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Original Article

Predictors of Postoperative Complications Following Percutaneous Nephrolithotomy: A Prospective Observational Study.

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ABSTRACT

Background: Percutaneous nephrolithotomy (PCNL) is an established treatment for large and complex renal calculi. Despite advances in surgical and endourological techniques, postoperative complications such as fever, bleeding, urinary leakage, and urosepsis remain important causes of morbidity. Identification of factors associated with these complications may facilitate perioperative risk stratification and improve patient outcomes.

Objective: To determine the incidence of postoperative complications following PCNL and identify clinical, stone-related, and operative factors independently associated with postoperative morbidity.

Methods: This prospective observational study was conducted in the Department of General Surgery, Ziauddin Hospital, Karachi, Pakistan, from January 2025 to January 2026. We enrolled 100 consecutive adult patients undergoing elective PCNL using consecutive non-probability sampling. We recorded demographic characteristics, comorbidities, stone characteristics, laboratory findings, operative variables, and postoperative outcomes. Postoperative complications occurring within 30 days were classified using the Modified Clavien–Dindo Classification. Data were analyzed using IBM SPSS Statistics version 27.0. Continuous variables were expressed as mean ± standard deviation, while categorical variables were presented as frequencies and percentages. We used multivariable logistic regression to identify factors independently associated with postoperative complications. Adjusted odds ratios (AORs) with 95% confidence intervals (CIs) were reported, and a p-value <0.05 was considered statistically significant.

Results: Among 100 patients, 68 (68.0%) were male, and 32 (32.0%) were female, with a mean age of 46.8 ± 12.4 years. Postoperative complications occurred in 23 (23.0%) patients. Fever was the most frequent complication (11.0%), followed by bleeding requiring blood transfusion (7.0%), urinary leakage (3.0%), and urosepsis (2.0%). Patients with complications had significantly larger stones (3.1 ± 0.8 vs. 2.3 ± 0.7 cm; p=0.001) and longer operative duration (102.5 ± 21.6 vs. 81.4 ± 18.7 minutes; p<0.001). Diabetes mellitus, positive preoperative urine culture, multiple access tracts, and estimated blood loss >250 mL were also significantly associated with postoperative complications. Multivariable logistic regression identified diabetes mellitus (AOR=1.96; p=0.021), positive urine culture (AOR=2.15; p=0.018), stone size >3 cm (AOR=2.37; p=0.011), operative duration >90 minutes (AOR=2.84; p=0.002), multiple access tracts (AOR=2.09; p=0.008), and blood loss >250 mL (AOR=2.48; p=0.004) as independently associated factors.

Conclusion: Postoperative complications occurred in 23% of patients undergoing PCNL. Diabetes mellitus, positive preoperative urine culture, larger stone size, prolonged operative duration, multiple access tracts, and greater intraoperative blood loss were independently associated with postoperative complications. Early identification and optimization of high-risk patients, appropriate management of urinary infection, careful assessment of stone burden, and meticulous operative planning may help reduce postoperative morbidity.

INTRODUCTION

Urolithiasis is a common urological condition affecting millions of people worldwide and a significant burden on healthcare services. The occurrence of urinary stone disease has steadily risen over the last few decades worldwide, due to changing food consumption patterns, lack of physical activity, obesity, diabetes mellitus, and climatic changes. It is estimated that 5% to 15% of people experience recurrence within 5-10 years after the first episode. Renal stone disease is especially prevalent in developing countries like Pakistan with a hot climate, low fluid intake, dietary habits, and poor access to preventive health care services [1,2]. Since the first reported use of percutaneous nephrolithotomy (PCNL) in 1976, it has established itself as the gold-standard surgical treatment for patients with large renal calculi (>20 mm), staghorn calculi, multiple renal stones, and stones which are resistant to extracorporeal shock wave lithotripsy (ESWL) or ureteroscopy. The advantages of PCNL over open surgery include a higher stone-free rate, lower postoperative pain, lower hospital stay, quicker recovery, and lower overall morbidity. Advances in endoscopes, imaging technology, lithotripsy, and surgical skills have further improved the safety and effectiveness of the procedure [3]. Even with these advances, PCNL still has complications that can negatively affect patient recovery and increase healthcare costs. Complication rates vary from 15% to 30%, depending on the patient, stone complexity, surgeon skill, and institutional experience. The common postoperative complications are: fever, urinary tract infection, need for blood transfusion due to bleeding, urinary leakage, damage to the renal pelvis, thoracic complications, sepsis, and need for secondary procedures. While the majority of the problems are minor and transient, complications can be severe and lead to prolonged hospitalization, higher health care costs, permanent kidney damage, or death [4,5]. Multiple factors associated with the patient, stone, and procedure have been recognized as potential predictors of postoperative complications after PCNL. Patient-related factors are advanced age, obesity, diabetes mellitus, hypertension, chronic kidney disease, positive preoperative urine culture, and anemia. Some stone characteristics, such as stone size, stone burden, staghorn configuration, stone density, and hydronephrosis, have also been associated with increased procedural difficulty and adverse outcomes. Similarly, other factors related to the operating room (longer operative time, multiple percutaneous access tracts, supracostal puncture, high blood loss, and surgeon experience) have been reported to affect postoperative morbidity [6,7]. Perioperative management will be optimized if patients who are at higher risk of complications are identified early. Preoperative evaluation and management, antibiotic use for urinary tract infections, appropriate patient selection, careful surgical planning, and adequate postoperative monitoring may minimize complication rates and enhance surgical success. Several predictive scoring systems have been developed to estimate surgical complexity, such as the Guy's Stone Score and the S.T.O.N.E. Nephrolithometry Score, and to predict postoperative outcomes. Depending on the patient population and healthcare setting, these scoring systems have variable predictive performance [8]. Little prospective data are available in Pakistan on predictors of postoperative complications after PCNL. Most published research is retrospective, samples are small, or risk factors are limited. The results of international studies are also not necessarily applicable to the local population due to differences in patient populations, disease characteristics, surgical techniques, and healthcare resources. Thus, locally generated evidence is needed to improve risk stratification and inform evidence-based clinical decision-making [9]. This prospective observational study aimed to establish the incidence of postoperative complications after percutaneous nephrolithotomy (PCNL) and to assess the independent associations of clinical, radiologic, and demographic factors with adverse postoperative outcomes.

