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PYELOCALYCEAL DISTRIBUTION OF KIDNEY STONES USED AS AN OUTCOME PREDICTOR IN PERCUTANEOUS NEPHROLITHOTOMY – A PROSPECTIVE STUDY

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ABSTRACT

Background- Objective: To evaluate the classification system based on Pyelocalyceal Distribution of Kidney stones and its role as an Outcome Predictor in Percutaneous Nephrolithotomy.**Materials And Methods:** This is a prospective observational study conducted on 144 patients of partial/total staghorn urolithiasis consenting for PCNL, for a period of 2 years at Institute of Nephro-urology, Bangalore. With regard to stone distribution in the pyelocaliceal system, the patients were classified as ‘‘no extra stone in middle calix’’ (NESMC) and ‘‘extra stone in middle calix’’ (ESMC). **Results:** In this study, 144 patients with urolithiasis were studied. The mean age was 44.53 years, with a predominance of males (93 patients, Mratio 1.82:1). Most stones were right-sided (57.6%) and single calculi were more common (57.6%). Radiopacity was found in 87.5% of cases, with non-staghorn calculi in 86.8%. Mid-calyx involvement was seen in 30.6% of patients, significantly associated with residual calculus (P = 0.010). Staghorn calculi were associated with a higher rate of residual calculus (57.9%, P = 0.007). There was no significant difference in residual calculus between single and multiple stones, or between right and left-sided stones. **Conclusion:** In conclusion, this study provides valuable insights into the factors influencing residual calculus following PCNL. By identifying significant predictors such as mid-calyx involvement and stone type, clinicians can better stratify patients for tailored treatment strategies, ultimately optimizing surgical outcomes and enhancing patient care in the management of urolithiasis.

INTRODUCTION

Urolithiasis is one of the common disease worldwide currently with a prevance of 12% both in the world and in India. It is more common in the northern India with a prevalence of 15%.[1] Urolithiasis can have varying presentation from asymptomatic to fever, vomiting, loin/groin pain, increased frequency, burning micturition, hematuria.[2] While common treatments include extracorporeal shock wave lithotripsy (ESWL) and ureterorenoscopy (URS), percutaneous nephrolithotomy (PCNL) stands out as the preferred approach for managing complex kidney stones due to its demonstrated higher stone-free rates (SFRs).[3,4] The anatomical distribution of kidney stones within the renal pyelocalyceal system plays a pivotal role in determining the technical feasibility and clinical outcomes of PCNL procedures. Stone location influences surgical access, procedural complexity, and the likelihood of achieving complete stone clearance, thereby impacting postoperative outcomes such as complication rates and treatment success.[5] While previous research has underscored the importance of stone localization in predicting procedural outcomes in PCNL[4], the precise role of pyelocalyceal distribution as an independent predictor remains an area of active investigation. This study therefore aims to identify stone characteristics crucial in determining PCNL outcomes by developing a classification system tailored to predict procedural success based on comprehensive stone attributes. By enhancing our understanding of these predictive factors, we aim to refine treatment strategies and optimize patient outcomes in the management of kidney lithiasis.

MATERIALS AND METHODS

This is a prospective observational study conducted on 144 patients of partial/total staghorn urolithiasis consenting for PCNL, for a period of 2 years, from November 2017 to October 2019 at Institute of Nephro-urology, Bangalore. Study subjects will be selected after applying inclusion-exclusion criteria.

Inclusion Criteria: Age greater than 15 years, All patients with staghorn and/or partial staghorn calculus, consenting for PCNL in Prone position, Those who undergo Pre-operative CT evaluation, Those who undergo Post-Operative X-ray and USG evaluation

Exclusion criteria:

Patients refusing consent for PCNL, All patients who does not undergo Pre-operative CT Study and post op X-ray/USG, All Urolithiasis patients in whom PCNL is contraindicated, PCNL done for single calculus in renal pelvis/calyces, PCNL done in Anatomically abnormal kidney, PCNL done in supine/lateral position, Re-look PCNL

Information is collected through prepared proforma from each patient including demographic details, history, examination, routine blood and urine work up. Preoperative CT and X-ray findings eliciting various characteristics of the stones like laterality, number, position, type, nature (obstructive/non obstructive)and radio opacity of the stones along with associated secondary findings like hydronephrosis, pyelonephritis were noted. With regard to stone distribution in the pyelocaliceal system, the patients were classified as ‘‘no extra stone in middle calix’’ (NESMC) and ‘‘extra stone in middle calix’’ (ESMC). This was based on the stone distribution and the degree of difficulty in reaching them (estimated before the procedure), the expertise of the urologists and the data extrapolated from the preoperative CT. Post- operative KUB to know the residual status.

