Section: Miscellaneous

Original Research Article

COMPARATIVE OUTCOMES OF UPPER VS. LOWER CALYCEAL ACCESS IN PERCUTANEOUS NEPHROLITHOTOMY FOR COMPLEX RENAL STONE

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ABSTRACT

Background: Percutaneous nephrolithotomy (PCNL) is the preferred surgical approach for managing complex renal stones, with the choice of calyceal access—upper or lower—playing a critical role in procedural success and complication rates. The upper calyceal approach offers improved stone clearance but carries higher risks, especially in supracostal punctures, whereas lower calyceal access is safer but may have lower stone-free rates. Despite several comparative studies, an optimal access strategy remains debated. **Objectives:** This study aims to compare upper and lower calyceal access in PCNL for complex renal stones by evaluating patient demographics, operative parameters, stone clearance rates, complications, and overall surgical outcomes.

Materials and Methods: A retrospective analytical study was conducted on patients undergoing PCNL at Adichunchanagiri Institute of Medical Sciences between January 2024 and December 2024. Inclusion criteria comprised patients aged ≥18 years with radiopaque complex renal calculi, normal urinary tract anatomy, and a single calyceal puncture for PCNL. Data were collected on demographics, stone characteristics, operative details, and postoperative outcomes, including stone-free rates (SFRs), complications, and hospital stay duration. Statistical analyses included Chi-square and t-tests, with significance set at $p<0.05$.

Results: The study included 100 patients (Upper access: 46, Lower access: 54). The mean stone size and hemoglobin drop were comparable ($p>0.05$). The upper calyceal access group achieved a higher success rate (91.3% vs. 75.93%, $p<0.001$) and a greater stone clearance rate (86.96% vs. 75.93%). However, complications were significantly higher in the upper access group ($p<0.05$), particularly in supracostal punctures. Hospital stay did not differ significantly between groups.

Conclusion: Upper calyceal access in PCNL enhances stone clearance and success rates but is associated with a higher complication risk, particularly with supracostal punctures. Lower calyceal access, though safer, has lower stone-free rates. The choice of access should be individualized based on patient risk factors to optimize outcomes.

Keywords: Percutaneous nephrolithotomy, calyceal access, stone clearance, complications, supracostal puncture, renal calculi, PCNL outcomes.

INTRODUCTION

Percutaneous nephrolithotomy (PCNL) is the preferred surgical intervention for managing large and complex renal calculi, offering superior stone clearance rates compared to other minimally invasive techniques.[1] The choice of calyceal access in PCNL—whether upper or lower—significantly influences surgical outcomes, complication rates, and post-operative recovery. The upper calyceal approach provides direct access to renal calculi located in the renal pelvis and upper calyx, facilitating efficient fragmentation and extraction. However, it is often associated with increased risk of pleural and vascular injuries, particularly in supracostal punctures.[2] Conversely, the lower calyceal approach, commonly employed due to its safety profile, may present limitations in stone retrieval efficiency, particularly for large and complex renal stones.[3]

Several studies have compared upper and lower calyceal access in terms of stone-free rates (SFRs), complication rates, and procedural efficiency. A recent study comparing upper, middle, and lower calyceal accesses in prone PCNL found no statistically significant differences in SFRs among the groups, though the upper calyceal approach demonstrated a marginally higher clearance rate.[4] Similarly, a retrospective analysis indicated that the upper pole approach in PCNL affords better visualization and stone clearance but requires caution due to its higher complication rates.[5] Moreover, advancements in imaging modalities and robotic-assisted PCNL techniques aim to optimize access selection, reducing complications and improving surgical precision.

Despite ongoing research, the debate over the optimal calyceal access in PCNL remains unresolved, necessitating further randomized controlled trials to establish definitive guidelines. Hence this study aims to compare patient demographic data, including history of previous open surgery and stone size, operative parameters, and surgical outcomes—specifically stone-free status—between the upper and lower calyceal access groups in percutaneous nephrolithotomy for complex renal stones.

MATERIALS AND METHODS

This retrospective analytical study was conducted on patients who underwent percutaneous nephrolithotomy (PCNL) in Prone Position for complex renal stones at the Adichunchanagiri institute of medical sciences, BG Nagara, Nagamangala taluk, Mandya district, Karnataka, in inpatient department (IPD) between January 2024 and December 2024. Data were systematically collected from hospital records, imaging studies, and intraoperative and postoperative reports. The study included patients based on predefined inclusion and exclusion criteria. Inclusion criteria required patients to be aged 18 years or older, provide informed consent, and have radiopaque complex renal calculi confirmed through X-ray KUB and CT scans. Additionally, only those with normal upper urinary tract anatomy, as assessed by ultrasound and CT urography, and who underwent PCNL via a single calyceal puncture (either upper or lower pole access) were included. Patients were excluded if they refused to participate, had radiolucent renal calculi, suffered from pyonephrosis, or had significant comorbid conditions such as diabetes, hypertension, or anticoagulant therapy. Furthermore, congenital renal anomalies like PUJ obstruction, bifid pelvis, megaureter, and horseshoe kidney, along with cases requiring multiple calyceal tract punctures, were also grounds for exclusion.

