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Comparative Study of Modified Supine versus Standard Prone Position in Percutaneous Nephrolithotomy: A Prospective Randomized Trial

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Abstract: ***Percutaneous nephrolithotomy (PCNL) is the standard treatment for large renal stones, traditionally performed in the prone position. However, the supine approach has gained attention due to anesthetic advantages and potential reduction in complications. This prospective randomized study compared 30 patients undergoing modified supine PCNL with 30 patients in the prone position. Outcomes assessed included operative time, stone-free rate, hospital stay, pain, and complications. Supine PCNL significantly reduced operative time and major complications while maintaining comparable stone clearance. Findings suggest the supine approach is a safe and efficient alternative, particularly for obese or high-risk patients.***

Keywords: Percutaneous nephrolithotomy (PCNL), Modified supine position, Prone PCNL, Stone free rate, Operative time, Complication.

1. Introduction

Percutaneous nephrolithotomy (PCNL) has evolved as the cornerstone intervention for the management of large and complex renal calculi. Since its first description by Fernström and Johansson in 1976, PCNL has gained worldwide acceptance due to its efficacy in achieving high stone clearance rates, particularly for stones larger than 2 cm or lower calyceal stones exceeding 1.5 cm in diameter [1]. Traditionally, the prone position has been the standard approach for PCNL. The prone orientation offers urologists a wider surface area of renal exposure, improved calyceal access, and a familiar operative field. However, prone PCNL is not without drawbacks, particularly concerning anesthetic management, cardiovascular stress, and the risk of thoracic and visceral complications [2].

The development of the supine technique was a major innovation in PCNL. Valdivia and colleagues were the first to propose supine decubitus PCNL in 1987, primarily motivated by the need to minimize the incidence of colon injury associated with the prone approach [2]. Subsequent refinements, such as the Galdakao-modified Valdivia position, have gained traction due to additional benefits including easier airway control for anesthesiologists, decreased circulatory compromise, and reduced pulmonary restriction during surgery [3]. Moreover, the supine position provides the unique advantage of simultaneous antegrade and retrograde access, allowing combination procedures such as ureteroscopy to be performed without repositioning [4].

Despite these theoretical advantages, some surgeons argue that supine PCNL poses challenges related to reduced renal mobility, increased puncture depth, and limited maneuverability of surgical instruments [5]. These technical constraints have restricted its universal adoption, especially in centers where the prone position has been entrenched as routine practice. Consequently, there remains a need for high-quality comparative studies that evaluate both positions with regard to surgical efficacy, operative safety, perioperative morbidity, and patient recovery.

Recent meta-analyses and multicenter trials have provided growing evidence supporting the safety and effectiveness of supine PCNL. For instance, Yuan et al. (2016) conducted a meta-analysis that demonstrated comparable stone-free rates between supine and prone PCNL, with shorter operative times observed in the supine group [3]. Similarly, Wu et al. (2011) highlighted that the supine position reduced the risk of colonic injury while providing better anesthetic access [4]. A global study by the Clinical Research Office of the Endourological Society (CROES) further corroborated that supine and prone PCNL yield equivalent stone clearance, while supine positioning may reduce perioperative complications [5]. These findings challenge the long-held belief that prone PCNL is the unequivocal gold standard.

From the anesthetic perspective, supine PCNL is advantageous in patients with cardiovascular or respiratory comorbidities. Airway control is safer and more convenient in the supine position, as intubation and extubation can be performed without the need to reposition the patient intraoperatively [6]. This is particularly significant in obese patients and those with high anesthetic risks, where prone positioning may exacerbate cardiopulmonary compromise. Additionally, radiation exposure is reduced for the surgeon in the supine approach, as their hands are less likely to be within the C-arm fluoroscopy field [6].

Nevertheless, surgeon familiarity continues to influence the choice of positioning. Many urologists have undergone extensive training in prone PCNL and are reluctant to adopt newer approaches without substantial supportive evidence. Moreover, concerns about incomplete stone clearance due to restricted renal access in supine PCNL remain prevalent. Therefore, the selection of patient positioning is frequently determined by institutional protocols, surgeon experience, and individual patient factors.

