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Residual stone area greater in obese patients after conventional percutaneous nephrolithotomy

Obez hastalarda perkütan nefrolitotomi sonrası rezidü taş alanı daha büyüktür

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Abstract

Purpose: To assess the safety and effectiveness of percutaneous nephrolithotomy (PNL) in patients with obesity.
Materials and methods: The records of patients who underwent conventional PNL were retrospectively evaluated using our database in Department of Urology, Gazi Hospital, Samsun, Turkey, from January 2015 to January 2020. Patients were divided into four groups based on body-mass index (BMI) range <25 (Group 1), 25-29.9 (Group 2), 30-34.9 (Group 3), and ≥35 kg/m^2 (Group 4). Baseline characteristics, outcomes, and complications were then compared between the groups. Achieving stone-free status or a residual-stone size of ≤4 mm was regarded as an operational success.
Results: A total of 462 patients, 121 (26.2%) in Group 1, 159 (34.4%) in Group 2, 133 (28.8%) in Group 3, and 49 (10.6%) in Group 4, were enrolled in the study. No significant difference was determined in terms of operative time, access number, hemoglobin drop, hospital stay, and success/complication rates. Residual-stone area increased in line with BMI. However, this increase in residual-stone area was only statistically significant in Group 1 and Group 4 (*p*=0.009). The overall stone clearance rate was 81.8%, and the complication rate requiring invasive procedures was 16.4%.
Conclusion: Our study revealed that obesity does not affect the outcomes of PNL without residual-stone size.

Key words: Complication, nephrolithiasis, obesity, percutaneous nephrolithotomy, residual stone.

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Öz

Amaç: Obez hastalarda perkütan nefrolitotominin (PNL) güvenliğini ve etkinliğini değerlendirmektir.
Gereç ve yöntem: Ocak 2015-Ocak 2020 tarihleri arasında Samsun Gazi Hastanesi, Üroloji Kliniği'nde konvansiyonel PNL yapılan hastaların kayıtları retrospektif olarak veri tabanımız kullanılarak değerlendirildi. Hastalar vücut kitle indeksi (VKİ) kullanılarak <25 (Grup 1), 25-29,9 (Grup 2), 30-34,9 (Grup 3) ve ≥35 kg/m^2 (Grup 4) olmak üzere dört gruba ayrıldı. Hastaların klinik özellikleri, operasyon bilgileri ve komplikasyonları değerlendirildi. Taşsızlık veya ≤4 mm küçük taş boyutu operasyonel başarı olarak kabul edildi.
Bulgular: Grup 1'de 121 (%26,2), Grup 2'de 159 (%34,4), Grup 3'te 133 (%28,8) ve Grup 4'te 49 (%10,6) olmak üzere toplam 462 hasta çalışmaya alındı. Ameliyat süresi, akses sayısı, hemoglobin düşüşü, hastanede kalış süresi ve başarı/komplikasyon oranları açısından gruplar arasında anlamlı bir fark saptanmadı. VKİ ile uyumlu olarak rezidü taş alanının arttığı görüldü. Ancak bu artış sadece Grup 1 ve Grup 4 arasında anlamlıydı (*p*=0,009). Başarı oranımız %81,8 ve invaziv işlem gerektiren komplikasyon oranımız %16,4'dü.
Sonuç: Çalışmamızda obezitenin rezidü taş dışında PNL'nin sonuçlarına etkisi olmadığı bulunmuştur.

Anahtar kelimeler: Komplikasyon, böbrek taşı, obezite, perkütan nefrolitotomi, rezidü taş.

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Introduction

Obesity is a life-threatening clinical condition that develops due to excess fat deposition, and it is a risk factor in the development of multiple chronic diseases. The prevalence of obesity -the disease of the modern age- is continuously increasing across the world. If it continues to increase at the present rate, more than half the world population will be overweight or more by 2030 [1]. Body-mass index (BMI) is used to evaluate and classify obesity. The World Health Organization defines BMI values >25 kg/m^2 as overweight and values >30 kg/m^2 as indicating obesity [2]. Obesity, itself a severe health problem, has also been linked to a higher risk of perioperative and postoperative complications. Many factors may be involved, including a higher prevalence of diabetes mellitus (DM), hyperlipidemia, hypertension, and coronary heart disease. Some difficulties linked to obesity such as cardiorespiratory changes, potential anesthetic distresses, thromboembolic tendencies, and technical challenges during surgery also significantly impact on perioperative outcomes [3].

