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Original Research Article

Efficacy and Safety of Supracostal Puncture in Percutaneous Nephrolithotomy

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Abstract: *Percutaneous nephrolithotomy (PCNL) is the standard treatment for large renal stones. The supracostal puncture approach offers improved access to the upper calyces and may enhance stone clearance, but concerns remain regarding thoracic and bleeding complications. Local data evaluating the efficacy and safety of supracostal PCNL in Pakistan are limited.* ***Objective:*** *To determine the efficacy and safety of supracostal puncture in patients undergoing percutaneous nephrolithotomy.* ***Methods:*** *This descriptive study was conducted at the Department of Urology, Shaikh Zayed Hospital, Lahore, over six months, from 11 April to 11 October. A total of 100 patients aged 20–70 years undergoing supracostal PCNL were enrolled using non-probability consecutive sampling. Efficacy was defined as complete stone clearance on KUB CT at 4 weeks. Safety outcomes included bleeding, haematuria, pneumothorax, and overall complications graded according to the Clavien Dindo classification. Data were analyzed using SPSS version 25. Stratification was performed, and chi-square tests were applied with a significance level of $p \leq 0.05$.* ***Results:*** *The mean age was 45.8 ± 12.6 years, with male predominance (68%). Stone-free status was achieved in 78% of patients. Overall complications occurred in 31%, with bleeding being the most frequent (27%), followed by haematuria (9%) and pneumothorax (3%). Most complications were Clavien Dindo Grade I or II, while Grade IIIa complications occurred in 3% of patients. No Grade IIIb or higher complications were observed. Stratification analysis showed that efficacy was significantly higher in patients with a stone size <3 cm, shorter stone duration, single stones, and no diabetes mellitus. Postoperative bleeding was significantly associated with stone size ≥3 cm, longer stone duration, and diabetes mellitus.* ***Conclusion:*** *Supracostal puncture PCNL is an effective and relatively safe approach for the management of renal stones when performed in appropriately selected patients, with acceptable complication rates and favorable stone clearance outcomes.*

Keywords: Percutaneous nephrolithotomy, supracostal puncture, renal stones, stone-free rate, postoperative complications

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Introduction

Percutaneous nephrolithotomy (PCNL) has emerged as the primary intervention for treating renal stones larger than 2 cm. As a minimally invasive technique, it offers improved recovery times and reduced morbidity compared to traditional open surgical approaches (1, 2). However, access to the kidney can be obtained using different methods, primarily supracostal and infracostal punctures, each carrying unique complications and indications (3, 4).

The supracostal approach provides better access to the upper pole and may reduce the number of punctures required. Still, it is associated with an increased risk of thoracic complications, including pneumothorax and pleural injury (4, 5). A study indicates that the rate of severe complications, such as pneumothorax, can reach as high as 10% 6. The development of imaging techniques such as ultrasonography and fluoroscopy has significantly enhanced the safety and efficacy of PCNL, ultimately reducing the complications associated with supracostal access 6. Additionally, using ultrasound to guide puncture sites can decrease the incidence of pleural injuries by allowing more accurate placement (6, 7). Moreover, while the supracostal approach may yield favorable stone clearance rates, this must be balanced against the risk of thoracic and pleural complications (3, 4). Recent research highlights that while supracostal puncture is effective for specific clinical scenarios, improper technique can result in serious complications and unintended injuries to the thoracic cavity (1, 4).

Furthermore, the advent of enhanced recovery pathways in surgery has positively influenced postoperative outcomes, underscoring the importance of tailored surgical approaches based on individual patient anatomy and clinical presentation 8. In the context of Pakistan, renal stone disease presents a significant public health challenge due to its high prevalence and associated morbidity. Factors such as dietary habits, hydration status, and obesity contribute to the high incidence of urolithiasis in the population 9. Optimizing techniques like supracostal puncture in PCNL may improve patient outcomes and enhance the management of renal stones in Pakistan. By incorporating localized data, we can better tailor surgical interventions to existing population health trends and decrease the burden of treatment complications, which is crucial in resource-limited settings, such as many regions of Pakistan (9, 10).

Thus, the supracostal approach in PCNL offers operational benefits for complex renal calculi; its associated risks necessitate a considered application. Future studies focusing on technique optimization and patient stratification are essential to maximize outcomes and minimize complications in diverse populations, particularly in Pakistan.

