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Evaluation of factors affecting the success of percutaneous nephrolithotomy in kidney stones sized 2 cm and above

2 cm ve üzeri böbrek taşlarında perkütan nefrolitotomi başarısını etkileyen faktörlerin değerlendirmesi

Osman Barut [1], Mehmet Kutlu Demirkol [1]

[1] **Sutcu Imam University, Faculty of Medicine, Department of Urology, Kahramanmaras, Turkey**

ORCID ID of the author(s)
OB: 0000-0002-8296-9717
MKD: 0000-0003-1678-9889

Corresponding author/Sorumlu yazar:
Osman Barut
Address/Adres: Kahramanmaraş Sütçü İmam Üniversitesi, Üroloji Anabilim Dalı, Onikişubat, Kahramanmaraş, Türkiye
e-Mail: osmanbrt@hotmail.com

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Abstract

Aim: Although percutaneous nephrolithotomy (PNL) is the preferred minimally invasive treatment method for large and complex kidney stones, complications may develop, and the operation may fail. In this study, we aimed to evaluate the factors affecting the success of PNL as well as the significance of surgical experience.

Methods: In this retrospective cohort study, the reports of 106 patients who underwent PNL between September 2017 and August 2019 were analyzed. The features of the stones and urinary system, operation parameters and postoperative findings of all patients were noted. The surgical experience was divided into two groups as the first 53 and the last 53 cases. The stones were classified as simple stones and complex stones by their location in the kidney. The patients were evaluated with kidney ureter bladder (KUB) x-ray on the first day after the operation and by non-contrasted computed tomography (CT) in the 3rd postoperative month.

Results: Among 106 patients who underwent PNL, 64 (60.3%) were male, 42 were female (39.7%), and the mean age was 52.65 (9.36) years. The mean size of the stones in the patients was 4.25 (1.37) cm, and 48 of them had simple stones and 58 had complex stones. The mean operation time was 58.70 (9.41) minutes, and the mean duration of hospitalization was 52.11 (8.62) hours. KUB was successful in 90 (84.9%) of 106 kidney stone cases in the first postoperative day. Following additional treatment administration in 8 cases, this rate increased to 92.4% in the 3rd postoperative month, in which the rate of stone-free cases was 91.7% in simple kidney stones, and 79.3% in complex kidney stones. Assessment of surgical experience revealed that failure rate was 22.7% in the first 53 cases and 7.6% in the last 53 cases (P=0.016).

Conclusion: PNL is a minimally invasive treatment method that may be preferred in simple and complex kidney stones of 2 cm and above. The size of the stone, the localization of the stone, the number of percutaneous interventions and surgical experience are crucial factors affecting success rates.

Keywords: Percutaneous nephrolithotomy, Kidney stones, Surgical experience

Öz

Amaç: Perkütan nefrolitotomi (PNL), büyük ve karmaşık böbrek taşları için tercih edilen minimal invaziv tedavi yöntemi olmasına rağmen, komplikasyonlar gelişebilir ve operasyon başarısızlıkla sonuçlanabilir. Bu çalışmada PNL'de başarıyı etkileyen faktörleri ve cerrahi tecrübenin PNL'ye etkisini değerlendirmeyi amaçladık.

Yöntemler: Bu retrospektif kohort çalışmasında, Eylül 2017 ve Ağustos 2019 tarihleri arasında PNL operasyonu yapılan toplam 106 hastanın kayıtları incelendi. Bütün hastaların taş ve üriner sistem özellikleri, operasyon parametreleri ve postoperatif bulguları kaydedildi. Cerrahi tecrübe sırasıyla ilk 53 ve son 53 vaka olmak üzere iki gruba ayrıldı. Taşlar böbrekteki yerleşimine göre basit taşlar ve kompleks taşlar olarak sınıflandırıldı. Hastalar operasyon sonrası 1. gün çekilen direk üriner sistem grafisi (DÜSG) ve 3. ayda çekilen kontrastsız bilgisayarlı tomografi (BT) ile değerlendirildi.

