ORIGINAL RESEARCH

The Clinical Safety and Efficacy of Upper Pole Access Percutaneous Nephrolithotomy (uPPCNL) for Inferior Pole Stones

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Objective: Traditionally, percutaneous nephrolithotomy (PCNL) for lower pole stones are directly removed through an inferior polar access. The authors preferentially treated inferior pole calculi with an upper polar access and evaluated the clinical outcomes.
Methods: Between January 2010 and April 2016, 32 patients with inferior calyceal stones were treated uPPCNL. All stones were diagnosed using an unenhanced CT scan. The efficacy (stone-free rate) was determined by comparing the preoperative and postoperative imaging. Clinical safety was assessed based on intraoperative parameters pertaining to operative time, blood loss, urinary extravasation, calyceal injury, pelvic perforation and other untoward events. These complications were summarized using the Clavien-Dindo grading system.
Results:The male to female ratio is 1.1:1. All stones included in the study were pure inferior calyceal in location. The average stone size was 1.65±0.84 cm (Range:0.6-4.4) with a mean durility of 936±298HU (Range:350-1500). Stone-free rate was 96.8% (31/32) after a single session of PCNL. The mean operative time was 97±43 minutes (Range:40-230). According to the Clavien-Dindo classification, 26 (81.3%) had no complication, 5 (15.6%) had Grade 1 (fever), and 1 (3.1%) had Grade 2.
Conclusion: uPPCNL is effective and safe for patients with inferior calyceal stones and confers the following advantages 1) shorter skin-to-calyceal distance 2) straight line to the UPJ and inferior pole 3) a panoramic view of the collecting system 4) less stone migration 5) minimal torque of the nephroscope. This minimally invasive procedure achieves a high stone clearance rate with acceptably low complication rates.

Key words: Upper Pole Access Percutaneous Nephrolithotomy

Introduction

Percutaneous nephrolithotomy is the treatment of choice for staghorn calculi, complex renal stones and upper ureteral stones.[1] The success of PCNL hinges on the right choice of access site and accurate creation of a percutaneous tract that provides direct access to the stone.[2] Traditionally, inferior calyceal stones are approached through the posterior inferior calyx because it has been perceived to have fewer complications.[2] However, complete clearance is not always possible through a single tract when dealing with complex inferior calyceal anatomy because of the acute angles between the calyces.[2,3,4] A large stone in the inferior calyx may also interfere with the placement of an Amplatz sheath and cause difficult manipulation of the nephroscope resulting to decreased stone clearance.[5]

When dealing with inferior pole stones, a superior polar access potentially confers the following advantages of 1) a short skin-to-calyceal distance, 2) a straight line to the ureteropelvic junction for passage of a guidewire and tract stabilization and direct visualization of the stones in the inferior group of calyces.[2,3] These anatomical advantages can favor a higher stone clearance rate.[2,6,7] However, many hesitate using an upper pole access because of unfamiliarity with the technique and the fear of an accentuated increase in pulmonary complications.[8]

The objective of this study was to determine the safety and efficacy of an upper pole access for the percutaneous removal of inferior calyceal stones.

Materials and Methods

A retrospective chart review was done on all patients with inferior calyceal stones who underwent PCNL via upper pole access between January 2010 to April 2016. Patients with no preopearative CT stonogram, concomitant ureteral obstruction, inferior calyceal stones with concomitant stones in the other calyces were excluded from the study. The data gathered were dealt with utmost confidentiality and information was limited only to the principal investigator and the co-author.

The efficacy (stone-free rate) of the upper pole access PCNL was determined by comparing the preoperative and postoperative imaging to determine the absence of stones postoperatively and on follow-up. Clinical safety was assessed based on intraoperative parameters pertaining to operative time, blood loss, urinary extravasation, calyceal injury, pelvic perforation and other untoward events. Postoperative events were described including but not limited to infection, urosepsis bleeding, pleural effusion, atelectasis, hemothorax and extrarenal organ injury. Other parameters included length of hospital stay, return of bowel function, and delayed presentation of extrarenal organ injury and mortality. These complications were summarized using the Clavien-Dindo grading system.

Statistics

Quantitative variables include the patients' age, gender, preoperative creatinine, estimated GFR and the presence of co-morbid conditions. Stone characteristics include number, size, laterality and durility. The calyceal anatomy where these stones are located were categorized as either favorable or unfavorable based on the radiographic features of inferior pole stones described previously.[9] Data were presented as means and standard deviations. The qualitative variables like stone clearance and complications were presented as frequency and percentage. Fisher's exact test for statistical significance of outcomes was applied. $P<0.05$ was considered significant.

Results

Patient demographics are summarized in Table 1. The mean age of patient was 50±9 (range 32-65) with a male to female ratio of 1.1:1. Nine (28%) of the patients were hypertensive; seven (19%) were diabetic; two (6%) had chronic kidney disease; three (9%) had solitary kidneys (previous nephrectomy), seven (22%) had previous renal surgery (pelvolithotomy, nephrolithotomy) and twelve (38%) had previously undergone ESWL. All had negative preoperative urine culture except for two who were treated with an appropriate antibiotic three days preoperatively based on sensitivity patterns.

