



Supine vs Prone Percutaneous Nephrolithotomy (PCNL) for Renal Stone

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Abstract

Background: Urolithiasis affects 1–15% of the global population, with management influenced by stone size and location. Percutaneous Nephrolithotomy (PCNL) is the gold standard for treating large or complex renal stones. Traditionally performed in the prone position for optimal access, prone PCNL poses challenges such as patient repositioning, anesthetic limitations, and increased risk in specific populations. Supine PCNL, introduced in 1987, offers advantages like improved ergonomics, anesthetic control, and reduced complications, but its adoption remains limited due to technical concerns and a learning curve.

Aim of the study: This study aims to compare the outcome of supine and prone PCNL based on operating time, fluoroscopy time, stone free rates and postoperative complications in a tertiary care hospital in Bangladesh.

Methods: This prospective, observational cohort study was conducted over one year from 1st January to 31st December, 2024 at the Department of Urology, Mugda Medical College and Hospital, Dhaka, to compare outcomes of supine (Group A) versus prone (Group B) percutaneous nephrolithotomy (PCNL) in 50 adult patients with renal stones. Patients were assigned to each group based on clinical condition and surgeon discretion. Data were collected preoperatively, intraoperatively, and postoperatively, including demographics, stone characteristics, operative details, and complications. Primary outcomes were operative time, complications (Clavien–Dindo), stone-free rate, and hospital stay. Secondary outcomes included blood loss, postoperative fever, and residual stones.

Result: The study included two groups with similar baseline characteristics in age (42.6 ± 11.4 vs. 45.8 ± 10.7 years; $p=0.28$), sex ($p=0.76$), BMI (25.9 ± 3.5 vs. 26.4 ± 3.2 kg/m²; $p=0.54$), comorbidities, stone size (17.8 ± 4.6 vs. 19.1 ± 5.2 mm; $p=0.31$), and burden (290.5 ± 95.6 vs. 312.3 ± 101.2 mm²; $p=0.42$). Operative time was significantly shorter in the supine group (72.4 ± 13.7 vs. 84.2 ± 14.5 min; $p=0.01$). Other parameters, including fluoroscopy time, complication rates, stone-free rate (84% vs. 76%; $p=0.47$), and hospital stay (3.4 ± 1.0 vs. 3.8 ± 1.2 days; $p=0.17$), were comparable. No significant differences were observed in postoperative outcomes, including readmission (4% in both) and need for further procedures (8% vs. 12%; $p=0.63$).

Conclusion: This study concludes that supine and prone PCNL are safe and effective for renal stone management. However, the supine approach offers shorter operative time and anesthesia advantages, making it preferable for high-risk patients. Choice of position should be individualized based on patient needs, surgeon experience, and institutional practices.

Keywords: Percutaneous Nephrolithotomy (PCNL), Supine Position, Prone Position, and Renal Calculi.

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Introduction:

Urolithiasis, or the formation of renal calculi, is a prevalent urological condition affecting approximately 1-15% of the global population, with variations based on geography, diet, and socioeconomic factors.¹ Among the available treatment modalities, Percutaneous Nephrolithotomy (PCNL) has emerged as the gold standard for managing large and complex renal stones, especially those greater than 2 cm in diameter or resistant to extracorporeal shock wave lithotripsy (ESWL).² Since its introduction in the late 1970s, PCNL has evolved significantly in technique, instrumentation, and patient positioning to improve outcomes and reduce complications. Traditionally, PCNL has been performed in the prone position, which offers a wide surface area for renal access, improved gravitational drainage of irrigation fluid, and better anatomical orientation for posterior calyceal puncture.³ However, prone PCNL presents certain limitations, including the need for patient repositioning after anesthesia induction, difficulty in cardiopulmonary monitoring, and increased risk in obese or critically ill patients.⁴ These challenges have prompted interest in alternative positioning strategies, particularly the supine position, first described by Valdivia-Uria in 1987.⁵ Supine PCNL provides several theoretical and practical advantages, such as a more ergonomic position for the surgeon, better anesthetic control, and the ability to perform combined retrograde and antegrade procedures without repositioning the patient.⁶ Additionally, it may reduce operative time, minimize intra-abdominal pressure changes, and lower the risk of certain complications such as bowel injury or thromboembolic events.⁷ Despite these potential benefits, the adoption of supine PCNL remains limited in many centers, partly due to concerns over restricted renal access, unfamiliar anatomy, and a steeper learning curve.⁸ Numerous studies have compared the two positions, but findings remain variable. Some have reported comparable stone-free rates and complication profiles, while others suggest marginal benefits or drawbacks associated with one position over the other.^{9,10} Moreover, most comparative data are derived from high-volume centers with extensive experience, which may not be generalizable to hospitals in the early stages of adopting supine PCNL. In the context of our tertiary care hospital, which recently began incorporating supine PCNL into clinical practice, evaluating the initial experience with this technique becomes

essential. This study aims to compare the outcomes of supine and prone PCNL in terms of operative time, stone-free rates, complications, and patient recovery.