STATISTICAL ANALYSIS

Continuous variables with normal distribution were expressed as mean and range. Categorical variables were expressed as absolute value and percentage. Univariate logistic regression analysis were done to asses all the preoperatory characteristics that determine the presence of RL by using software SPSS 22. It included number of stones (multiple vs single), total volumetry (mm3), side (left or right), type of stone (staghorn vs nonstaghorn), radioopacity (radio-opaque vs radiolucent), preoperatory UTI (infection vs no infection), distribution of the stones along with other relevant patient information. A $p < 0.05$ or an OR with 95% CI was considered statistically significant.

RESULTS

A total of 144 patients with urolithiasis were studied. Patient’s age ranged between 18 years and 76 years with a mean age of 44.53±13.16. Most of them were males (93 patients) with M: F ratio of 1.82:1. Mean volumetry (mm^3) of stones were 2941.29$\pm$3878.30. Distribution of stones were seen more on right sided (57.6%, 83 patients) than on left side (42.4%, 61 patients).Single calculus (57.6%, 83 patients) were seen more common than multiple calculi (42.4%, 61 patients). 87.5% (126 patients) of the stones were radiopaque in comparison with only 12.5% (18 patients) of them being radiolucent. 86.8% (125 patients) showed non staghorn calculi while 13.2% (19 patients) showed staghorn calculi. (Table 1)

Table 1: Patients and stone characteristics

Age in years	44.53±13.16
Volumetry (mm3)	2941.29±3878.30
Mid-Calyx involvement	
Yes	44(30.6%)
Number of stones	
Multiple	61(42.4%)
Single	83(57.6%)
Side	
Left	61(42.4%)
Right	83(57.6%)
Radio-opacity	
Radio-opaque	126(87.5%)
Radiolucent	18(12.5%)
Type of stones	
Staghorn	19(13.2%)
Non staghorn	125(86.8%)

30.6% (44 patients) showed mid calyx involvement and were classified under ‘‘extra stone in middle calix’’ (ESMC) category out of which 45.5% (20 patients) showed residual calculus. Rest of them (69.4%, 100 patients) with no middle calyx involvement were classified under ‘‘no extra stone in middle calix’’ (NESMC) out of which 29.9% (43 patients) showed residual calculus. P value of 0.010 was obtained and therefore, there was a statistically significant difference found between residual calculus and Mid-Calyx involvement. (Table 2).

57.9% (11 patients) out of 19 staghorn calculus and 25.6% (43 patients) showed residual calculus post operatively. P value of 0.007 was obtained and therfore, there was a statistically significant difference found between residual calculus and type of stone. (Table 2)

Table 2: Distribution of subjects according to mid calyx involvement and type of stone showing residual calculus

	Residual calculus		Total	P value ($p \leq 0.05$, statistically significant)
	Present	Absent		
ESMC	20	24	44	0.010
	45.5%	54.5%	100.0%	
NESMC	23	77	100	
	23.0%	77.0%	100.0%	
Total	43	101	144	
	29.9%	70.1%	100.0%	
Staghorn	11	8	19	0.007
	57.9%	42.1%	100.0%	
Non staghorn	32	93	125	
	25.6%	74.4%	100.0%	
Total	43	101	144	
	29.9%	70.1%	100.0%	

23 out of 83 patients with single calculus (27.7%) and 20 out of 61 patients with multiple calculi (32.8%) show residual calculus. P value of 0.582 was obtained and therefore, there was no statistically significant difference found between residual calculus and number of stones. (Table 3). 25 out of 83 patients with right sided calculus (30.1%) and 18 out of 61 patients with left sided calculi (29.5%) show residual calculus. P value of 0.937 was obtained and therfore, there was no statistically significant difference found between residual calculus and side involved. (Table 3). 37 out of 126 patients with radio-opaque calculus (29.4%) and 6 out of 18 patients with radiolucent calculi (33.3%) show residual calculus. P value of 0.785 was obtained and therfore, there was no statistically significant difference found between residual calculus and radio opacity. (Table 3).

Table 3:Distribution of subjects according number, laterality and radio opacity of stones showing residual calculus

	Residual calculus		Total
	Present	Absent	
Multiple	20	41	61
	32.8%	67.2%	100.0%
Single	23	60	83
	27.7%	72.3%	100.0%
Total	43	101	144
	29.9%	70.1%	100.0%
Left	18	43	61
	29.5%	70.5%	100.0%
Right	25	58	83
	30.1%	69.9%	100.0%
Total	43	101	144
	29.9%	70.1%	100.0%
Radiopaque	37	89	126
	29.4%	70.6%	100.0%
Radiolucent	6	12	18
	33.3%	66.7%	100.0%
Total	43	101	144
	29.9%	70.1%	100.0%

Univariate analysis using odds ratios (OR) and their 95% confidence intervals (CI) for various factors related to kidney stones were calculated. Patients with mid-calyx involvement have 2.79 times higher odds of residual calculus. Staghorn stones have 3.996 times higher odds of outcome compared to those with non-staghorn stones. The confidence interval suggests this difference is statistically significant. Multiple stones versus a single stone is associated with an odds ratio of 1.273 for some outcome, but the confidence interval includes 1, indicating the difference may not be statistically significant. There is no significant difference in the odds of the outcome between left and right sides of involvement and in the odds of the outcome between radiopaque and radiolucent stones. (Table 4)

