass index on outcomes of laparoscopic adrenal surgery. *Surg Innov*. 2011;18:358–367.
28. Kazaure HS, Roman SA, Sosa JA. Obesity is a predictor of morbidity in 1,629 patients who underwent adrenalectomy. *World J Surg*. 2011;35:1287–1295.
29. Zonca P, Buzga M, Ihnat P, Martinek L. Retroperitoneoscopic adrenalectomy in obese patients: is it suitable? *Obes Surg*. 2015;25:1203–1208.
30. Hasegawa M, Miyajima A, Jinzaki M, Maeda T, Takeda T, Kikuchi E, et al. Visceral fat is correlated with prolonged operative time in laparoendoscopic single-site adrenalectomy and laparoscopic adrenalectomy. *Urology*. 2013;82:1312–1318.
31. Ersoz F, Erbil Y, Sari S, Salmaslioglu A, Issever H, Aral F, et al. Predictive value of retroperitoneal fat area measurement for detecting metabolic syndrome in patients undergoing adrenalectomy. *World J Surg*. 2011;35:986–994.
32. Erbil Y, Barbaros U, Sari S, Agcaoglu O, Salmaslioglu A, Ozarmagan S. The effect of retroperitoneal fat mass on surgical outcomes in patients performing laparoscopic adrenalectomy: the effect of fat tissue in adrenalectomy. *Surg Innov*. 2010;17:114–119.
33. Callender GG, Kennamer DL, Grubbs EG, Lee JE, Evans DB, Perrier ND. Posterior retroperitoneoscopic adrenalectomy. *Adv Surg*. 2009;43:147–157.
34. Varela JE. Retroperitoneoscopic adrenalectomy for pheochromocytoma in a morbidly obese. *Obes Surg*. 2009;19:1180–1182.
35. Agha A, von Breitenbuch P, Gahli N, Piso P, Schlitt HJ. Retroperitoneoscopic adrenalectomy: lateral versus dorsal approach. *J Surg Oncol*. 2008;97:90–93.
36. Cooper AB, Habra MA, Grubbs EG, Bednarski BK, Ying AK, Perrier ND, et al. Does laparoscopic adrenalectomy jeopardize oncologic outcomes for patients with adrenocortical carcinoma? *Surg Endosc*. 2013;27:4026–4032.
37. Gonzalez RJ, Shapiro S, Sarlis N, Vassilopoulou-Sellin R, Perrier ND, Evans DB, et al. Laparoscopic resection of adrenal cortical carcinoma: a cautionary note. *Surgery*. 2005;138:1078–1085 discussion 85–6.