ORIGINAL RESEARCH
Endrourology

Doi: 10.4274/jus.galenos.2019.2660
Journal of Urological Surgery, 2019;6(4):283-288

Does Increased Stone-skin Distance Due to Obesity Affect Outcomes of Percutaneous Nephrolithotomy?

Obeziteye Bağlı Artmış Taş-deri Mesafesi Perkütan Nefrolitotomi Sonuçlarını Etkiler mi?

Batuhan Ergani[1], Mustafa Karabıçak[2], Hakan Türk[3], Mehmet Yoldaş[4], Cemal Selçuk İşoğlu[5], Tufan Süelözgen[1], Gökhan Koç[1], Yusuf Özlem İlbey[1]

[1]*University of Health Sciences, Tepecik Training and Research Hospital, Clinic of Urology, İzmir, Turkiye*
[2]*Batman Region State Hospital, Clinic of Urology, Batman, Turkiye*
[3]*Uşak University Faculty of Medicine Training and Research Hospital, Clinic of Urology, Uşak, Turkiye*
[4]*Kemalpaşa State Hospital, Clinic of Urology, İzmir, Turkiye*
[5]*Ceyhan State Hospital, Clinic of Urology, Adana, Turkiye*

What's known on the subject? and What does the study add?

Stone skin distance is one of the important parameters affecting the success of extracorporeal shock wave lithotripsy. For this reason, percutaneous nephrolithotomy seems to be a more suitable treatment modality in order to ensure complete stonelessness in stone patients with more stone skin distance. However, there are no studies and recommendations evaluating the effect of stone skin distance on percutaneous nephrolithotomy success in the literature and current urology guidelines. In this study, we aimed to evaluate the effect of stone skin distance on stone-free after percutaneous nephrolithotomy and to shed light on literature, current urology guidelines and routine urology practice.

Abstract

Objective: Numerous factors may affect the outcomes of percutaneous nephrolithotomy (PCNL). Skine-to-stone distance (SSD) is a stronger predictor of the success of extracorporeal shock wave lithotripsy. In this study, we investigated the effect of SSD on PCNL.

Materials and Methods: Data of 957 patients, who underwent PCNL between January 2007 and September 2018, were analyzed retrospectively. Of those, 424 patients, who underwent single access and had computed tomography imaging within 3 months preoperatively and post-operatively, were included in the study. The length of tract, which is the distance from the skin to the calyx of access, was measured by means of preoperative computed tomography imaging. The patients were divided into 2 groups with respect to the mean SSD: group 1 (239 patients, SSD≤100.1 mm) and group 2 (185 patients, SSD>100.1 mm). Stone-free rates were determined by detecting no-fragment status in postoperative imaging. The groups were compared by preoperative, peroperative and postoperative parameters.

Results: There was no significant difference in terms of age, gender, body mass index, stone location, site of operation, length of hospital stay, operative time, fluoroscopy time, drop in hematocrit, stone-free status and access places between the groups. Stone burden and density and transfusion requirements were found to be significantly higher in group 1 than in group 2 ($p<0.05$).

Conclusion: In this study, we found that body mass index did not affect the stone-free rate in patients who underwent PCNL. Our results suggest that PCNL is a safe, effective and favorable treatment method in patients of various body mass indices.

Keywords: Extracorporeal shock wave lithotripsy, Obesity, Percutaneous nephrolithotomy, Stone-free rate, Stone-skin distance

Öz

Amaç: Perkütan nefrolitotomi (PCNL) sonuçlarını birçok faktör etkiler. Taş deri mesafesi (TCM) ekstrakorporal şok dalga litotripsi başarısında daha güçlü bir etkendir. Biz bu çalışmada TCM'nin PCNL üzerine etkisini araştırdık.

Gereç ve Yöntem: Ocak 2007 ile Eylül 2018 tarihleri arasında PCNL yapılan 957 hasta retrospektif olarak incelendi. Preoperatif bilgisayarlı tomografisi olan, tek akses yapılmış, postoperatif 3 ay içerisinde görüntülemesi olan 424 hasta çalışmaya alındı. Deri kaliks arası mesafe preoperatif bilgisayarlı tomografi ile ölçüldü. Ortalama TCM'ye göre hastalar grup 1 (239 hasta, TCM <100,1 mm) ve grup 2 (185 hasta, TCM >100,1 mm) şeklinde

Correspondence: Batuhan Ergani MD, Health Sciences University, Tepecik Training and Research Hospital, Department of Urology, İzmir, Turkiye
Phone: +90 531 505 80 35 **E-mail:** batuhan-133@hotmail.com **ORCID-ID:** orcid.org/0000-0002-4667-855X
Received: 06.03.2019 **Accepted:** 25.03.2019

Cite this article as: Ergani B, Karabıçak M, Türk H, Yoldaş M, İşoğlu CS, Süelözgen T, Koç G, İlbey YÖ. Does Increased Stone-skin Distance Due to Obesity Affect Outcomes of Percutanous Nephrolithotomy? J Urol Surg 2019;6(4):283-288.