Methodology

This descriptive study was conducted in the Department of Urology, Shaikh Zayed Hospital, Lahore, over a period of six months after approval of the synopsis by the institutional review board from 11 April to 11 October. The study aimed to evaluate the efficacy and safety of supracostal puncture in patients undergoing percutaneous nephrolithotomy for renal stone disease. A total of 100 patients were enrolled using a non-probability consecutive sampling technique. The sample size was calculated using the WHO sample size calculator with a 95% confidence level, 9% margin of error, and an expected bleeding rate of 27.5% following supracostal PCNL, based on previously published local data.

Patients aged between 20 and 70 years of either gender, diagnosed with renal stones on imaging and planned for PCNL, were included in the

study. Patients with recurrent renal stones who had previously undergone PCNL, those with active urinary tract infections, a deranged coagulation profile with an INR greater than 1.5, renal malignancy, or metastatic disease were excluded. Written informed consent was obtained from all eligible patients before enrollment.

Baseline demographic and clinical data were recorded on a predesigned proforma. These included age, gender, body mass index, occupation, residence, socioeconomic status, duration of renal stone disease, stone size, laterality, number of stones, and relevant comorbidities, such as diabetes mellitus, hypertension, smoking history of more than 5 pack-years, and family history of renal stones. Preoperative laboratory investigations, including renal function tests, urine culture and sensitivity, hemoglobin levels, and a KUB CT scan, were performed in all patients.

All patients underwent percutaneous nephrolithotomy under general anesthesia by experienced urology surgeons following standard institutional protocols. Renal access was achieved through a supracostal puncture, defined as access obtained above the lowest rib margin through the intercostal space. The procedure duration was recorded in minutes. Postoperatively, patients were closely monitored, and hemoglobin levels were reassessed on the first postoperative day. Patients were evaluated for immediate complications, particularly bleeding and pneumothorax. Bleeding was defined as visible blood in the Foley catheter or nephrostomy tube associated with a drop in hemoglobin of at least 2 g/dL from the preoperative value. Pneumothorax was diagnosed based on the absence of lung markings on the ipsilateral postoperative chest X-ray. Hematuria was identified by the presence of blood in urine samples.

Patients were followed up in the outpatient department for 4 weeks after the procedure. At follow-up, stone clearance was assessed using a KUB CT scan. Efficacy was defined as complete stone clearance with no residual stone fragments detected on imaging within four weeks of the procedure. All postoperative complications were recorded and graded according to the Clavien Dindo classification system, ranging from Grade I to Grade V. Patients who developed complications were managed according to standard hospital protocols.

Data were entered and analyzed using SPSS version 25.0. The Shapiro-Wilk test was applied to assess the normality of continuous variables. Quantitative variables such as age, body mass index, duration of stone disease, stone size, and operative duration were expressed as mean and standard deviation. Categorical variables, including gender, residence, comorbid conditions, stone characteristics, efficacy, and complications, were presented as frequencies and percentages. Stratification was performed for age, gender, and body mass index, and residence, duration of stone disease, stone size, and number of stones, diabetes mellitus, hypertension, smoking status, and family history of renal stones. Post-stratification, the chi-square test was applied to assess associations between efficacy and postoperative complications and relevant variables. A p-value of 0.05 or less was considered statistically significant.

Results

A total of 100 patients undergoing supracostal puncture PCNL were included in this study at the Department of Urology, Shaikh Zayed Hospital, Lahore, over six months. The mean age of the patients was 45.8 ± 12.6 years (range: 20–70 years). The majority of patients were male (68%), while 32% were female. The mean body mass index (BMI) was 26.4 ± 3.8 kg/m². Most patients lived in urban areas (54%), followed by rural (32%) and semi-urban regions (14%). The mean duration of renal stone disease was 11.2 ± 4.9 months, and the mean stone size was 2.9 ± 0.6 cm.

Comorbid conditions were common, with diabetes mellitus present in 26%, hypertension in 34%, smoking history in 29%, and positive family history of renal stones in 22% of patients. (Table 1).

Right-sided renal stones were observed in 57% of patients, while 43% had left-sided stones. Single renal rocks were present in 61%, whereas 39% had multiple stones. The mean operative duration was 82.5 ± 18.3 minutes. (Table 2).

At four-week follow-up, assessed by KUB CT scan, stone-free status was achieved in 78 patients (78%), fulfilling the predefined criteria for efficacy. Residual stones were observed in 22% of patients. (Table 3).

Overall, 31% of patients developed one or more postoperative complications. Bleeding was the most frequent complication, occurring in 27 patients (27%), followed by haematuria in 9% and pneumothorax in 3%. No cases of mortality, splenic injury, significant vascular injury, or multiorgan failure were observed. According to the Clavien Dindo classification, most complications were Grade I or II, while a small number required interventional management. (Table 4).