Percutaneous nephrolithotomy (PNL) is the gold standard method in the surgical treatment of complex or multiple kidney stones, and has a high stone-free rate [4]. Successful PNL depends on both patient- and stone-related factors, such as a stone's size, location, and composition, pelvicalyceal anatomy, surgical experience, and previous urological procedures [5]. Studies investigating the effects of obesity on PNL outcomes have reported similar feasibility, safety, efficacy, and stone-free and complication rates in patients with and without obesity, and have concluded that PNL can safely be used with patients with obesity [6-8]. Although several previous studies have investigated the effects of obesity on PNL, the number investigating its effect on PNL outcomes in detail (such as its effect on residual stone size) is very small. The residual-stone area may be greater in patients with obesity compared to those without as a result of the surgeon's desire to keep the operative time short due to potential anesthetic complications [6].

The primary aim of this study was to investigate whether any difference exists between non-stone-free patients with and without obesity in terms of PNL. The secondary aim was to examine the effects of obesity on PNL outcomes and complications.

Materials and methods

Patients

After the ethics committee approval was obtained (Health Sciences University, Samsun Training and Research Hospital Non-Interventional Clinical Research Ethical Committee) the data of patients between January 2015 and March 2020 were evaluated retrospectively in our clinic. The clinical findings of patients from whom informed consent to surgery had been obtained before the operation were recorded. Non-contrast computed tomography (CT) was routinely performed on all patients. Stone location and size were assessed using CT. Stone size was calculated by multiplying the maximum stone length by the maximum width and was expressed in mm^2. Complications were evaluated based on the modified Clavien classification. Vital signs were closely monitored, and blood counts were measured postoperatively.

Patients were divided into four groups based on BMI values. Patients with BMI values of 18.5-24.99 kg/m^2 were regarded as normal weight (Group 1), those with BMI 25-29.99 kg/m^2 as overweight (Group 2), those with BMI 30-34.99 kg/m^2 as class 1 obese (Group 3), and those with BMI ≥35 kg/m^2 as class 2 obese (Group 4). Patients aged under 18 or undergoing unilateral PNL in the same session were excluded.

Demographic and clinical data, stone size and location, pre-operative blood count parameters, serum creatinine, hemoglobin drop, operative time, stone-free status, complication rates, residual size, and hospital stay were analyzed in both groups.

Surgical methods

Standard conventional PNL was performed on all patients, under general anesthesia, in the prone position (Figure 1). All procedures were carried out by experienced surgeons. Operative time was calculated from the insertion of the open-ended ureteral catheter to installation of the nephrostomy tube. Patients were evaluated on postoperative day 1 using kidney, ureter, and bladder X-rays (KUB) and biochemical tests. The final stone-free rate was evaluated using CT on postoperative day 15.

