Original Article

Comparative evaluation of upper versus lower calyceal approach in percutaneous nephrolithotomy for managing complex renal calculi

Rohit Singh, S. P. Kankalia, Vilas Sabale, Vikram Satav, Deepak Mane, Abhirudra Mulay, Bhupender Kadyan, Naveen Thakur

Department of Urology, Padmashree Dr. D. Y. Patil Medical College, Pimpri, Pune, Maharashtra, India

Abstract

Introduction: Percutaneous nephrolithotomy (PCNL) is the treatment of choice for staghorn and large renal stones. The success of PCNL is highly related to optimal renal access. Upper calyceal puncture being more difficult and more demanding have relatively few studies presented.

Aims and Objectives: This prospective study was carried out to evaluate the effectiveness and safety of upper calyceal versus lower calyceal puncture for the removal of complex renal stones through PCNL.

Materials and Methods: A total of 94 patients underwent PCNL for complex renal stone in our institute. Fifty-one of them underwent lower calyceal, while 43 underwent upper calyceal puncture. The two approaches are compared as per total duration of surgery, intraoperative blood loss, infundibular/pelvic tear, rate of complete clearance and rate of postoperative complications (pulmonary, bleeding, fever and sepsis, etc.).

Observation and Results: In our study, the success rate was 76.47% for those in the lower, 90.70% for those in the upper calyceal access group. Thoracic complications (hydrothorax) occurred to 1 patient in upper calyceal supracostal access group. Bleeding requiring blood transfusion happened to 5 patients in lower calyceal access and 1 in upper calyceal group.

Conclusion: In our study for the management of complex renal calculi, we conclude that in a previously unoperated kidney, upper calyceal puncture through subcostal or supra 12th rib is a feasible option minimizing lung/pleural rupture and gives a better clearance rate. We suggest that with due precautions, there should not be any hesitation for upper calyceal puncture in indicated patients.

Key Words: Percutaneous nephrolithotomy, staghorn, supracostal puncture

Address for correspondence:
Dr. Bhupender Kadyan, Department of Urology, Padmashree Dr. D. Y. Patil Medical College, Pimpri, Pune - 411 018, Maharashtra, India.
E-mail: drkadyan@yahoo.com
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INTRODUCTION

Percutaneous nephrolithotomy (PCNL) is considered as treatment of choice for renal stones, and some upper ureteric stones. It has been performed since 1980s, with overall success rates exceeding 90%.[1] Improvements in technique and instruments have diminished complication rates associated with this procedure.[2] However, complications such as hemorrhage, encountered in 1-23% of cases, intrathoracic complications, observed in 2-12.5%, and other organ injuries, observed in <1%, are being reported with percutaneous renal surgery.[1,2]

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Complex renal calculi as described by us are renal stones occupying the renal pelvis and at least two of the three major calyceal systems. It can be the extension of the pelvic stone (staghorn) or a multiple primary or secondary renal calculi occupying the calyceal group.[3] The successful removal of stones requires the accurate placement of a percutaneous tract that provides direct access to the stone (optimal kidney access). Inferior calyceal stones are usually approached through the posterior inferior calyx. In complex renal calculi, complete clearance may often not be possible through a single tract in an inferior calyx because of problems in negotiating the acute angles between calyces. However, inferior lower calyceal punctures are being performed more commonly because it has fewer complications.[4]

The supracostal upper pole access and multiple accesses provide a good approach and straight access to staghorn calculi, proximal ureteral calculi, and calculi associated with primary ureteropelvic junction obstruction, and calculi associated with retained ureteral stents. The upper pole of the kidney is aligned medially and posterior to the lower pole, making the upper pole a shorter and easier access route.[5] However, staghorn calculi are the most difficult cases, take a longer time to be completely removed. Furthermore, complications are set to be more frequent in supracostal puncture group cases.

MATERIALS AND METHODS

All patients having complex renal stones as defined above were included in our prospective study and underwent PCNL. Patients in the pediatric age group (<15 years), patients with, comorbid conditions (diabetes mellitus, hypertension, and on anticoagulant therapy), associated pyonephrosis, and congenital anomalies (pelvi ureteric junction obstruction, bifid pelvis, megaureter, horseshoe kidney, etc.) were excluded from the study. Patients were divided into two groups as per the primary calyceal punctures taken during PCNL. Institutional Ethical Committee approval was obtained prior to commencement of the study. Written and informed consent was taken from all patients undergoing PCNL.

