Comparative Analysis of Prone vs Supine Position in PCNL: A Hospital Based Prospective Study

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ABSTRACT

Introduction: Percutaneous nephrolithotomy is a standard minimally invasive procedure for managing large or complex renal calculi. While the traditional prone position is commonly used, the supine position has gained attention for its potential benefits in surgical access and outcome. **Aims: T**o compare the intraoperative and postoperative outcomes of prone versus supine percutaneous nephrolithotomy. **Methods:** A prospective hospital-based study was conducted at Nobel Medical College, Biratnagar, from February 2024 to January 2025. A total of 60 patients with renal stones undergoing percutaneous nephrolothotomy were enrolled and divided into two groups: Group A (prone position) and Group B (supine position), each with 30 patients. Parameters such as operative time (minutes), blood loss (g/dL), stone clearance rate (%), and postoperative complications were recorded and analyzed using SPSS version 16. **Results:** The mean operative time was shorter in the supine group (80 ± 12 minutes) compared to the prone group (95 ± 15 minutes). Blood loss was lower in the supine group, with fewer patients requiring transfusion. Stone clearance was slightly higher in the prone group (90%) versus the supine group (80%). Postoperative complications, including fever and pain, were comparable between the groups, with no significant differences observed. **Conclusion:** Both prone and supine percutaneous nephrolithotomy positions are safe and effective. However, the supine position demonstrated advantages in operative time and reduced blood loss, making it a favorable option in selected cases.

***Keywords**:* Comparative Analysis, Operative Time, Prone percutaneous nephrolithotomy, Stone Free Rate, Supine percutaneous nephrolithotomy

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INTRODUCTION

Kidney stones (renal calculi) are a prevalent urological condition, affecting approximately 12% of the global population, posing significant health challenges. Prevalence varies geographically, with rates of 1-5% in Asia, 7-13% in North America, and 5-9% in Europe, driven by differences in climate, diet, and socioeconomic factors.[1] In South Asia, hot climates, low fluid intake, and oxalate-rich diets exacerbate stone formation. Untreated stones can cause severe complications, including urinary obstruction, infections, chronic kidney disease, ureteral strictures, and recurrence. Percutaneous Nephrolithotomy (PCNL) is the gold standard for large or complex stones, involving a percutaneous tract into the kidney under fluoroscopy or ultrasound guidance. A nephroscope fragments and extracts stones using ultrasonic, pneumatic, or laser lithotripsy. Traditionally performed in the prone position, PCNL provides optimal access to the renal collecting system, high stone-free rates, and low morbidity. However, prone positioning presents challenges for obese patients or those with cardiopulmonary issues, requiring repositioning for ureteric catheter placement and anesthesia, increasing procedural complexity and risks.[2] In 1987, Gabriel Valdivia introduced supine PCNL, which reduces operative time, improves airway access for anesthesiologists, and enhances surgeon ergonomics. It enables simultaneous antegrade and retrograde access, minimizing positioning-related complications like nerve compression and radiation exposure.[3] However, concerns remain about potential risks of visceral or vascular injuries in complex cases.[2] Despite growing adoption, debate persists over supine PCNL's superiority compared to the prone approach. This prospective study analyzes clinical data to compare prone and supine PCNL, assessing advantages, limitations, and challenges to guide evidence-based technique selection in modern urology.

METHODS

This is a prospective simple randomized comparative study conducted at Department of Urology, Nobel Medical College, Biratnagar, Nepal over a period of one year from February 2024 to January 2025 following ethical approval from the Institutional Review Board of our institution. This comparative study consisted of 60 patients divided into two equal groups. 30 patients who underwent traditional prone PCNL and 30 patients who underwent supine PCNL during the study period were randomly assigned in the study as prone or supine groups. The inclusion criteria consisted of patients of both sexes, aged 18 years or older, undergoing PCNL for single renal stones measuring between 15 and 25 mm, with a radiologically confirmed diagnosis of renal calculi during the study period. Pediatric age group patients (<18 years), patients with active urinary tract infections, bleeding disorders, and complex anatomy like horseshoe kidney, pelvic kidney were excluded from the study. A prophylactic dose of intravenous Piperacillin-Tazobactam (4.5 g) was administered 30 minutes prior to the induction of anesthesia. Both prone and supine PCNLs were conducted under spinal anesthesia. For Prone PCNL following anesthesia, patients were initially placed in the lithotomy position. Cystoscopy was performed to insert a 6 Fr open-ended straight-tip ureteral catheter (Indovasive) into the ipsilateral pelvicalyceal system under fluoroscopic guidance. A retrograde pyelogram was performed, followed by calyceal selection and puncture under fluoroscopic guidance using a two-part needle. A 0.035" Terumo guidewire was then advanced into the collecting system. The choice of calyx and number of punctures were based on the size and location of the renal calculi. Tract dilation was performed using a screw fascial dilator, followed by placement of an Amplatz sheath of 18 Fr. Nephroscopy was conducted using a 12 Fr (Karl Storz) rigid nephroscope.

