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ENDOUROLOGY
Original Article

Is standard percutaneous nephrolithotomy still the standard treatment modality for renal stones less than three centimeters?

Üç santimetrenin altındaki böbrek taşlarında 'standart perkütan nefrolitotomi' hala standart tedavi modalitesi mi?

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ABSTRACT

Objective: The aim of study was to compare the efficiency and safety of standard percutaneous nephrolithotomy (sPNL) and miniaturized percutaneous nephrolithotomy (mPNL) in lower calyx and/or pelvic stones smaller than three centimeters.

Material and methods: From October 2010 to August 2015, 108 mPNL and 176 sPNL procedures were performed for renal stones smaller than three cm and located in the lower calyx and/or renal pelvis. All patients were evaluated preoperatively with intravenous pyelography and/or computed tomography. Intraoperative parameters, post-operative results and complications were recorded. Postoperative success was defined as complete stone clearance and/or clinically insignificant residual fragments at 3rd month.

Results: Preoperative characteristics were similar between sPNL and mPNL groups except previous renal stone operation history and gender. The mean operation time was significantly shorter in the sPNL group (p<0.001). The mean hemoglobin drop was significantly less in the mPNL group (p=0.001), we found a 1.27±1.4 and 0.5±1.3 decrease in mean hemoglobin levels (mg/dL) in the sPNL and mPNL groups, respectively. Transfusion rate was 1.9% in mPNL and 5.6% in sPNL groups, and the difference was statistically significant (p=0.048). Only one patient in the sPNL group needed angiography and embolization. Postoperative JJ stent insertion rate was significantly higher in the mPNL group (p=0.03).

Conclusion: Both sPNL and mPNL are safe and effective surgical procedures for lower calyx and/or pelvis stones smaller than 3 cm. However, use of smaller caliber instruments was associated with a lesser hemoglobin drop and need for transfusion.

Keywords: Lower calyx; mPNL; pelvis stone; percutaneous nephrolithotomy; urolithiasis.

ÖZ

Amaç: Bu çalışmadaki amacımız; alt kaliks ve/veya pelvis yerleşimli 3 santimetreden küçük böbrek taşlarının tedavisinde standart perkütan nefrolitotomi (sPNL) ve mini perkütan nefrolitotomi (mPNL) operasyonlarının etkinliği ve güvenirliğini karşılaştırmaktır.

Gereç ve yöntemler: Ekim 2010 ve Ağustos 2015 tarihleri arasında, alt kaliks ve/veya pelvis yerleşimli 3 santimetreden küçük böbrek taşları nedeniyle 108 hastaya mPNL ve 176 hastaya sPNL prosedürleri uygulandı. Tüm hastalar işlem öncesi intravenöz pyelografi ve/veya bilgisayarlı tomografi ile değerlendirildi. Operasyon esnasındaki parametreler, operasyon sonrası sonuçlar ve komplikasyonlar kaydedildi. Operasyon sonrası 3. ayda yapılan görüntülemelerde taşsızlık sağlanmışsa ve/veya klinik olarak önemsiz fragmanlar mevcut ise işlem başarılı kabul edildi.

Bulgular: İki grup arasında geçirilmiş böbrek cerrahisi hikayesi ve cinsiyet dışında belirgin farklılık yoktu. Operasyon süresi sPNL grubunda belirgin olarak daha kısaydı (p<0,001). Ortalama hemoglobin düşüşü mPNL grubunda belirgin olarak daha azdı. mPNL ve sPNL gruplarında ortalama hemoglobin düşüşü sırası ile 1,27±1,4 ve 0,5±1,3 şeklinde bulundu (p=0,001). Transfüzyon oranları mPNL gurubunda %1,9 ve sPNL grubunda %5,6 olarak saptandı ve bu fark istatiksel olarak anlamlı bulundu (p=0,048). sPNL grubunda sadece 1 hastaya anjioembolizasyon uygulanması gerekti. Operasyon sonrası JJ stent takılma oranı mPNL grubunda belirgin olarak daha fazla bulundu (p=0,03).