History of previous open renal surgery of the same unit where we plan PCNL in our study was evaluated as a predictor of surgical outcome. Preoperative complete blood count, serum creatinine, platelet count, bleeding and coagulation profile, and urine culture were obtained from all patients. Radiological evaluation included ultrasonography (USG), intravenous urography and in addition computed tomography (CT), if needed in certain patients having radiolucent calculi. The stone burden was measured as the sum of the largest linear dimensions of all stones based on kidneys, ureters, and bladder (KUB)/CT films.

Prophylactic antibiotics (ceftriaxone 1 g) was given intravenously at the time of induction of anesthesia and continued for 2 days. Each patient underwent PCNL under general anesthesia, and was performed by the same team of operating urologists. Beginning with cystoscopy and insertion of 6Fr ureteral catheter to allow contrast material delineation of the renal collecting system. The desired calyx was chosen according to the general principle for access site selection stated by Lingeman *et al.*,[6] that percutaneous access to the kidney should allow maximal stone removal using a rigid nephroscope. All lower calyceal [Figure 1] and upper calyceal infracostal punctures were made staying in between the posterior axillary line and para spinal line. All upper calyceal supracostal punctures were made in 11th intercostals space at mid scapular line [Figure 2]. In obese patients, the puncture site was lateral to mid scapular line. During supracostal punctures, skin and subcutaneous puncture was made during the expiratory phase, whereas renal parenchymal puncture was done during deep inspiration. Proper calyceal puncture was confirmed by free flow of urine through the needle and appropriate placement of teremo guidewire. For the patient in whom we believed a second puncture was necessary for complete clearance, we preferred to pass another guidewire at this stage of the procedure to be used later for the creation of the second access tract. Dilatation of the initial tract was done using alken's metal dilator system up to 24Fr followed by the introduction of an amplatz sheath. Rigid nephroscope (stortz 17/22Fr) was used and stones were fragmented by Swiss Lithoclast Master(Electro Medical Systems, Nyon, Switzerland). After fragmentation and stone removal, the collecting system was examined by direct nephroscopy and fluoroscopy for residual stones. Antegrade double-J stenting and nephrostomy placement is done in all cases.

In the postoperative period, patients having upper calyceal supracostal puncture, were closely monitored for dyspnea, tachypnea, chest pain or clinically decreased air entry. All patients with upper calyceal supracostal punctures had

Figure 1: Subcostal puncture

postoperative chest X-ray done. On suspicion of thoracic complications, intercostal drainage was planned if required. Hemoglobin (Hb) was checked and X-ray KUB was done on day one after surgery in all patients.

Relook PCNL, if required for residual stones were done after 48 h. We made a division, whether a new puncture was taken or not during second look, to assess the overall success rate of both the approaches in our study as defined below. All the patients in whom the stones could be removed during second look through the same tract, was because of the following reasons:

- Better visualization during second look that got hampered during first PCNL because of bleeding
- The stone in the inaccessible calyx was pushed into an accessible zone through stone puncture via initial puncture IP needle and flushed by normal saline (PCN flush)
- With fresh surgical mind, by using smaller nephroscope/ureteroscope, inaccessible stones were managed.

Procedure was evaluated in terms of operative time, complete clearance, Hb drop, blood transfusion required, secondary procedure required, fever and sepsis, hospital stay and success rate. In our study, complete clearance is set to be achieved if the postoperative X-ray KUB showed no radio-opaque shadow or the residual stone size is <4 mm on postoperative USG/CT. Blood transfusion was given, if the postoperative Hb drops below 8 g/dl. We defined the success rate as the number of patients achieving complete clearance, either after PCNL with <2 tracts or second look cases not requiring any new punctures during second look.

The statistical inference was obtained by computing Z test, Mann-Whitney test, *t*-test for the difference between any two values and considered as statistically significant if the $P < 0.05$.

Figure 2: Supracostal puncture

RESULTS

In our study, 94 patients underwent PCNL for complex renal calculi. These patients were grouped in two, as per the selection of primary calyceal puncture site. Patient's demographics are summarized in Table 1.