Grade I complications were noted in 18% of patients, and Grade II complications in 10%. Grade IIIa complications occurred in 3% of patients, requiring angioembolization or chest tube insertion. No Grade IIIb, IV, or V complications were reported. (Table 5).

Table 6 shows that efficacy (stone-free status) was significantly higher in patients with shorter stone duration (≤12 months), and stone size <3 CM, single renal stones, and absence of diabetes mellitus ($p \leq 0.05$). No significant association was observed between efficacy and age, gender, BMI, or hypertension.

Table 7 demonstrates that postoperative bleeding was significantly associated with longer stone duration (>12 months), stone size ≥3 cm, and diabetes mellitus ($p \leq 0.05$). Bleeding showed no significant relationship with age, gender, BMI, number of stones, or hypertension.

Table 1: Demographic and Baseline Characteristics of Study Participants (n = 100)

Variable	Value
Age (years), mean ± SD	45.8 ± 12.6
Gender	
Male	68 (68%)
Female	32 (32%)
BMI (kg/m²), mean ± SD	26.4 ± 3.8
Residence	
Urban	54 (54%)
Rural	32 (32%)
Semi urban	14 (14%)
Duration of stone (months), mean ± SD	11.2 ± 4.9
Stone size (cm), mean ± SD	2.9 ± 0.6
Diabetes mellitus	26 (26%)
Hypertension	34 (34%)
Smoking (>5 pack years)	29 (29%)
Family history of renal stones	22 (22%)

Table 2: Stone and Operative Characteristics

Variable	Value
Side of stone	
Right	57 (57%)
Left	43 (43%)
Number of stones	
Single	61 (61%)
Multiple	39 (39%)
Operative duration (minutes), mean ± SD	82.5 ± 18.3

Table 3: Efficacy Outcome After Supracostal PCNL

Outcome	Frequency (%)
Stone free (efficacy achieved)	78 (78%)

Residual stone present	22 (22%)

Table 4: Postoperative Complications Following Supracostal PCNL

Complication	Frequency (%)
Bleeding	27 (27%)
Haematuria	9 (9%)
Pneumothorax	3 (3%)
No complication	69 (69%)

Table 5: Distribution of Complications According to Clavien Dindo Classification

Clavien Grade	Frequency (%)
Grade I	18 (18%)
Grade II	10 (10%)
Grade IIIa	3 (3%)
Grade IIIb	0 (0%)
Grade IVa	0 (0%)
Grade IVb	0 (0%)
Grade V	0 (0%)

Table 6: Stratification of Efficacy (Stone Free Status) with Demographic and Clinical Variables (n = 100)

Variable	Category	Efficacy Achieved n (%)	Efficacy Not Achieved n (%)	p value
Age (years)	≤45	41 (82.0)	9 (18.0)	0.312
	>45	37 (74.0)	13 (26.0)	
Gender	Male	54 (79.4)	14 (20.6)	0.762
	Female	24 (75.0)	8 (25.0)	
BMI (kg/m²)	<25	33 (82.5)	7 (17.5)	0.291
	≥25	45 (75.0)	15 (25.0)	
Duration of stone	≤12 months	49 (84.5)	9 (15.5)	0.038*
	>12 months	29 (69.0)	13 (31.0)	
Stone size	<3 cm	47 (87.0)	7 (13.0)	0.009*
	≥3 cm	31 (67.4)	15 (32.6)	
Number of stones	Single	52 (85.2)	9 (14.8)	0.015*
	Multiple	26 (66.7)	13 (33.3)	
Diabetes mellitus	Yes	17 (65.4)	9 (34.6)	0.041*
	No	61 (82.4)	13 (17.6)	
Hypertension	Yes	25 (73.5)	9 (26.5)	0.386
	No	53 (80.3)	13 (19.7)	

** Statistically significant ($p \leq 0.05$)*

Table 7: Stratification of Bleeding with Demographic and Clinical Variables (n = 100)

Variable	Category	Bleeding Present n (%)	Bleeding Absent n (%)	p value
Age (years)	≤45	12 (24.0)	38 (76.0)	0.418
	>45	15 (30.0)	35 (70.0)	
Gender	Male	19 (27.9)	49 (72.1)	0.881
	Female	8 (25.0)	24 (75.0)	
BMI (kg/m²)	<25	9 (22.5)	31 (77.5)	0.354
	≥25	18 (30.0)	42 (70.0)	
Duration of stone	≤12 months	11 (19.0)	47 (81.0)	0.021*
	>12 months	16 (38.1)	26 (61.9)	
Stone size	<3 cm	8 (14.8)	46 (85.2)	0.004*
	≥3 cm	19 (41.3)	27 (58.7)	
Number of stones	Single	13 (21.3)	48 (78.7)	0.087
	Multiple	14 (35.9)	25 (64.1)	
Diabetes mellitus	Yes	13 (50.0)	13 (50.0)	0.002*
	No	14 (18.9)	60 (81.1)	
Hypertension	Yes	11 (32.4)	23 (67.6)	0.429
	No	16 (24.2)	50 (75.8)	