2 gruba ayrıldı. Taşsızlık oranları postoperatif görüntülemelerde sıfır fragman kalmasıyla belirlendi. Gruplar preoperatif, operatif ve postoperatif parametrelere göre karşılaştırıldı.

Bulgular: Gruplar arasındaki sonuçlara bakıldığında yaş, cinsiyet, vücut kitle indeksi, taşın lokalizasyonu, operasyon yapılan taraf, hastanede kalış süreleri, operasyon süreleri, floroskopi süreleri, hematokrit düşüşleri, taşsızlık durumu ve akses yerleri arasında anlamlı sonuç saptanmadı. Taş yükü, taşın yoğunluğu ve transfüzyon ihtiyaçları grup 1'de grup 2'ye oranla anlamlı oranda yüksek saptandı (p<0,05).

Sonuç: Biz bu çalışmamızda PCNL yapılan hastalarda VKİ'nin taşsızlık oranına etkisinin olmadığını bulduk. Bu sonuçlar farklı vücut yapısına sahip hastalarda PCNL'nin güvenli, efektif ve tercih edilebilir bir tedavi yöntemi olduğunu göstermektedir.

Anahtar Kelimeler: Ekstrakorporal şok dalga litotripsi, Obezite, Perkütan nefrolitotomi, Taşsızlık oranı, Taş-deri mesafesi

Introduction

Since its first description in 1976 by Fernstrom and Johansson, percutaneous nephrolithotomy (PCNL) has been used as the first-line treatment option for kidney stones larger than 2 cm, lower pole stones larger than 15 mm and complicated or staghorn upper urinary tract stones (1,2,3,4,5). The effect of extracorporeal shock wave lithotripsy (ESWL) is limited in the treatment of kidney stones in obese patients due to overweight and longer skin-to-stone distance (SSD) (6,7), and hence endourological methods such as PCNL, micro-PCNL or retrograde intrarenal surgery can be the recommended treatment even for small stones (8). Although PCNL complications are more common in obese patients, various studies revealed that PCNL was a safe technique in this patient group, although stone-free rates were lower (6,9).

PCNL results are related to several factors such as renal stone burden, stone location, anatomical factors and obesity (10). SSD may be different in patients with similar body mass index (BMI) since they might have different body types and different levels of retroperitoneal fat. SSD has been interpreted in various ways in scoring systems or nomograms (11,12,13). However, the relationship between SSD and stone-free rate following PCNL remains unclear.

SSD is related with stone location, renal parenchyma thickness, and subcutaneous and visceral adipose tissue. Tepeler et al. (14) investigated the effects of the thickness of renal parenchyma on PCNL and they found that renal parenchymal thickness had no impact on stone-free rate.

Some studies have investigated the effect of SSD on ESWL success and revealed that longer SSD would result in a lower stone-free rate after ESWL (15,16,17). These studies demonstrated that SSD was a stronger predicting factor for ESWL success compared to BMI (16,17). In this study, we investigated the effects of SSD on stone-free rate and complication rate in patients undergoing PCNL in the prone position.

Materials and Methods

Records of 957 patients, who underwent PCNL for upper urinary tract stone disease in our clinic between January 2007 and September 2018, were retrospectively reviewed. Preoperative computed tomography (CT) images and any image acquired within 3 months postoperatively were analyzed. Patients under the age of 18, with a solitary kidney or renal anomalies, those who underwent bilateral PCNL, had multiple accesses, had no preoperative CT result and underwent staged surgical procedures were excluded. A total of 424 patients with a mean SSD of 100.11 mm met the inclusion criteria. Since there is no threshold value determined for SSD, the patients were divided into two groups: group 1 (SSD≤ 100.1 mm; average SSD - 8 3.6 mm) and group 2 (SSD>100.1 mm; average SSD - 118.1 mm).