Methodology & Materials:

This study is a prospective, observational, comparative cohort study conducted at the Department of Urology at Mugda Medical College and Hospital, Dhaka, Bangladesh. The study's objective is to compare the outcomes of supine versus prone percutaneous nephrolithotomy (PCNL) for managing renal stones in adult patients. Patients who met the inclusion criteria were assigned to either the supine group (Group A) or the prone group (Group B) based on the surgeon's discretion and the patient's clinical condition. The primary outcomes include operative time, complications, stone-free rate, and hospital stay. Secondary outcomes include blood loss, postoperative fever, residual stones, and Clavien-Dindo classification of complications. The study included 50 adult patients (ages 18-80) with clinically significant renal stones undergoing their first PCNL procedure for renal stone extraction during one year from 1st January to 31st December 2024. These patients were categorized into two groups:

- Group A (Supine): 25 patients who underwent PCNL in the supine position.
- Group B (Prone): 25 patients who underwent PCNL in the prone position.

Inclusion Criteria

- Adult patients aged between 18 and 80 years.
- Patients diagnosed with renal stones (≥ 1 cm).
- Patients eligible for PCNL are eligible based on stone size, location, and failed conservative treatments or lithotripsy.
- First-time PCNL procedure.

Exclusion Criteria

- Patients with congenital renal anomalies.
- Pregnancy.
- Active urinary tract infections or sepsis.
- Severe bleeding disorders or uncontrolled comorbidities (e.g., cardiovascular or respiratory insufficiency).
- Patients requiring multiple sessions of PCNL.
- Patients with renal failure or those with a single kidney.

Data Collection: Data was collected at three stages: preoperatively, intraoperatively, and postoperatively, using a standardized data collection sheet. Preoperative data included demographic information such as age, sex, body mass index (BMI), and the presence of comorbidities like diabetes, hypertension, and chronic kidney disease (CKD), along with baseline hemoglobin (Hb) levels. Stone characteristics were recorded, including size (in mm), total burden (in mm²), anatomical location (pelvis, calyx, staghorn, or others), and laterality (left or right). Additionally, preoperative renal function was assessed through serum creatinine levels, and imaging studies such as CT scans or ultrasounds were reviewed to confirm the stone's size and location.

Intraoperative Data: The intraoperative data included operative and fluoroscopy times (measured in minutes) and details of the surgical approach and instrumentation used. Access sites varied among subcostal, intercostal, and other routes, with the number of access tracts recorded for each case. Depending on the clinical scenario, lithotripsy was performed using pneumatic, ultrasonic, or laser methods. The procedure utilized rigid, flexible, or both types of nephroscopes. Any intraoperative complications, such as organ injury, significant bleeding, or instrument failure, were meticulously documented to assess procedural safety and technical challenges.

Postoperative Data: Postoperative data were evaluated based on several key parameters. Complications during and after surgery included intraoperative issues, blood loss, hemoglobin drop, postoperative fever, urosepsis, and the presence of residual stones. The stone-free rate was determined through postoperative imaging (X-ray or ultrasound), indicating complete stone clearance. The duration of hospital stay was recorded in days. Patients were followed up for at least six weeks after surgery using imaging modalities such as CT or ultrasound to assess for any remaining stones. Postoperative complications were classified according to the Clavien-Dindo classification system to standardize assessment and reporting.

Outcome Measures: The outcome measures for the study included both primary and secondary parameters. Primary outcomes encompassed operative time, defined as the duration from the initial incision to the completion of the procedure; the occurrence of

complications, including both intraoperative and postoperative events, classified according to the Clavien-Dindo grading system; the stone-free rate, indicating the percentage of patients without detectable stone fragments following the procedure; and the length of hospital stay measured from post-procedure admission to discharge. Secondary outcomes included the amount of intraoperative blood loss, recorded in milliliters; postoperative fever, defined as a body temperature exceeding 38°C; and the presence of residual stones, identified postoperatively through imaging or clinical evaluation.