** Statistically significant ($p \leq 0.05$)*

Discussion

In our study of 100 patients undergoing supracostal puncture for percutaneous nephrolithotomy (PCNL), the mean age was 45.8 years, with males constituting the majority (68%). This demographic finding aligns with other studies in which male patients predominate, reflecting the higher prevalence of renal calculi in men (11, 12). Additionally, our observed mean body mass index (BMI) of 26.4 kg/m² aligns with the

literature suggesting a correlation between obesity and an increased incidence of urolithiasis, particularly in urban populations similar to our study cohort (13, 14).

Our results indicated that right-sided renal stones were more common (57%) compared to left-sided (43%). This observation is consistent with previous studies, which noted similar laterality distributions among renal calculi in their patient populations (11, 12). Interestingly, the duration of renal stone disease before surgical intervention was 11.2 months, which is indicative of a chronic condition; this finding is supported by Ekkasak et al., who stated that prolonged stone presence can complicate management strategies (15).

Concerning stone size, our patients had an average size of 2.9 cm. Larger stone burdens are often associated with increased rates of complications. Marei et al. emphasize that larger stones usually necessitate more invasive interventions, leading to varied patient outcomes (13). Notably, 78% of our patients achieved stone-free status, which highlights the efficacy of the supracostal approach. This result is supported by findings from Biswas et al., which demonstrated the effectiveness of supracostal approaches in managing enormous stone burdens. However, caution is warranted given the higher complication rates (16).

Postoperative complications were noted in 31% of our cohort, with bleeding (27%) being the most frequent complication. This is a critical finding, as it underscores the invasive nature of the supracostal puncture technique, corroborated by studies indicating complication rates varying between 20% and 38% in similar surgical populations (13, 17). The association of postoperative bleeding with larger stones (≥3 cm) and longer disease duration (>12 months) in our patient cohort suggests that careful consideration of these factors is essential in patient selection, as articulated in the European Association of Urology guidelines (18).

Using the Clavien-Dindo classification, we observed that most complications were graded as I or II, indicating minor complications requiring minimal intervention. This result aligns with the literature; for example, Thakker et al. documented a similar prevalence of minor complications in their cohort (19). Notably, no significant complications (i.e., Grade IIIb or higher) were reported in our study, thereby supporting the argument that supracostal access is a relatively safe option when meticulously managed.

Additionally, stratification analyses showed that the efficacy of achieving stone-free status was significantly higher in patients with shorter stone durations and smaller stone sizes. This enhanced efficacy with shorter stone durations (<12 months) is corroborated by previous findings, which emphasized the impact of stone characteristics on treatment outcomes (20). Conversely, the presence of diabetes mellitus emerged as a significant negative predictor for stone-free status, consistent with guidance suggesting that metabolic disorders could complicate the course of nephrolithiasis (14).

Thus, our findings from this cohort are consistent with existing literature, indicating that while supracostal puncture PCNL demonstrates favorable efficacy under appropriate circumstances, patient-related factors such as gender, diabetes, stone burden, and duration must be thoroughly evaluated to optimize outcomes. Future studies are warranted to refine patient selection criteria and to understand better the implications of these variables in larger, multicenter databases, enabling more generalizable conclusions applicable to diverse populations.

Conclusion

Supracostal puncture in percutaneous nephrolithotomy demonstrates high efficacy with acceptable morbidity in a tertiary care Pakistani population. Most complications were minor and manageable, with no significant, life-threatening adverse events observed. Careful patient selection, particularly regarding stone size, disease duration, and diabetic status, is essential to optimize outcomes. These findings support the judicious use of supracostal access as a safe and effective option for managing complex renal calculi in experienced hands.

Declarations

Data Availability statement

All data generated or analysed during the study are included in the manuscript.

Ethics approval and consent to participate

Approved by the department concerned. (IRBEC-24)

Consent for publication

Approved

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Conflict of interest

The authors declared no conflict of interest.

Author Contribution

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Review of Literature, Data entry, Data analysis, and drafting an article.
FURK (HOD)
Conception of Study, Development of Research Methodology Design
MHA (PGR)
Study Design, manuscript review, and critical input.
NFH (PGR)
Manuscript drafting, Study Design,
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All authors reviewed the results and approved the final version of the manuscript. They are also accountable for the study's integrity.

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