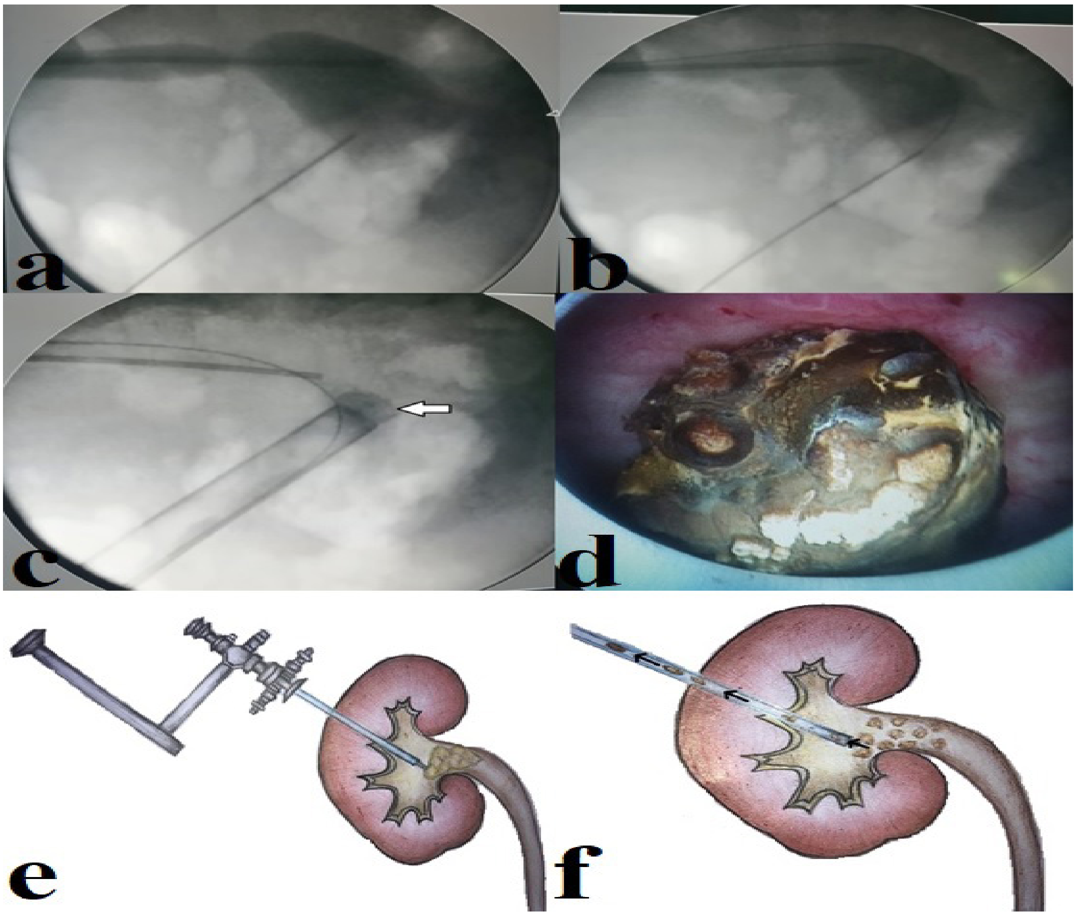

Figure 1. The different stages of percutaneous nephrolithotomy
a: Access to the renal collecting system is first established with a needle by means of a contrast agent;
b: Advancement of the guidewire into the bladder;
c: The tract is next dilated, after which the access sheath is installed (arrow: Radiological image of the stone);
d: Endoscopic view of the stone;
e: A nephroscope is employed to locate the stone, which is subsequently fragmented using a lithotripter;
f: Finally, a grasper and the nephroscope are employed to remove any stone fragments

Data analysis and statistics

The Kolmogorov Smirnov test was applied to determine normality of measurable data. Numerical variables were expressed as median values (interquartile range [IQR]:25th-75th percentile) and as number and (%) for nominal variables. Differences in categorical variables were evaluated using the chi-square test. Kruskal-Wallis test were applied to assess statistically significant differences among the groups. The Bonferroni-corrected Mann-Whitney U test was applied to determine the source of significance in variables identified as significant. A *p* values <0.05 were regarded as statistically significant. Data analysis was performed on SPSS 25 (Statistical Package for Social Sciences- IBM Corp., Armonk, NY, USA) software.

Results

Four hundred sixty-two patients (179 female, 283 male) with a mean age of 48 (36-58) years were included in the study. The patients' mean BMI value was 28.7 (24.85-31.78) kg/m^2. Stones were on the left side in 229 (49.6%) patients, and the most common location was the pelvic region, in 29% of patients. Mean stone area was 377 (297-639) mm^2, and mean operative time was 70 (60-88.5) minutes. Mean hemoglobin drop was 1.6 (1.1-2.4) g/dL and mean length of hospital stay was 3 (3-4) days and the stone-free rate was 81.8%.

