Original Article

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Quasi-Experimental Comparison between Upper and Lower Calyceal Approach in Percutaneous Nephrolithotomy for Complex Renal Calculi in Bangladesh

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ABSTRACT

Background: *Percutaneous Nephrolithotomy (PCNL) is the treatment of choice for staghorn stones, large renal stones not amenable to Extra Corporeal Shockwave Lithotripsy (ESWL) and some upper ureteric 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. The aim of this study was to compare the effectiveness and safety of upper calyceal versus lower calyceal puncture for the removal of complex renal calculi through PCNL.*

Materials and methods: *This hospital-based quasi-experimental study was conducted on admitted patients with complex renal stone who underwent PCNL either by upper calyceal or by lower calyceal approach PCNL technique in the Department of Urology, Chittagong Medical College Hospital and different private hospitals in Chattogram. A total of 75 patients who underwent PCNL were included in the study (37 of them underwent lower calyceal, while 38 underwent upper calyceal puncture). All patients were evaluated to compare the total duration of surgery, intra-operative blood loss, infundibular/ pelvic tear, rate of complete clearance and rate of postoperative complications (Pulmonary, bleeding, fever and sepsis, etc.). SPSS (Statistical Package for Social Science) for Windows version 23 software was used for the analyses.*

Results: *The mean age of the patients was 40.1±11.3 years and 62.67% of them were male. Almost one-third of the patients were obese. The prevalence of hypertension, diabetes and chronic obstructive airway disease was 16%, 6.67% and 6.67%, respectively. The mean size of the stones was for upper and lower calyceal approach was 35.4±5.3 mm and 36.1±6.2 mm, respectively and mostly involved the right kidney. The success rate was similar for upper calyceal and lower calyceal access (89.5% versus 75.7% respectively; p=0.115). Thoracic complications (Hydrothorax and pneumothorax) occurred in 2 patients in upper calyceal access group. Bleeding requiring blood transfusion happened to 5 patients in lower calyceal access and 3 in upper calyceal group (p=0.543). Overall mean operative time and mean length of hospital stay was not significantly different between two groups (p = 0.219 and p=0.603 respectively).*

Conclusion: *Based on the study findings it could be suggested that, there is no significant difference in outcome between upper calyceal and lower calyceal approach for PCNL in patients with complex renal stone.*

Key words : Nephrolithotomy; Prostate; Renal caliculi.

Introduction

Nowadays, urinary tract stone accounts for the third largest number of urological cases after urinary tract infection and prostate problems.[1] In earlier times, upper urinary tract stone had the same prevalence with bladder stone, but now the prevalence of upper urinary tract stone has increased significantly to 90%.[2] Complex renal calculi as described by Singh et al are renal stones occupying the renal pelvis and at least two of the three major calyceal systems.[3] It can be the extension of the pelvic stone (Staghorn) or a multiple primary or secondary renal calculus occupying the calyceal group.[4]

The advent and continuous evolution of percutaneous nephrolithotomy (PCNL) have led to a revolution in the management of renal stones.[5,6] PCNL is now the preferred treatment for patients with renal calculi and is a safe and successful method used for the removal of different types of stones.[7] The morbidity of PCNL is less than that of open surgery with better stone-clearance rates.[8]

The successful removal of stones requires the accurate placement of a percutaneous tract that provides direct access to the stone (Optimal kidney access). The upper calyceal approach is believed to favor good manipulations of the nephroscope and forceps within

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the pelvicalyceal system while the lower calyceal approach caused undue angulations and torque.[9] This difference is believed to be because of the straight tract of the upper infundibulum along the long axis of the kidney and the anatomical lie of the kidney over the iliopsoas muscle that causes the upper pole positioned more posterior as compared with the lower pole and these two factors provide excellent visualization of the PCS when an approach is made through the upper calyx.[3,10] Preminger et al. reported cephalad movement (Averaging 2.2 cm) of the kidney when patients were placed prone rather than supine, as viewed in IVU.[11] Thus, direct access to a superior calyx would require a supracostal puncture in >80% of patients which may cause serious thoracic complications. The incidence of thoracic complications during supracostal punctures in various studies ranges between 3 and 16 %.[12,13]

The subcostal inferior calyx approach to staghorn stones can induce angulation and torque on the kidney, which can cause trauma and bleeding.[12] Although it is technically more demanding, access through a superior calyx provides a short and straight tract along the axis of the kidney. This ability to operate via the long axis of the kidney causes less torque of the rigid nephroscope, and reduces the chance of injuring the peri-infundibular venous plexus that is possible if angulation of the tract is required to reach the stone-bearing area, thereby reducing the chances of excessive bleeding.[14] Sampaio et al reported injury to an interlobar vessel in two-thirds of kidneys on puncturing the upper-pole infundibulum, while only 13% of kidneys had an arterial injury when accessed through the lower-pole infundibulum.[15] The aim of this study was to compare the effectiveness and safety of upper calyceal versus lower calyceal puncture for the removal of complex renal calculi through PCNL.

