

Supracostal Punctures for Percutaneous Nephrolithotomy: Factors that Predict Safety, Success, and Stone-Free Rate in Patients with Renal Stone

Rahman KMA¹, Hasan MM², Rashid MM³, Alam MM⁴, Khan SI⁵, Arafuzzaman K⁶, Alam MA⁷, Amin MA⁸

ABSTRACT

Percutaneous nephrolithotomy (PCNL) is the standard treatment for large or complex renal stones. Supracostal puncture offers an alternative access route when infra-costal access is challenging, but it carries potential risks. A cross-sectional, observational study was conducted in the Department of Urology, Mugda Medical College Hospital, Dhaka, Bangladesh, between January 2022 and December 2024, to evaluate the safety, success, and stone-free rates of supracostal PCNL and identify factors predicting outcomes in patients with renal stones. A total of 70 patients (40 males and 30 females) undergoing PCNL via supracostal puncture were included in this study. Stone characteristics, puncture levels, operative details, complications, and stone-free rates were analyzed. The mean age of the patients was 29.6±8.4 years. Stone-free rate (SFR) was 89.4%. Complications occurred in 14.3% of the patients including intraoperative haemorrhage (5.7%), hydrothorax (4.3 pneumothorax (2.9%), and delayed haemorrhage (1.4%). Multivariate logistic regression analysis showed that stone size (OR=0.65, 95% CI 0.48–0.89, $p<0.01$), stone type (staghorn vs non-staghorn; OR=0.42, 95% CI 0.18–0.98, $p<0.05$), and degree of hydronephrosis (OR=1.34, 95% CI 1.01–1.78, $p<0.05$) are independent predictors of stone-free status. However, gender, puncture level, and number of tracts were not significant predictors ($p>0.05$). Supracostal PCNL is a safe and effective approach for complex renal stones when infra-costal access is not feasible. Careful patient selection and surgical expertise are critical to maximizing stone-free rates and minimizing complications.

Keywords: Supracostal percutaneous nephrolithotomy, renal calculi, staghorn stone, operative outcome, minimally invasive urology

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INTRODUCTION

Renal stone disease is a common urological condition, with an increasing incidence worldwide due to dietary changes, obesity, and metabolic disorders.¹ Large or complex renal calculi, particularly staghorn stones, pose significant challenges to effective management and are associated with increased

morbidity if left untreated.² Percutaneous nephrolithotomy (PCNL) has emerged as the standard treatment modality for stones larger than 2 cm, offering high stone clearance rates with relatively low complication rates.³

The success of PCNL depends largely on optimal access to the collecting system. Traditionally,

1. Dr. K M Arifur Rahman, Assistant Registrar, Department of Urology, Mugda Medical College Hospital, Dhaka-1214. Email: arifrpmch@gmail.com (Corresponding author)
2. Dr. Md. Mahmud Hasan, Associate Professor, Department of Urology, Mugda Medical College & Hospital, Dhaka-1214.
3. Dr. Mohammad Mamunur Rashid, Associate Professor, Department of Urology, Mugda Medical College & Hospital, Dhaka-1214.
4. Dr. Muhammad Mahmud Alam, Associate Professor, Department of Urology, Mugda Medical College & Hospital, Dhaka-1214.
5. Dr. Shariful Islam Khan, Senior Consultant, Department of Urology, Mugda Medical College Hospital, Dhaka-1214.
6. Dr. Khondaker Arafuzzaman, Assistant Professor, Department of Urology, Mugda Medical College & Hospital, Dhaka-1214.
7. Dr. Md. Akter Alam, Assistant Professor, Department of Urology, Mugda Medical College & Hospital, Dhaka-1214.
8. Dr. Mohammad Al Amin, Assistant Professor, Department of Urology, Mugda Medical College & Hospital, Dhaka-1214.