Table 4: Odds ratio with 95%CI for various parameters

	Odds ratio	95%CI	
Mid-Calyx involvement		Lower	Upper
Yes vs No	2.790	1.312	5.932
Number of stones			
Multiple vs signal	1.273	.620	2.611
Side involved			
Left vs right	0.971	.471	2.001
Radio-opacity			
Radiopaque vs radiolucent	0.831	.290	2.382
Type of stone			
Staghorn vs non staghorn	3.996	1.477	10.812

DISCUSSION

This study aimed to investigate the factors influencing residual calculus following percutaneous nephrolithotomy (PCNL) in patients with urolithiasis. The analysis encompassed various patient demographics and stone characteristics to identify predictors of procedural outcomes.

The demographic profile of the study cohort, comprising 144 patients with a mean age of 44.53 years and a male predominance (M: F ratio of 1.82:1), reflects typical trends observed in urolithiasis epidemiology[6]. Stone characteristics revealed a mean volumetry of 2941.29 mm^3, predominantly right-sided distribution (57.6%), and a higher prevalence of single calculi (57.6%). Radiopacity was predominant (87.5%), with non-staghorn calculi representing the majority (86.8%) of cases. Study by Tirapegui *et al.*[7] showed mean age of 55.4 years, male predponderance, even distribution of stones, predominantly single,radio opaque with mean total volumetry of 5815mm^3.Chen *et al.*[8] showed demographic findings with

mean age of 61.1 years, male predominance with M:F ratio 0f 1:1.05,predominant right side laterality (53.8%) and single calculi (82.1%).

Analysis of mid-calyx involvement demonstrated a statistically significant association with residual calculus (P = 0.010), with patients exhibiting mid-calyx stones showing 2.79 times higher odds of residual calculus compared to those without mid-calyx involvement (OR = 2.790, 95% CI: 1.312-5.932).Based on the midcalyx involvement, the patients were classified as ‘‘no extra stone in middle calix’’ (NESMC) and ‘‘extra stone in middle calix’’ (ESMC). This finding underscores the importance of stone location within the renal collecting system in predicting treatment success and underscores the need for meticulous surgical planning and thorough stone clearance in such cases. Tirapegui *et al.*[7] showed similar findings with significant association between midcalyx involvement and residual calculus (Odds ratio 11.36).Many PCNL result models have been publish based on pre operative clinical and radiological findings of the patient and the calculi.[9-14] An ideal predictive model ought to be precise, well-calibrated, straightforward, capable of replication, and hold clinical relevance.[15-17] Sampaio and collegues[18] have described two groups based on midcalyceal involvement, one group as upper and lower calyx with middle calyx draining into either of them which showed a higher chance of incomplete clearance than the second group with a separate middle calyx drainage. Others include Guy Stone Score by Thomas *et al.*[12], normogram predicting lithiasis burden and SFR by Smith *et al.*[14], Seoul National University Renal Stone Complexity (SReSC) scoring system by Jeong *et al.*[11].Verma A *et al.*[19] studied multiple site calculus and high chance of incomplete stone clearance was seen with all three calyx involvement followed by midcalyx involvement. This study also emphasises the importance of the puncture site and stone free rate/stone clearance rate.

Similarly, the type of stone significantly influenced treatment outcomes, with staghorn calculi showing a markedly higher risk of residual calculus (P = 0.007, OR = 3.996, 95% CI: 1.477-10.812). This aligns with existing literature highlighting the complexity and challenges associated with staghorn stones in PCNL procedures.[3] Tirapegui *et al.*[7] showed similar findings with significant association between type of stone involved and residual calculus (Odds ratio 6.641). A study by the Clinical Research Office of the Endourological Society (CROES) revealed that staghorn patients treated with PCNL have lesser clearance rate with a stone free rate of 56.9% compared to non-staghorn patients with a stone free rate of 82.5%.[20]

Conversely, the analysis did not find significant associations between residual calculus and the number of stones (P= 0.582), side of stone involvement (P = 0.937), or radiopacity (P = 0.785)similar to the findings of Tirapegui *et al.*.[7] These findings suggest that while these factors may influence procedural aspects such as surgical approach and complexity, they may not independently predict postoperative stone clearance. However, a study by Fiorello *et al.*[21] showed statistically significant relation between multiple stone and residual calculus with a p value of 0.000146.

The limitations of this study include its retrospective nature and the single-center design, which may restrict generalizability to broader patient populations. Future prospective studies with larger cohorts and multi-center collaborations are warranted to validate these findings and further refine predictive models for PCNL outcomes.

CONCLUSION

In conclusion, this study provides valuable insights into the factors influencing residual calculus following PCNL. By identifying significant predictors such as mid-calyx involvement and stone type, clinicians can better stratify patients for tailored treatment strategies, ultimately optimizing surgical outcomes and enhancing patient care in the management of urolithiasis.

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