Given this ongoing debate, the present study was designed as a prospective randomized comparison between the modified supine position and the standard prone position in PCNL. The aim was to evaluate both approaches across critical outcome measures including operative time, stone-free rate, length of

hospital stay, incidence of complications, and postoperative pain scores. By systematically comparing these outcomes in a controlled study environment, this research seeks to provide evidence to guide clinical decision-making on the optimal positioning strategy for PCNL.

In summary, PCNL remains the preferred technique for managing large renal stones. However, the choice between prone and supine positioning continues to generate discussion in contemporary urological practice. While prone PCNL offers traditional familiarity and broader exposure, supine PCNL promises advantages in anesthetic safety, operative efficiency, and patient comfort. This study adds to the growing body of literature assessing the comparative merits of both techniques, with the overarching goal of enhancing patient safety and surgical outcomes in renal stone management.

2. Materials and Methods

Study Design
This was a prospective, randomized comparative study conducted at Dhanalakshmi Srinivasan Medical College, Perambalur, between April 2023 and April 2024. A total of 60 patients scheduled for PCNL were enrolled and randomly allocated into two groups: 30 patients underwent PCNL in the modified supine position, while 30 patients underwent PCNL in the standard prone position. Randomization was performed using a computer-generated sequence to minimize selection bias.

Inclusion and Exclusion Criteria
Patients were eligible for inclusion if they had renal calculi less than 3 cm in maximum diameter. Exclusion criteria included patients with bleeding disorders, pregnancy, pediatric age (<18 years), complex renal anatomy, staghorn calculi, or significant medical comorbidities deemed high risk for surgery.

Preoperative Evaluation
All patients underwent baseline clinical evaluation including history, physical examination, and relevant laboratory tests. Imaging studies, such as ultrasonography and non-contrast CT scans, were performed to assess stone size, location, and renal anatomy. Patients were optimized preoperatively with appropriate hydration, correction of coagulopathies, and prophylactic antibiotics.

Surgical Technique
In the **prone group**, patients were initially placed in the lithotomy position for ureteric catheter insertion, followed by repositioning into the prone position. Percutaneous access was achieved under fluoroscopic guidance, with tract dilatation performed using Amplatz dilators up to the required size. Stone fragmentation and retrieval were carried out using pneumatic lithotripters.

In the **supine group**, patients were placed in the Galdakao-modified Valdivia position. This facilitated simultaneous retrograde access via ureteroscopy, allowing combined procedures when necessary. The puncture was performed under fluoroscopic guidance, with similar dilatation and fragmentation techniques as in the prone group. The supine approach avoided the need for intraoperative repositioning, thereby reducing anesthesia time [2,5].

Outcome Measures
The primary endpoints included stone-free rate, operative time, and length of hospital stay. Secondary outcomes were intraoperative and postoperative complications, requirement of blood transfusion, postoperative pain assessed by Smiley score, and incidence of residual stones on follow-up imaging. Pain was evaluated using a standardized visual analog scale.

Statistical Analysis
Data were entered into a structured database and analyzed using SPSS software. Continuous variables such as operative time and length of stay were compared using Student's *t*-test, while categorical variables including complication rates were analyzed with the Chi-square test. A *p*-value of <0.05 was considered statistically significant.

Ethical Considerations
The study was conducted in compliance with the ethical standards of the institutional review board. Written informed consent was obtained from all participants prior to inclusion in the study. Confidentiality of patient data was strictly maintained throughout.

3. Results

A total of 60 patients were enrolled and equally randomized into the modified supine PCNL group (n=30) and the prone PCNL group (n=30). The mean age was 39.8 ± 8.6 years in the supine group and 44.7 ± 9.2 years in the prone group, with no statistically significant difference ($p = 0.12$). The mean BMI was significantly higher in the supine group (26.8 ± 3.4 kg/m²) compared to the prone group (22.3 ± 2.9 kg/m²; $p = 0.03$).