Demographic data, complete blood count, blood biochemistry, urine culture, imaging examinations, operational data, and postoperative complications were taken from the hospital records. Stone burden was assessed by CT and was calculated by multiplying the maximum anteroposterior and lateromedial lengths in the axial plane. Stone burden of multiple stones was calculated by measuring the largest 3 stones and adding up all the three results.

As the surgical procedure, cystoscopy was initially performed for retrograde catheterization while the patient was in the lithotomy position under general anesthesia. A 5 F or 6 F ureteral catheter was inserted. Then, the patient was taken to the prone position. The targeted calyx was entered with an 18 gauge needle under the guidance of biplanar fluoroscopy, and the tract was dilated with a one-shot dilatation using a 26-30 F amplatz sheath over the guide wire. Lithotripsy was performed using a pneumatic or ultrasonic lithotripter and some stones were collected by stone forceps.

Tract length was determined by preoperative CT. This length was determined as the distance between the skin and the lateral/superficial side of the optimal calyx for entry (the optimal calyx for entry was confirmed by intraoperative fluoroscopic images). Preoperative images were taken with the patient in the supine position using low-dose CT stone protocol. The length of the tract was determined by taking the average of the measurements of horizontal, vertical and 45° oblique axes between the medial corner of the stone and the skin surface, in millimeters (18) (Figure 1). Location of the stone, stone burden, stone density and SSD were noted for each patient. All measurements were taken at the maximum dimensions to ensure standardization. Six skilled urologists performed the measurements independently. Additionally, all punctures were performed by 6 endourologists with the patients in the prone position, most commonly at the posterior calyx.

Complications were defined by examining the medical records of each patient and in accordance with the modified Clavien classification (19). Clavien grade 1 and 2 were regarded as minor complications and grade 3-5 as major complications.

Stone-free status was analyzed in the postoperative 3 months with CT, plain x-ray of the urinary tract pathogens (UTP) or intravenous pyelogram (IVP). Stone-free status was confirmed by detecting no fragments in the postoperative imaging. Stones <4 mm were considered clinically insignificant residual fragments and patients having such stones were included in the group with no fragments.

Group comparisons were done for age, gender, BMI, stone location (non-staghorn/partial staghorn/complete staghorn), PCNL side, stone burden, stone density, transfusion requirements, operative time, fluoroscopy time, length of hospital stay, drops in hematocrit (Htc), stone-free status and access site. Staghorn stones are defined as branched stones filling all or part of the renal pelvis and branch into several or all of the calyces. Partial staghorn stones refer to stones filling the renal pelvis and one calyx only (20).

Statistical Analysis

All statistical analyses were performed using SPSS 20.0 software package for Windows. Logistic regression analysis and chi-square tests were used to evaluate the data. A p value of less than 0.05 was considered statistically significant.

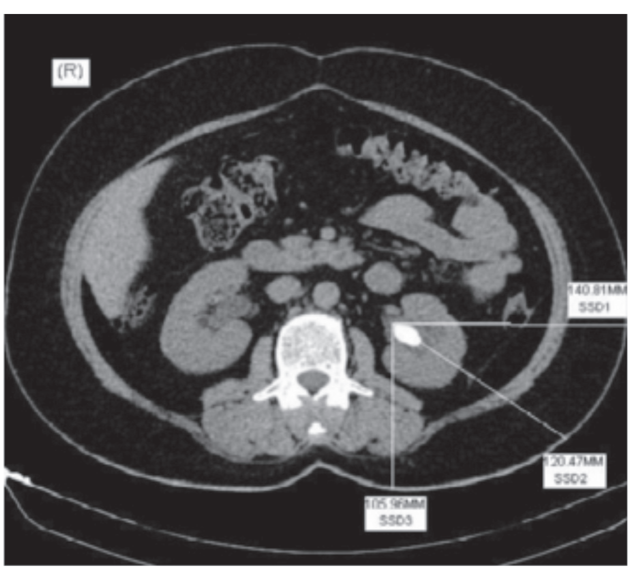

Figure 1. Skine-to-stone distance measurement on axial plane computed tomography imaging

Results

Of 957 patients who underwent PCNL, 424 met the inclusion criteria of this study. Preoperative data of the two groups are shown in Table 1. There was no statistically significant difference in age, gender, BMI, side of PCNL and stone location between the groups (p>0.05).