The four groups were homogeneous in terms of preoperative laboratory values, preoperative positive urine culture, side of PNL, stone location, stone size, access number, operative time, hemoglobin drop, hospital stay, stone free and complication rates. As expected, the prevalence of DM, age, and American Society of Anesthesia 3 score were all higher in the groups with obesity. The proportion of female patients was statistically significantly higher in Group 4 than in the other groups (*p*=0.001). No difference was observed between groups 1, 2 and 3 in terms of proportions of female patients. The preoperative characteristics in each group are listed in Table 1.

Table 1. Detailed information of patients in the study

Variables	Group 1	Group 2	Group 3	Group 4	*p* value
N, %	121 (26.2%)	159 (34.4%)	133 (28.8%)	49 (10.6%)	
BMI (kg/m²)*	23.85 (22.46-24.37)	28.4 (27.2-29.1)	31.78 (30.7-32.78)	36.4 (35.85-38.25)	<0.001
Age (years)*	38 (29-51.5)	49 (38-58)	53 (42.5-62)	50 (42-59.5)	<0.001
Sex, (n, %)					
Female	35 (28.9%)	56 (35.2%)	58 (43.6%)	30 (61.2%)	0.001
Male	86 (71.1%)	103 (64.8%)	75 (56.4%)	19 (38.8%)	
History of diabetes, (n, %)	8 (6.6%)	17 (10.7%)	22 (16.5%)	24 (49%)	<0.001
Preoperative laboratories*					
Blood WBC, (K/uL)	7.2 (6.4-7.96)	7.2 (6.3-8)	7.2 (6.4-8.1)	7.3 (6.5-8.4)	0.77
Blood Platelet, (K/uL)	231 (196.5-278)	238 (209-280)	243 (198-280)	231 (196.5-279)	0.33
Blood Hemoglobin, (g/dL)	14 (12.8-15.1)	13.7 (12.72-14.9)	13.8 (12.6-14.9)	13.6 (12.75-14.85)	0.67
Serum Creatinin, (mg/dL)	0.82 (0.7-0.91)	0.81 (0.7-0.97)	0.77 (0.63-0.96)	0.78 (0.65-0.9)	0.19
Positive urine culture, (n, %)	24 (19.8%)	27 (17%)	15 (11.3%)	9 (18.4%)	0.28
Side of PNL (n, %)					0.51
Right	55 (45.5%)	83 (52.2%)	67 (50.4%)	28 (57.1%)	
Left	66 (54.5%)	76 (47.8%)	66 (49.6%)	21 (42.9%)	
Stone location (n, %)					0.09
Pelvis	29 (24%)	57 (35.8%)	38 (28.6%)	10 (20.4%)	
Isolated calyx	34 (28.1%)	40 (25.2%)	35(26.3%)	10 (20.4%)	
Pelvis+Calyx	33 (27.2%)	28 (17.6%)	37 (27.8%)	10 (20.4%)	
Staghorn	25 (20.7%)	34 (21.4%)	23 (17.3%)	19 (38.8%)	
Stone size (mm²)*	393 (294-614)	361 (294-550)	373 (298-610)	456 (312.5-986)	0.29
ASA score (n, %)					<0.001
ASA I	79 (65.3%)	69 (43.4%)	52 (39.1%)	11 (22.4%)	
ASA II	35 (28.9%)	70 (44%)	63 (47.4%)	27 (55.1%)	
ASA III	7 (5.8%)	20 (12.6%)	18 (13.5%)	11 (22.4%)	
Access number*	1 (1-1.5)	1 (1-1)	1 (1-1)	1 (1-2)	0.19
Hemoglobin drop (g/dL)*	1.7 (1.13-2.3)	1.52 (1.1-2.5)	1.6 (1.1-2.3)	1.6 (1-2.8)	0.92
Operative time (minute)*	70 (60-85)	65 (55-85)	70 (60-90)	72 (55-90)	0.08
Hospital stay (day)*	3.3 (3-3)	3 (3-3)	3 (3-4)	3 (3-4)	0.05
Stone Free (n, %)	100 (82.6%)	129 (81.1%)	110 (82.7%)	39 (79.6%)	0.95

* Data presentation of median and interquartile range (IQR, 25^{th}-75^{th} percentile)
ASA, American Society of Anesthesia; BMI, Body mass index
PNL, Percutaneous nephrolithotomy; WBC, White blood cell

Residual stone area increased in line with BMI values in this study. The increase in amount of residual stone was only statistically significant between Group 1 and Group 4 (Table 2).