Statistical Analysis: Data was analyzed using SPSS software (version 26.0). Descriptive statistics were used to summarize patient demographics, stone characteristics, and procedural variables. Continuous variables were presented as mean±standard deviation (SD), and categorical variables were presented as frequency and percentage. Group comparisons for continuous variables were performed using the independent t-test, and categorical variables were analyzed using the Chi-square test. A p-value < 0.05 was considered statistically significant.

Result:

The demographic data show no significant differences between the groups in terms of age (42.6±11.4 years in Group A vs. 45.8±10.7 years in Group B; p=0.28), sex distribution (18 males and seven females in Group A vs. 17 males and eight females in Group B; p=0.76), or body mass index (25.9±3.5 kg/m² in Group A vs. 26.4±3.2 kg/m² in Group B; p=0.54). Regarding comorbidities, there was no significant difference in the prevalence of diabetes mellitus (6 patients in Group A vs. 7 in Group B; p=0.73), hypertension (5 patients in Group A vs. 6 in Group B), or chronic kidney disease (CKD) (2 patients in Group A vs. 3 in Group B), indicating similar baseline clinical characteristics between the two groups (Table 1). In terms of stone characteristics, the stone size (17.8±4.6 mm in Group A vs. 19.1±5.2 mm in Group B; p=0.31) and stone burden (290.5±95.6 mm² in Group A vs. 312.3±101.2 mm² in Group B; p=0.42) were comparable. The laterality and stone location did not differ significantly between the two groups (Table 2). Preoperative hemoglobin levels (12.6±1.2 g/dL in Group A vs. 12.4±1.3 g/dL in Group B; p=0.48), serum Creatinine (1.02±0.3 mg/dL in Group A vs. 1.05±0.4 mg/dL in Group B; p=0.61), and urine culture positivity (7 patients in Group A vs. 8 in Group B; p=0.76) were

also similar between the groups. The operative time was significantly shorter in the supine group (72.4±13.7 minutes) compared to the prone group (84.2±14.5 minutes; $p=0.01$), indicating that the supine position may be more efficient. However, fluoroscopy time (5.2±2.0 minutes in Group A vs. 6.1±2.2 minutes in Group B; $p=0.08$) and number of access tracts (1.2±0.4 in Group A vs. 1.3±0.5 in Group B; $p=0.37$) were similar. The access site was predominantly subcostal in both groups (80% in Group A vs. 68% in Group B), and there was no significant difference in lithotripsy method (pneumatic, ultrasonic, or laser) or nephroscope type (rigid, flexible, or both) (Table 3). Regarding postoperative complications, intraoperative complications were similar (2 patients in Group A vs. 3 in Group B; $p=0.63$), and there was no significant difference in blood loss (170.2±60.3 ml in Group A vs. 190.5±70.4 ml in Group B; $p=0.22$). The drop in hemoglobin was also comparable (1.2±0.7 g/dL in

Group A vs. 1.5±0.9 g/dL in Group B; $p=0.14$). There was no significant difference in the rates of postoperative fever (12% in Group A vs. 16% in Group B; $p=0.68$), urosepsis (4% in Group A vs. 8% in Group B; $p=0.55$), or residual stones (16% in Group A vs. 24% in Group B; $p=0.48$). The stone-free rate was slightly higher in Group A (84%) compared to Group B (76%), but this difference was not statistically significant ($p=0.47$). Hospital stay was also similar between the groups (3.4±1.0 days in Group A vs. 3.8±1.2 days in Group B; $p=0.17$), and the rate of Clavien-Dindo e" Grade II complications was comparable (8% in Group A vs. 12% in Group B; $p=0.63$) (Table 4). During the follow-up period, the mean follow-up duration was similar between the groups (6.1±1.6 weeks in Group A vs. 6.3±1.7 weeks in Group B; $p=0.63$). The rate of readmission within 30 days was identical in both groups (4%), and the need for additional procedures was also comparable (8% in Group A vs. 12% in Group B; $p=0.63$) (Table 5).

