The effect of abdominal fat parameters on percutaneous nephrolithotomy success

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Abstract

Introduction: Obesity has been suggested to lower the success of percutaneous nephrolithotomy (PCNL). However, the relationship between abdominal fat parameters, such as visceral and subcutaneous abdominal adipose tissue, and PCNL success remained unclear. In this study, we aimed to investigate the effect of abdominal fat parameters on PCNL success.

Methods: A total of 150 patients who underwent PCNL were retrospectively enrolled in this study. Group 1 consisted of patients who had no residual stones or residual stone fragments <3 mm in diameter while group 2 included patients with residual stone fragments ≥3 mm. PCNL procedure was defined as successful if all stones were eliminated or if there were residual stone fragments <3 mm in diameter confirmed by non-contrast computed tomography (NCCT) performed postoperatively. Preoperative NCCT was used to determine abdominal fat parameters.

Results: Group 1 consisted of 117 (78.0%) patients while group 2 included 33 (22.0%) patients. On univariate analysis, stone number, stone surface area (SSA), visceral fat area (VFA), abdominal circumference on computerized tomography (ACCT), and duration of procedure were found to be predictive factors affecting PCNL success. Logistic regression analysis revealed that ACCT and SSA were independent prognostic factors for PCNL success.

Conclusions: PCNL success was not affected by VFA, subcutaneous fat area (SFA) and body mass index (BMI) in our series. However, ACCT and SSA had negative associations with PCNL success. We conclude that both ACCT and SSA can be used as tools for predicting PCNL outcomes.

Introduction

Obesity is a common health problem with significant adverse health outcomes.[1] It has an established relationship with several chronic diseases, including cardiovascular disease and diabetes.[2] In addition, ample evidence exists that obesity is associated with metabolic derangements that may lead to the formation of urinary stones.[3-5]

Obesity is defined by the quantity of adipose tissue rather than total body weight.[6] Recently, it has been recognized that abdominal adipose tissue is distributed into two main compartments with different anatomical and functional features: visceral abdominal adipose tissue and subcutaneous abdominal adipose tissue.[7] Visceral abdominal adipose tissue is the adipose tissue that is stored within the abdominal cavity.[7] As its name implies, subcutaneous abdominal adipose tissue is the adipose tissue that lies directly under the abdominal skin.[7] Previous studies concluded that visceral and subcutaneous abdominal adipose tissues were bio-energetically different from each other and, therefore, might have different relations with adverse health outcomes.[7-9]

Percutaneous nephrolithotomy (PCNL) is the standard treatment modality for stones >2 cm, complex stones, and staghorn stones.[10] Although the potential impact of obesity on PCNL success has been investigated, the influence of different abdominal adipose tissue compartments and abdominal fat parameters on PCNL outcomes remained unclear.[11,12] In the present study, we aimed to investigate the effect of abdominal fat parameters and stone characteristics on PCNL success.

Methods

Study design

After we obtained the approval from the local ethics committee, medical records of 1423 patients whom underwent PCNL procedure between March 2007 and November 2014 were reviewed retrospectively. Patients whose imaging studies were performed at other centres prior to their referral were excluded. Additional exclusion criteria of this study were patient age less than 18 years, solitary kidney, congeni-

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tal kidney anomalies, chronic renal failure, and incomplete data. The remaining 150 patients were enrolled in the study. Patients were divided into two groups according to their residual stone status, which was confirmed by a non-contrast computed tomography (NCCT) performed postoperatively.

Group 1 consisted of patients who had no residual stones or residual stone fragments <3 mm in diameter while group 2 included patients with residual stone fragments ≥3 mm in diameter. PCNL procedure was defined as successful in cases where all stones were eliminated or there were residual stone fragments <3 mm in diameter. Thus, group 1 included the patients who underwent successful PCNL. Study groups were compared in terms of abdominal fat parameters, stone characteristics, demographic data, and surgical parameters. Statistical analyses were performed with SPSS version 19.0 for Windows (IBM, NY, U.S.).