The operative and postoperative data of both groups are shown in Table 2. There was no significant difference in length of hospital stay, operative time, fluoroscopy time, drop in Htc, access site and stone-free rates between the groups (p>0.05). The mean stone burden and stone density was considerably higher in group 1 than in group 2. In group 1, 7 patients (2.9%) required intraoperative and 3 (1.2%) patients required postoperative blood transfusion; whereas in group 2, 1 (0.5%) required intraoperative and 4 (2.1%) required postoperative blood transfusion (p<0.019). The difference in total blood transfusion rate was statistically significant between the groups (p<0.019).

Postoperative complications evaluated according to the modified Clavien Classification are shown in Table 3. Fever that can be controlled pharmacologically, not requiring surgical intervention was considered grade 1 complication. Hematuria requiring blood transfusion but can be controlled without any surgical intervention was considered grade 2 complication. Any complication which was not life-threatening but requiring surgical intervention was considered grade 3 complication. Grade 4 and 5 complications developed in neither group. The surgical interventions included ureterorenoscopy (URS), double J stent (DJS) insertion and arteriovenous fistula (AVF) embolization and all were performed under local or regional

Table 1. The demographic data and preoperative information

Patient data	Group 1 (n=239)	Group 2 (n=185)	p
Age (year)	46.37±15.0	52.58±13.7	0.09
Gender			
Male	154 (64%)	99 (53%)	0.171
Female	85 (36%)	86 (47%)	
BMI (kg/m²)	26.0±4.7	30.7±6.0	0.263
Stone localization			
Calyx	61 (25.5%)	29 (15.8%)	
Pelvis	59 (24.7%)	70 (38%)	0.816
Pelvis+Calyx	115 (48.1 %)	80 (43.5%)	
Stahgorn	4 (1.7%)	6 (2.7%)	
PCNL side			
Right	130 (54.4%)	96 (51.8%)	0.248
Left	109 (45.6%)	89 (48.2%)	

BMI: Body mass index, PCNL: Percutaneous nephrolithotomy

Table 2. Operative and postoperative data			
Operation data	Group1 (n=239)	Group 2 (n=185)	p
Stone burden (mm²)	728.85±970.72	584.33±698.16	0.002
Stone density (HU)	1117.51±323.03	1044.87±354.97	0.029
Length of hospital stay (days)	2.77±2.42	2.52±2.00	0.106
Operation time (minutes)	67.95±42.75	58.40±35.85	0.236
Floroscopy time (seconds)	124.73±94.91	108.32±71.32	0.977
Drop in hematocrit (%)	2.27 (5.59%)	2.13 (5.21%)	0.235
Transfusion requirement (n)			0.019
Intraoperative	7 (2.9%)	1 (0.5%)	
Postoperative	3 (1.2%)	4 (2.1%)	
Stone-free status			0.248
Fragment +	114 (47.7%)	77 (41.6%)	
No fragments	125 (52.3%)	108 (58.4%)	
Access site			0.548
Subcostal	209 (87.4%)	173 (93.5%)	
Supracostal	30 (12.6%)	12 (6.5%)	

HU: Hounsfield unit

Table 3. Postoperative complications according to the modified Clavien Classification			
Grade	Group 1, n (%)	Group 2, n (%)	p
No complication	208 (87%)	169 (91.3%)	-
1			
Fever	6 (2.5%)	3 (1.6%)	-
2			
Blood transfusion	3 (1.2%)	4 (2.1%)	-
Hemorrhage	5 (2%)	1 (0.5%)	
3			
Fever	4 (1.6%)	0	-
Hemorrhage	1 (0.4%) (AVF)	1 (0.5%)	
Ureteric colic	9 (3.7%)	4 (2.1%)	
Wound discharge	2 (0.8%)	3 (1.6%)	
Pain	1 (0.4%)	0	
Total	31 (12.9%)	16 (8.6%)	0.0514

AVF: Arteriovenous fistula

anesthesia. Complications developed in 31 patients of group 1 (minor complications in 14 and major in 17) and in 16 patients of group 2 (minor in 8 and major in 8). In group 1, embolization was performed in 1 patient with AVF; URS was performed or a DJS was inserted in 16 patients with fever, pain, wound discharge and renal colic due to ureteral stones. In group 2, however, URS was performed or a DJS was inserted in 8 patients for bleeding, renal colic due to ureteral stones and wound discharge (p>0.05). There was no significant difference between the groups in terms of general postoperative complications (p>0.05).