Sonuç: Alt kaliks ve/veya pelvis yerleşimli 3 santimetreden küçük böbrek taşlarının tedavisinde sPNL ve mPNL operasyonları güvenli ve etkili cerrahi prosedürlerdir. Ancak, boyut olarak daha küçük aletlerin kullanımı ile ortalama hemoglobin düşüş oranları ve transfüzyon ihtiyacı azalmaktadır.

Anahtar Kelimeler: Alt kaliks; mini PNL; pelvis taşı; perkütan nefrolitotomi; ürolitiazis.

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Introduction

Percutaneous nephrolithotomy (PNL) was first described by Fernstrom and Johansson[1] as a less invasive alternative to open stone surgery. To date, PNL is the preferred treatment modality for large-volume renal stones and staghorn stones, regardless of the type of renal stone.[2] Traditionally, nephrostomy tract from 24F to 34F is used for the PNL procedure and this procedure is called standard percutaneous nephrolithotomy (sPNL).[3] With improvements in surgical equipment and the effort of surgeons to reach better outcomes, instruments of smaller diameter have been developed for PNL. If PNL procedure is performed with an access sheath of 12F-20F diameter; this procedure is called miniaturized percutaneous nephrolithotomy (mPNL).[4,5]

Although described as a minimally invasive technique, PNL has some serious potential complications such as fever, septicemia, adjacent organ injury and bleeding.[6,7] In general, bleeding is limited without the further need of any intervention or manipulation but in some cases blood transfusion, super-selective renal angiography and embolization, open exploration or nephrectomy might be required.[8] Bleeding may even lead to death of the patient in certain cases.[9] Several studies have reported that surgeons' experience, stone burden, operation time, number and sites of accesses and dilatation method are related with bleeding in PNL procedure.[10,11] Trauma to the renal parenchyma and renal vessels is the most important underlying reason for bleeding in PNL, and it has been proven that smaller size percutaneous tracts may prevent bleeding.[12]

In this study, we aimed to compare the safety and efficiency of sPNL and mPNL, especially in terms of bleeding complications. Treatment modalities for managing complications were also evaluated.

Material and methods

Between October 2010 and August 2015, 108 mPNL and 176 sPNL operations were performed for stones smaller than 3 cm and located in the lower calyx and/or renal pelvis. Choice of the procedure was made according to surgeons' or patients' preference after giving detailed information about each procedure to the patients. Patients under 18 years of age and those with renal anomalies were excluded from our study. We compared intraoperative, post-operative results and complications seen in patients.

All patients were evaluated preoperatively with intravenous pyelography (IVP) and/or computed tomography (CT), complete blood count, biochemical, and coagulation parameters. Stone sizes were calculated in consideration of the sum of maximal diameters of stones. Preoperative urine cultures of all patients were sterile. All patients signed an informed consent form prior to surgery, and received prophylactic antibiotics at the induction of anesthesia. We performed kidney, ureter, and bladder (KUB) X-ray or urinary system ultrasonography (USG) on the second post-operative day. In addition, if a nephrostomy tube was inserted during operation, we removed it under antegrade fluoroscopy during postoperative period. Postoperative success was defined as complete stone clearance and/or presence of stone fragments under 4 mm on postoperative 3rd month abdominal CT. If detected fragments were above 4 mm in diameter, then those cases were classified as failure. This study was designed in compliance with World Medical Association Declaration of Helsinki. Ethical Principles for Medical Research. Involving Human Subjects.

Surgical technique

A 5-Fr ureteral catheter was inserted and fixed to the 16-Fr urethral catheter with the patient in the lithotomy position under general anesthesia. The calyceal system was visualized using contrast media with the patient in the prone position. Intrarenal access was achieved using an 18-G percutaneous access needle under C-armed scopy unit. A 0.035-inch hydrophilic guide wire was inserted, and a second guidewire was inserted with the aid of a dual lumen catheter. Dilatation was performed using Amplatz or balloon dilators, and an 18/20 (mini PNL) or 30-Fr Amplatz sheath (sPNL) was inserted. A 17-Fr or 26-Fr nephroscope (Karl Storz, Germany) was used for nephroscopy. Fragmentation was performed using a laser or ultrasonic lithotripter, and stones removed using a 5-Fr stone extraction device. The surgery was finalized after insertion of a 14-Fr nephrostomy tube under fluoroscopy, in case of need.