Preoperative data collection involved extracting patient demographics, medical and surgical history, and stone characteristics from electronic medical records (EMRs) and physical case files. Demographic details included age, sex, and body mass index (BMI). Medical history considered previous renal surgeries, including open procedures and PCNL. Stone characteristics were evaluated based on size, burden, and location (upper, middle, lower calyx, renal pelvis, or staghorn calculi), as determined using X-ray KUB, ultrasound, and CT urography. Additionally, stone density was measured in Hounsfield units (HU) through CT scans. Renal function tests, including serum creatinine and estimated glomerular filtration rate (eGFR), were conducted before surgery.

Intraoperative data were gathered from surgical records, intraoperative imaging, and anesthesia reports, documenting operative techniques and parameters. The type of calyceal access in prone position (upper or lower pole) was noted from surgical reports, while details on needle puncture angle and fluoroscopic guidance were retrieved from procedural notes. Operative time was measured from the initial puncture to the completion of stone retrieval. Tract dilation size, typically within the 24–30 Fr range, was recorded. The method of stone fragmentation, whether laser lithotripsy, pneumatic lithotripsy, or ultrasonic lithotripsy, was specified based on intraoperative records. Stone clearance was assessed in real-time using fluoroscopy, and any surgical complications such as major bleeding, pleural injury, adjacent organ damage, or difficulties in tract formation were documented.

Postoperative data collection focused on outcomes, monitored through patient follow-up records, discharge summaries, and imaging studies. Stone-free status (SFR) was defined as residual fragments <4 mm, confirmed via X-ray KUB or CT scan at 48 hours post-PCNL, and reassessed at four weeks postoperatively using ultrasound or CT KUB. Complications such as bleeding requiring transfusion, infection or sepsis (based on blood culture and fever records), and the need for secondary interventions (repeat PCNL, ureteroscopy, or extracorporeal shock wave

lithotripsy [ESWL]) were recorded. The duration of hospital stay, measured from admission to discharge, was documented along with nephrostomy tube placement and removal timing. Follow-up details included symptom assessment, presence of residual fragments, and any complications reported during the one-month follow-up visit.

For statistical analysis, data collected from medical records were entered into a structured database and analyzed using statistical software such as SPSS or STATA. A comparative analysis between upper and lower calyceal access groups was conducted based on demographic and preoperative factors, intraoperative parameters, and postoperative outcomes, including stone-free rates, complications, and hospital stay duration. The Chi-square test and t-tests were employed to determine statistical significance, with a p-value < 0.05 considered significant.[6,7]

RESULTS

Table 1: Profile of subjects in the study

Parameter	Upper (n=46)	Lower (n=54)	P Value
Age (Yrs) Mean ± SD	44.83 ± 13.57	49.02 ± 13.32	0.123
Sex	28 (60.9%)	33 (61.1%)	0.980
	18 (39.1%)	21 (38.9%)	
Previous Open Surgery	4 (8.7%)	7 (12.9%)	0.496
	42 (91.3%)	47 (87.1%)	
Pelvicalyceal Tear	3 (6.5%)	5 (9.3%)	0.615
	43 (93.5%)	49 (90.7%)	

In the present study, the mean age of subjects in the Upper group was 44.83 ± 13.57 years, while in the Lower group, it was 49.02 ± 13.32 years. The difference in age distribution between the two groups was not statistically significant (P > 0.05). Regarding sex distribution, there were 28 males and 18 females in the Upper group, while in the Lower group, there were 33 males and 21 females, with no statistically significant difference between the groups (P > 0.05). Previous open surgery was reported in 4 (8.7%) subjects in the Upper group and 7 (12.9%) subjects in the Lower group, with no significant difference (P > 0.05). Pelvicalyceal tear was observed in 3 (6.5%) cases in the Upper group and 5 (9.3%) cases in the Lower group, again with no significant difference (P > 0.05) [Table 1].

Table 2: Stone size and Hb drop Parameter's comparison between two groups

Parameter	Upper (n=46)	Lower (n=54)	P value
	Mean ± SD	Mean ± SD	
Stone Size (mm)	39.07 ± 6.14	39.41 ± 7.03	0.799
Hb drop (gm%)	1.58 ± 0.50	1.57 ± 0.52	0.922

The mean stone size in the Upper group was 39.07 ± 6.14 mm, whereas, in the Lower group, it was 39.41 ± 7.03 mm. There was no statistically significant difference in stone size between the groups (P > 0.05). Similarly, the mean haemoglobin (Hb) drop was 1.58 ± 0.50 gm% in the Upper group and 1.57 ± 0.52 gm% in the Lower group, with no statistically significant difference (P > 0.05) [Table 2].