Materials and methods

This quasi-experimental investigation was carried out at the Department of Urology, Chittagong Medical College Hospital, Chattogram, Bangladesh. 75 Patients admitted with complex renal stone and underwent PCNL during the study period in the Department of Urology, CMCH were the study population. Patients undergoing PCNL for complex renal stone, aged 18 years or more and with normal renal function who provided consent to enter the study were selected by consecutive sampling method. Patients or attendants who denied formal consent, patients with pyonephrosis, and congenital anomalies (Pelvi-ureteric junction obstruction, bifid pelvis, megaureter, horseshoe kidney, etc.) radio lucent stones, associated distal ureteric or lower urinary tract stone or stricture, patients with single kidney., renal malformation., anatomical abnormality that hampers patient positioning, i.e. scoliosis., patients with history of previous open surgery and PCNL of that kidney were excluded from the study. Patients were later divided into two groups (38 patients underwent PCNL by upper calyceal approach and 37 patients underwent PCNL by lower calyceal approach) as per the primary calyceal punctures taken during PCNL based on random number table.

For data analysis, we utilized Stata (Version 16, StataCorp, College Station, TX, USA). Using a histogram, a normal Q-Q plot, and the Kolmogorov-Smirnov test, the normality of continuous data were determined. Continuous variables were expressed as mean (±standard deviation) and range (minimum-maximum). Categorical variables were expressed as frequency (percentages). Independent sample t test was used to test the mean differences of continuous variables between study groups. Chi-square test or Fisher's exact test were used to determine the association between two categorical variables. $P<0.05$ was considered as statistical significance. A two-tailed p-value < 0.05 was regarded as statistically significant. This study was authorized by the Institutional Review Board (IRB) of Chittagong Medical College (Approval number: CMC/PG/2019/720).

Results

A total of 75 patients underwent upper and lower calyceal approach in percutaneous nephrolithotomy (PCNL) were included in the study. In Table I, both groups were comparable with age and sex distribution. There was male predominance in both groups and majority of the patients in both groups were of >40 years of age. Ten patients (26.3%) in the upper calyceal approach group were overweight and obese compared to 11 (29.6%) patients in the lower calyceal approach group.

Table I Comparison of demographic characteristics between two groups of patients undergoing PCNL (n=75)

Attributing factors		PCNL approach		p value
		Upper calyceal (n=38)	Lower calyceal (n=37)	
Age (Years)	<30 years	11 (28.9%)	7 (18.9%)	
	30-40 years	9 (23.7%)	11 (29.7%)	0.624
	>40 years	18 (47.4%)	19 (51.4%)	
	Mean ±SD	40.1±11.3	39.7±10.3	0.712
Sex	Male	23 (60.5%)	24 (64.9%)	0.698
	Female	15 (39.5%)	13 (35.1%)	
BMI	BMI <25 kg/m^2	28 (73.7%)	26 (70.3%)	0.742
	BMI ≥25 kg/m^2	10 (26.3%)	11 (29.7%)	
Comorbidities	HTN	7 (18.4%)	5 (13.5%)	0.562
	DM	3 (7.9%)	2 (5.4%)	0.666
	COAD	3 (7.9%)	2 (5.4%)	0.666

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BMI: Body Mass Index, HTN: Hypertension, DM: Diabetes Mellitus, COAD: Chronic Obstructive Airway Disease, SD: Standard Deviation.
Data are expressed as frequency (Percentage) if not otherwise mentioned.

Stone characteristics with respect to their size and side of involvement by their PCNL access route are shown in Table II. It shows that, both the groups were comparable at baseline with respect to their mean stone size and stone site (p>0.05 in each case).

Table II Comparison of preoperative stone characteristics between two groups of patients undergoing PCNL (n=75)

Stone characteristics (Unit)		PCNL approach		p value
		Upper calyceal (n=38)	Lower calyceal (n=37)	
Size (mm)	Mean ±SD	35.4±5.3	36.1±6.2	0.412
	Range	24-50	25-51	
Side involved	Right	22 (57.9%)	24 (64.9%)	0.535
	Left	16 (42.1%)	13 (35.1%)	

Data are expressed as frequency (Percentage) if not otherwise mentioned.

