Original Paper

Urologia Internationalis

Urol Int
DOI: 10.1159/000345711

Received: September 10, 2012
Accepted: November 6, 2012
Published online: January 5, 2013

Is the Percutaneous Nephrolithotomy Procedure Complicated in Patients with Anterior Caliceal Stones?

Abdulkadir Tepeler[a] Omer Faruk Bozkurt[b] Berkan Resorlu[b] Mesrur Selcuk Silay[a] Ekrem Ozyuvali[b] Cevper Ersoz[a] Muzaffer Akcay[a] Tolga Akman[a] Abdullah Armagan[a] Ali Unsal[b]

[a]Department of Urology, Faculty of Medicine, Bezmialem Vakif University, Istanbul, and [b]Department of Urology, Kecioren Teaching and Research Hospital, Ankara, Turkey

Key Words
Renal stone · Percutaneous nephrolithotomy · Anterior calyx · Posterior calyx

Abstract
Objectives: It was the aim of this study to evaluate and compare the outcomes of percutaneous nephrolithotomy (PNL) for the treatment of posterior and anterior caliceal stones. ***Patients and Methods:*** We performed a retrospective analysis of 86 patients with isolated caliceal stones who underwent PNL between 2011 and 2012. The patients were classified into two groups according to the localization of the stone, either in the anterior (group 1, n = 41) or posterior (group 2, n = 45) calyx, on axial plane computed tomography. ***Results:*** The mean age, male/female ratio and stone size and location were similar in both groups. Fluoroscopy, operation time and duration of hospitalization were also similar between groups. Patients in group 1 had a greater postoperative hemoglobin drop than patients in group 2. Blood transfusion was required for 5 patients in group 1 and for 4 patients in group 2. In addition, open conversion was required for 2 patients in group 1 during the early postoperative period because of extensive bleeding. Hemodynamics were stabilized with angioembolization in 2 patients with prolonged hematuria in group 1. The overall success and complication rates were similar in both groups. ***Conclusion:*** Although the postoperative hemoglobin drop did not significantly differ between groups, hemorrhaging was more severe in patients with anterior caliceal stones than in those with posterior caliceal stones.

Introduction

Since percutaneous nephrolithotomy (PNL) was first performed by Fernström and Johansson [1] in 1976, it has been accepted as a first-line treatment modality for renal stones >2 cm, with technological developments in instruments and refinement of the technique [2].

A number of patient-, stone- and operation-related factors that impact the outcomes of endourologic procedures have been previously investigated [3–7]. Stone size and complexity are the main factors affecting the outcomes of PNL [3, 8]. Recently, the pelvicaliceal system anatomy (infundibular length and width, infundibulopelvic angle and pelvicaliceal surface area) has been a popular subject and has been explored in patients undergoing PNL and retrograde intrarenal surgery [9, 10]. The

KARGER
Fax +41 61 306 12 34
E-Mail karger@karger.ch
www.karger.com

0042–1138/13/0000–0000$38.00/0

Accessible online at:
www.karger.com/uin

Abdulkadir Tepeler, MD
Faculty of Medicine, Bezmialem Vakif University
Adnan Menderes Avenue
TR–34093 Fatih, Istanbul (Turkey)
E-Mail akadirtepeler@yahoo.com

European Association of Urology guidelines suggest different treatment algorithms for stones in the renal pelvis or the upper/middle calyx and for stones in the lower pole because of the complexity of the lower pole anatomy [2].

The PNL procedure is performed through renal access from the skin to the renal collecting system. Therefore, gaining proper access plays an important role in the procedure outcome [7]. Ideal access should transverse a minimal amount of renal parenchyma to prevent hemorrhagic complications. From this perspective, the location of a stone in the anterior calyx could affect the PNL success and complication rates. However, such a relationship has not yet been studied.

In this study, we evaluated and compared the outcomes of PNL for the treatment of posterior and anterior caliceal stones.

Materials and Methods

We performed a retrospective analysis of 86 patients (55 males, 31 females) with isolated caliceal stones detected by computed tomography (CT) and treated with PNL by two experienced urology teams at two referral hospitals in Turkey between January 2011 and February 2012. The patients were classified into two groups according to the localization of the stone: either the anterior (group 1) or posterior (group 2) calyx. Patients <18 years of age and patients with caliceal diverticular stones were excluded from the study. Patient- and procedure-related factors and peri- and postoperative variables, such as operation and fluoroscopy times, hemoglobin drop, complication and success rates, as well as hospitalization time, were compared.