Statistical analysis

The IBM Statistical Package for Social Sciences (SPSS Inc; Chicago, IL, USA) version 16.0 was used for statistical analyses. Data were presented as number, mean ± standard deviation, and comparisons were performed using the chi-square test and the independent samples t or Mann-Whitney U tests.

Results

Preoperative patient characteristics are summarized in Table 1. Preoperative demographic data of 108 mPNL and 176 sPNL patients were similar with regards to age, body mass index (BMI), stone size, preoperative hemoglobin level, preoperative creatinine level, stone opacity, grade of hydronephrosis, stone localization, and patient side. However, history of previous operation including open surgery and gender differed between groups. The mPNL group included more patients with secondary kidney stone ($p<0.001$) and more male patients ($p=0.011$).

Intraoperative data of the patients are summarized in Table 2. The mean operation time was significantly shorter in the sPNL group

Table 1. Comparison of preoperative demographic data of patients

	Standard	Miniaturized	p
Patients, n	176	108	
Mean age (years)	45.2±14.2 (18-83)	43.9±13.4 (18-76)	0.152
Gender			0.011
Male	95 (54.0%)	78 (72.2%)	
Female	81 (46.0%)	30 (27.8%)	
Body Mass Index[a] (kg/m^2)	27.1±4.8 (17-42)	26.3±4.0 (17-35)	0.330
Stone size[a] (mm)	18.9±3.6 (10-30)	22.8±7.2 (10-30)	0.730
Preoperative hemoglobin level[a] (mg/dL)	13.5±2.7	14.1±1.6	0.107
Preoperative creatinine level[a] (mg/dL)	0.89±0.34	0.81±0.16	0.099
Previous history of surgery			0.014
Primary	146 (82%)	70 (65%)	
Secondary	30 (18%)	38 (35%)	
Opacity of stone			0.484
Opaque	158 (90%)	102 (95%)	
Grade of hydronephrosis			0.09
0	14 (8.0%)	6 (5.5%)	
1	104 (59.1%)	76 (70.4%)	
2	49 (27.8%)	17 (15.7%)	
3	9 (5.1%)	8 (7.5%)	
4	0.0%	1 (0.9%)	
Localization of stone		0.202	
Lower calyx	91 (51.7%)	59 (54.6%)	
Pelvis	57 (32.4%)	25 (23.2%)	
Pelvis+lower calyx	28 (15.9%)	24 (22.2%)	
Laterality of the stone			0.680
Left	96 (54.5%)	62 (57.4%)	
Right	80 (45.5%)	46 (42.6%)	

[a]: mean

Table 2. Comparison of intraoperative data of patients

	Standard	Miniaturized	p
Operation time [a] (minutes)	56.1±28.6	100.1±35.0	<0.001
Fluoroscopy screening time [a] (minutes)	7.0±4.9	6.4±4.2	0.477
Access site			0.438
Lower calyx	158 (89.8%)	104 (96.2%)	
Middle calyx	13 (7.4%)	2 (1.9%)	
Upper calyx	3 (1.7%)	0%	
Multiple calyces	2 (1.1%)	2 (1.9%)	
Access number			0.681
Single	167 (94.9%)	101 (93.5%)	
Multiple	9 (5.1%)	7 (6.5%)	
Intercostal access	4 (2.3%)	4 (3.7%)	0.643

[a]: mean

Table 3. Comparison of postoperative results and complication rates

	Standard	Miniaturized	p
Hemoglobin drop [a] (mg/dL)	1.27±1.4	0.5±1.3	0.001
Hospitalization time [a] (hours)	63.6±44.2	69.7±25.9	0.319
Complications			0.856
Grade 1	5 (2.8%)	1 (0.9%)	
Grade 2			
UTI	4 (2.3%)	0 (0%)	
Requirement for transfusion	10 (5.6%)	2 (1.9%)	
Grade 3a			
Postoperative JJ insertion without anesthesia	9 (5.1%)	12 (12.1%)	
Grade 3b			
Postoperative JJ insertion with anesthesia	4 (2.3%)	7 (6.4%)	
Requirement for angioembolisation	1(0.6%)	0 (0%)	
Failure	14 (8.0%)	8 (7.5%)	
Stone-free rate (3^{rd} month follow up)	162 (92.0%)	100 (92.5%)	0.468