Discussion

Different endourological procedures are used in the treatment of kidney stones; PCNL is the preferred treatment for complicated or staghorn stones greater than 2 cm (3,5,21) and used instead of ESWL to treat kidney stones in obese patients because of excess weight and relatively long SSD (7). Body fat distribution varies between genders and races (11,12,22). It may be speculated that retroperitoneal fat distribution is not same in people with the same BMI. PCNL was determined to be safer in obese patients but resulted in lower stone-free rates (6,9). As expected, in this study, we showed a positive relationship between BMI and SSD but increased BMI had no effect on stone-free status.

BMI has been excessively used for defining obesity index; nonetheless it has been shown in some important studies that visceral fat tissue was a better predictor of obesity and risks associated with endoscopic surgery than BMI (23,24). In this study, although statistically insignificant BMI values were found to be lower in the group 1 patients than in group 2 patients. These results suggest that SSD values increase in parallel to subcutaneous and visceral fat tissue increase in patients with high BMI values.

BMI may be a predictive factor for PCNL outcomes. In a PCNL study of 3709 patients, Fuller et al. (9) grouped patients by BMI and found lower stone-free rates in obese patients. El-Assmy et al. (6) argued that obesity had no impact on stone-free rates. This result was also achieved by a few studies with a smaller population and as our results (25,26). In our study, the patients were grouped by SSD, and SSD was shown to increase with BMI. The stone-free rate was found to vary between 52.3% and 58.4% between the groups, which was not statistically significant. Upon these results, we may conclude that SSD has no impact on the success of PCNL.

In their study, Tepeler et al. (14) reported no relationship of PCNL success with operative time, fluoroscopy time and duration of hospital stay. In our study, it was observed that operative time, fluoroscopy time and length of hospital stay were longer in group 1 patients but the difference was statistically insignificant. Thus, SSD had no significant effect on operative time, fluoroscopy time and length of hospital stay.

Factors such as stone burden, stone complexity and stone shape are correlated with PCNL outcomes (7). In preoperative scoring systems, SSD is apparently a variable parameter influencing stone-free rates (13). Considering various components in obese patients, SSD may be a more important factor affecting PCNL results than BMI. Theoretically, increased SSD may be interpreted as a distinct level of difficulty experienced due to the rigid instruments being forced while passing through the tract during standard PCNL procedure. According to Curtis et al. (27), an incision through the muscular fascia would help reaching the stone easier. In a study by Giblin et al. (28), long access sheats were recommended to be used in obese patients. In our study, stone burden was significantly higher in group 1 but SSD was short in this group. However, the stone-free rate was similar between the groups. This similarity may be due to positive effect of short SSD in group 1.

In their study, Fuller et al. (9) demonstrated that the rate of subcostal renal access was statistically significantly higher in super obese patients (87.4%) than in normal weight group (81.2%). In addition, it was found that the rate of pulmonary complications were significantly decreased in super obese patients in whom supracostal puncture was done. Pulmonary complications, which are difficult to tolerate by obese patients, occur more commonly during supracostal access. In our study, the subcostal access rate was higher in group 2 (93.5%) than in group 1 (87.4%), but the difference was not statistically significant. We did not experience any pulmonary complications in any of the supracostal accesses.

Some studies reported no correlation between hemorrhage and blood transfusion rates and increased BMI in PCNL operations (6,9,29). This result may be explained by blockage of hemorrhage in the tract by retroperitoneal fat tissue (19). Our data for blood transfusion rate and Htc drops after PCNL support the results of the above mentioned studies; group 2 with higher BMI showed lower blood transfusion rates ($p<0.019$) and smaller drop in Htc ($p<0.235$) than those of group 1.

Complications after PCNL were classified according to the modified Clavien Classification system (30,31). Minor complications (grade 1 and grade 2) were observed rarely while major complications (grade 3-5) were common in morbidly obese patients. Accordingly, obese patients required URS or re-PCNL more frequently. In their study including 3709 patients strafied by BMD, Fuller et al. (9) reported a significantly higher re-treatment rate in obese patient groups ($p<0.001$). In a study by Sergeyev et al. (25), increased reoperation risk was determined in obese patients with stone burden >300 mm2. El-Assmy et al. (6) detected no difference in postoperative complications and reoperation rates between obese and non-obese patients. Our rate of complications was consistent with the data obtained by El-Assmy et al (6). and no significant difference was observed between the two groups. With these results, it can be concluded that PCNL complications do not increase in different SSD values.