infracostal punctures below the 12th rib are preferred due to the reduced risk of thoracic complications.⁴ However, in certain cases, particularly when stones are located in the upper pole or calyces with complex anatomy, supracostal punctures – accessing the kidney above the 12th or 11th rib – may be necessary to achieve direct tract alignment and facilitate complete stone clearance.^{5,6} Despite its advantages in providing a straight tract to the upper pole, supracostal access has been associated with increased risk of complications, including pneumothorax, hydrothorax, and pleural injury.^{7,8} Previous studies have evaluated the safety and efficacy of supracostal PCNL, reporting variable complication rates and stone-free outcomes. For instance, studies have demonstrated stone-free rates ranging from 80% to 95%, with major thoracic complications occurring in 2–10% of cases.^{9,10} Factors influencing the success of PCNL include stone size, composition, location, degree of hydronephrosis, and surgeon experience.¹¹ Understanding these predictors is crucial to optimize patient selection, minimize complications, and improve outcomes.

Despite the growing body of literature, data from single-center experiences, particularly in developing countries, remain limited. Local anatomical variations, differences in patient demographics, and variations in surgical expertise may influence outcomes, underscoring the need for institution-specific analyses.¹² Evaluating supracostal PCNL in such contexts provides insights into its applicability, safety, and effectiveness in routine clinical practice. Therefore, the present study aims to assess the outcomes of supracostal PCNL in patients with renal stones, focusing on stone-free rates, safety profile, and factors predicting successful clearance. By analyzing perioperative parameters, complications, and predictive factors, this study seeks to contribute to the evidence base guiding the selection and optimization of supracostal access in renal stone management.

METHODS

This cross-sectional, observational study was conducted in the Department of Urology, Mugda Medical College Hospital, Dhaka, Bangladesh, between January 2022 and December 2024. The study included patients with renal stones requiring percutaneous nephrolithotomy (PCNL) via a supracostal approach. A total of 70 patients

(comprising 40 males and 30 females) were enrolled in the study. Inclusion criteria were patients with renal stones larger than 2 cm, complex staghorn calculi, impacted stones at pelvi-ureteric junction, or stones located in the upper pole calyces requiring supracostal access. Our exclusion criteria included patients with radiolucent stone, uncorrected coagulopathy, untreated urinary tract infection, or severe cardiopulmonary comorbidities precluding general anaesthesia.

All patients underwent a detailed history and physical examination. Laboratory investigations included complete blood count, renal function tests, coagulation profile, and urine culture. Imaging studies consisted of non-contrast computed tomography (NCCT) of the kidneys, ureters, and bladder to assess stone size, number, location, and anatomy of the collecting system. Hydronephrosis grading was noted for each patient.^{4,5}

PCNL was performed under general anaesthesia with the patient in the prone position. Supracostal puncture was achieved either above the 12th rib or, in selected cases, above the 11th rib, depending on stone location and collecting system anatomy. Fluoroscopy guidance was used to localize the calyx for puncture. After successful puncture, a guidewire was introduced into the collecting system, followed by tract dilation using serial Alken dilators up to 24–30 Fr. Nephroscopy was introduced, and stones were fragmented using a pneumatic or ultrasonic lithotripter.^{6,7}

A nephrostomy tube and D-J stent were placed at the conclusion of the procedure in all patients. Postoperative analgesia and antibiotics were administered as per standard protocol. Hemoglobin levels and vital parameters were monitored, and patients were assessed for complications including bleeding, pneumothorax, hydrothorax, and sepsis.⁸

The primary outcome was the stone-free rate (SFR), defined as the absence of residual fragments >4 mm on postoperative imaging (x-ray of KUB region) within 7 days as residual stone <4 mm is considered clinically insignificant residual fragment. Secondary outcomes included perioperative complications, duration of surgery, number of access tracts required, and hospital stay. Complications were graded using the Clavien-Dindo classification.^{9,10}

Data was scrutinized, compiled and coded. Data analysis was done using IBM SPSS Statistics for

Windows, version 23 (IBM Corp., Armonk, NY, USA). Continuous variables were presented as mean±SD (standard deviation), while categorical variables were expressed as frequencies and percentages. Then, univariate and multivariate logistic regression analyses were performed. A p-value <0.05 was considered statistically significant.