The mean operative time was shorter in the supine group (71.6 ± 10.2 minutes) compared to the prone group (82.3 ± 11.7 minutes), with a statistically significant difference ($p < 0.001$). The mean hospital stay was comparable between the two groups (3.2 ± 0.9 days vs 3.5 ± 1.0 days, $p = 0.052$).

Postoperative pain was lower in the supine group, with 76.7% reporting Smiley scores <5 compared to 66.7% in the prone group. Stone-free rates were similar, with residual fragments (3–6 mm) observed in 2 patients in the supine group and 4 in the prone group ($p = 0.41$).

Complications were fewer in the supine group (26.7%, mostly minor) compared to the prone group (33.3%, including 3 major complications).

Table 1 presents baseline demographics and operative outcomes. Figure 1 depicts operative time distribution, while Figure 2 illustrates complication profiles between groups.

Table 1: Baseline demographics and operative outcomes

Parameter	Supine (n=30)	Prone (n=30)	p-value	Remarks
Age (years)	39.8 ± 8.6	44.7 ± 9.2	0.12	NS
BMI (kg/m²)	26.8 ± 3.4	22.3 ± 2.9	0.03	Significant
Operative time (min)	71.6 ± 10.2	82.3 ± 11.7	<0.001	Significant
Hospital stay (days)	3.2 ± 0.9	3.5 ± 1.0	0.052	NS
Stone-free rate (%)	93.3	86.7	0.41	NS
Complication rate (%)	26.7 (minor 7, major 1)	33.3 (minor 7, major 3)	-	Supine fewer major