Table III shows that, mean operative time was comparatively lower in upper calyceal approach without any statistical significance (p=0.219). In contrast, need for blood transfusion and significant bleeding was more common in lower calyceal approach without any statistical significance. There was no injury to adjacent structure in the study population irrespective of the PCNL approach.

Table III Comparison of per-operative outcome between two groups of patients undergoing PCNL (n=75)

Variables (unit)	PCNL approach		p value
	Upper calyceal (n=38)	Lower calyceal (n=37)	
Operative time (Min)			
Mean ±SD	94.43 ±14.84	98.86 ±15.05	0.219
Range	(70-130)	(70-130)	
Injury to adjacent structure			
No	38 (100%)	37 (100%)	NA
Yes	0 (0%)	0 (0%)	
Blood transfusion			
No	37 (97.4%)	33 (89.2%)	0.642
Yes	1 (2.6%)	4 (10.8%)	
Per-operative bleeding‡			
No	38 (100%)	35 (94.6%)	0.475
Yes	0 (0%)	2 (5.4%)	

NA: Not Applicable.

Data are expressed as frequency (Percentage) if not otherwise mentioned.

‡Significant bleeding means need Blood Transfusion (BT) more than one unit.

Figure 1 shows the complication (Both general and thoracic complications) in two groups. Though the frequency of general complications were comparatively more in lower calyceal group compared to upper calyceal group, none of them were statistically significant. On the other hand, thoracic complications (Like pneumothorax, hemothorax, hydrothorax) were seen only in upper calyceal group. Likewise, general complications, these were also statistically non-significant.

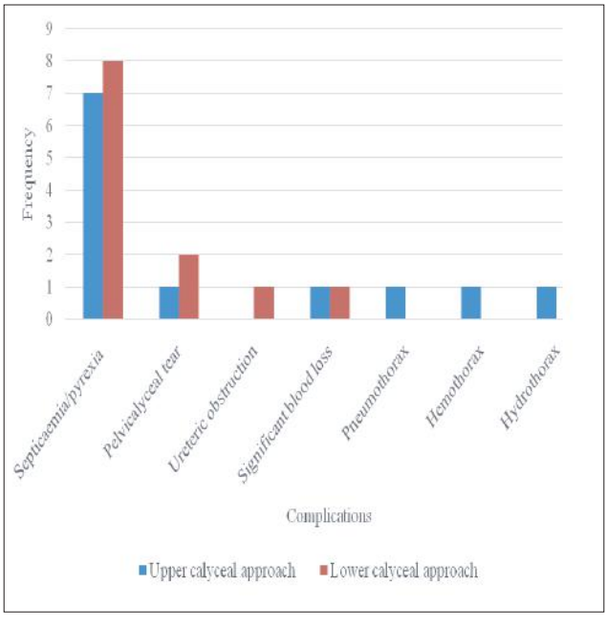

Figure 1 Comparison of complications between two groups (n=75)

Complete clearance after PCNL was achieved in 62 patients; out of 75, 34 (89.5%) were in the upper calyceal group and 28 (75.7%) were in the lower calyceal group. Secondary procedure required in 6 (15.8%) patients in upper calyceal group, while 7 (18.9%) patients were in lower calyceal group, which further requires ancillary procedure as summarized in Table IV. It is to be noted that, none of these differences were statistically significant. There was no significant difference between the groups regarding length of stay in hospital

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Table IV Comparison of surgical outcome between two groups (n=75)

Variables	PCNL approach		p value
	Upper calyceal (n=38)	Lower calyceal (n=37)	
PCNL			
1 tract	26 (68.42%)	20 (54.05%)	0.201
2 tracts	11 (28.95%)	14 (37.84%)	0.414
>2 tract s	1 (2.63%)	3 (8.11%)	0.358
Secondary procedure			
2nd look using previous tract	3 (7.9%)	1 (2.7%)	0.687
2nd look using new tract	1 (2.6%)	2 (5.4%)	0.899
ESWL	2 (5.3%)	4 (10.8%)	0.412
Overall result			
Success rate	34 (89.5%)	28 (75.7%)	0.115
Failure rate	4 (10.5%)	9 (24.3%)	
Mean length of hospital stay (Days)	2.3 ± 0.6	2.4 ± 0.8	0.603

PCNL: Percutaneous Nephrolithotomy, ESWL: Extra Corporeal Shockwave Lithotripsy
Data are expressed as frequency (Percentage) if not otherwise mentioned.

Discussion

A proper selection of an ideal access tract is the prerequisite for maximum clearance during PCNL in kidneys having large stone burdens. This study was conducted to compare the outcomes and complications of PCNL for complex renal stone in upper and lower calyceal approach. This study results confirms that the upper calyceal access has benefits over inferior calyceal access in patients with complex renal stones in terms of complete stone clearance rate. However, the beneficial effect failed to reach statistical significance probably due to small sample size.