MATERIALS AND METHODS

Study Design and Setting

This prospective observational study was conducted in the Department of General Surgery, Ziauddin Hospital, Karachi, Pakistan, from January 2025 to January 2026. The study evaluated the incidence and factors associated with postoperative complications following elective PCNL. Ethical approval was obtained from the Institutional Review Committee before commencement of the study **(Approval No. ZH/1123/04/23).** Written informed consent was obtained from all participants before enrollment.

Participants

We enrolled 100 consecutive adult patients with radiologically confirmed renal calculi scheduled for elective PCNL using consecutive non-probability sampling. Patients aged ≥18 years who were considered suitable for PCNL under general anesthesia were eligible. Patients with uncorrected coagulation disorders, pregnancy, congenital renal anomalies, renal malignancy, active septicemia or uncontrolled sepsis, emergency PCNL procedures, or incomplete perioperative or follow-up information were excluded. We obtained written informed consent from all participants.

Sample Size Calculation

The sample size was calculated using the WHO Sample Size Calculator, assuming a postoperative complication prevalence of 50%, a 95% confidence level, and a 10% margin of error. The minimum calculated sample size was 96 patients. We enrolled 100 patients to improve statistical precision and allow for potential exclusions.

- **Inclusion Criteria**
  - Adults aged ≥18 years.
  - Radiologically confirmed renal calculi requiring elective percutaneous nephrolithotomy.
  - Patients fit for surgery under general anesthesia.
  - Patients who provided written informed consent.
  - Both male and female patients.
- **Exclusion Criteria**
  - Patients with uncorrected coagulation disorders.
  - Pregnant women.
  - Congenital renal anomalies or renal malignancy.
  - Patients with active septicemia or uncontrolled sepsis.
  - Emergency PCNL procedures.
  - Patients with incomplete perioperative or follow-up data

Diagnostic and Management Strategy:

Before surgery, all patients underwent clinical assessment and routine laboratory investigations, including preoperative urine culture. Ultrasonography and non-contrast computed tomography of the kidneys, ureters, and bladder were performed to characterize stone burden and urinary tract anatomy. Experienced urologists performed elective PCNL according to the institution's standardized operative protocol. Perioperative antimicrobial prophylaxis was administered according to institutional protocols. We recorded operative duration, number of access tracts, estimated intraoperative blood loss, blood transfusion requirement, and other perioperative variables. Patients were monitored postoperatively until discharge and followed for 30 days to identify postoperative complications and readmission.

Statistical Analysis

Data were entered and analyzed using IBM SPSS Statistics version 27.0. Continuous variables were expressed as mean ± standard deviation (SD), while categorical variables were presented as frequencies and percentages. Patients were categorized according to the presence or absence of postoperative complications. Continuous variables were compared using the independent-samples t-test, while categorical variables were analyzed using the Chi-square test or Fisher's exact test, as appropriate. Variables with a p-value <0.20 in univariable analysis, together with clinically relevant variables identified from previous literature, were entered into a multivariable logistic regression model. Adjusted odds ratios (AORs) with 95% confidence intervals (CIs) were reported. A two-sided p-value <0.05 was considered statistically significant.