Twenty-six out of thirty two (81%) patients had favorable calyceal anatomy. All of them, were rendered stone free after one session of PCNL. Among the six patients with unfavorable calyceal anatomy: (2 out 3 factors present; infundibulum length >5cm, width <5 cm and infundibulopelvic angle of > 30 degrees), only one had residual stone after PCNL. Statistical analysis showed no significant correlation between the stone clearance and the nature of calyceal anatomy (Fisher's =0.1875, $p < .05$).

Table 1. Patient characteristics

Patients	
Age	50±9 (range 32-65)
Gender	1.1:1
Male	17
Female	15
Preoperative creatinine	1.5±0.8 (range 0.6-4.0)
Estimated GFR	71.94±34.4 (range 16.8-163.9)
Co-morbid conditions	Frequency
Diabetes mellitus	7
Hypertension	9
Chronic kidney disease	2
Cardiovascular disease	1
Previous renal surgery	7
Previous ESWL	12

Table 2. Stone characteristics

Number	
Size	1.65±0.84(range 0.6-4.4)
Durility (Hounsfield units)	936±298 (range 350-1500)
Laterality	
Left	18
Right	14
Location and calyceal anatomy	
Favorable	26
Unfavorable	6

Table 3. Stone clearance

Complete	31
Residual	1

All were accessed through a single upper pole puncture followed with serial dilation with Amplatz dilators. No balloon dilatation was used for any of the procedures. The mean operative time was 97±43(range 40-230)minutes and all stones were fragmented using combined pneumatic and ultrasonic lithotripter. The mean blood loss was 190±153 (range 30-600) cc. There were no reported intraoperative complications in this study.

Table 4. Intraoperative events

Operative time (minutes)	97±43 (range 40-230)
Blood loss	190±153 (range 30-600)
Urinary extravasation	none
Calyceal injury	none
Renal pelvic perforation	none

Tables 4 and 5 summarize the intraoperative and postoperative complications. There were no reported intraoperative complications. Postoperatively, twenty-six out of thirty two (81%) patients had no complications. Of these, 31/32 (96.8%) had complete stone clearance while only 1/31 (3.1%) had incomplete clearance. Statistical analysis showed no significant correlation between operative time and complications (Fisher's=0.6529, $p < .05$). It also showed no significant correlation between stone size and complications (Fisher's=0.647, $p < .05$).

Table 5. Postoperative events

Bleeding	
Transfusion requirements	1
Infection	
Fever	5
Urosepsis	none
Pulmonary complications	
Hemothorax	none
Pneumothorax or atelectasis	none
Hydrothorax	none
Length of hospital stay	4±1(range 3-9)
Others	
Ileus	none
Extrarenal organ injury	none

Five out of thirty-two patients (16%)had Grade 1 complications (fever), among which all had complete clearance. One out of thirty-two (3%) patients had Grade 2 (blood transfusion) complications and all of these had complete stone clearance after a single session. There were no reported Grade 3-5 complications.

Table 6. Clavien-Dindo Grading System of Complications

Grade 1	5
Grade 2	1
Grade 3	0
Grade 4	0
Grade 5	0

Discussion

Ever since its inception in the early 1990's, percutaneous nephrolithotomy is the recognized standard for the management of staghorn calculus and nephrolithiases more than 2 cm.[1] For inferior calyceal calculi measuring 1-2cm, the recommended options include PCNL, retrograde intrarenal surgery (RIRS), and extracorporeal shockwave lithotripsy.[1] ESWL is an attractive option for the patient and physician because this totally non-invasive outpatient procedure may be used to fragment stones with low Hounsfield units. However, certain unfavorable anatomic variants in the lower calyceal system prohibit a high stone clearance rate for this procedure. These include a long infundibulum > 5cm, narrow infundibular width < 5mm and a lower pole infundibulopelvic angle of < 70 degrees.[9] In such cases, PCNL and RIRS has become the mainstay of treatment. However, despite advances in flexible ureteroscopy (RIRS), the stone clearance rate of PCNL is still superior.[2,7,11]

A successful PCNL always starts with a good access. The access site selected must be the safest, provide the shortest possible route and provide the best chance of stone clearance.[2,7] Traditionally, an inferior pole stone is approached via an inferior pole access. Stones in a single inferior calyx can be easily removed with access through a tract in that calyx. However, stones in compound calyces in the inferior pole may necessitate multiple tracts for stone clearance.[2] The undue angulation between the Amplatz sheath and the pelvocalyceal system in an inferior pole access creates torque and may lead to unnecessary trauma and bleeding.[2,7]

The upper pole approach for the treatment of lower calyceal stones has still not been universally accepted due to the unfamiliarity of the technique as well as the reported pulmonary complications. However when done properly, the superior pole access has a higher stone clearance rate with complication rates comparable to the inferior pole approach.[2,5,6,7]