Table 3: Outcome and complications comparison between two groups

		Upper (n=46)	Lower (n=54)	Total	P Value
Clearance	Complete Clearance (CC)	40 (86.96%)	41 (75.93%)	81 (81%)	0.161
	Residual Stones (RS)	6 (13.04%)	13 (24.07%)	19 (19)	
Hospital Stay (Days) [Mean ± SD]		3.80 ± 1.20	3.67 ± 1.12		0.576
Outcome	Success	42 (91.3%)	41 (75.93%)	82 (82%)	0.04*
	Failure	4 (8.7%)	13 (24.07%)	18 (18%)	
Complications	Present	20 (43.5%)	10 (18.5%)	30 (30%)	0.006*
	Absent	26 (56.5%)	44 (81.5%)	70 (70%)	

Complete clearance (CC) of stones was achieved in 40 (86.96%) subjects in the Upper group and 41 (75.93%) subjects in the Lower group, while residual stones (RS) were present in 6 (13.04%) and 13 (24.07%) subjects in the respective groups. The total stone clearance rate was 81% across both groups. The mean hospital stay was 3.80 ± 1.20 days in the Upper group and 3.67 ± 1.12 days in the Lower group, with no significant difference (P > 0.05).

Regarding the outcome, success was observed in 42 (91.3%) subjects in the Upper group compared to 41 (75.93%) in the Lower group. The difference was statistically significant (P < 0.001), indicating a higher success rate in the Upper group. Failure was reported in 4 (8.7%) and 13 (24.07%) subjects in the respective groups.

Complications were present in 20 subjects in the Upper group and 10 in the Lower group, making a total of 30 cases with complications. The difference was statistically significant (P < 0.05), indicating a

higher complication rate in the Upper group [Table 3].

Table 4: Hb Drop in Cases with Previous Open Surgery or Pelvicalyceal Tear

	Upper		Lower		P Value
Hb Drop in Cases with	**Count**	**Mean ± SD**	**Count**	**Mean ± SD**	
Previous open surgery	4	2.65 ± 0.52	7	1.82 ± 0.59	0.044*
Pelvicalyceal Tear	3	1.7 ± 0.7	5	1.9 ± 0.58	0.620

Among subjects with previous open surgery, the mean hemoglobin drop was 2.65 ± 0.52 gm% in the Upper group and 1.82 ± 0.59 gm% in the Lower group. The difference was statistically significant (P < 0.05), suggesting a greater hemoglobin drop in cases with previous open surgery in the Upper group.

In subjects with pelvicalyceal tear, the mean hemoglobin drop was 1.7 ± 0.7 gm% in the Upper group and 1.9 ± 0.58 gm% in the Lower group. The difference was not statistically significant (P > 0.05) [Table 4].

Table 5: Complications in Supracostal vs Infracostal Puncture among Upper calyceal access

Complications	Supracostal (n=23)	Infracostal (n=23)	Total	P value
Present	15 (65.2%)	5 (21.7%)	20 (43.5%)	0.002*
Absent	8 (34.8%)	18 (78.3%)	26 (56.5%)	
Total	23	23	46	

Among subjects undergoing supracostal puncture (n=23), complications were present in 15 (65.22%) cases, whereas in the infracostal puncture group (n=23), complications were observed in only 5 (21.74%) cases. The difference was statistically significant (P < 0.05), indicating a higher complication rate with supracostal puncture. Conversely, complications were absent in 8 (34.78%) cases in the supracostal group and in 18 (78.26%) cases in the infracostal group. This highlights the increased risk of complications associated with supracostal puncture [Table 5].

DISCUSSIONS

The present study aimed to compare the upper and lower calyceal access groups in percutaneous nephrolithotomy (PCNL) for complex renal stones concerning demographic data, operative parameters, and surgical outcomes. Our findings indicate a significantly higher success rate in the upper calyceal access group but also a higher complication rate, especially in cases requiring supracostal puncture. Similar results have been reported in the literature, where upper calyceal access has been associated with better stone-free rates but increased complications. A study by Desai et al,[8] reported an 88% success rate with upper calyceal access, which aligns closely with our findings. However, their study noted a slightly lower complication rate than ours, possibly due to differences in surgical expertise or case selection criteria.

Conversely, lower calyceal access has been shown in some studies to have a lower complication rate, making it a preferred choice in patients with high-risk profiles. The study by Kumar et al,[9] demonstrated a 76% success rate with lower calyceal access, similar to our results, and emphasized its safety profile. The significant hemoglobin drop in cases with previous open surgery in the upper group (P < 0.05) corroborates findings from past studies that highlight increased bleeding risks in previously operated kidneys.[10] Our study also observed that supracostal access was associated with a significantly higher complication rate (P < 0.05), a finding consistent with reports by Turna et al,[11] who suggested that supracostal access increases the likelihood of pleural injury. The variations in results among studies may stem from differences in sample sizes, patient demographics, surgical techniques, and operator expertise.

CONCLUSION

This study highlights the advantages and drawbacks of upper and lower calyceal access in PCNL for complex renal stones. While upper calyceal access offers a higher stone clearance rate and overall procedural success, it is associated with an increased risk of complications, particularly with supracostal puncture. Lower calyceal access, though associated with a lower stone clearance rate, presents a safer profile with fewer complications. The choice of access should be tailored to individual patient profiles, considering factors such as previous surgeries, stone burden, and the risk of complications. These findings underscore the importance of a meticulous approach in selecting the appropriate access route, balancing efficacy with patient safety.

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