Study Limitations

This study has a few limitations. In this retrospective study, firstly; SSD was measured by preoperative supine CT, which can lead to different results for the preoperatively measured SSD and the actual SSD used during prone surgery. Secondly; stone load and other CT measurements were carried out by multiple urologists. Thus, calculated stone load may yield different results in different observations (32). Thirdly, presence of preoperative CT images was among inclusion criteria whereas examination for residual stones within the postoperative 3 months was done with postoperative CT, IVP or UTP.

Conclusion

There was no significant difference between the groups in terms of demographic data, stone-free status, and PCNL complications. Nevertheless, it is recommended to examine all possible factors causing a change in SSD and to evaluate patients according to these factors preoperatively. Further studies with larger patient populations are needed to specify a threshold value for SSD.

Ethics

Ethics Committee Approval: All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed Consent: Consent form was filled out by all participants.

Peer-review: Externally peer-reviewed.

Authorship Contributions

Concept: B.E., H.T., Data Collection and/or Processing: B.E., M.K., H.T., M.Y., C.S.İ., T.S., Y.Ö.İ., Literature Research: B.E., G.K.

Conflict of Interest: The authors declare that they have no conflicts of interest.

Financial Disclosure: No grants or funding was provided for this study.

References

1. Preminger GM, Assimos DG, Lingeman JE, Nakada SY, Pearle MS, Wolf JS. Chapter 1: AUA guideline on management of staghorn calculi: diagnosis and treatment recommendations. J Urol 2005;173:1991-2000.
2. Turk CKT, Petrik A, Sarica K, Straub M, Seitz C (2012) Guidelines on Urolithiasis.
3. Fernström I, Johansson B. Percutaneous pyelolithotomy. A new extraction technique. Scand J Urol Nephrol 1976;10:257-259.
4. Tiselius HG, Ackermann D, Alken P, et al. Guidelines on Urolithiasis. Arnhem, European Association of Urology, 2007.
5. Deane LA, Clayman RV. Advances in percutaneous nephrostolithotomy. Urol Clin North Am 2007;34:383-395.
6. El-Assmy AM, Shokeir AA, El-Nahas AR, Shoma AM, Eraky I, El-Kenawy MR, El-Kappany HA. Outcome of percutaneous nephrolithotomy: effect of body mass index. Eur Urol 2007;52:199-204.

7. Thomas R, Cass AS. Extracorporeal shock wave lithotripsy in morbidly obese patients. J Urol 1993;150:30-32.

8. Preminger GM. Micro-percutaneous nephrolithotomy (micro-PNL) vs retrograde intra-renal surgery (RIRS): dealer's choice? The devil is in the details. BJU Int 2013;11:280-281.

9. Fuller A, Razvi H, Denstedt JD, Nott L, Pearle M, Cauda F, Bolton D, Celia A, de la Rosette J; Croes PCNL Study Group: The croes percutaneous nephrolithotomy global study: the influence of body mass index on outcome. J Urol 2012;188:138-144.

10. Thomas K, Smith NC, Hegarty N, Glass JM. The Guy's stone score—grading the complexity of percutaneous nephrolithotomy procedures. Urology 2011;78:277-281.

11. Gao H, Salim A, Lee J, Tai ES, van Dam RM. Can body fat distribution, adiponectin levels and inflammation explain differences in insulin resistance between ethnic Chinese, Malays and Asian Indians? Int J Obes 2012;36:1086-1093.

12. Lee S, Kim Y, Kuk JL, Boada FE, Arslanian S. Wholebody MRI and ethnic differences in adipose tissue and skeletal muscle distribution in overweight black and white adolescent boys. J Obes 2011;2011:159373.

13. Okhunov Z, Friedlander JI, George AK, Duty BD, Moreira DM, Srinivasan AK, Hillelsohn J, Smith AD, Okeke Z. stone nephrolithometry: novel surgical classification system for kidney calculi. Urology 2013;81:1154-1160.

14. Tepeler A, Binbay M, Akman T, Erbin A, Kezer C, Silay MS, Yuruk E, Kardas S, Akcay M, Armagan A, Muslumanoglu AY. Parenchymal thickness: does it have an impact on outcomes of percutaneous nephrolithotomy? Urol Int 2013;90:405-410.

