Percutaneous nephrolithotomy for isolated calyceal stones: How important is the stone location?

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ABSTRACT

Objective: To evaluate the effect of percutaneous access site on the success and complication rates of isolated calyceal stones.

Material and methods: We retrospectively evaluated 2700 patients who underwent percutaneous nephrolithotomy (PNL) in our clinic between October 2002 and August 2014. We selected only the patients with isolated lower, middle or upper calyceal stones and we grouped the patients according to the location of their stones. Successful operation was defined as complete stone clearance or retention of stone fragments smaller than 4 mm which do not lead to infection, obstruction or pain requiring treatment. Intraoperative and postoperative complications were also recorded.

Results: Totally 360 patients underwent PNL for their isolated upper, middle and lower calyceal stones. Access sites for those patients were selected based on stone location. The stones were localized in the lower (n=304), middle (n=14), and upper (n=42) calices. There was no statistically significant difference between the groups with respect to operation and scopy times. Hemoglobin drop was seen more frequently in the upper calyceal access group, without any significant intergroup difference. Thoracic complications including hemothorax, pneumothorax and pleural effusion were more common in the upper calyceal access group (11.9%; $p<0.001$). Complete stone clearance was accomplished in 81.9%, 92.9% and 78.6% of the patients with lower, middle and upper calyceal stones respectively without any significant intergroup difference ($p=0.537$).

Conclusion: PNL is an effective and safe treatment modality for isolated calyceal kidney stones and upper calyceal access causes thoracic complications more than other access sites.

Keywords: Isolated calyceal stones; kidney calculi; percutaneous nephrolithotomy.

Introduction

Currently, in the Guidelines of Stone Diseases prepared by the European Association of Urology, percutaneous nephrolithotomy (PNL) is recommended as the first-line treatment alternative both for the renal stones larger than 2 cm in diameter, and staghorn renal stones.^[1] When compared with open renal stone surgery, despite its minimally invasive nature, and lower complication rates, PNL can not always achieve complete stone-free rates.^[2] In the literature, many studies have shown the effects of surgeon's experience, body mass index of the patient, previous surgery, size, and location of the stone, and access site on the success of PNL.^[3,4]

Nowadays, during PNL most frequently access into pelvicalyceal system is performed

through the lower calyceal access group. In complete staghorn stones, in stones localized in the upper ureter, in isolated middle, and upper calyceal stones, attempts of intrarenal access performed through lower calyces can fail.^[5] Especially in isolated calyceal stones entry directly into the calyx with the stone seems to be a logical approach. However, during access into upper calyx, relevant complications as pneumothorax, hydrothorax, and hemorrhagic complications should be kept in mind.^[6] Although some studies have advocated easy approach into upper calyceal stones through middle calyx, this route of access is not generally preferred.^[7]

In this study, we investigated patients who underwent PNL operation in our clinic because of isolated calyceal stones using a single

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access site at the same location. In our study, we aimed to evaluate the impact of single calyceal access performed in our clinic targeted at the calyceal location of the stone on PNL success, and complication rates in cases with isolated renal stones.

Material and methods

Medical files of 2700 patients who underwent conventional PNL operations in our clinic between October 2002, and August 2014 were retrospectively analyzed. Isolated lower, middle, or upper calyceal stones were included in the study. In order to evaluate the results of the PNL operation, we selected only patients with isolated calyceal stones in whom we performed single intracalyceal access through the same access site. The patients were divided into 3 groups based on percutaneous entry sites. Patients with renal anomalies, and those younger than 18 years of age were excluded from the study. Stone area was calculated based on the following formula: width x length of the stone x $\pi/4$.^[8] Preoperatively, enlightened surgical consent forms were obtained from all patients.

Technique

Under general anesthesia 5 Fr ureteral catheter was implanted in all patients. The patient was tenderly placed in prone position, and access was performed with the aid of fluoroscopy. Access tract was dilated up to 30 Fr, and 26 Fr rigid nephroscope was used. Ultrasonic (Swiss Lithoclast®, EMS Electro Medical System, Nyon, Switzerland), and pneumatic (Vibrolith®, Elmed, Ankara, Turkey) lithotriptors were employed for the fragmentation of the stone. In case of need, stones were taken out using a grasper. Operative time was calculated as the time from the implantation of the ureteral catheter up to the placement of a nephrostomy tube.