Preoperative patient assessment included medical history, physical examination, urinalysis, urine culture, complete blood count, serum biochemistry, coagulation tests and computerized tomography (CT). The location of the stone was identified using preoperative CT, and the size was determined by multiplying the stone length by its width in millimeters. Specifically, the orientation of the calyx that included the stone (anterior or posterior) was identified on the axial images.

Operative Technique

At all centers, a standardized PNL procedure was performed in all cases, as described previously [11]. Briefly, a 5- or 6-Fr ureteral catheter was initially placed in a lithotomy position under general anesthesia. Percutaneous access was performed on patients in a prone position by the surgeon under fluoroscopic guidance using an 18-gauge needle and a guide wire. Before the percutaneous puncture is made, the collecting system is visualized and delineated with the aid of contrast medium injected through a ureteral catheter. All percutaneous punctures were targeted to the related calyces. The caliceal puncture was targeted using multidirectional fluoroscopic images. The tract was dilated with Amplatz dilators. Fragmentation and stone removal were accomplished in all patients using pneumatic or ultrasound energy and retrieval graspers through a rigid 22- or 24-Fr nephroscope. Additional tracts were created when indicated in the same session. Stone clearance and the integrity of the collecting system were assessed intraoperatively by fluoroscopic screening, endoscopic visualization and antegrade nephrostography. In the majority of cases, at the conclusion of the procedure, a 14-Fr nephrostomy tube was placed inside the involved calyx. A tubeless procedure was indicated in patients with mild or moderate stone burden, no residual stones or no perioperative complication, depending on surgeon preference.

Table 1. Demographic parameters of the groups

	Group 1 (anterior caliceal stones)	Group 2 (posterior caliceal stones)	p
Patients	41	45	
Age, years	41.6 ± 13.4 (18–67)	45.0 ± 12.1 (24–68)	0.28
Males/females	26/15	29/16	0.9
Stone size, mm	22.56 ± 6.3 (10–40)	21.88 ± 6.41 (12–40)	0.44
Stone location			0.2
Middle pole	7	13	
Lower pole	34	32	

Follow-Up

Plain radiography of the kidneys, ureters and the bladder was performed on postoperative day 1. The nephrostomy tube was routinely removed on postoperative day 1–2. All patients were evaluated with spiral CT 1–3 months postoperatively. The results were classified as stone-free, clinically insignificant residual fragments (CIRFs) and unsuccessful (residual stones). CIRFs were defined as ≤4 mm, nonobstructing, noninfectious and asymptomatic residual fragments [4]. Complications were classified according to the modified Clavien grading system [12, 13].

Statistical Analyses

The results are presented as the mean ± standard deviation. Data were processed using SPSS-16 for Windows (SPSS, Inc., Chicago, Ill., USA). Continuous variables were compared with the Mann-Whitney U test. The proportions of categorical variables were analyzed for statistical significance using the χ^2 test or Fisher's exact test. In all analyses, two-sided hypothesis testing was performed, and probability values <0.05 were deemed significant.

Results

Patient and Stone Characteristics

A total of 86 patients with either anterior (n = 41, group 1) or posterior (n = 45, group 2) caliceal stones underwent PNL. Patient age, male/female ratio, stone size and stone location were similar in both groups (p = 0.28, 0.9, 0.44 and 0.2, respectively) (table 1).

Table 2. Peri- and postoperative parameters

	Group 1 (anterior caliceal stones)	Group 2 (posterior caliceal stones)	p
Operation time, min	56.09 ± 25.5 (20–120)	45.6 ± 16.89 (20–190)	0.08
Fluoroscopy time, min	2.53 ± 1.44 (0.5–5.1)	2.53 ± 1.48 (1–7.3)	0.9
Duration of hospitalization, days	3.02 ± 3.25 (1–20)	2.35 ± 1.15 (1–7)	0.4
Hemoglobin drop	2.1 ± 1.94 (0.1–8)	1.52 ± 1.13 (0.2–5.4)	0.3
Success			0.48
Stone-free	37	43	
CIRFs	1		
Rest	3	2	
Complication	6	5	0.75
Additional treatment	3	4	1
SWL	1	2	
URS	1	1	
Second-look PNL	1	1	

Figures in parentheses are ranges. SWL = Shock wave lithotripsy; URS = ureterorenoscopy.