Bulgular: PNL uygulanan 106 hastanın 64'ü (%60,3) erkek, 42'si kadın (%39,7), ortalama yaş 52,65 (9,36) yıl idi. Hastaların taş boyutları ortalama 4,25 (1,37) cm idi ve 48'i basit taşlara, 58'i kompleks taşlara sahipti. Ortalama operasyon süresi 58,70 (9,41) dk., ortalama yatış süresi 52,11 (8,62) saat idi. 106 böbrek taşı vakasının 90'ında (%84,9) postoperatif birinci günde çekilen DÜSG'de başarı elde edildi. Olguların 8´ine uygulanan ek tedavi sonrası postoperatif 3. ayda bu oran %92,4'e yükseldi. Operasyon sonrası 3. ay basit böbrek taşlarındaki taşsızlık oranı %91,7 iken, kompleks böbrek taşlarında bu oran %79,3 olarak bulundu. Cerrahi tecrübenin etkisi değerlendirildiğinde ilk 53 vakada %22,7, son 53 vakada %7,6 başarısızlık saptandı (P=0,016).

Sonuç: PNL, 2 cm ve üzeri basit ve kompleks böbrek taşlarında tercih edilebilecek minimal invaziv bir tedavi yöntemidir. Taşın boyutu, taşın lokalizasyonu, perkütan girişim sayısı ve cerrahi tecrübe başarı oranlarını etkileyen önemli faktörlerdir.

Anahtar kelimeler: Perkütan nefrolitotomi, Böbrek taşları, Cerrahi tecrübe

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Introduction

Percutaneous nephrolithotomy (PNL), a minimally invasive surgical method that is used in the treatment of urinary system stone disease, was first defined by Fernstrom and Johansson in 1976 [1].

Today, extracorporeal shock wave lithotripsy (ESWL), PNL, retrograde intrarenal surgery (RIRS), their combinations and laparoscopic techniques are used in the treatment of kidney stones in the adult and pediatric patients [2]. The purpose of the treatment is to remove stones maximally with minimal damage to the patient. PNL is recommended as a first line treatment for >2 cm, ESWL resistant, complex, and staghorn kidney stones with various abnormalities. Due to short operation times, low morbidity rates, short hospitalization duration, and its minimally invasive nature, it has been a feasible treatment option for indicated kidney stones, replacing open stone surgery [3].

Improvements in instruments as well as lithotripsy (stone destruction) technology have increased the efficacy of percutaneous stone destruction and the rate of stone-free cases to above 90% [4].

A successful PNL operation depends on factors related to patient and the stone, such as bleeding degree, complication rate, fluoroscopy, and duration of surgery.

The aim of this study is to evaluate the factors which may predict success and development of various complications, when success is considered as "removing the stone completely or the presence of a residual stone smaller than 4 mm following PNL operation".

Materials and methods

A total of 106 patients who underwent PNL in our clinic between September 2017 and August 2019 were included in the study. All patients were evaluated with detailed a history form before the operation. A general internal examination was performed, and systemic diseases were investigated. Hemogram, blood biochemistry and urine culture were obtained preoperatively. Patients with urine culture growth were operated following the administration of appropriate antibiotherapy. Operations of patients using aspirin and other anticoagulant drugs were postponed for 7-10 days after drug discontinuation. Patients with bleeding diathesis or comorbidities were operated following necessary treatments. The patients over the age of 18 years who were operated for simple or complex kidney stones larger than 2 cm were included in the study. Patients with kidney stones smaller than 2 cm, those with spinal deformity, neuromuscular diseases, coagulation disorders and the patients with sensitivity to anesthetic drugs were excluded, in addition to patients under the age of 18, patients with renal abnormalities or solitary kidney.

Demographic data including age, gender, features of the stones and urinary system (stone size, surgical history and/or ESWL history), operation parameters (operation time, fluoroscopy duration, number and location of insertion, blood transfusion, complications) and postoperative findings (hospitalization duration, blood transfusion, complications, the rate of stone-free cases) as well as the medical records of the patients were evaluated retrospectively. Maximum stone length measured by non-contrast computed tomography (CT) was defined as stone size. In the kidney-ureter-bladder (KUB) X-ray performed after the operation, stones that were 4 mm and below were considered clinically insignificant residual fragments (CIRF). The complications were graded by the Clavien classification. The patients were evaluated by non-contrasted CT at the 3rd postoperative month. Success was defined as complete removal of stones (Stone Free/SF) or the presence of clinically insignificant residual stones (CIRF, smaller than 4 mm, asymptomatic).

Demographic data, stone sizes, operative parameters and postoperative findings were evaluated. The operation duration was defined as the time from the initiation of the cystoscopy until nephrostomy was inserted and fixed to the skin. The duration of hospitalization began with surgery date and ended at date of discharge.