Complications requiring Grade 2 or higher invasive procedures according to the modified Clavien classification system developed in 76 (16.4%) patients. The most severe complications were sepsis in three patients, myocardial infarction in one, and selective angio-embolization in one. No patients developed nephrectomy or died due to complications (Table 3).

Table 2. Residual stone area of groups (Data presentation of median and interquartile range (IQR, 25th-75th percentile)

Variables	Overall	Group 1	Group 2	Group 3	Group 4	*p* value
N	84	21	30	23	10	
Residu size (mm²)	44 (24-62)	28 (19.5-51.5)	41 (23.5-56.75)	44 (28-64)	64 (52-82.75)	0.048*

* Gruop 1 and Group 2, *p*=0.33; Gruop 1 and Group 3, *p*=0.14; Gruop 1 and Group 4, *p*=0.009
Group 2 and Group 3, *p*=0.54; Gruop 2 and Group 4, *p*=0.033; Gruop 3 and Group 4, *p*=0.07

Table 3. Complication rates in groups

Complication, N (%)	Overall (n=462)	Group 1 (n=121)	Group 2 (n=159)	Group 3 (n=133)	Group 4 (n=49)	*p* value
Total						
Blood transfusion	76 (16.4%)	20 (16.5%)	23 (14.5%)	23 (17.3%)	10 (20.4%)	0.19
DJS insertion	40 (8.6%)	10 (8.3%)	13 (8.2%)	13 (6.7%)	4 (8.2%)	
URS	15 (3.2%)	4 (3.3%)	4 (2.5%)	5 (3.8%)	2 (4.1%)	
Hydrotorax	9 (1.9%)	4 (3.3%)	3 (1.9%)	1 (0.8%)	1 (2%)	
Sepsis	3 (0.6%)	1 (0.8%)	1 (0.6%)	1 (0.8%)	-	
Primer repair	3 (0.6%)	-	1 (0.6%)	1 (0.8%)	1 (2%)	
Urinoma	2 (0.4%)	1 (0.8%)	1 (0.6%)	-	-	
Embolization	2 (0.4%)	-	-	1 (0.8%)	1 (2%)	
Myocardial infarction	1 (0.2%)	-	-	1 (0.8%)	-	
	1 (0.2%)	-	-	-	1 (2%)	

DJS, Double J stent; URS, Ureterorenoscopy

Discussion

This study investigated of the effects of obesity on PNL outcomes and complications. The findings indicate a correlation between obesity and residual-stone area, with residual-stone area increasing in line with degree of obesity. This increase was only statistically significant in Group 1 and Group 4, however, and not among the other groups. Despite the differences in obesity levels, no difference was observed in surgical outcomes. Operative time, hemoglobin drop, stone-free rate, hospital stay, and overall complication rate were also comparable between the BMI groups.

The European Association of Urology (EAU) guidelines recommend shockwave lithotripsy (SWL) or flexible ureterorenoscopy (F-URS) as first-line interventions for the treatment of kidney stones less than 2 cm in size [4]. The application of SWL is limited in patients with morbid obesity, however, due to a weight limit, difficulty in stone localization, and increased skin-to-stone distance, with poor results being observed in patients with a large stone burden [4, 9]. The use of F-URS in patients with large stones entails the risk of a prolonged operation time, secondary procedure, and secondary anesthetic. The EAU therefore recommends PNL as the gold standard for the treatment of renal stones larger than 2 cm [4]. Obesity nonetheless presents a number of problems in PNL. Patients with obesity may present various technical challenges, such as with anesthesia, patient positioning, proper radiological visualization of the stone, increased skin-to-collecting-system distance, the need for extra-long devices, and nephrostomy-tube dislodgement. Despite all these problems, similar stone-free and complication rates were reported with PNL among patients with and without obesity in single-center studies [6-8,10]. Consistent with these studies, no relationship was found between obesity and operative success rates in the present study, and our results indicate that PNL outcome is independent of BMI.