Table 3. Complications observed in both groups are summarized

Complications	Group 1	Group 2
Clavien grade I complication		
Urinary tract infection	1	1
Clavien grade II complication		
Bleeding requiring blood transfusion	1	3
Clavien grade IIIa complication		
Prolonged urine leakage	0	1
Clavien grade IIIb complication		
Bleeding requiring open conversion	2	0
Bleeding requiring angioembolization	2	0

Operative Findings and Postoperative Data

Although the operation time was longer in group 1 than in group 2, no significant difference was detected (56.09 ± 25.5 vs. 45.6 ± 16.89 min; p = 0.08). Fluoroscopy time and duration of hospitalization were also similar between the groups (p = 0.9 and 0.4, respectively) (table 2). Patients in group 1 had a greater postoperative hemoglobin drop than patients in group 2 (2.1 ± 1.94 vs. 1.52 ± 1.13 g/dl; p = 0.3). Blood transfusions were required for 5 patients in group 1 and for 4 patients in group 2. In addition, 2 patients in group 1 required open conversion during the early postoperative period because of anuria, metabolic acidosis and deterioration in the vital status due to extensive bleeding (a Clavien grade IIIb complication). In addition, hemodynamics were stabilized with angioembolization in 2 patients with prolonged hematuria in group 1 (a Clavien grade IIIa complication). The other complications observed included urinary tract infection (n = 1 in both groups, a Clavien grade I complication) and prolonged urinary drainage (n = 1 in group 2, a Clavien grade IIIa complication) (table 3). Although the complication rates were statistically similar (p = 0.75), the incidence of major complications requiring intervention was higher in group 1 than in group 2.

The success rates in group 1 and group 2 were 92.68 and 95.5% (including CIRFs in 2.43 and 0%), respectively (p = 0.48). Additional treatment modalities, including shock wave lithotripsy, second-look PNL and ureterorenoscopy, were performed in 3 patients in group 1 and in 4 patients in group 2 (p = 1) (table 2).

Discussion

Urologists' understanding of the 3-dimensional anatomy of the renal pelvicaliceal system plays a critical role in their ability to perform minimally invasive stone treatment modalities such as shock wave lithotripsy, retrograde intrarenal surgery and PNL. Anatomic factors are well known to influence the success of the procedure and treatment modality selection. The caliceal structures are mainly classified into three groups in the craniocaudal plane, i.e. the upper, middle and lower poles [14, 15]. In

addition to this plane, the caliceal system can be classified as anterior or posterior according to the facing plane. The anatomies of the collecting systems of the lower and the middle pole are more complex than that of the upper pole [14]. In the present study, 34 patients with lower anterior caliceal stones and 7 patients with middle anterior caliceal stones were enrolled. While middle caliceal stones were located posteriorly in 13 patients, lower caliceal stones were located posteriorly in 32 patients.

The posterior calyx is the preferred entry point to the collecting system because it commonly avoids vascular injuries, allows the greatest maneuverability of the rigid endoscope and facilitates reaching the pelvicaliceal system in a prone position [14]. However, the stones located in the anterior calyces present a challenge because of anatomical factors. Flexible nephroscopes are used to relocalize the anterior calyx stone to an easily accessible location such as the pelvis or posterior calyx and for disintegration using laser fibers. Despite all efforts, access to the anterior calyx from the posterior calyx may sometimes become impossible with rigid or flexible nephroscopes because of unfavorable anatomical factors such as a narrow caliceal neck, a long infundibulum and acute angulation. Although an anterior caliceal puncture is undesirable, it may be sometimes inevitable for isolated anterior caliceal stones. In addition, it may be required for complex renal stones treated with multi-caliceal accesses. In the present study, 41 patients with anterior caliceal stones and 45 patients with posterior caliceal stones were treated with PNL. The puncture was targeted to the calyx including the stone in all of the included patients.