15. Park BH, Choi H, Kim JB, Chang YS. Analyzing the effect of distance from skin to stone by computed tomography scan on the extracorporeal shock wave lithotripsy stone-free rate of renal stones. Korean J Urol 2012;53:40-43.

16. Perks AE, Schuler TD, Lee J, Ghiculete D, Chung DG, D'A Honey RJ, Pace KT. Stone attenuation and skin-to-stone distance on computed tomography predicts for stone fragmentation by shock wave lithotripsy. Urology 2008;72:765-769.

17. Pareek G, Hedican SP, Lee FT, Nakada SY. Shock wave lithotripsy success determined by skin-to-stone distance on computed tomography. Urology 2005;66:941-944.

18. Wiesenthal JD, Ghiculete D, Honey RJD'A, Pace KT. Evaluating the importance of mean stone density and skin-to-stone distance in predicting successful shock wave lithotripsy of renal and ureteric calculi. Urol Res 2010;38:307-313.

19. Dindo D, Demartines N, Clavien PA. Classification of surgical complications: a new proposal with evaluation in a cohort of 6336 patients and results of a survey. Ann Surg 2004;240:205-213.

20. Astroza GM, Neisius A, Tsivian M, Wang AJ, Preminger GM, Lipkin ME. Does the nephrostomy tract length impact the outcomes of percutaneous nephrolithotomy (PNL)?. Int Urol Nephrol 2014;46:2285-2290.

21. Amer T, Ahmed K, Bultitude M, Khan S, Kumar P, De Rosa A, Khan MS, Hegarty N. Standard versus tubeless percutaneous nephrolithotomy: a systematic review. Urol Int 2012;88:373-382.

22. Vega GL, Adams-Huet B, Peshock R, Willett D, Shah B, Grundy SM. Influence of body fat content and distribution on variation in metabolic risk. J Clin Endocrinol Metab 2006;91:4459-4466.

23. Yoshikawa K, Shimada M, Kurita N, Iwata T, Nishioka M, Morimoto S, Miyatani T, Komatsu M, Mikami C, Kashihara H. Visceral fat area is superior to body mass index as a predictive factor for risk with laparoscopy-assisted gastrectomy for gastric cancer. Surg Endosc 2011;25:3825-3830.

24. Hagiwara M, Miyajima A, Hasegawa M, Jinzaki M, Kikuchi E, Nakagawa K, Oya M. Visceral obesity is a strong predictor of perioperative outcome in patients undergoing laparoscopic radical nephrectomy. BJU Int 2012;110:E980-E984.

25. Sergeyev I, Koi PT, Jacobs SL, Godelman A, Hoenig DM. Outcome of percutaneous surgery stratified according to body mass index and kidney stone size. Surg Laparosc Endosc Percutan Tech 2007;17:179-183.

26. Bagrodia A, Gupta A, Raman JD, Bensalah K, Pearle MS, Lotan Y. Impact of body mass index on cost and clinical outcomes after percutaneous nephrostolithotomy. Urology 2008;72:756-760.

27. Curtis R, Thorpe AC, Marsh R. Modification of the technique of percutaneous nephrolithotomy in the morbidly obese patient. Br J Urol 1997;79:138-140.

28. Giblin JG, Lossef S, Pahira JJ. A modification of standard percutaneous nephrolithotripsy technique for the morbidly obese patient. Urology 1995;46:491-493.

29. Wang Y, Jiang F, Wang Y, Hou Y, Zhang H, Chen Q, Xu N, Lu Z, Hu J, Lu J, Wang X, Hao Y, Wang C. Post-percutaneous nephrolithotomy septic shock and severe hemorrhage: a study of risk factors. Urol Int 2012;88:307-310.

30. Tefekli A, Karadag MA, Tepeler K, Sari E, Berberoglu Y, Baykal M, Sarilar O, Muslumanoglu AY. Classification of percutaneous nephrolithotomy complications using the modified Clavien grading system: looking for a standard. Eur Urol 2008;53:184-190.

31. Toksoz S, Dirim A, Kizilkan Y, Ozkardes H. The effect of American Society of Anesthesiology scores on percutaneous nephrolithotomy outcomes. Urol Int 2012;89:301-306.

32. Patel SR, Stanton P, Zelinski N, Borman EJ, Pozniak MA, Nakada SY, Pickhardt PJ. Automated renal stone volume measurement by noncontrast computerized tomography is more reproducible than manual linear size measurement. J Urol 2011;186:2275-2279.