RESULTS

A total of 70 patients underwent supracostal PCNL. The mean age was 29.6±8.4 years (ranging between 18 and 55 years). There were 40 males (57.1%) and 30 females (42.9%). Right kidney stones were present in 42 patients (60%) and left kidney stones in 28 patients (40%). Staghorn stones were present in 31 patients (44.3%), while non-staghorn stones were seen in 39 patients (55.7%). The mean stone size was 28.4±9.6 mm. Supracostal puncture above the 12th rib was performed in 50 cases (71.4%) and above the 11th rib in 20 cases (28.6%). Single-tract PCNL was achieved in 62 patients (88.6%), while multiple tracts were required in 8 patients (11.4%). The mean duration of operation was 85±20 minutes. (Table-I). The overall stone-free rate (SFR) was 89.4% (63/70). Complete clearance was achieved in 100% of stones <2 cm, 93.3% in stones 2–3 cm, and 77.4% in staghorn stones. Patients with severe hydronephrosis had 100% SFR, while moderate hydronephrosis was associated with 87.1% SFR (Fig. 1). Overall, 14.3% (10/70) of patients experienced complications. Intraoperative hemorrhage occurred in 4 patients (5.7%), hydrothorax in 3 patients (4.3%), pneumothorax in 2 patients (2.9%), and delayed haemorrhage in 1 patient (1.4%). None of patients required thoracostomy (Table-II). Multivariate logistic regression identified stone size (OR 0.65, 95% CI 0.48–0.89, p<0.01), stone type (staghorn vs non-staghorn; OR 0.42, 95% CI 0.18–0.98, p<0.05), and degree of hydronephrosis (OR 1.34, 95% CI 1.01–1.78, p<0.05) as independent predictors of stone-free status. Gender, puncture level, and number of tracts were not significant predictors (p>0.05) (Table-III).

Table-I: Demographic and clinical characteristics of the patients (N=70)

Variables	Frequency	Percentage
Gender		
Male	40	57.1
Female	30	42.9
Affected kidney		
Right	42	60.0
Left	28	40.0
Stone types		
Staghorn	31	44.3
Non-staghorn	39	55.7
Puncture level		
Supra-12th rib	50	71.4
Supra-11th rib	20	28.6
Number of tracts		
Single	62	88.6
Multiple	8	11.4

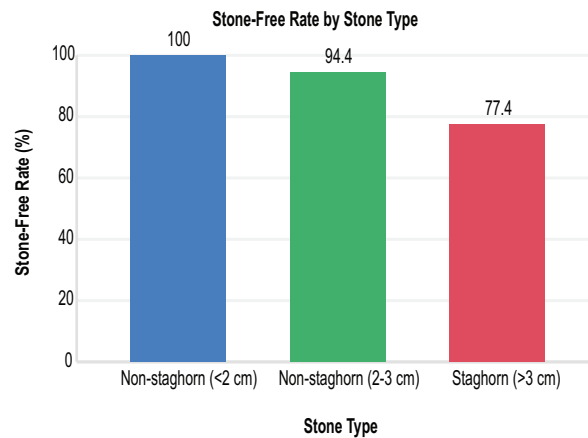


Fig. 1: Bar diagram showing stone-free rate by stone types.