There is debate about the identification of the anterior calyx in the pre- and perioperative periods using anterior-posterior radiography or monoplanar fluoroscopy. In a Brödel-type kidney, the posterior calyces are observed laterally and the anterior calyces are observed medially. The orientation of the caliceal structure is the opposite of that in Hodson-type kidneys [14]. While a Brödel-type orientation is more common in right kidneys, the Hodson-type orientation is more common in left kidneys. In the preoperative period, the use of axial plane CT is mandatory to clarify this confusion and determine stone location in either the anterior or posterior calyx. The use of 2-dimensional imaging methods to detect which calyx is posterior is more complicated. Eisner et al. [16] concluded that the most medial lower pole calyx on 2-dimensional imaging was almost always anterior, facing the calyx. As a result, the author recommended targeting the second calyx or the lateral lower pole calyx for a proper renal puncture. However, as mentioned in their study, the prevalence of Hodson-type kidneys was <5%. In the present study, we used CT in the preoperative period to detect the anterior-posterior calyx.

The use of the air pyelogram is an alternative for demonstrating and differentiating the caliceal planes during PNL. In a prone position, air fills and outlines the superficial posterior calyces [17]. Authors using air pyelograms state that radiation exposure was decreased using this method. Multidirectional fluoroscopic images can be useful for differentiating the posterior and anterior calyces. Ultrasonography is another viable option to perform a proper access with advantages of being radiation-free and allowing 3-dimensional visualization of the kidney. However, its main limitation is the need for experience. In the present study, we used a retrograde pyelogram with iodinated contrast and multiplanar fluoroscopic images to ensure the position of the stone and calyx and the adequacy of the puncture. The fluoroscopic screening time was similar in both groups ($p = 0.9$).

The ideal and safest puncture site should be directed into the caliceal fornix in a straight line and transverse a minimal amount of parenchymal tissue. Thus, damage to the infundibular arteries neighboring the caliceal infundibula and arcuate arteries is avoided [14]. Studies exploring the factors related to blood loss have identified associations between significantly increased blood loss and diabetes, multiple-tract procedures, tract size, prolonged operative and puncture time and the occurrence of intraoperative complications [7, 18–23]. In addition, the hemoglobin drop was higher in patients with a renal parenchymal thickness >10 compared to <10 mm ($p = 0.05$) [18]. Although no study has explored the relationship between blood loss and the thickness of the transected renal parenchyma during access creation, it is clear that anterior renal access requires a larger renal parenchyma transection. The caliceal fornix, which is accepted as the safest site for access, is located anterolaterally in anterior calyces. Thus, the infundibular or segmental arteries could be damaged when accessing the anterior calyx [14]. In our study, all patients with similarly sized stones were treated via a single caliceal puncture using similarly sized instruments. Therefore, the factors related to bleeding, such as access number, tract size as well as stone complexity and size, were excluded.

Although the postoperative hemoglobin drop was higher in patients with anterior caliceal stones (2.1 ± 1.94 vs. 1.52 ± 1.13 g/dl; $p = 0.3$), no significant difference was observed. However, the clinical presentation of bleeding in group 1 was more severe than in group 2, and intervention was required for 4 patients in group 1. Blood

transfusion was an adequate treatment modality for 1 patient in group 1 and for 3 patients in group 2. However, an urgent open conversion was performed for 2 patients in group 1 because of anuria, metabolic acidosis and the deterioration in vital status. Lower pole bleeding was controlled with hemostatic sutures. The postoperative period of these patients was uneventful. In addition, prolonged hematuria requiring blood transfusion was controlled with angiographic intervention in 2 patients in group 1. The overall success rate and the duration of hospitalization were also similar in both groups ($p = 0.48$ and 0.4, respectively).

A small number of cases in both groups and the retrospective nature of the study are limitations of this study. In addition, the lack of information about the puncture time that may affect the complication rate [7] might be considered as another limitation factor. Prospective comparative studies with a larger series of patients are required to further assess the results of PNL for anterior and posterior caliceal stones.

Conclusion

PNL is an effective treatment modality with an acceptable complication rate and a high success rate for both anterior and posterior caliceal stones. Although the postoperative hemoglobin drop did not significantly differ between groups, hemorrhaging was more severe in patients with anterior caliceal stones than in those with posterior caliceal stones. While the blood transfusion rate was similar in patients with posterior and anterior caliceal stones, further intervention was performed in patients with anterior caliceal stones in the presence of a hemorrhage.