In the Supine PCNL group, patients were positioned in the modified Valdivia position. Cystoscopy and urethral catheterization was performed as prone PCNL, followed by calyceal selection. Puncture done by same as supine position using two path needle. The guidewire was then advanced into the upper ureter to maintain tract access. Tract dilation was performed using a screw fascial dilator, followed by placement of an Amplatz sheath of 18 Fr. Nephroscopy was conducted using a 12 Fr (Karl Storz) rigid nephroscope. Stones were visualized and fragmented using a pneumatic lithotripter (Nidhi) in both cases. Finally, the stone fragments were extracted using grasping forceps or flushed out with an irrigation pump. Operative time was defined as the duration from ureteral catheterization to the completion of the procedure. On the first postoperative day, the Foley catheter was removed. If a nephrostomy tube had been placed, it was typically removed on the second postoperative day. Patients who were stable—afebrile, comfortable, and with a dry nephrostomy site (for patients who underwent standard PCNL) were discharged on the same day as nephrostomy removal. Double-J (DJ) stents were removed after a four-week interval. A stone-free status was defined as the absence of residual stones on X-ray KUB or ultrasonography (USG) at the one-month follow-up. Residual fragments measuring ≤4 mm and deemed non-obstructive on imaging were considered clinically insignificant. Patients with significant residual stones were scheduled for either Retrograde Intrarenal Surgery (RIRS) or a second-stage PCNL. Postoperative complications were categorized using the Modified Clavien-Dindo Classification System.[4] Collected data included patient demographics, stone-free rate, stone volume, operative time, access time, irrigation volume, and the drop in hemoglobin levels pre- and postoperatively.

SPSS software package (versions 16.0) was used for all statistical analyses. The results were expressed as the mean ± standard deviation and range. Fisher's exact test and student's T test were applied to find out the significant differences between the two groups. p value < 0.05 was considered statistically significant.

RESULTS

In this study, a total of 60 patients undergoing percutaneous nephrolithotomy (PCNL) were equally divided into two groups: prone (n = 30) and supine (n = 30) positions. The demographic and baseline characteristics were comparable between the two groups. The mean age of patients in the prone group was 47.3 ± 12.5 years, while in the supine group it was 49.1 ± 11.8 years (p = 0.52). The proportion of male patients was 70% in the prone group and 66.7% in the supine group (p = 0.78). The mean body mass index (BMI) was 26.4 ± 3.2 kg/m² in the prone group and 25.9 ± 3.6 kg/m² in the supine group (p = 0.47). The average stone size was similar between the two groups, measuring 22.1 ± 6.3 mm in the prone group and 21.8 ± 5.9 mm in the supine group (p = 0.83). Stone laterality was also comparable, with right/left distribution of 17/13 in the prone group and 16/14 in the supine group (p = 0.79). The prevalence of diabetes mellitus was 20% in the prone group and 16.7% in the supine group (p = 0.73), while hypertension was observed in 23.3% and 26.7% of patients, respectively (p = 0.77). The distribution of ASA (American Society of Anesthesiologists) scores (I/II/III) was 10/15/5 in the prone group and 9/16/5 in the supine group (p = 0.96). Previous history of renal surgery was noted in 13.3% of prone and 10% of supine patients (p = 0.68). These findings indicate no statistically significant differences in demographic or clinical baseline characteristics between the two groups (Table I).