In upper calyceal puncture group patients, supracostal puncture was made in 21 patients, whereas the remaining 22 achieved upper calyceal puncture through infracostal approach (just below 12th rib).

The results of operative time, secondary puncture required, complications, and hospital stay are summarized in Table 2.

We found a significant Hb drop ($P < 0.0001$) in the subgroup of patients undergoing previous open surgery and having pelvicalyceal tear in upper calyceal group when compared to the same type of patients in lower calyceal group as summarized in Table 3.

Complete clearance after PCNL was achieved in 77 patients; out of 77, 36 (83.72%) were in the upper calyceal group and 41 (80.39%) were in the lower calyceal group. Secondary procedure required in 7 (16.28%) patients in upper calyceal group, while 10 (19.61%) patients were in lower calyceal group, which further requires ancillary procedure as summarized in Table 4.

DISCUSSION

A proper selection of an ideal access tract is the prerequisite for maximum clearance during PCNL in kidneys having large stone burdens. Until date, many studies have been conducted comparing upper and lower calyceal punctures in achieving maximum clearance with minimal acceptable complications (potential thoracic complication in supracostal approach).

The success rate achieved in our study was 90.70% in upper calyceal group patients, whereas it was 76% in lower

Table 1: Patients demographics

Characteristics	Upper calyceal puncture (*n*=43)	Lower calyceal puncture (*n*=51)	Total	*P* value
Number of patient (%)	43 (45.7)	54 (54.3)	94	
Age	39.84 (±10.42)	39.53 (±10.23)		>0.05
Male	28	33	61	
Female	15	18	33	
Right side	22	27	49	
Left side	21	24	45	
Previous open surgery (%)	4 (9.30)	7 (13.73)	6	>0.05
Stone size (mm)	39.02±6.27	39.53±7.17	-	>0.05

Table 2: Operative parameters

Characteristics	Upper calyceal puncture (*n*=43)	Lower calyceal puncture (*n*=51)	*P* value
Operative time (min)	71.70±8.53	73.02±8.86	>0.05
Secondary puncture required (%)	6 (13.95)	13 (25.49)	>0.05
Hospital stay in days	4.74±1.33	4.69±1.32	>0.05
Complications (%)			
Pelvicalyceal tear	2 (4.65)	5 (9.80)	>0.05
BT required	1 (2.33)	5 (9.80)	>0.05
Hydrothorax	1 (2.33)	0	>0.05
Fever/sepsis	9 (20.93)	8 (15.69)	>0.05
Hb drop (g)	1.64±0.59	1.56±0.53	>0.05

BT: Blood transfusion, Hb: Hemoglobin

Table 3: Hb% drop in subgroups

Characteristics	Upper calyceal puncture (*n*=43)	Lower calyceal puncture (*n*=51)	*P* value
Previous open surgery	2.89±0.21 (*n*=4)	1.66±0.64 (*n*=7)	<0.0001
Pelvicalyceal tear	2.10 (*n*=2)	1.44±0.32 (*n*=5)	<0.0001
Required 2nd puncture	2.20±0.88 (*n*=6)	1.97±0.45 (*n*=13)	>0.05

Hb: Hemoglobin

Table 4: Surgical outcome

Complete clearance achieved after	Upper calyceal group (*n*=43)	Lower calyceal group (*n*=51)
PCNL		
1 tract	30	28
2 tracts	5	9
>2 tracts	1	4
Secondary procedure		
2nd look using previous tract	4	2
2nd look using new tract	1	3
ESWL	2	5
Overall result (%)		
Success rate	39 (90.70)	39 (76.47)
Failure rate	4 (9.30)	12 (23.53)

PCNL: Percutaneous nephrolithotomy, ESWL: Extracorporeal shock wave lithotripsy

calyceal group. We found easier accessibility to many calyces when an approach is made through upper calyx that favors good manipulations of the nephroscope and forceps within pelvicalyceal system. The same is not true when a tract was established through lower calyx, requiring undue angulation, and torque. We believe that this difference is because of the straight tract of upper infundibulum along the long axis of the kidney and the anatomical lie of the kidney over iliopsoas muscle that cause the upper pole positioned more posterior as compared with the lower pole. These two factors provide excellent visualization of the pelvicalyceal system when an approach is made through upper calyx. Netto *et al.*[7] and Aron *et al.*[4] in their respective studies found similar results when upper calyceal approach was made.