Before the operation all patients with opaque stones were evaluated as for stone-free state at postoperative second day with urinary system graphies (KUBs). Stone clearance was evaluated using urinary ultrasound in patients with non-opaque stones. All patients were reviewed with respect to stone-free rates at 3 months postoperatively with abdominal computed tomograms. Successful operation was defined as achievement of complete stone-free rates, and postoperative retention of clinically asymptomatic stones smaller than 4 mm in diameter. All intraoperative, and postoperative complications, and treatment methods of these complications were recorded in medical files of the patients. Isolated lower, middle, and upper calyceal stones were compared in terms of preoperative demographic data, intraoperative data, PNL success, and complication rates.

Statistical analysis

For statistical analysis Statistical Package for the Social Sciences (SPSS Inc., Chicago, IL, USA) 16.0 software program

was used. Data were presented as numbers, standard deviation, and percentages. For the comparison of numbers, and rates chi-square test, and for the comparison of means one-way ANOVA test were used. Since data demonstrated heterogenous distribution, in post-hoc analyses Tamhane test was preferred.

Results

A total of 360 patients with isolated calyceal stones had undergone PNL operation through the same access site. These patients had isolated lower (n=304), middle (n=14), and upper (n=42) calyceal stones. The patients did not demonstrate different characteristics as for gender, mean age, mean body mass index, mean stone area, previous surgery or extracorporeal shock wave lithotripsy (ESWL), and preoperative blood chemistry (Table 1). All of the patients had not hydronephrosis or they were mildly hydronephrotic. Lower (96.7%), middle (78.6%) or upper calyceal (100%) opaque stones were also observed in respective incidences. Opaque stones were significantly more frequent in the upper calyces when compared with the other group (p=0.04).

A significant difference was not seen among three groups as for operative, and scopy times. However, intercostal access through 11-12 intercostal interval was significantly more frequent in the upper calyceal access group (p<0.001). Intercostal access was performed in four (1.3%) patients who had previously undergone PNL through lower calyceal access. Intercostal access was carried out in 30 (65.2%) patients who had previously undergone upper calyceal access (Table 2).

Although drop in hemoglobin levels most frequently occurred in the upper calyceal access group, when compared with the other groups, intergroup difference was not significant (p=0.605). Requirement for transfusion was similar in all groups. Pulmonary complications (hemotorax, pneumothorax, pleural effusion) occurred more frequently in the upper calyceal access group (11.9%; p<0.001). Patients who developed hemothorax, and pneumothorax were managed with placement of an intrathoracic tube, while those with pleural effusion were treated with medical therapy. Intercostal access was realized in 5 out of 6 patients with upper calyceal stones and pulmonary complications were seen in 2 out of 3 cases with lower calyceal stones. Linear regression analyses performed on many factors which might cause pulmonary complications including access site, and presence of intercostal access. It was observed that only intercostal access played a role in the development of pulmonary complications *per se*. (p<0.001) (Table 3).

In post-hoc analyses, operative time for nephrostomy in the upper calyceal access group was significantly longer when compared with middle calyceal access group (p=0.008), but it was not significantly different from that detected for the lower

Table 1. Comparison of preoperative demographic data according to access sites

	Access site			p
	Lower calyx	Middle calyx	Upper calyx	
N	304	14	42	-
Gender				0.112
Male	164	5	27	
Female	140	9	15	
Mean age (year)	44.6±13.6 (44)	47.5±10.4 (46)	46.7±14.1 (49)	0.516
Mean (median) body mass index (kg/m ²)	26.1±4.2 (25.7)	27.4±3.1 (27.1)	26.9±4.1 (26.2)	0.342
Mean (median) preoperative hemoglobin value (g/dL)	13.5±1.7 (13.5)	13.2±1.7 (13)	13.9±1.2 (14.1)	0.283
Mean (median) preoperative creatinine level (mg/dL)	0.91±0.27 (0.9)	0.86±0.17 (0.87)	0.92±0.25 (0.9)	0.769
Mean (median) stone area (mm ²)	431±258 (400)	472.9±459 (300)	466.7±168 (400)	0.616
Previous PNL	22 (7.2%)	0	1 (2.4%)	0.294
History of open stone surgery	74 (24.3%)	2 (14.3%)	4 (9.5%)	0.074
Previous ESWL	106 (34.9%)	3 (21.4%)	16 (38.1%)	0.521
Laterality of the access site				0.012
Left	169 (55.6%)	5 (35.7%)	14 (33.3%)	
Right	135 (44.4%)	9 (64.3%)	28 (66.7%)	
Opacity of stones				0.004
Non opaque	2.7%	14.3%	0	
Opaque	96.7%	78.6%	100%	
Semi-opaque	0.7%	7.1%	0	
Grade of hydronephrosis				0.956
0	9.9%	14.3%	11.1%	
1	60.3%	64.3%	61.1%	
2	29.8%	21.4%	27.8%	