Data elements

Demographic data and surgical parameters, such as age, gender, body mass index (BMI), duration of procedure, total flouroscopy time, and stone radiopacity were recorded in our database. The BMI was calculated by dividing the weight (kg) by height squared (m^2). Duration of procedure was calculated as the time between the introduction of the access needle and Amplatz sheath removal. The amount of time the operator's foot was pressing on the fluoroscopy pedal was considered as total fluoroscopy time. Stone characteristics (i.e., stone number, location, laterality, stone surface area (SSA), Hounsfield unit (HU) density, stone-skin distance) and abdominal fat parameters (i.e., visceral fat area (VFA), visceral fat percentage (VFP), subcutaneous fat area (SFA), and abdominal circumference were identified for each patient by reviewing the preoperative NCCT scans and recorded in the database for study purposes.

Surgical technique

All PCNL procedures were performed according to current guideline indications.[13] 24°F rigid nephroscope (Storz®, Karl Storz Endoskope, Tuttlingen, Germany) was used for percutaneous renal stone management. All procedures were performed by the same attending urologist, who was experienced in PCNL surgery. Retrograde catheterization was performed with 6F ureteral catheter. Subsequently, patients were taken to prone position and the targeted calyx was entered with 18-gauge access needle under the guidance of biplanar fluoroscopy.

After tract dilatation by Amplatz dilators over the guidewire, a standard PCNL procedure was performed with the lithotripsy done by ultrasonic lithotripter, and the stone fragments taken with the grasping forceps.

NCCT measurements

Renal stone protocol NCCT was performed for each patient preoperatively with a 64 multislice computerized tomography device (Aquilion, Toshiba Medical Systems, Tokyo, Japan). A single radiologist, who was blinded to the clinical outcomes of the patients, reviewed the NCCT images retrieved from picture archiving and communication system (PACS) and identified the abdominal fat parameters and stone characteristics for each patient.

VFA and SFA were measured for each patient, as previously described.[14] Visceral fat was defined as intra-abdominal fat bound by parietal peritoneum or transversalis fascia excluding the vertebral column and the paraspinal muscles.[14] Subcutaneous fat was defined as fat superficial to the abdominal and back mucles.[14] VFA and SFA were identified on the NCCT axial slice at umbilical level using the Aquarius iNtuition fat analysis tool (Aquarius iNtuition Edition ver.4.4.8.85.3194). A fixed attenuation range from -190 to -30 HU was used as the standard of reference.[15] The pixels with attenuation values in the selected attenuation range were depicted in different colours, representing different abdominal fat areas (Figs. 1 and 2).

VFP (%) was calculated with the formula: (VFA/VFA+SFA) x 100.[16] Abdominal circumference on computerized tomography (ACCT) was calculated automatically by the same software on the axial slice that was used to measure VFA and SFA.Subsequently, stone characteristics, such as stone number, location, laterality, HU density and stone-skin distance were identified for each patient. SSA was calculated as

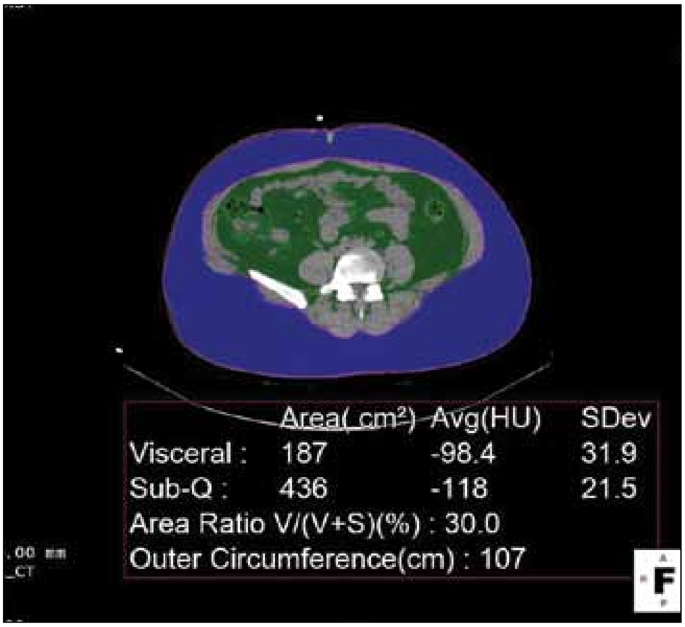

Fig. 1. Sample CT axial slice at umbilical level of a patient with a relatively high subcutaneous fat area (SFA). Blue area represents the SFA based on the attenuation range for fat.