In our study, stone size, stone location, number of accesses and surgical experience were evaluated as the factors affecting success in PNL operations. Stone size was divided into two groups, as those between 2-4 cm and >4 cm. The stones were classified as simple stones (single calyx or pelvis stone) and complex stones (coraliform or multiple calyx stones) based on their location in the kidney. The number of accesses was divided into two groups as 1 and >1. The surgical experience was divided into two groups, the first 53 and the second 53 cases.

All procedures in the studies involving human participants were performed in accordance with the 1964 Helsinki Declaration and its later amendments.

PNL technique

All operations were performed under general or spinal anesthesia. In both groups, a 6 Fr ureter catheter was inserted by a cystoscope to the relevant ureter in the lithotomy position and then fixed to a 16 Fr foley catheter. Then, patients were placed in prone position. After the opaque substance was delivered to the targeted calyx through the ureter catheter accompanied by C-arm fluoroscopy, an 18-gauge percutaneous insertion needle was advanced into the renal collector system by a 0.038-inch guidewire. The insertion site was dilated on the guide wire with a 30Fr Amplatz dilator and a sheath (30 Fr) was inserted. A 26 Fr nephroscope was inserted into the renal collector system, and the stone(s) were broken by pneumatic lithotripter and extracted by a grasper. Stone-free status was confirmed by either direct nephroscope or fluoroscopy. In patients with stones in different calyxes, an additional insertion was performed to obtain the maximum stone-free status in cases when a single insertion was not sufficient. After the operation was completed, a 14 Fr nephrostomy tube was placed in the insertion sheath and the operation was terminated after checking by fluoroscopy. The next morning, the foley catheter was removed according to the color of the urine bag.

Statistical analysis

The data were analyzed using the IBM SPSS version 20.0 software (IBM Inc., Chicago, IL, USA). Data were presented as mean (SD) values. Conformity of the variables to normal distribution was determined with Kolmogorov-Smirnov and Shapiro-Wilk tests. As the patient numbers did not show normal distribution, Mann Whitney U test was used to compare both groups. The Chi-square test was used to compare values in

different groups. *P*-value of <0.05 was considered statistically significant.

Results

The demographic variables and stone characteristics are shown in Table 1. Among all patients, 64 (60.3%) were men, 42 were women (39.7%), and the mean age was 52.65 (9.36) years. Fifty-seven (53.8%) had right-sided and 49 (46.2%) had left-sided kidney stones. Before the operation, grade 2 or grade 3 hydronephrosis was detected in 64.2% of the patients.

Subcostal insertion was optimal in 102 patients, while intercostal insertion was performed in 6 patients. The lower calyx, middle calyx and the upper calyx insertion were performed in 88 (83%), 10 (9.4%) and 2 (1.9%) patients, respectively. Six cases (5.7%) underwent insertion through multiple calices. The mean size of the stones was 4.25 (1.37) cm, with 48 simple and 58 complex stones. The mean operation and hospitalization durations were 58.70 (9.41) minutes and 52.11 (8.62) hours, respectively.

Ninety (84.9%) of 106 renal stone cases underwent successful PNL, as observed in direct radiographs on the first postoperative day. This rate increased to 92.4% in 8 cases with additional treatment in the 3rd postoperative month. For this purpose, 5 cases were treated with ESWL, 2 cases were treated with ureterorenoscopy and 1 case was re-treated with PNL.

The complications were determined by the modified Clavien classification system and presented in Table 2. In 8 (7.5%) patients, double j catheter was placed due to prolonged drainage and/or extravasation after nephrostomy tube was removed. Blood transfusion was administered to 3 patients due to decreased hemoglobin. None of the patients had major vascular and visceral organ injuries.

In the third postoperative month, the rate of stone-free cases was 91.7% in simple kidney stones, and 79.3% in complex kidney stones. Success was achieved in 91.9% of the cases with 2-4 cm stones and in 75% in those with stones over 4 cm (*P*=0.034) (Figure 1). The success rates by mean sizes and localization of the stones are presented in Table 3 in detail.

Ninety-four patients had single access surgeries while 12 patients were operated with two or more accesses. Success rates were found to decrease with increased number of accesses (*P*=0.042). Failure rate was 22.7% in the first 53 cases and 7.6% in the last 53 cases (*P*=0.016).