In a recent meta-analysis, Gunawan et al. found that PCNL with single upper pole access has similar stone free rate and complication rates compared to lower pole approach PCNL.[16] In line with this finding, though the stone free rate is higher in superior pole access in the present study compared to lower calyceal approach it was statistically similar. The success rate achieved in the present study was 89.5% in upper calyceal group patients, whereas it was 75.7% in lower calyceal group (p=0.115).

In the current study only one patient develops thoracic complication and so the rate of thoracic complications (Hydrothorax and pneumothorax) did not differ between both groups (p=0.984). Although previous studies demonstrated an increasing risk of intrathoracic and other complications associated with an upper pole access, in recent years these kinds of complications have decreased exponentially. In adult patients whom undergo PCNL for renal calculi reported 3.1% patients who had a supracostal puncture developed pleural injury leading to hydro-pneumothorax.[17,18,13,19] Furthermore, even if these thoracic complications did occur, the majority of patients that experienced these complications will recover either spontaneously or by simple intervention with minimal future comorbidity.[20]

In the present study, out of 38 patients who underwent upper calyceal 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. The incidence of thoracic complication during supracostal punctures in various studies range between 3% and 16%.[12,13,21]

Main complication seen in both groups of the current study was fever/sepsis (18.3% in upper calyceal and 21.6% in lower calyceal group). Wong and Leveillee had 11.54% of incidence of fever, whereas Raza et al., had 19.12% incidence of septicemia/pyrexia in their respective studies.[22,23] Olbert et al in their study did not find any evidence for a relationship of urinary tract infection with the outcome of PCNL.[24] Authors 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.[30] In the present study, none of the patient progressed to urosepsis. All the patients in the present study underwent preoperative urine culture and any preoperative UTI was treated accordingly based on culture report. A single dose of ceftriaxone 1 gm iv was given to all patients as prophylaxis in the present study. Mariappan et al 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.[25]

However, the current study and other recent studies confirms that, complex renal stones can be managed by either superior or inferior calyceal access based on personal preference but superior calyceal access is associated with better stone clearance.

Conclusion

In conclusion, the present study has demonstrated that, the success rate in upper calyceal puncture group was better without a statistical significance than lower calyceal puncture group for the management of complex renal calculi. The safety of both the punctures was same. In complex/large staghorn calculi, upper calyceal puncture is a helpful method and should always be kept in mind.

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Disclosure

All the authors declared no competing interest.

References

1. McAninch JW, Lue TF. Smith & Tanagho's General Urology. 19th ed. McGraw Hill. 2020.

2. Antonelli JA, Beardsley H, Faddegon S, et al. A Novel Device to Prevent Stone Fragment Migration During Percutaneous Lithotripsy: Results from an In Vitro Kidney Model. J Endourol. 2016;30(11):1239-1243.
doi:10.1089/END.2016.0466.

3. Singh R, Kankalia SP, Sabale V, et al. Comparative evaluation of upper versus lower calyceal approach in percutaneous nephrolithotomy for managing complex renal calculi. Urol Ann. 2015;7(1):31.
doi:10.4103/0974-7796.148591.

4. Segura JW. The Role of Percutaneous Surgery in Renal and Ureteral Stone Removal. J Urol. 1989;141(3):780-781.
doi:10.1016/S0022-5347(17)41009-3.

5. Skolarikos A, Alivizatos G, de La Rosette JJMCH. Percutaneous nephrolithotomy and its legacy. Eur Urol. 2005;47(1):22-28.
doi:10.1016/J.EURURO.2004.08.009.

6. Hosseini MM, Basiri A, Moghaddam SMH. Percutaneous nephrolithotomy of patients with staghorn stone and incidental purulent fluid suggestive of infection. J Endourol. 2007;21(12):1429-1432.
doi:10.1089/END.2007.0092.

7. Honeck P, Wendt-Nordahl G, Krombach P, et al. Does open stone surgery still play a role in the treatment of urolithiasis? Data of a primary urolithiasis center. J Endourol. 2009;23(7):1209-1212.
doi:10.1089/END.2009.0027.

8. Cormio L, Perrone A, di Fino G, et al. TachoSil(®) sealed tubeless percutaneous nephrolithotomy to reduce urine leakage and bleeding: Outcome of a randomized controlled study. J Urol. 2012;188(1):145-150.
doi:10.1016/J.JURO.2012.03.011.