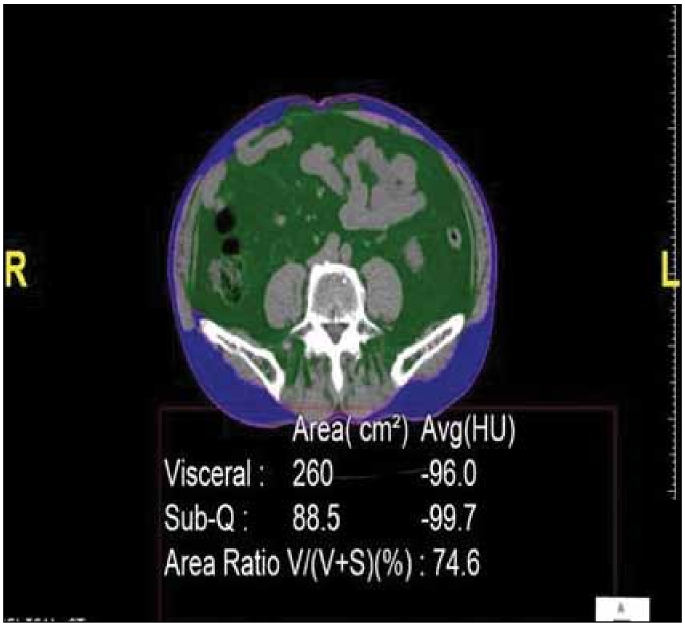

Fig. 2. Sample CT axial slice at umbilical level of a patient with a relatively high visceral fat area (VFA). Green area represents the VFA based on the attenuation range for fat.

Table 1. Demographic data, stone characteristics, abdominal fat, and surgical parametres

Variable	Mean±SD
Age	50.43±14.27
Gender (Male/Female)	76 (50.7%)/ 74 (49.3%)
VFA (cm²)	183.60±76.74
SFA (cm²)	276.49±129.69
VFP (%)	41.18±11.20
ACCT (cm)	97.16±13.19
BMI (kg/m²)	29.10±5.29
Stone-skin distance (mm)	93.08±21.03
Hounsfield unit density (HU)	1043.65±332.42
Stone surface area (mm²)	617.67±599.38
Stone number (Single/Multiple)	57 (38.0%)/93 (62.0%)
Stone laterality (Right/Left)	68 (45.3%)/82 (54.7%)
Stone location (Upper/Mid/Lower pole)	40 (26.7%)/26 (17.3%)/111 (74.0%)
Stone radiopacity (Opaque/ Non-opaque)	132 (88.0%)/18 (12.0%)
Duration of procedure (min)	54.24±35.41
Total fluoroscopy time (sec)	91.38±73.51

ACCT: abdominal circumference on computerized tomography; BMI: body mass index; SD: standard deviation; SFA subcutaneous fat area; VFA: visceral fat area; VFP: visceral fat percentage.

a measure of stone burden.[17] We used the following formula to calculate SSA: width x height x ϖ × 0.25.[18] Stone-skin distance was measured using a technique described by Pareek et al.[19] Three distances were measured on axial CT from the stone's centre to the skin surface horizontally, perpendicular, and at 45° between the first two measurements.

Statistical analysis

Parametric variables were analyzed using t-tests. Categorical variables were analyzed by chi-square test. Backward stepwise logistic regression model was used to evaluate the relationship between PCNL outcome and variables. All tests were two-sided and $p<0.05$ was considered statistically significant. Statistical analyses were performed with SPSS version 19.0 for Windows (IBM, NY, U.S.).

Results

A total of 150 patients were enrolled in the study. Demographic data, stone characteristics, abdominal fat, and surgical parameters are shown in Table 1.

Division of the study group according to residual stone status revealed two patient groups (Table 2). Group 1 consisted of 117 (78.0%) patients with no residual stones or residual stone fragments <3 mm in diameter. Group 2 included 33 (22.0%) patients with residual stone fragments ≥3 mm in diameter.