PNL: percutaneous nephrolithotomy; ESWL: extracorporeal shock wave lithotripsy

calyceal access group (p=0.216). Similarly, hospitalization period was significantly longer in the upper calyceal access group relative to the middle calyceal access group (p=0.039), but it was not significantly different from that of the lower calyceal access group (p=0.368). Any difference among groups was not seen as for postoperative complications including fever, leakage from wound site, need for angioembolization, and stent implantation during postoperative period. Success rates of 93.1, 92.9, and 88.1% were achieved in the lower, middle, and upper calyceal access groups, respectively. In the upper calyceal access group lower stone-free rates were detected without any statistically significant intergroup difference (p=0.537).

Discussion

Treatment of isolated calyceal stones takes an important place in the urology practice. Nowadays, these stones can be treated

with retrograde intrarenal surgery (RIRS), ESWL, and percutaneous nephrolithotomy.^[9,10] ESWL, and RIRS can be successfully performed for stones smaller than 2 cm in diameter, and increased stone size decreases success rates of both treatment modalities.^[11] Besides, narrow, and elongated neck of the calyx containing the stone prevents spontaneous passage of fragmented stone particles.^[12] In our study mean stone area was calculated as 435±259 mm² (median, 400 mm²). Besides, aspiration of stone fragments using ultrasonic lithotripter, and their removal using a grasper eliminate unfavourable characteristics of calyceal neck.

In percutaneous nephrolithotomy, direct access into isolated calyceal stones, lesser need for manoeuvring inside pelvicalyceal system, and smaller size of fragmented stone particles increase the success rates of PNL. Okhunov et al.^[13] published a nomogram entitled “S.T.O.N.E. nephrolithometry”, and

Table 2. Comparison of intraoperative data according to access sites

	Access site			p
	Lower calyx	Middle calyx	Upper calyx	
N	304	14	42	-
Mean (median) operative time (min)	52.4±20.1 (50)	55.9±15.5 (58)	55.1±17.4 (50)	0.609
Mean (median) scopy time (min)	7.3±4.6 (6)	6.9±3.8 (6.75)	7.0±3.3 (7)	0.874
Intercostal access	4 (1.3%)	0	27 (64.3%)	<0.001

Table 3. Comparison of postoperative data according to access sites

	Access site			p
	Lower calyx	Middle calyx	Upper calyx	
N	304	14	42	-
Mean (median) duration of nephrostomy (days)	2.38±1.29 (2)	2.07±0.47 (2)	2.62±0.73 (2.5)	0.294
Mean (median) duration of hospitalization (days)	2.7±1.7 (2)	2.14±0.532 (2)	3.43±3.1 (2.5)	0.036
Mean (median) drop in hemoglobin levels (g/dL)	1.49±1.47 (1.4)	1.59±1.21 (1.75)	1.72±1.24 (2)	0.605
Postoperative complications				
Fever, n (%)	9 (3%)	0	3 (7.1%)	0.286
Leakage from the wound site, n (%)	4 (1.3%)	0	0	0.689
Requirement for transfusion, n (%)	20 (6.6%)	1 (7.6%)	3 (7.1%)	0.609
Requirement for angio embolization, n (%)	1 (0.3%)	0	0	0.912
Pulmonary complications, n (%)	3 (1%)	0	6 (14.3%)	<0.001
Postoperative requirement for DJ implantation, n (%)	11 (3.6%)	0	4 (9.5%)	0.145
Result				0.537
Complete stone clearance, n (%)	256 (81.9%)	13 (92.9%)	36 (78.6%)	
Residual stone, n (%)	21 (6.9%)	1 (7.1%)	6 (11.9%)	
CIRF, n (%)	35 (11.2%)	0	4 (9.5%)	
CIRF: clinically insignificant stone fragments				