References

1 Fernström I, Johansson B: Percutaneous pyelolithotomy. A new extraction technique. Scand J Urol Nephrol 1976;10:257–259.
2 Türk C, Knoll T, Petrik A, et al: Guidelines on urolithiasis. http://www.uroweb.org/gls/pdf/Urolithiasis%202010.pdf.
3 de la Rosette J, Assimos D, Desai M, Gutierrez J, Lingeman J, Scarpa R, Tefekli A; CROES PCNL Study Group: The Clinical Research Office of the Endourological Society Percutaneous Nephrolithotomy Global Study: indications, complications, and outcomes in 5803 patients. J Endourol 2011;25:11–17.
4 Rassweiler JJ, Renner C, Eisenberger F: The management of complex stones. BJU Int 2000;86:919–928.
5 Michel MS, Trojan L, Rassweiler JJ: Complications in percutaneous nephrolithotomy. Eur Urol 2007;51:899–906.
6 Turna B, Ekren F, Nazli O, et al: Comparative results of shockwave lithotripsy for renal calculi in upper, middle, and lower calices. J Endourol 2007;21:951–956.
7 Wang Y, Jiang F, Wang Y, et al: Post-percutaneous nephrolithotomy septic shock and severe hemorrhage: a study of risk factors. Urol Int 2012;88:307–310.
8 Turna B, Umul M, Demiryoguran S, et al: How do increasing stone surface area and stone configuration affect overall outcome of percutaneous nephrolithotomy? J Endourol 2007;21:34–43.
9 Binbay M, Akman T, Ozgor F, et al: Does pelvicaliceal system anatomy affect success of percutaneous nephrolithotomy? Urology 2011;78:733–737.
10 Resorlu B, Oguz U, Resorlu EB, et al: The impact of pelvicaliceal anatomy on the success of retrograde intrarenal surgery in patients with lower pole renal stones. Urology 2012;79:61–66.
11 Unsal A, Resorlu B, Atmaca AF, et al: Prediction of morbidity and mortality after percutaneous nephrolithotomy by using the Charlson comorbidity index. Urology 2012;79:55–60.
12 Dindo D, Demartines N, Clavien PA: Classification of surgical complications: a new proposal with evaluation in a cohort of 6,336 patients and results of a survey. Ann Surg 2004;240:205–213.
13 de la Rosette JJ, Opondo D, Daels FP, Giusti G, Serrano A, Kandasami SV, Wolf JS Jr, Grabe M, Gravas S, CROES PCNL Study Group: Categorisation of complications and validation of the Clavien score for percutaneous nephrolithotomy. Eur Urol 2012;62:246–255.
14 Wolf JS Jr: Percutaneous approaches to the upper urinary tract collecting system; in Wein AJ, Kavoussi LR, Novick AC, Partin AW, Peters CA (eds): Campbell-Walsh Urology, ed 10. Philadelphia, Saunders Elsevier, 2012, pp 1321–1353.
15 Sampaio FJ, Pereira-Sampaio MA, Favorito LA: The pig kidney as an endourologic model: anatomic contribution. J Endourol 1998;12:45–50.
16 Eisner BH, Cloyd J, Stoller ML: Lower-pole fluoroscopy-guided percutaneous renal access: which calix is posterior? J Endourol 2009;23:1621–1625.
17 Lipkin ME, Mancini JG, Zilberman DE, et al: Reduced radiation exposure with the use of an air retrograde pyelogram during fluoroscopic access for percutaneous nephrolithotomy. J Endourol 2011;25:563–567.
18 Kukreja R, Desai M, Patel S, et al: Factors affecting blood loss during percutaneous nephrolithotomy: prospective study. J Endourol 2004;18:715–722.
19 Turna B, Nazli O, Demiryoguran S, et al: Percutaneous nephrolithotomy: variables that influence hemorrhage. Urology 2007;69:603–607.
20 Akman T, Binbay M, Sari E, et al: Factors affecting bleeding during percutaneous nephrolithotomy: single surgeon experience. J Endourol 2011;25:327–333.
21 Skolarikos A, de la Rosette J: Prevention and treatment of complications following percutaneous nephrolithotomy. Curr Opin Urol 2008;18:229–234.
22 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.
23 Lojanapiwat B, Kitirattrakarn P: Role of preoperative and intraoperative factors in mediating infection complication following percutaneous nephrolithotomy. Urol Int 2011;86:448–452.