Table 1: Demographic and Clinical Characteristics

Variable		Group A (Supine) n (%) Mean ± SD	Group B (Prone) n (%) Mean ± SD	p-value
Age (years)		42.6 ± 11.4	45.8 ± 10.7	0.28
Sex	Male	18 (72.00%)	17 (68.00%)	0.76
	Female	7 (28.00%)	8 (32.00%)	
BMI (kg/m ²)		25.9 ± 3.5	26.4 ± 3.2	0.54
Comorbidities	Diabetes Mellitus	6 (24.00%)	7 (28.00%)	0.73
	Hypertension	5 (20.00%)	6 (24.00%)	
	CKD	2 (8.00%)	3 (12.00%)	
	None	12 (48.00%)	9 (36.00%)	

Table 2: Stone and Preoperative Characteristics

Variable		Group A (Supine) n (%) Mean ± SD	Group B (Prone) n (%) Mean ± SD	p-value
Stone size (mm)		17.8 ± 4.6	19.1 ± 5.2	0.31
Stone burden (mm ²)		290.5 ± 95.6	312.3 ± 101.2	0.42
Laterality	Right	14 (56.00%)	13 (52.00%)	0.78
	Left	11 (44.00%)	12 (48.00%)	
Stone Location	Pelvis	10 (40.00%)	9 (36.00%)	0.73
	Calyx	5 (20.00%)	4 (16.00%)	
	Staghorn	3 (12.00%)	5 (20.00%)	
	Others	7 (28.00%)	7 (28.00%)	
	Pre-op Hb (g/dL)	12.6 ± 1.2	12.4 ± 1.3	
Serum Creatinine (mg/dL)		1.02 ± 0.3	1.05 ± 0.4	0.61
Urine Culture Positive		7 (28.00%)	8 (32.00%)	0.76
ASA Score		1.8 ± 0.6	1.9 ± 0.5	0.52

Table 3: Intraoperative Details

Variable		Group A (Supine) n (%) Mean ± SD	Group B (Prone) n (%) Mean ± SD	p-value
Operative time (min)		72.4 ± 13.7	84.2 ± 14.5	0.01
Fluoroscopy time (min)		5.2 ± 2.0	6.1 ± 2.2	0.08
No. of access tracts		1.2 ± 0.4	1.3 ± 0.5	0.37
Access Site	Subcostal	20 (80.00%)	17 (68.00%)	0.33
	Intercostal	5 (20.00%)	8 (32.00%)	
Lithotripsy Method	Pneumatic	18 (72.00%)	20 (80.00%)	0.38
	Laser	7 (28.00%)	5 (20.00%)	
Nephroscope	Rigid	16 (64.00%)	18 (72.00%)	0.54
	Flexible	3 (12.00%)	2 (8.00%)	
	Both	6 (24.00%)	5 (20.00%)	

Table IV: Postoperative Outcomes

Variable		Group A (Supine) n (%) Mean ± SD	Group B (Prone) n (%) Mean ± SD	p-value
Intraoperative complications		2 (8.00%)	3 (12.00%)	0.63
Blood loss (ml)		170.2 ± 60.3	190.5 ± 70.4	0.22
Drop in Hb (g/dL)		1.2 ± 0.7	1.5 ± 0.9	0.14
Postoperative fever		3 (12.00%)	4 (16.00%)	0.68
Urosepsis		1 (4.00%)	2 (8.00%)	0.55
Residual stones		4 (16.00%)	6 (24.00%)	0.48
Stone-free rate		21 (84.00%)	19 (76.00%)	0.47
Hospital stay (days)		3.4 ± 1.0	3.8 ± 1.2	0.17
Clavien-Dindo ≥Grade II		2 (8.00%)	3 (12.00%)	0.63

Table 5: Follow-up Outcomes

Variable		Group A (Supine) n (%) Mean ± SD	Group B (Prone) n (%) Mean ± SD	p-value
Follow-up (weeks)		6.1 ± 1.6	6.3 ± 1.7	0.63
Readmission within 30 days		1 (4.00%)	1 (4.00%)	1
Additional procedure needed		2 (8.00%)	3 (12.00%)	0.63

Discussion:

Percutaneous nephrolithotomy (PCNL) remains the standard treatment for large and complex renal stones, offering high stone clearance rates while minimizing invasiveness compared to open surgery.¹¹ The choice between supine and prone patient positioning during PCNL has been debated among urologists, with each

position offering specific advantages and challenges.^{12,13} This prospective observational study aimed to compare the operative parameters, complications, stone clearance, and hospital stay between supine and prone PCNL in a Bangladeshi tertiary care setting, providing valuable insights from an initial local experience. Our results demonstrate that