Comparison of the data elements among patient groups 1 and 2 did not reveal any significant difference in terms of VFP, SFA, stone location, laterality, stone-skin distance, BMI, and total fluoroscopy time (Table 2). On the other hand, there was significant difference between the groups in terms of VFA, ACCT, stone number, SSA, HU density, duration of procedure, and stone radiopacity ($p<0.05$). Subsequently, a multivariate logistic regression analysis was performed in order to evaluate the strength of these predictive factors (Table 3). This analysis revealed that the main independent predictive factors for PCNL success were SSA (odds ratio [OR] 14.76, 95% confidence interval [CI] 5.64–38.60, $p<0.01$) and ACCT (OR 4.50, 95% CI 1.68–12.08, $p<0.01$).

Discussion

Obesity is a major global health problem that has received much attention during the past two decades and is of paramount importance due to its association with multiple adverse health outcomes.[2,20,21] It is a risk factor for several chronic diseases, including cardiovascular disease, diabetes, and diseases of kidney and liver.[2,20] Obesity is also associated with metabolic derangements, which can increase the risk of urinary stone formation.[4,5]

Since obese patients undergoing surgery pose a challenge to those caring for them, the impact of obesity on surgical complications has always been a topic of interest.[22] Choban et al reported that obesity was associated with an increase in the frequency and severity of complications in a wide variety of surgical procedures.[22] On the other hand, studies investigating the relationship between obesity and PCNL

Table 2. Comparison of variables between two groups

Variable	Stone-free group (mean±SD)	Residual stone group (mean±SD)	*p* value
Age	58.68±14.4	55.56±12.5	0.411
Gender (Male/Female)	54(46.1%)/63 (53.9%)	22 (66.7%)/11 (33.3%)	0.302
VFA (cm²)	171.62±72.43	218.91±79.13	0.001
SFA (cm²)	269.42±137.7	297.31±112.68	0.253
VFP (%)	40.74±11.52	42.48±10.23	0.409
ACCT (cm)	95.65±13.55	101.62±11.07	0.015
BMI (kg/m²)	28.77±5.44	30.06±4.75	0.193
Stone-skin distance (mm)	93.4±19.04	91.9±26.2	0.702
Hounsfield unit density (HU)	1000.80±314.00	1169.94±356.7	0.006
SSA (mm²)	492.93±408.69	1198.50±750.92	0.001
Stone number (Single/Multiple)	49 (41.9%)/68 (58.1%)	8 (24.2%)/25(75.8%)	0.015
Stone laterality (Right/Left)	58(49.6%)/59(50.4%)	10(30.3%)/23 (69.7%)	0.52
Stone location (Upper/Mid/Lower pole)	24(21.4%)/15(13.4%)/85(75.9%)	16(42.1%)/11(28.9%)/26 (68.4%)	0.241
Stone radiopacity (Opaque/Non-opaque)	95 (84.8%)/ 17 (15.2%)	37 (97.4%)/1(2.6%)	0.044
Duration of procedure (min)	47.28±33.46	74.76±33.35	0.001
Total fluoroscopy time (sec)	87.53±79.44	102.76±51.50	0.271

ACCT: abdominal circumference on computerized tomography; BMI: body mass index; SD: standard deviation; SFA subcutaneous fat area; SSA: stone surface area; VFA: visceral fat area; VFP: visceral fat percentage.

complications gave conflicting results.[11,12,23,24] The Clinical Research Office of the Endourological Society (CROES) PCNL Global Study evaluated 5803 patients treated at 96 centres around the world.[11] In this study, patients were categorized as normal weight, overweight, obese, and morbid obese according to their BMI.[11] This work concluded that obesity was associated with a longer duration of procedure, an inferior stone-free rate, and a higher re-intervention rate.[11]

Conversely, Koo et al found that PCNL success was independent of the patients' BMI.[23] Faerber et al compared normal weight patients with morbid obese patients in terms of PCNL outcomes and found similar stone-free rates.[24] In a retrospective study including 546 obese patients, El-Assmy et al reported that PCNL success rate was 84.8% in obese patients.[12] This rate was similar to that obtained in nonobese patients.[12] Thus, these authors concluded that PCNL success was independent of the patient's BMI.[12]

In our study, BMI did not emerge as a significant predictive factor for PCNL success. However, the fact that our patients were not categorized according to their BMI must be kept in mind while evaluating this finding.