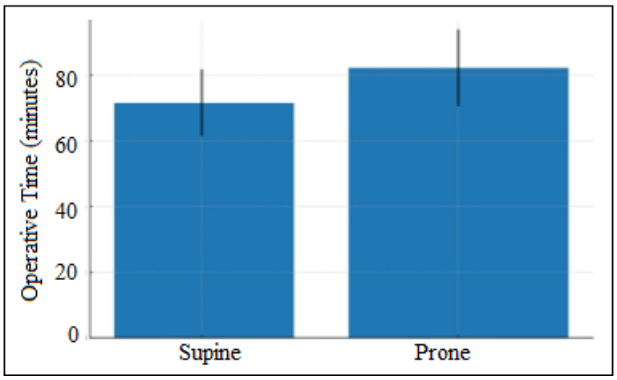

Figure 1: Operative time comparison between supine and prone PCNL

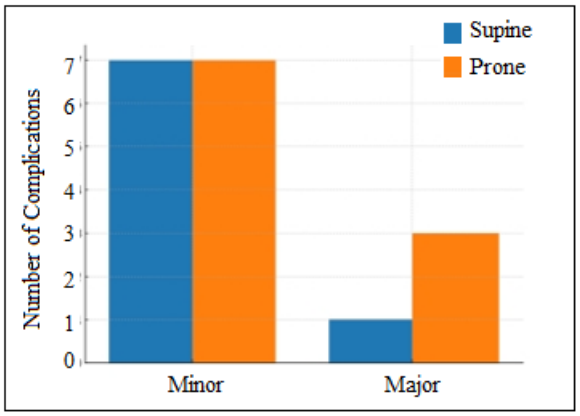

Figure 2: Complication profiles in supine vs prone PCNL

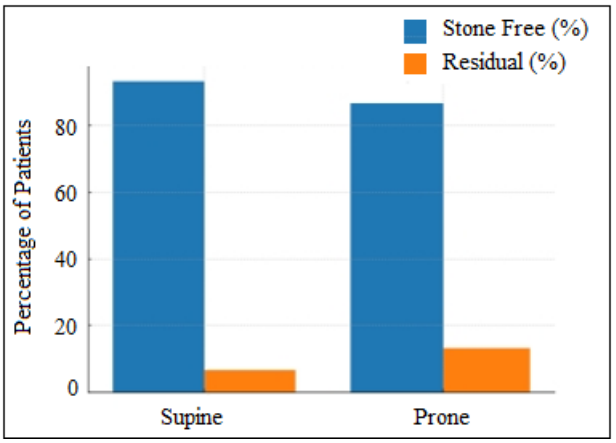

Figure 3: Stone-free and residual stone rates in supine vs prone PCNL

4. Analytical Statistics

Independent Student's t-test was applied for continuous variables such as operative time, age, BMI, and hospital stay. The analysis revealed a statistically significant reduction in operative time in the supine group ($p < 0.001$), and a significantly higher BMI among patients in the supine cohort ($p = 0.03$). Other continuous variables including age and hospital stay did not demonstrate statistical significance ($p > 0.05$).

Chi-square analysis was used for categorical outcomes including stone-free rate, pain scores, and complication rates. There was no statistically significant difference in stone-free rates between supine and prone groups ($p = 0.41$). Postoperative pain distribution favored the supine group, though the difference did not reach significance. Complication rates were lower in the supine group, especially major complications (1 vs 3), though not statistically significant due to limited sample size. These findings suggest the supine position is associated with reduced operative duration and lower perioperative risk without compromising stone clearance.

Table 2: Analytical statistical comparison between supine and prone PCNL

Variable	Supine (Mean ± SD / n, %)	Prone (Mean ± SD / n, %)	Statistical Test	p-value
Age (years)	39.8 ± 8.6	44.7 ± 9.2	t-test	0.12 (NS)
BMI (kg/m²)	26.8 ± 3.4	22.3 ± 2.9	t-test	0.03 (Sig.)
Operative time (min)	71.6 ± 10.2	82.3 ± 11.7	t-test	<0.001 (Sig.)
Hospital stay (days)	3.2 ± 0.9	3.5 ± 1.0	t-test	0.052 (NS)
Stone-free rate (%)	28/30 (93.3%)	26/30 (86.7%)	Chi-square	0.41 (NS)
Residual stones (%)	2/30 (6.7%)	4/30 (13.3%)	Chi-square	0.41 (NS)
Postoperative pain (Smiley <5)	23/30 (76.7%)	20/30 (66.7%)	Chi-square	0.38 (NS)
Complication rate (%)	8/30 (26.7%)	10/30 (33.3%)	Chi-square	0.56 (NS)
Major complications	1/30 (3.3%)	3/30 (10%)	Chi-square	0.29 (NS)

5. Discussion

This prospective randomized study compared the outcomes of modified supine versus standard prone PCNL in terms of operative efficiency, safety, and stone clearance. The findings demonstrated that the supine approach significantly reduced operative time compared with the prone position, without compromising stone-free rates. These results are consistent with previous meta-analyses that identified shorter operative times in the supine group due to avoidance of patient repositioning and easier access for combined endourological procedures [3,4].

Although the stone-free rates were comparable between the two groups, the supine cohort exhibited fewer major complications. Only one patient in the supine group required blood transfusion compared to three in the prone group, one of whom also developed hemothorax. This observation aligns with reports from the CROES PCNL global study, which emphasized a lower incidence of severe complications in the supine position [5]. Furthermore, the supine approach provided greater anesthetic safety by maintaining easier airway access, especially valuable in obese patients and those with compromised cardiopulmonary reserve [6].

The present study also noted significantly higher BMI among patients managed with supine PCNL, supporting earlier literature that supine positioning is advantageous in obese populations [6]. Postoperative pain scores favored the supine approach, though differences were not statistically significant.

Nevertheless, the study has limitations, including modest sample size and single-institution design, which may restrict generalizability. Larger multicenter trials are warranted to validate these findings and further explore long-term outcomes such as quality of life and recurrence rates.

In conclusion, the modified supine position for PCNL is an effective and safe alternative to the traditional prone approach. It offers advantages in operative efficiency and safety profile, particularly for high-risk and obese patients, while maintaining comparable stone clearance rates. Surgeons should individualize positioning based on patient characteristics and their own expertise.

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