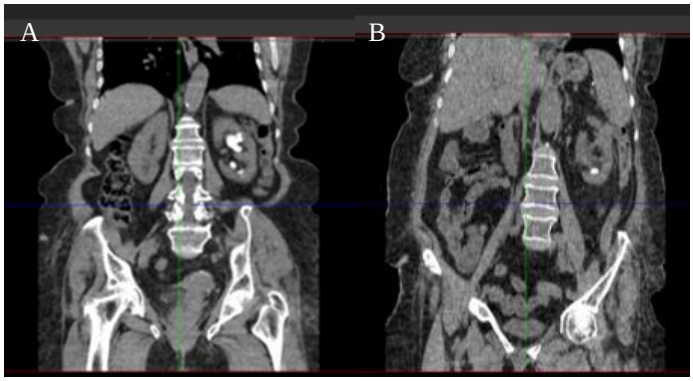

Figure 1: A: Preoperative complex kidney stones, B: Postoperative 3rd month, residual fragment larger than 4 mm

Table 1: Patient demographics and stone characteristics

Variables	Value
Patients, n	106
Mean (SD) age, years	52.65 (9.36)
Gender, n (%)	
Male	64 (60.3)
Female	42 (39.7)
Mean (SD) stone size, cm	4.25 (1.37)
Laterality, n (%)	57:49
Right	57 (53.8%)
Left	49 (46.2%)
Site of stone, n (%)	
Pelvis	52 (49%)
Upper calyx	4 (3.8%)
Middle calyx	11 (10.4%)
Lower calyx	39 (36.8%)
Stone location, n (%)	
Simple stone	48 (45.3%)
Complex stone	58 (54.7%)
Previous surgery	14 (13.2%)
Previous ESWL	19 (17.9%)

SD: Standard deviation, n: Number, ESWL: Extracorporeal shock wave lithotripsy

Table 2: Intraoperative and postoperative variables

Variables	Value
Operation time, minutes mean (SD)	58.70 (9.41)
Postoperative complications, n (%)	25 (23.5%)
Hematuria (Clavien I)	12 (11.3%)
Fever (Clavien I)	5 (4.7%)
Postoperative double-J stenting, n (%)	8 (7.5%)
Hemoglobin drop g/dl mean (SD)	1.36 (0.81)
Hospital stay, hours mean (SD)	52.11 (8.62)

SD: Standard deviation, n: Number

Table 3: Factors affecting of success

Variables	Successful n (%)	Unsuccessful n (%)	*P*-value
Stone size, cm			0.034
2-4 cm	57 (91.9%)	5 (8.1%)	
>4 cm	33 (75%)	11 (25%)	
Stone location			0.026
Simple stone	44 (91.7%)	4 (8.3%)	
Complex stone	46 (79.3%)	12 (20.7%)	
Number of access			0.042
1	81 (86.1%)	13 (13.9%)	
>1	9 (75%)	3 (25%)	
Surgical experience			0.016
First 53 cases	41 (77.3%)	12 (22.7%)	
Last 53 cases	49 (92.4%)	4 (7.6%)	
Total, n (%)	90 (84.9%)	16 (15.1%)	

n: Number

Discussion

PNL is a minimally invasive surgical treatment method with advantages such as low morbidity, high success rate and short duration of hospitalization in the treatment of multiple, larger than 2 cm and complex stones in the upper urinary system. PNL procedure is contraindicated in patients with uncontrolled bleeding diathesis, pregnancy, active urinary infection, and suspected renal tumor [3,5].

A nephrolithometric nomogram has been developed by the Clinical Research Office of Endourological Society (CROES) PNL working group to predict the success of PNL. Using multivariate variations, the relationship between preoperative markers and stone-free rate was determined and it was concluded that the stone burden is the most effective factor affecting success. Other factors include surgical experience, previous stone treatment, the presence of staghorn stones, stone localization, and number of stones [6].

According to European guidelines, PNL is the first-line treatment option for the treatment of pelvic, upper and middle calyx group stones over 2 cm. PNL and flexible URS are recommended for stones over 1.5 cm in the bottom pole, because ESWL activity is limited due to factors such as resistant stones, vertical infundibular-pelvic angle, narrow infundibulum (<5mm), long lower pole calyx (>10mm) [3].

As a result of the PNL operation, the concept of Clinical Insignificant Residual Fragments (CIRF) has been introduced for

stones that are not clinically significant since they do not cause obstruction, pain, and infection in the urinary system. Eighty-five percent of stones of this size may fall spontaneously without causing any clinical symptomatic pain, and detection of residual stones of this size following PNL have been considered surgical success [7].