The compartmentation of abdominal adipose tissue paved the way for the studies investigating the effect of each abdominal adipose tissue compartment (visceral and subcutaneous) seperately on adverse health outcomes.[8,9,25] Interestingly, some of these studies reported that a particular adverse health outcome was related with one abdominal adipose tissue compartment, but not with the other.[9,25] By taking the conflicting results of the studies investigating the relationship between obesity and PCNL complications into account, we used a relatively new approach — we investigated the effect of each abdominal adipose tissue compartment and abdominal fat parameter on PCNL success seperately.

In addition, we conceived that the effect of each abdominal adipose tissue compartment on the factors determining the surgical success of a PCNL procedure (i.e., radiographic visualization, identification of anatomical landmarks, ease of access to pelvicalyceal system) could be potentially different.

In a cohort of 150 patients, we found VFA and ACCT as the abdominal fat parameters that can potentially predict PCNL success. However, further statistical analysis identified ACCT as the main independent predictive factor. Today, it is widely accepted that accurate measures of abdominal fat can be made by CT and abdominal circumference can be used to assess the abdominal fat content.[26,27]

Table 3. Multivariable Cox regression analysis predicting PCNL success

Variable	Hazard ratio	95% CI	*p* value
VFA (cm²)	2.07	0.72–5.96	0.175
SFA (cm²)	0.96	0.46–2.02	0.932
VFP (%)	1.32	0.63–2.77	0.450
ACCT (cm)	4.50	1.68–12.08	<0.01
BMI (kg/m²)	1.24	0.59–2.60	0.562
Stone-skin distance (mm)	0.75	0.35–1.58	0.456
Hounsfield unit density (HU)	1.99	0.92–4.28	0.078
SSA (mm²)	14.76	5.64–38.60	<0.01
Stone number (Single/Multiple)	1.39	0.42–4.61	0.584
Stone radiopacity (Opaque/Non-opaque)	0.09	0.011–0.889	0.039
Duration of procedure (min)	2.25	0.77–6.57	0.137
Total fluoroscopy time (sec)	1.37	0.64–2.94	0.410

ACCT: abdominal circumference on computerized tomography; BMI: body mass index; CI: confidence interval; SFA subcutaneous fat area; SSA stone surface area; VFA: visceral fat area; VFP: visceral fat percentage.

Despite the fact that VFA and SFA both contribute to the abdominal circumference, PCNL success was not affected by either of these parameters. Instead, PCNL success was affected solely by ACCT. In light of this finding, it can be hypothesized that individual abdominal adipose tissue compartments act together and produce a synergistic effect, which makes identification of anatomical landmarks, radiographic visualization, and pelvicalyceal system access challenging during a PCNL procedure.

We identified SSA as another main independent predictive factor for PCNL success. This finding is not surprising since SSA is a measure of stone burden and PCNL success was defined as absence of residual stone fragments or presence of stone fragments <3 mm in diameter in our study.[17] This result is compatible with the relevant literature.[11,28]

To our knowledge this is the first report evaluating the effect of abdominal adipose tissue compartments and abdominal fat parameters on PCNL success. However, this study has limitations that need to be considered in interpreting the findings. First, it is a retrospective study with a small sample size. Second, there could be selection bias, as this is a single-centre study. Third, as noted before, patients were not categorized according to their BMI. As such, the influence of abdominal fat parameters on PCNL complications was not investigated within the context of this study.

However, despite these limitations, we may conclude that ACCT can be used as an additional tool for predicting PCNL outcomes. Moreover, the effects of different abdominal adipose tissue compartments and abdominal fat parameters on PCNL success need further investigation. Future studies in larger, multicentre, prospective cohorts are warranted in this regard.

Conclusion

ACCT and SSA can be used to predict PCNL success. The effect of different abdominal adipose tissue compartments and abdominal fat parameters on PCNL outcomes needs further investigation. These investigations may help in clarifying the relation between obesity and PCNL success.

Competıng interests: The authors declare no competing financial or personal interests.

This paper has been peer-reviewed.

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