Apart from the renal and pelvicalyceal anatomy, we found that the free mobility of the renal unit is also an important factor in achieving better clearance through PCNL. We felt some degree of difficulty in manipulating within the pelvicalyceal system due to restricted renal movement in a patient having previously open renal surgery. This led to the necessity of going for extra punctures for tackling the stones in inaccessible calyces. In their study Margel *et al.*[8] they found higher percentage of ancillary procedures required to achieve complete clearance in a patient with a history of open nephrolithotomy probably due to scarred surrounding tissues and anatomical changes leading to restricted renal movement.

The incidence of thoracic complication during supracostal punctures in various studies range between 3% and 16%.[9,10] In our study, out of 21 patients who underwent upper calyceal supracostal puncture, only 1 patient developed subclinical hydrothorax diagnosed on postoperative chest X-ray. He did not develop any clinical symptom and was managed conservatively without requiring intercostal drainage placement. Anatomically the parietal pleura crosses the middle of the 12th rib posteriorly and 11th rib at posterior axillary line. It makes the 11th intercostal space lateral to mid scapular line a safe zone with a minimal risk of any pleural injury. We believe that our site of supracostal puncture at 11th intercostal space at/lateral to mid scapular line and technique of puncturing the skin and subcutaneous tissue during expiration whereas renal parenchyma puncture during inspiration (for adequate renal descent) makes this puncture as safe as infracostal punctures, reducing the risk of thoracic complication as minimum.

We did not find any statistical significance between the type of puncture and blood loss. All the 6 patients requiring blood transfusion in our study were found to have low preoperative Hb (mean 9.2 g%) which dropped below 8 g% after surgery. However, when the amount of blood loss was evaluated between patients with history of previous open renal surgery and intraoperative pelvicalyceal tear, there was significant blood loss seen in upper calyceal puncture group as compared with lower calyceal group. This can be explained due to the injury caused to upper infundibulum either during puncture to upper calyx or excessive torque during intrarenal manipulations leading to upper infundibular tear. Sampaio and Aragao[11] stated that upper infundibulum is almost completely involved, both anteriorly and posteriorly by segmental or interlobar (infundibular) arteries in 86.6% of cases, whereas in 62% of the cases the posterior aspect of the lower major calyceal infundibulum was free from arteries. Sampaio *et al.*[12] in a different study reported injury to an interlobar vessel in two-thirds of the kidney puncturing the upper pole infundibulum, while only 13% had an arterial injury when punctured through the lower pole infundibulum.

In our study, the main complication seen in both groups was fever/sepsis (20.93% in upper calyceal and 15.69% in lower calyceal group). Wong and Leveillee[13] had 11.54% of incidence of fever, whereas Raza *et al*.[14] had 19.12% incidence of septicemia/pyrexia in their respective studies. Olbert *et al*.[15] in their study did not find any evidence for a relationship of urinary tract infection (UTI) with the outcome of PCNL. He mentioned that postoperative fever seems to be a frequent phenomenon in the postoperative course of PCNL, but the progression to sepsis is uncommon and it appears to be quite difficult to predict who is likely to develop an infectious complication and who is not. In our study, none of our patient progressed to urosepsis. All the patients, in our study underwent preoperative urine culture and any preoperative UTI was treated accordingly based on culture report. Mariappan *et al*.[16] found that 1 week prophylactic course of ciprofloxacin in spite of negative urine culture prior to PCNL significantly reduced upper UTI and urosepsis in the postoperative period. We, in our study did not make any antibiotic course mandatory to all the patients unless the urine culture comes positive.

CONCLUSION

In our study, the success rate was found to be better in upper calyceal puncture group than lower calyceal puncture group for the management of complex renal calculi. The safety of both the punctures was same with a better efficacy of upper calyceal puncture. In complex/large staghorn calculi, upper calyceal puncture is a handy technique and should always be kept in mind. In a mobile kidney, upper calyceal puncture through supra 12th rib is a feasible option minimizing lung/pleural injury and gives a better clearance rate. We suggest that there should not be any hesitation for upper calyceal puncture in indicated patients.

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