[a]: mean

(p<0.001). The mean fluoroscopy time, percutaneous access sites, number of accesses and the need for intercostal accesses did not differ significantly between the groups. None of the mPNL procedures were performed through upper calyceal access. Cases performed through upper calyceal access did not necessitate blood transfusion and febrile episodes were not observed.

Postoperative data of the patients were summarized in Table 3. The differences between complication rates were not statistically significant between groups. However, when complications were evaluated separately, the mean hemoglobin drop was significantly less in the mPNL group (p=0.001). Requirement for eransfusion was significantly higher in the sPNL group (p=0.048). Post-operative angioembolisation was performed in only one patient in sPNL group (p=0.610). Postoperatively, JJ stent insertion was performed for 7.4% of sPNL and 17.6% of

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mPNL patients due to persistent urinary leakage from the nephrostomy side or ureteral obstruction detected on postoperative nephrostograms (p=0.03). Success rates were 92% for sPNL (162/176) and 92.5% for mPNL groups (100/108), respectively. This difference was not statistically significant with regards to post-operative 3rd month radiological findings (p=0.468). Number of intercostal accesses, access number, operation time, grade of hydronephrosis, stone size and body mass index parameters were also evaluated and there were no significant correlation between these parameters and bleeding necessitating blood transfusion.

Discussion

The aim of mPNL is to achieve equal success rates when compared with sPNL, in the hope of decreasing complications related with larger access tracts and instruments. Jackman et al. [13] described mPNL in preschool children with acceptable stone free rates. However, some concerns about smaller caliber tracts and instruments such as impaired vision, increased operative time and lower stone-free status have been reported. [14] Mishra et al.[15] demonstrated a 96% success rate with mPNL, similar with our stone- free rates. That study analyzed stones between one to two centimeters and all stones were located in renal pelvis or one isolated calyx. Zeng et al.[16] achieved a 71% stone-free rate after 12482 cases of mPNL, but the stone- free rate was 66.4% for complex stones. We have achieved a 92.5% success rate, and the mean stone burden of our patients was 22.8 mm^2.

Operation time was longer in mPNL group when compared with the sPNL group. We emphasize that this diversity might be due to different methods of fragmentation and stone retrieval for each procedure. Stones were fragmented by Holmium laser and fragments were collected with a basket catheter in mPNL procedure and this process is more time consuming when compared with the stone fragmentation and retrieval method in sPNL procedure. Stones are fragmented and absorbed by ultrasonic lithotripter in sPNL, and they can be fragmented into bigger pieces by pneumatic lithotriptor and collected in a faster manner by special retrieval instruments.

Multivariate analysis of various studies shows the importance of preoperative factors on bleeding in sPNL and also mPNL. Hypertension, diabetes mellitus and aging lead to development of arteriosclerosis and accelerate bleeding in PNL.[17] History of renal surgery, high stone burden, type of stone and experience of the surgeon are predictive factors for the higher amount of blood loss.[18] Urinary tract infections also prevent blood clot formation and facilitate bleeding.[19] In our study, none of the preoperative and intraoperative parameters were associated with blood transfusion and angioembolisation rates.

Intraoperative or postoperative bleeding in PNL is the result of traumatized renal parenchyma or injury of vascular structures. Bleeding may occur during any stage of the operation such as during needle puncture, dilatation of the tract, stone fragmentation or manipulation of stone retrieval device inside the collecting system.[20] Stoller et al.[21] and Clayman et al.[22] noted the mean reductions in hemoglobin level as 3.1 and 1.5 mg/dL in sPNL and mPNL, respectively. We found the mean reductions in hemoglobin levels as 1.27±1.4 and 0.5±1.3 mg/dL in sPNL and mPNL groups, respectively. This statistically significant difference demonstrated the benefit of using smaller tract and smaller caliber instruments so as to decrease blood loss for stones of <3 cm.