Demographic Parameter	Prone PCNL (n=30)	Supine PCNL (n=30)	p-value
Age (years, mean ± SD)	47.3 ± 12.5	49.1 ± 11.8	0.52
Male (%)	21 (70%)	20 (66.7%)	0.78
BMI (kg/m², mean ± SD)	26.4 ± 3.2	25.9 ± 3.6	0.47
Stone size (mm, mean ± SD)	22.1 ± 6.3	21.8 ± 5.9	0.83
Laterality (Right/Left)	17/13	16/14	0.79
Diabetes Mellitus (%)	6 (20%)	5 (16.7%)	0.73

Hypertension (%)	7 (23.3%)	8 (26.7%)	0.77
ASA Score (I/II/III)	10/15/5	9/16/5	0.96
Previous Renal Surgery (%)	4 (13.3%)	3 (10%)	0.68

Table I: Comparison of Demographic and Baseline Characteristics Between Prone and Supine PCNL Groups

In terms of surgical outcomes, the stone-free rate was higher in the prone PCNL group (90%) compared to the supine group (80%), although the difference was not statistically significant (p = 0.3). Blood transfusions were required in 10% of patients in the prone group and 3.3% in the supine group (p = 0.3). Postoperative complications were observed in 16.7% of patients undergoing prone PCNL and in 10% of those undergoing supine PCNL, with no significant difference between the groups (p = 0.44). These findings suggest comparable surgical efficacy and safety profiles between the two patient positions (Table II).

Variable	Prone PCNL n (%)	Prone PCNL n (%)	p-value
Stone Free Rate	27 (90%)	24 (80%)	0.3
Transfusion	3 (10%)	1 (3.3%)	0.3
Complications	5 (16.7%)	3 (10%)	0.44

Table II: Comparison of Surgical Outcomes between Prone and Supine PCNL Groups

The mean operative time was significantly longer in the prone group (95 ± 15 minutes) compared to the supine group (80 ± 12 minutes), with a statistically significant difference (p = 0.001). The mean hemoglobin (Hb) drop was also greater in the prone group (1.8 ± 0.6 g/dL) than in the supine group (1.4 ± 0.5 g/dL), showing a significant difference (p = 0.010). Additionally, the average duration of hospital stay was slightly longer in the prone group (3.5 ± 1.0 days) compared to the supine group (3.0 ± 0.8 days), which was statistically significant (p = 0.040) (Table III).

Variable	Prone n (%)	Supine n (%)	p-value
Operative Time (minutes)	95 ± 15	80 ± 12	0.001
HB Drop (g/dL)	1.8 ± 0.6	1.4 ± 0.5	0.010
Hospital Stay (days)	3.5 ± 1.0	3.0 ± 0.8	0.040

Table III: Comparison of Operative and Postoperative Parameters between Prone and Supine PCNL Groups

DISCUSSION

In the present study, the stone-free rate (SFR) was higher in the prone percutaneous nephrolithotomy (PCNL) group (90%) compared to the supine group (80%), although the difference was not statistically significant (p = 0.3). This finding is consistent with the results reported by Kumar et al., who observed SFRs of 88.6% and 81.4% in the prone and supine groups, respectively, without statistical significance.[5] Similarly, a 2024 propensity score-matched analysis by Choi et al. reported SFRs of 74.3% for supine and 65.7% for prone PCNL (p = 0.356).[6] Sofer et al also demonstrated comparable stone clearance rates between the two positions.[7] Conversely, Shao and Chang, in their meta-analysis, found no significant difference in SFR between the lateral decubitus and prone positions.[8] Notably, Valdivia-Uria et al, who first introduced the supine PCNL technique, reported favorable outcomes with supine PCNL, particularly emphasizing ergonomic advantages and improved access to lower pole stones.[9]

A statistically significant difference in operative time was observed, with the supine group demonstrating a shorter mean duration (80 ± 12 minutes) compared to the prone group (95 ± 15 minutes, p = 0.001). This aligns with the findings from the CROES PCNL Global Study by de la Rosette et al, which analyzed over 5,800 procedures and concluded that supine PCNL is generally associated with reduced operative time due to easier patient positioning and the feasibility of simultaneous retrograde ureteroscopy.[10] Micali et al also reported reduced operative times in supine PCNL, attributing this to better anesthetic control and the avoidance of intraoperative repositioning.[11] Chapagain et al reported operative times of 44.63 ± 12.44 minutes for supine and 53.02 ± 12.67 minutes for prone groups, with statistical significance.[12] Miah Md et al found a significantly shorter operative time in the supine group (74.67 ± 11.94 minutes) compared to the prone group (90.33 ± 8.70 minutes).13 Similarly, Paudyal et al reported a mean operative time of 76.63 ± 12.42 minutes in the supine group versus 90.02 ± 12.67 minutes in the prone group, with a mean difference of 16 minutes.[14] Choi et al also found operative times of 85.5 ± 25.2 minutes for supine and 96.4 ± 25.8 minutes for prone PCNL (p = 0.012).[6] A 2024 randomized trial by Kara et al further confirmed shorter operative times and hospital stays for the supine approach.[15] Kannan et al. similarly reported a significant reduction in operative time with supine PCNL (p < 0.001).[16]