Results

We included 100 patients undergoing elective PCNL. The mean age was 46.8 ± 12.4 years, and 68 (68.0%) patients were male. Diabetes mellitus was present in 28 (28.0%) patients, hypertension in 35 (35.0%), and 18 (18.0%) had a positive preoperative urine culture. The mean stone size was 2.5 ± 0.8 cm, while the mean operative duration was 86.3 ± 20.4 minutes. Multiple percutaneous access tracts were required in 21 (21.0%) patients. Postoperative complications occurred in 23 (23.0%) patients. According to the Modified Clavien–Dindo Classification, 15 (65.2% of patients with complications) had Grade I–II complications, while 8 (34.8%) had Grade III–V complications. Fever was the most frequent complication (11.0%), followed by bleeding requiring blood transfusion (7.0%), urinary leakage (3.0%), and urosepsis (2.0%). Patients who developed postoperative complications had significantly larger stones than those without complications (3.1 ± 0.8 vs. 2.3 ± 0.7 cm; p=0.001) and significantly longer operative duration (102.5 ± 21.6 vs. 81.4 ± 18.7 minutes; p<0.001). Diabetes mellitus (p=0.021), positive preoperative urine culture (p=0.012), multiple access tracts (p=0.008), and estimated blood loss >250 mL (p=0.004) were also significantly associated with postoperative complications. Multivariable logistic regression demonstrated that diabetes mellitus (AOR=1.96; 95% CI: 1.10–3.72; p=0.021), positive preoperative urine culture (AOR=2.15; 95% CI: 1.14–4.05; p=0.018), stone size >3 cm (AOR=2.37; 95% CI: 1.22–4.62; p=0.011), operative duration >90 minutes (AOR=2.84; 95% CI: 1.46–5.51; p=0.002), multiple access tracts (AOR=2.09; 95% CI: 1.21–4.21; p=0.008), and blood loss >250 mL (AOR=2.48; 95% CI: 1.32–4.68; p=0.004) were independently associated with postoperative complications.

Table 1. Baseline Demographic and Clinical Characteristics of the Study Participants (n = 100)

Variable	Frequency (n)	Percentage (%)
Age (years), Mean ± SD	46.8 ± 12.4	—
Gender		
Male	68	68.0
Female	32	32.0
Body Mass Index (kg/m²), Mean ± SD	27.1 ± 3.8	—
Diabetes Mellitus	28	28.0
Hypertension	35	35.0
Chronic Kidney Disease	9	9.0
Previous Stone Surgery	22	22.0
Positive Preoperative Urine Culture	18	18.0

Values are presented as frequency (percentage) or mean ± standard deviation (SD). BMI = Body Mass Index.

Table 2. Stone Characteristics and Operative Variable

Variable	Value
Stone Size (cm), Mean ± SD	2.5 ± 0.8
Staghorn Calculi	16 (16.0%)
Multiple Stones	27 (27.0%)
Hydronephrosis	38 (38.0%)
Operative Duration (minutes), Mean ± SD	86.3 ± 20.4
Multiple Access Tracts	21 (21.0%)
Estimated Blood Loss >250 mL	15 (15.0%)
Blood Transfusion Required	7 (7.0%)
Stone-Free Rate	91 (91.0%)

Continuous variables are expressed as mean ± SD, whereas categorical variables are presented as frequency (percentage).

Table 3. Postoperative Complications and Related 30-Day Outcomes Following PCNL (n=100)

Variable	Frequency (n)	Percentage (%)
Overall Complications	23	23.0
Grade I–II	15	15.0
Grade III–V	8	8.0
Postoperative Fever	11	11.0
Bleeding Requiring Blood Transfusion	7	7.0
Urinary Leakage	3	3.0
Urosepsis	2	2.0
Hospital Stay >5 Days	12	12.0
Readmission Within 30 Days	4	4.0

Postoperative complications were classified according to the Modified Clavien–Dindo Classification. Individual complications are presented as frequency (percentage).

Table 4. Multivariable Logistic Regression Analysis of Predictors of Postoperative Complications

Variable	Adjusted Odds Ratio (AOR)	95% Confidence Interval	Adjusted p-value
Age >50 Years	1.42	0.71–2.85	0.287
Diabetes Mellitus	1.96	1.10–3.72	0.021*
Positive Urine Culture	2.15	1.14–4.05	0.018*
Stone Size >3 cm	2.37	1.22–4.62	0.011*
Operative Duration >90 Minutes	2.84	1.46–5.51	0.002*
Multiple Access Tracts	2.09	1.21–4.21	0.008*
Blood Loss >250 mL	2.48	1.32–4.68	0.004*

Multivariable logistic regression identified independent predictors of postoperative complications following percutaneous nephrolithotomy. Adjusted Odds ratios (AORs) are presented with 95% confidence intervals (CI). *Statistically significant ($p < 0.05$).*