The incidence of bleeding necessitating blood transfusion after sPNL differed from 2% to 45%.[23] Smaller caliber intruments seems to reduce blood loss in mPNL compared with sPNL. Cheng et al.[24] found a 1.4% blood transfusion rate in their mPNL series. Similarly, Abdelhafez et al.[25] demonstrated a 0.5% blood transfusion rate independent of stone size in 191 mPNL cases, which was remarkably lower than other sPNL series in the literature. In our study, the transfusion rate was lower in mPNL and the intergroup difference was statistically significant (5.6% vs. 1.9) (p:0.048). The transfusion rate was 1.9% in mPNL group which was slightly higher when compared with other mPNL series in the literature. The reason for this result may be two-fold. Firstly, our anesthetists believe that if the estimated blood loss were high during the operation, early blood transfusion would contribute to an early postoperative recovery period. Secondly, our hospital is a training and research hospital and mPNL procedures are performed not only by specialists but also by residents and fellowship students.

Injury of renal arteries in PNL may lead to the development of arteriovenous fistulas and pseudoaneurysms, which are both well defined sources of bleeding. Under these conditions, and high pressure, blood leaks from the renal artery into a lower pressure system such as into the connective tissue space or a vein.[26] Richstone[27] reported that pseudoaneurysm was the most common arteriovenous malformation after sPNL with a 53% incidence based on angiographic assessments. El-Nahas[28] showed that arteriovenous fistula and pseudoaneurysm were one of the most common two findings associated with bleeding after PNL. In our study only one patient in the sPNL group necessitated angiography and embolization. During angiography, arteriovenous fistula was detected in the lower pole and bleeding was terminated by using angioembolization.

Urine leakage and fever are two other major problems following PNL. In our study, requirement for JJ stent insertion was significantly higher in the mPNL group. We believe that this finding was associated with the type of the stone lithotripter

used during mPNL procedures. In the mPNL group, after fragmentation of the stones into 2 mm stone particles with laser lithotripter, we left residual particles for spontaneous passage which may lead to ureteral obstruction in some cases. Therefore, we inserted a JJ stent to relieve the obstruction and facilitate the passage of fragments, especially in our early cases. We preferred laser lithotripter in the mPNL group and ultrasonic lithotripter in the sPNL group. After we noticed higher JJ stent insertion rate in the mPNL group, we started to remove all residual fragments by using a basket catheter to reduce our JJ stent insertion rates. Also, withdrawal of stone particles by ultrasonic lithotripter in mPNL may have prevented obstruction and decreased JJ insertion rates in the sPNL group. Comparative evaluation of ultrasonic lithotripter and laser lithotripter in mPNL may be the subject of another study. Postoperative fever was observed in only four patients in the sPNL group and all patients were treated by appropriate antibiotics.

We think that it is important to clarify the effect of mPNL and sPNL on bleeding and transfusion rates in patients with the same preoperative demographic properties. However, our study has some limitations. Firstly, our study has a retrospective design. Also, we have enrolled patients only with lower pole and pelvis stones and most of the stones were managed only with one intrarenal access. It is possible that complex or staghorn stones requiring multiple accesses may expose the real effect of using miniaturized instruments. Finally, procedures were performed by different surgeons, and the experience of our surgeons could have affected the results.

Our study is the first study in the literature which compares the effectiveness and safety of sPNL and mPNL for lower calyx and pelvis stones smaller than 3 cm. Our results have demonstrated that both sPNL and mPNL are both well accomplished treatment options for lower calyx and pelvis stones smaller than 3 cm with acceptable complication rates. However, using smaller caliber instruments leads to a significantly lower hemoglobin drop and lesser need for blood transfusion.

Ethics Committee Approval: Authors declared that the research was conducted according to the principles of the World Medical Association Declaration of Helsinki "Ethical Principles for Medical Research Involving Human Subjects", (amended in October 2013).

Informed Consent: Written informed consent was obtained from patients who participated in this study.

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