Postoperative complications were slightly higher in the prone group (16.7%) compared to the supine group (10%), though this difference was not statistically significant (p = 0.44). Paudyal et al reported overall complication rates of 15.62% in the supine group and 25% in the prone group.[14] According to Miah Md et al, both blood transfusion requirements and complication rates were slightly higher in the supine group, but these differences were not statistically significant.[13] Chapagain et al observed similar rates of postoperative fever and septic complications in both groups.[13] These results are corroborated by a meta-analysis conducted by Zhang et al, which found no significant difference in overall complication rates between the supine and prone positions.[17] Kannan et al also noted slightly higher early and late complication rates, such as postoperative fever or hematuria, in the supine group.[16] Choi et al reported overall complication rates of 8.6% in the supine group and 4.3% in the prone group (p = 0.301).[6]

In our study, the mean hemoglobin drop was significantly lower in the supine group (1.4 ± 0.5 g/dL) compared to the prone group (1.8 ± 0.6 g/dL, p = 0.010), suggesting reduced intraoperative blood loss. This aligns with findings from the meta-analysis by Shao and Chang.[8] De Sio et al reported complication rates of 20.5% for supine and 13.9% for prone PCNL[18] while Falahatkar et al observed rates of 27.5% for supine and 30% for prone PCNL.[19] In our study, blood transfusion rates were higher in the prone group (10% vs. 3.3%), although not statistically significant (p = 0.3). This observation is in line with Tay et al, who reported lower transfusion rates in the supine group, attributing this to improved renal access and reduced parenchymal trauma.[20] Liu L reported transfusion rates of 27.6% in the supine group and 18.2% in the prone group 2 while Mak et al found that patients in the prone group required more transfusions than those in the supine group (27.5% vs. 7.5%).[21] Miah Md et al, however, reported nearly identical transfusion rates between the two groups (20.0% in prone and 16.7% in supine; p = 1.000).[13]

The mean hospital stay was also shorter in the supine group (3.0 ± 0.8 days) compared to the prone group (3.5 ± 1.0 days, p = 0.040). Manohar et al similarly reported shorter recovery times and earlier ambulation with the supine approach.[22] This is supported by Kara et al, who found reduced hospital stays in supine PCNL patients.[15] Paudyal et al found significantly shorter hospital stays in the supine group (2.40 ± 0.74 days) compared to the prone group (3.20 ± 0.92 days, p < 0.001).[14] However, Mulay et al reported no significant difference in hospital stay between supine (2.76 days) and prone (2.64 days) PCNL (p = 0.44).[23] Miah Md et al reported a significantly longer hospital stay in the prone group (3.10 ± 0.61 days) compared to the supine group (2.30 ± 0.47 days).[13]

Taken together, our findings support the growing body of evidence that while both prone and supine PCNL are effective and safe, the supine position may offer certain peri-operative advantages such as reduced operative time, less blood loss, and quicker recovery. Nevertheless, the choice of position should remain individualized, based on patient anatomy, stone characteristics, and the surgeon's expertise.

LIMITATIONS

This study was conducted at a single tertiary care center, which may limit the generalizability of the findings to other settings with different patient populations or surgical expertise. The non-randomized design, limited follow-up, and the use of X-ray KUB instead of computed tomography (CT) scan for stone clearance evaluation due to financial constraints and radiation exposure may potentially affecting accuracy of the findings.

CONCLUSION

Both prone and supine positions are effective and comparable for performing percutaneous nephrolithotomy. The prone position demonstrated a slightly higher stone clearance rate, whereas the supine position was associated with shorter operative time and reduced blood loss. Therefore, the selection of patient positioning should be individualized, taking into account anatomical considerations, surgeon expertise, and institutional capabilities.

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