9. Aron M, Goel R, Kesarwani PK, Seth A, Gupta NP. Upper pole access for complex lower pole renal calculi. BJU Int. 2004;94(6):849-852.
doi:10.1111/J.1464-410X.2004.05045.X.

10. Netto NR, Ikonomidis J, Ikari O, Claro JA. Comparative study of percutaneous access for staghorn calculi. Urology. 2005;65(4):659-662.
doi:10.1016/J.UROLOGY.2004.10.081.

11. Preminger GM, Schultz S, Clayman R v., Curry T, Redman HC, Peters PC. Cephalad renal movement during percutaneous nephrostolithotomy. J Urol. 1987;137(4):623-625.
doi:10.1016/S0022-5347(17)44157-7.

12. Sukumar S, Nair B, Kumar PG, Sanjeevan K v., Bhat HS. Supracostal access for percutaneous nephrolithotomy: Less morbid, more effective. Int Urol Nephrol. 2008;40(2):263-267.
doi:10.1007/S11255-007-9270-2.

13. Lojanapiwat B, Prasopsuk S. Upper-pole access for percutaneous nephrolithotomy: comparison of supracostal and infracostal approaches. J Endourol. 2006;20(7):491-494.
doi:10.1089/END.2006.20.491.

14. Sampaio FJB, Aragao AHM. Anatomical relationship between the intrarenal arteries and the kidney collecting system. J Urol. 1990;143(4):679-681.
doi:10.1016/S0022-5347(17)40056-5.

15. Sampaio FJB, Zanier JFC, Aragao AHM, Favorito LA. Intrarenal Access: 3-Dimensional Anatomical Study. J Urol. 1992;148(6):1769-1773.
doi:10.1016/S0022-5347(17)37024-6.

16. Gunawan S, Birowo P, Rasyid N, Atmoko W. Outcome and safety of upper pole versus non-upper pole single puncture PCNL for staghorn stones: A systematic review and meta-analysis [Version 1; peer review: 1 approved with reservations]. F1000Res. 2019;8:537.
doi:10.12688/F1000RESEARCH.17806.1

17. Golijanin D, Katz R, Verstandig A, Sasson T, Landau EH, Meretyk S. The supracostal percutaneous nephrostomy for treatment of staghorn and complex kidney stones. J Endourol. 1998;12(5):403-405.
doi:10.1089/END.1998.12.403.

18. Kekre NS, Gopalakrishnan GG, Gupta GG, Abraham BN, Sharma E. Supracostal approach in percutaneous nephrolithotomy: Experience with 102 cases. J Endourol. 2001;15(8):789-791.
doi:10.1089/089277901753205753.

19. Amaresh M, Hegde P, Chawla A, de la Rosette JJMCH, Laguna MP, Kriplani A. Safety and efficacy of superior calyceal access versus inferior calyceal access for pelvic and/or lower calyceal renal calculi- a prospective observational comparative study. World J Urol. 2021;39(6).
doi:10.1007/S00345-020-03409-3.

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20. Anand A, Kumar R, Dogra PN, Seth A, Gupta NP. Safety and efficacy of a superior caliceal puncture in pediatric percutaneous nephrolithotomy. J Endourol. 2010;24(11):1725-1728. doi:10.1089/END.2010.0164.

21. Blum KA, Parkhomenko E, Thai J, Tran T, Gupta M. A contemporary lower pole approach for complete staghorn calculi: Outcomes and efficacy. World J Urol. 2018;36(9):1461-1467. doi:10.1007/S00345-018-2284-9.

22. Wong C, Leveillee RJ. Single upper-pole percutaneous access for treatment of > or = 5-cm complex branched staghorn calculi: Is shockwave lithotripsy necessary? J Endourol. 2002;16(7):477-481. doi:10.1089/089277902760367430.

23. Raza A, Moussa S, Smith G, Tolley DA. Upper-pole puncture in percutaneous nephrolithotomy: A retrospective review of treatment safety and efficacy. BJU Int. 2008;101(5):599-602. doi:10.1111/J.1464-410X.2007.07388.X

24. Olbert PJ, Hegele A, Schrader AJ, Scherag A, Hofmann R. Pre- and perioperative predictors of short-term clinical outcomes in patients undergoing percutaneous nephrolitholapaxy. Urol Res. 2007;35(5):225-230. doi:10.1007/S00240-007-0112-6.

25. Mariappan P, Smith G, Moussa SA, Tolley DA. One week of ciprofloxacin before percutaneous nephrolithotomy significantly reduces upper tract infection and urosepsis: A prospective controlled study. BJU Int. 2006;98(5):1075-1079. doi:10.1111/J.1464-410X.2006.06450.X.