In this study, the stone clearance rate of the 32 patients with inferior calyceal stones via a superior pole approach is 98.1%. This stone clearance rate is at par and even better compared to previous studies.[2,6,7] The upper pole is considered the most versatile access point as it has the direct advantage of looking straight down the collecting system and to the renal pelvis.[2] This can be attributed to the advantages of a short skin-to-calyceal distance, a straight line to the ureteropelvic junction for passage of a guidewire and tract stabilization and direct visualization of the stones in the inferior group of calyces.[2,3] An upper pole access also negates the need of a second access in cases of large inferior pole stones in a compound calyceal system.[2,3] Manipulation of the nephroscope, progression of the Amplatz sheath, and lithotripsy of stones is easier compared to a lower pole access.[2,3,6] All these advantages contribute to a high stone clearance rate.

The unfavorable factors in the lower calyceal system which limits the stone clearance rate in ESWL do not affect the outcome in PCNL.[9] In the present study, such factors were present in 6 of the patients. Correlation between the presence of unfavorable factors and stone clearance rate was not statistically significant.

The fear of pulmonary complications (pneumothorax, hemothorax, pleural effusion) of an upper pole access still limits its use today. In the literature, the reported incidence of pleural injury ranges from 5-12%.[2,5,7,8] Familiarity with several techniques can be used to minimize or limit pleural injury.[4,10] Puncturing the upper pole on full expiration, staying above the lateral half of the 12th rib, and not going above the 11th rib are some of the techniques, which can reduce pleural injury.[2,4,7,10] Hemorrhage secondary to injury to the intercostal arteries can be prevented by staying immediately above the upper rib. Knowledge of the spatial anatomy of the kidney with the colon, spleen and liver as well not going above the 11th rib can reduce visceral injuries.[2,7]

In this study, there were no reported pleural or visceral injuries.

All of the complications reported in this study were Clavien grade 1 and 2. There were 5 incidents of postoperative fever which eventually resolved within the 2nd postoperative day. No case of septicemia was noted in this study. This can be explained by the fact that all patients either had a urine culture negative result or were adequately treated with antibiotics based on sensitivity patterns prior to PCNL.

Conclusion

Upper pole access PCNL (uPPCNL) is effective and safe for patients with inferior calyceal stones and confers the following advantages 1) shorter skin-to-calyceal distance, 2) straight line to the UPJ and inferior pole, 3) a panoramic view of the collecting system, 4) less stone migration, and 5) minimal torque of the nephroscope This minimally invasive procedure achieves a high stone clearance rate with acceptably low complication rates.

References

1. Preminger GM, et al. AUA nephrolithiasis guideline panel. AUA guidelines on management of staghorn calculi; diagnosis and treatment recommendations. J Urol 173 (6): 1991-2000.

2. Aron M, Goel R, Kerswani PK, Gupta NP. Upper pole access for complex renal calculi. BJU Int 2004; 94: 849-52.

3. Binbay M, Tolga A, et al. Does pelvocalyceal anatomy affect success of percutaneous nephrolithotomy? J Urol 2011; 78(4) 733-7.

4. De Lisa, Caddeo G. PCNL: tips and tricks in targeting, puncture and dilation. Arch Ital Urol Androl 2010; 82: 31-3.

5. Albala DM, Assimos DG, Clayman R. Lower pole. A prospective randomized trial of ESWL and PCNL for lower pole nephrolithiasis-initial results. J Urol 2001; 166(20): 72-80.

6. Singh V, Garg Y, Sharma K, Sinha R, Gupta S. Prospective randomized comparison between superior calyceal access versus inferior calyceal access in PCNL for inferior calyceal stones with or without pelvic stones. Urolithiasis 2015.

7. Sohail M, Malik M, Khalid M, Iqbal Z. Percutaneous nephrolithotmy through upper calyceal approach for complex renal calculi. JUMDC 6; 3.

8. Golijanin D, Verstandig A, Sasson T, Landau E, Meretyk S. The supracoastal percutaneous nephrostomy for treatment of Staghorn and complex kidney stones. J Endourol 1998; 12:5.

9. Elbahnasy AM, Clayman RV, Shalhav AL, et al. Lower-pole caliceal stone clearance after shockwave lithotripsy, percutaneous nephrolithotomy, and flexible ureteroscopy: impact of radiographic spatial anatomy. J Endourol 1998; 12(2): 113-9.

10. Hopper KD, Yakes WF. The posterior intercostal approach for percutaneous renal procedures. Risk of puncturing the lung, spleen, and liver as determined by CT. AJR 1990; 154: 115-7.

11. El-Nahas AR, Ibrahim HM, Youssef RF, Sheir KZ. Flexible ureterorenoscopy versus extracorporeal shock wave lithotripsy for treatment of lower pole stones of 10-20 mm. BJU Int 2012.