suggested that success rate of PNL can be predicted preoperatively, and indicated increased success rates for isolated calyceal stones. In a study by Bayar et al.^[14] the authors compared the outcomes of PNL operation performed for isolated upper, and lower calyceal, pelvic stones, and complex stones, and reported success rates of 77% for isolated, and 53% for complex stones. In our study we obtained an overall success rate of 92.5% for isolated calyceal stones.

In relevant studies, difficulty exercised in performing upper calyceal access through intercostal area during percutaneous nephrolithotomy has been indicated. It has been reported that because of close vicinity of upper calyces to the lungs, pneumothorax, pleural effusions, calyco-pleural fistulas were more frequently seen during upper calyceal access, and pulmonary complications were observed in nearly one fourth of the patients who had undergone intercostal access.^[15]

Considering renal perfusion, it has been reported that anterior segmental arteries are more exposed to trauma during upper calyceal access.^[16,17]

Tefekli et al.^[18] investigated outcomes of 4494 PNL operations, and analyzed patients who had undergone single access PNLs performed for upper, and lower calyces. They indicated that middle calyceal access was not preferred much, and technically it resembled lower calyceal access because of anatomic similarities. In this study, the authors indicated shorter hospital stay, and lower complication rates in the lower calyceal access group, while development of hydrothorax had been 2.5-fold more frequent in the lower calyceal access group. Besides, transfusion was required in the upper, and lower calyceal access groups were seen in 7.3, and 4% of the cases, respectively.

In this study the impact of access site on surgical outcomes, and complications was investigated. Dimensions of isolated calyceal stones were found to be smaller than those indicated in other studies. We attributed our relatively shorter operative times to our smaller calyceal stones. Intercostal access was preferred in 64.3% of the patients with upper calyceal stones which was evaluated as nearly equivalent to that found in the Clinical Research Office of the Endourological Society (CROES) system. In 6 out of 42 (14.3%) patients who had undergone upper calyceal access, pulmonary complications were seen, and in 5 patients intercostal access had been performed. When factors which might be effective on pulmonary complications were subjected to multivariate analyses, intercostal single access might have induced these complications, rather than upper calyceal accesses. Surgical stone-free rates achieved in lower, middle, and upper calyceal access groups were calculated as 93.3, 92.9, and 88.1%, respectively with an insignificant intergroup difference.

Bleeding is one of the important complications following PNL operations, and it is mostly venous bleeding. During postoperative period, clamping of the nephrostomy tube is sufficient to control bleeding in most of the patients who received blood transfusions, while in only 0.5% of the patients angioembolization is needed.^[19] In this study only one patient in the lower calyceal stone group whose clinical picture did not improve despite transfusion, urgently underwent selective angioembolization. None of the patients needed emergency exploration. In PNL patients who will undergo PNL through upper calyceal access, physical (and if required radiological) examination of the lungs should be performed postoperatively. Removal of the nephrostomy tube as soon as possible will prevent pulmonary complications. In cases of diffuse hemothorax or pleural effusion, emergency decompression should be performed using insertion of a thoracostomy tube.^[20] In our case series where we suspected of pulmonary complications, we evaluated the patients with chest

X-rays, and pulmonary tomography. We applied thoracostomy tubes in 4 cases with symptomatic dyspnea whose oxygen saturation did not improve despite oxygen therapy.

Retrospective design of our study, lower number of patients with middle calyceal stones when compared with other groups, and inability to perform stone analysis in every patient can be considered as limitations of the study. Besides, the study was conducted in a training and research hospital, the operations were performed by different specialists, and residents which can be considered as another limitation of the study.

In conclusion, PCNL is a treatment alternative which can be used successfully, and safely in the management of isolated calyceal stones. However, in accesses targeted at upper calyceal stones, bleeding, and pulmonary complications are more frequently encountered.

Ethics Committee Approval: Due to the retrospective nature of this study, ethics committee approval was waived.

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

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