Table-II: Complications (Clavien-Dindo Classification) (N=10)

Complications	Frequency	Percentage	Clavien-Dindo Grade
Intraoperative haemorrhage	4	5.7	II
Hydrothorax	3	4.3	II
Pneumothorax	2	2.9	IIIa
Delayed haemorrhage	1	1.4	II

Table-III: Univariate and multivariate logistic regression analyses

Prediction factors	Univariate analysis (p-value)	Multivariate analysis (OR)	95% CI	Multivariate analysis (p-value)
Stone size	0.01*	0.65	0.48–0.89	0.01*
Stone type (staghorn vs. non-staghorn)	0.02*	0.42	0.18–0.98	0.04*
Degree of hydronephrosis	0.03*	1.34	1.01–1.78	0.03*
Gender	0.88	-	-	0.91
Puncture level (11th vs. 12th)	0.45	-	-	0.52
Number of tracts	0.12	-	-	0.08

*=Statistically significant; OR=Odds Ratio, CI=Confidence Interval.

DISCUSSION

The mean age of the patients was 29.6±8.4 years, with a slight male predominance (57.1%), which aligns with previous reports indicating a higher prevalence of urolithiasis among young adult males.^{1,2} Right-sided stones were more common (60%), consistent with the anatomical predilection described in prior studies.^{3,4} The mean stone size was 28.4±9.6 mm, with nearly half of the patients presenting with staghorn stones (44.3%). This reflects a challenging patient population, as staghorn stones are typically associated with lower stone-free rates (SFR) and higher procedural complexity.⁴

Supracostal access was predominantly performed above the 12th rib (71.4%), with a minority requiring supra-11th rib puncture. Single-tract PCNL was feasible in 88.6% of cases, and the mean operative time was 85±20 minutes. These findings corroborate prior literature reporting that single supracostal tracts can provide adequate access for most renal stones, minimizing invasiveness while maintaining high clearance rates.^{5,6} Multiple tracts were required only in complex or staghorn stones, which is consistent with established practice that more extensive stone burdens necessitate additional access points to achieve complete clearance.⁷

The overall SFR in our study was 89.4%, comparable to previously published series of supracostal PCNL reporting SFRs between 85–95%.^{8,9} Stratification by stone type and size showed that small non-staghorn stones (<2 cm) were completely cleared in all patients (100%), medium stones (2–3 cm) in 94.4%, and staghorn stones in 77.4% with only 7 (10.6%) patients may need ancillary therapy. These results highlight that stone complexity remains the primary determinant of clearance. Notably, patients with severe hydronephrosis achieved 100% SFR, possibly

due to the dilated collecting system facilitating easier access and manipulation of calculi.¹⁰ Multivariate analysis confirmed that stone size and staghorn morphology were independent predictors of incomplete clearance, while hydronephrosis positively influenced stone-free outcomes. Puncture level, number of tracts, and gender did not significantly impact SFR, suggesting that procedural technique and patient anatomy are secondary to stone characteristics in determining success.

The overall complication rate was 14.3%, with most events being minor (Clavien-Dindo grade II) including intraoperative haemorrhage (5.7%), hydrothorax (4.3%) and delayed haemorrhage in 1 patient (1.4%). Pneumothorax occurred in 2 patients (2.9%), which was classified as grade IIIa; however, none of patients required thoracostomy. These findings are in line with the reported risk profile of supracostal PCNL, where pleural complications occur in 2–5% of cases, and hemorrhage is the most frequent adverse event.^{11–14} The relatively low complication rate in our cohort may be attributed to careful imaging guidance, limited tract number, and adherence to standard surgical protocols. Overall, our results reinforce that supracostal PCNL is a safe and effective option for managing renal stones, including complex staghorn calculi, especially when performed with a single tract whenever feasible.

Our study has some limitations that are comprised with small sample size from a single center with short follow up period. Large sample with multicenter long follow up period is recommended. The study also underscores the importance of preoperative assessment of stone size, morphology, and hydronephrosis in predicting procedural success. Surgeons should anticipate lower clearance rates for

staghorn and larger stones and counsel patients accordingly, while minor complications can generally be managed conservatively.

CONCLUSION

To conclude, supracostal PCNL offers high SFR with acceptable morbidity, with stone size, type, and degree of hydronephrosis being the main determinants of outcome. These findings support its continued use as a first-line approach for complex renal calculi, provided careful planning and technique are employed.

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