the supine PCNL group had a significantly shorter operative time than the prone group (72.4±13.7 vs. 84.2±14.5 minutes, $p=0.01$). This finding is consistent with several previous studies that have reported decreased procedural duration in the supine position.^{14,15} The reduced operative time in supine PCNL may be attributed to eliminating the need for repositioning the patient after anesthesia induction and easier airway management throughout the procedure.¹² Furthermore, supine positioning allows simultaneous retrograde access if needed, facilitating stone clearance and potentially reducing operative complexity.⁹ Although fluoroscopy time was slightly less in the supine group, the difference was insignificant ($p=0.08$). This aligns with the comparable access characteristics observed between the groups, including similar access tracts and subcostal approach predominance. This indicates that positioning did not adversely impact fluoroscopic guidance or access feasibility. Comparable fluoroscopy times have been reported by Falahatkar et al. (2016) and Li et al. (2010), suggesting that the radiation exposure to patients and staff is similar regardless of position when performed by experienced surgeons.^{14,16} Stone clearance rates were high in both groups, with the supine group showing a slightly higher but statistically non-significant stone-free rate (84% vs. 76%, $p=0.47$). This observation supports randomized controlled trial findings that supine and prone PCNL provide comparable stone clearance.^{9,17} Our stone-free rates align with 75–90% overall for PCNL in large renal stones.¹¹ Residual stone rates were also comparable, emphasizing that the choice of positioning does not compromise the efficacy of stone removal. Blood loss and hemoglobin drop, important indicators of intraoperative safety, were slightly lower in the supine group, but differences were not statistically significant. This finding echoes the results from multiple studies suggesting no significant difference in bleeding complications between the two positions.^{9,15} Notably, the similar hemoglobin drop and transfusion requirements indicate that both approaches are safe from a hemodynamic perspective when proper technique and patient selection are employed. Postoperative complication rates, including fever, urosepsis, and Clavien-Dindo \geq Grade II complications, were similar between the groups. Fever occurred in approximately 12–16% of patients, consistent with previously reported post-PCNL infection rates ranging between 10–20%.¹⁸ The comparable incidence of urosepsis, a critical

complication of PCNL, further highlights the safety of both approaches. These findings align with systematic reviews that report no significant differences in postoperative morbidity between supine and prone PCNL.^{14,17} Length of hospital stay was slightly shorter in the supine group, but without statistical significance. Early mobilization and easier anesthetic management may contribute to this trend, although the difference did not reach significance in our cohort. Previous studies have reported mixed results regarding hospital stay, with some favoring supine PCNL due to quicker recovery and others finding no difference.^{15,16} The overall short hospital stays (3–4 days) observed reflect good perioperative care and low complication rates in our setting. The comparable need for additional procedures and readmission rates within 30 days indicates similar mid-term efficacy and safety profiles for both positions. Follow-up durations were consistent, allowing adequate assessment of residual stones and complications. Our findings support the growing evidence that supine PCNL is a viable alternative to the traditional prone approach, offering comparable stone clearance and safety with shorter operative time.^{9,14} Supine PCNL can be particularly beneficial in patients with obesity, cardiopulmonary comorbidities, or spinal deformities, where prone positioning poses greater anesthetic risks.¹⁷ Additionally, the supine position facilitates simultaneous combined antegrade and retrograde endoscopic procedures, potentially enhancing stone clearance for complex cases.¹⁸ Nonetheless, prone PCNL remains widely practiced and offers excellent exposure for complex stone burdens, especially staghorn calculi, due to a broader surface for renal access and optimal posterior calyceal puncture.¹⁷ Our comparable results regarding stone clearance and complications suggest that surgeon expertise and patient factors may be more critical determinants of outcomes than patient positioning alone.

Limitations of the study:

This study's findings support the adoption of supine PCNL as an efficient and safe alternative to prone PCNL, several limitations should be acknowledged. The small sample size ($n = 50$) limits the statistical power to detect potentially more minor clinically relevant differences. Furthermore, patient allocation was based on the surgeon's discretion rather than randomization, introducing potential selection bias.

Conclusion and Recommendations:

This study demonstrates that supine and prone PCNL are safe and practical approaches for managing renal stones, with comparable postoperative, complication, and stone-free outcomes. However, the supine position offers a significantly shorter operative time, suggesting improved surgical efficiency without compromising safety or efficacy. Given its benefits in anesthesia management and patient positioning, the supine approach may be particularly advantageous in high-risk or comorbid patients. As both techniques yield similar clinical outcomes, the choice of position can be individualized based on patient characteristics, surgeon expertise, and institutional preferences, especially in high-volume tertiary care settings.

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