Percutaneous nephrolithotomy may be prolonged in patients with obesity for such reasons as difficulty in positioning, in working with long equipment, and in attaching the nephrostomy tube to the skin, as well as poor radiological visualization of the stone and frequent working-sheath displacement. In a meta-analysis of 4.962 patients, however, Zhou et al. [6] reported no significant difference in operative time between patients with and without obesity, although it was significantly longer in patients with super-obesity (>40 kg/

m^2). No statistically significant association was observed between obesity and operative time in studies with a similar design to that of the present study [7, 8, 11].

The residual stone area in the present study was higher in Group 4 than in the other groups. However, the difference in this elevation was only statistically significant between Group 4 and Group 1. No significant difference in residual stone area was observed between the other groups. The prone position reduces total lung capacity and functional residual capacity due to abdominal compression associated with muscle relaxation. At the same time, compression of the vena cava inferior is hazardous and reduces oxygenation due to potentially reducing the amount of blood reaching the heart [12]. Increased obesity also increases the risk of venous thromboembolism [13]. We attribute the higher residual stone area in Group 4 to the surgeon avoiding secondary manipulations (use of flexible cystoscopy, avoiding removal of large stones due to sheet safety, avoiding extra access despite a high stone area) that might reduce the amount of residual stone out of a desire to conclude the case early due to anesthetic and thromboembolic complications.

Urinary tract stone development is associated with various geographical, climatic, ethnic, and genetic factors, of which obesity is one. Obesity is an independent risk factor for urinary tract disease for both sexes, and also for recurrence of the disease, and stone formation increases in line with the degree of obesity [14, 15]. Insulin receptors in the renal tubular epithelium increase in obesity, and hydrogen ions excreted and passing into urine also therefore increase. The amount of free fatty acid released into urine secondary to obesity also rises. For all these reasons, urinary pH values decrease and the risk of urinary tract stone disease increases. Obesity also alters the biochemical content of urine, with levels of sodium, calcium, uric acid, sulfate, phosphate, oxalate, and cysteine all increasing. Levels of urinary citrate and magnesium, stone inhibitors, also decrease in patients with obesity. Urinary supersaturation and inhibitor substance levels in urine therefore decrease [16]. The risk of obesity-related urinary tract stone disease rises for all these reasons. Some studies have reported a higher stone area in patients with obesity, while others have observed no difference [7, 10, 17, 18]. Interestingly in the present study, stone area was higher in patients with normal weight compared to individuals with overweight and class 1 obesity. The highest stone area in this study was in Group 4, although this elevation was not statistically significant.

No significant difference was observed between the groups in this study even when complications were grouped based on modified Clavien classification systems. Myocardial infarction developed in one patient in Group 4, who was discharged after medical treatment. Arteriovenous fistula developed in one patient in Group 3, who was successfully treated with selective embolization. No patients developed nephrectomy or died due to complications.

There are several limitations to this study, including its retrospective and single-center nature. The number of patients in Group 4 was also very small. Further prospective, multi-center studies are therefore now needed to better interpret the current findings and to identify potential new risk factors.

Although not statistically significant, the results of this study indicate that residual stone area increases in line with obesity. A significant difference was only observed between individuals with class 2 obesity and normal patients in this study. Additionally, PNL is an effective method with high success and low complication rates that can therefore be safely applied safely in patients both with and without obesity.

Conflicts of interest: The authors declare that there is no conflict of interest.

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Ethics committee approval: Health Sciences University, approved by the Samsun Training and Research Hospital, Non-Interventional Clinical Research Ethical Committee (date: 29.01.2020 and ref no. GOKA/2020/4/19).

Contributions of the authors to the article

K.O. analyzed data, wrote the paper, and prepared the manuscript. E.A. designed and performed the paper, analyzed data, wrote the paper, and prepared the manuscript. M.G. supervised the research and prepared the manuscript. M.B.U. supervised the data, analysis and prepared the manuscript. S.T.C. analyzed data and prepared the manuscript. All authors reviewed the results and approved the final version of the manuscript.