The success of PNL operation varies between 72-98% in large series [8,9]. Segura [10] reported the success rate as 98% in 1000 cases. In the first PNL studies conducted in our country, the rate of stone destruction was reported as 60% by Muslumanoğlu et al. [11] and as 77% by Unsal et al. [12]. In our 106-case series, success rate was 84.9%, and this rate increased to 92.4% in the postoperative 3rd month after additional treatments were administrated in 8 cases. Lingeman et al. [13] reported PNL success (88-91%) in 1-3 cm stones; and reported that this rate may decrease to 75% in the stones above 3 cm. In our study, success was achieved in 91.9% of the cases with 2-4 cm stones and in 75% with stones over 4 cm.

One of the most important steps of a successful PNL surgery is to achieve optimal access, preferably from the right. Choosing the most suitable tract for the method is very important and the preferred approach is the posterior calyx route. In some cases, more than one access may be required in the same session. Lee et al. [14] and Merhej et al. [15] used multiple accesses in 73% and 78% of patients with staghorn stones. The success rate decreases in staghorn or complex stones accessed multiple times compared to simple stones. Stone-free rate (SFR) after PCNL monotherapy for staghorn stone is reported to range between 49% and 78% [16]. SFR in our study was not very different from the research conducted by El-Nahas et al. [17] (56.6%) and Desai et al. [18] (56.9%). Single access was performed in 94 patients, and 2 or more accesses were used in 12 patients in our study. As the number of accesses increased, success rates decreased. Again, success rate was 79.3% in patients with 58 complex stones. When evaluated in terms of complete stone-free cases, the lowest success rate was obtained in complete coraliform stones and multiple calyx stones concomitant with pelvis stones.

Our study showed that the history of renal stone surgery did not affect PNL success negatively. The data we obtained were similar to the results of the study conducted by Kurtulus et al. [19], in which the patients who had undergone PNL surgery for the first time due to kidney stones were compared with those who had previously undergone open kidney stone operations. No statistically significant difference was found in CIRF rates. In some other studies, it had been reported that open stone surgery may increase PNL failure rate [20].

Another factor affecting the success of PNL is surgical experience. Sofikerim et al. [21] reported that surgical experience was one of the most important factors affecting success. How many cases should be done to ensure adequate surgical experience in PNL operations is an especially important issue. Tanriverdi et al. [22] defined the learning curve for PNL and showed that the average operating times may be achieved after an average of 60 cases. According to the common results obtained from these two studies, the surgeon may determine his own average value after reaching a certain number of cases. In our study, success rate was 77.3% in the first 53 cases, and it increased to 92.4% in the last 53 cases.

PNL is a remarkable treatment alternative with high success rates, however, it should be noted that serious and even life-threatening complications may develop during or after this operation. In the study of Segura et al. [23] published in 1985 conducted on 1000 PNL cases, one of the first series on this field, the major complication rate was 3.2%. In this study, peroperative bleeding was the most common complication which required the termination of the operation, occurring in a total of 6 (0.6%) patients. In Lee et al.'s [24] comprehensive study published in 1987 on 582 patients who underwent PNL operation, the major and minor complication rates were 6.8% and 50%, respectively. The complication data of our study showed that a double j catheter was placed in 8 (7.5%) patients due to prolonged drainage and/or extravasation after nephrostomy tube was removed. Blood transfusion was administered to 3 patients due to decreased hemoglobin.

Limitations

This study has various limitations, the major one being its retrospective nature. Other limitations are the relatively low number of patients, and its single centered design. Also, we did not compare body mass index values.

In this study, we demonstrated which factors affect success in PNL operation. We observed that as the size of the stone, the localizations, and the number of accesses increased, the success of the operation decreased. In addition, we showed that the increase of surgical experience increased stone-free rates following the operation. These findings were consistent with the literature [17,21,22]. This article will lead future, multicenter prospective studies with more patients.

Conclusion

In conclusion, the size and the localization of the stone, the number of percutaneous interventions, surgical experience and need for additional treatment are statistically significant factors affecting the success rates. PNL is a minimally invasive treatment method that may be preferred for simple and complex kidney stones of 2 cm and above due to its shorter duration of hospitalization, lower postoperative care costs and less labor loss as compared to open operation. Further, prospective studies with large patient series are required to shed light on the issue.

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