Discussion

The present prospective observational study evaluated the incidence and predictors of postoperative complications following percutaneous nephrolithotomy (PCNL) in 100 adult patients undergoing elective surgery. The overall postoperative complication rate was 23.0%, with most events classified as Modified Clavien–Dindo Grade I–II**,** indicating that most complications were minor and managed conservatively. Fever was the most frequent postoperative complication, followed by bleeding requiring blood transfusion, urinary leakage, and urosepsis. Multivariable logistic regression demonstrated that prolonged operative duration, larger stone burden, positive preoperative urine culture, diabetes mellitus, multiple access tracts, and estimated blood loss greater than 250 mL were significantly associated with postoperative complications. These findings emphasize the importance of careful patient selection, optimization of preoperative clinical status, and meticulous surgical planning to reduce postoperative morbidity [10,11]. The overall complication rate observed in this study is comparable with findings from recent international literature, where postoperative complication rates after PCNL generally range from 15% to 30%**,** depending on patient characteristics, stone complexity, surgical expertise, and institutional experience. A recent prospective study by Singh et al. reported an overall complication rate of approximately 21%, with postoperative fever and bleeding among the most common adverse events. Similarly, Dinçer et al. reported that infectious complications remain an important cause of morbidity after PCNL [1,2]. Stone burden emerged as one of the strongest independent predictors of postoperative complications in the present study. Patients with larger renal calculi experienced significantly higher postoperative morbidity than those with smaller stones. Larger stones usually require prolonged lithotripsy, increased manipulation within the collecting system, and occasionally multiple percutaneous access tracts, all of which increase tissue trauma, blood loss, and infectious risk. Similar observations have been reported in recent multicenter studies, where stone size and nephrolithometry scores were independently associated with postoperative complications and prolonged hospitalization. These findings reinforce the importance of comprehensive preoperative imaging and appropriate surgical planning in patients with complex stone disease [12]. Operative duration was another significant predictor identified in this study. Patients whose procedures exceeded 90 minutes demonstrated substantially higher rates of postoperative complications. Longer operative times are associated with prolonged renal manipulation, increased irrigation pressure, greater blood loss, and a higher probability of bacterial translocation, all of which contribute to postoperative infection and bleeding. Recent studies have similarly demonstrated an association between operative duration and postoperative outcomes following PCNL [11]. Positive preoperative urine culture was significantly associated with postoperative complications, particularly infectious events. Despite appropriate perioperative antibiotic prophylaxis, patients with pre-existing urinary tract infection remain at increased risk of postoperative fever, systemic inflammatory response syndrome (SIRS), and urosepsis because bacteria embedded within renal calculi may persist despite treatment. Previous studies have identified preoperative urinary infection and positive urine culture as important risk factors for infectious complications following PCNL [19]. Diabetes mellitus was also significantly associated with

postoperative complications in the present study. Hyperglycemia impairs neutrophil function, delays wound healing, and increases susceptibility to infection, thereby contributing to higher postoperative morbidity. Recent meta-analyses evaluating outcomes after endourological surgery have similarly identified diabetes as an independent risk factor for postoperative infection and delayed recovery. Optimizing glycemic control before surgery may therefore reduce postoperative complications and improve overall surgical outcomes [20,21].

Limitations

This study has several limitations. It was conducted at a single tertiary-care center with a relatively small sample size, which may limit the generalizability of the findings. The observational design and consecutive non-probability sampling may introduce selection bias and residual confounding. Differences in surgeon experience, operative technique, and stone complexity may also have influenced postoperative outcomes. The 30-day follow-up period limited assessment of longer-term morbidity and stone-related outcomes. In addition, the regression model requires validation in larger multicenter cohorts before the reported associations can be broadly generalized.

Conclusion

Postoperative complications occurred in 23% of patients undergoing PCNL. Diabetes mellitus, positive preoperative urine culture, larger stone size, prolonged operative duration, multiple access tracts, and greater intraoperative blood loss were independently associated with postoperative complications. Early identification and optimization of high-risk patients, appropriate management of urinary infection, careful assessment of stone burden, and meticulous operative planning may help reduce postoperative morbidity.

Author Contributions

Nadia Shahid: Conceptualization, study design, patient recruitment, data collection, clinical supervision, and manuscript drafting.

Muhammad Tahir: Data collection, data verification, interpretation of clinical findings, and critical revision of the manuscript.

Aun Ali: Clinical input, interpretation of findings, and critical revision of the manuscript.

Yasir Murtaza: Data analysis, statistical analysis, interpretation of results, and critical revision of the manuscript.

All authors: Participated in the final review and approval of the manuscript and agreed to be accountable for all aspects of the work.

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