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Supine and Prone Positions in Percutaneous Nephrolithotomy: Exploring Their Roles in Operative Efficiency and Patient Comfort

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ABSTRACT

Aim: This study aimed to compare the effects of supine and prone positions during percutaneous nephrolithotomy (PCNL) on operative characteristics, patient out-comes and postoperative quality of recovery.

Material and Methods: A retrospective analysis was conducted on 78 patients who underwent PCNL for renal stones ≥2 cm at a single center between December 2022 and August 2024. Patients were divided into two groups: 41 treated in the mini-PCNL (mPCNL) supine position and 37 in the standart PCNL (sPCNL) prone position. Demographic data, operative time, hospital stay duration, complication rates, postoperative pain and analgesic requirements and quality of recovery scores (QoR) were compared. Treatment efficacy was assessed based on residual stone presence at 2 months postoperatively, with <2 mm considered stone-free.

Results: Operative and access times were significantly shorter in the supine group and these patients had a reduced hospital stay. Quality of recovery improvement was more pronounced in the supine group with lower postoperative pain and analgesic requirements. Additionally, supine-positioned patients had a lower rate of residual stones compared to the prone group, suggesting enhanced treatment efficacy.

Conclusion: The supine position in mPCNL offers advantages over the prone position in terms of operative efficiency, patient comfort and postoperative quality of recovery. Given these benefits the supine position may be a preferable choice for PCNL procedures. Further multicenter studies are recommended to validate these findings across broader patient populations.

Keywords: Percutaneous nephrolithotomy; supine position; prone position; quality of life; quality of recovery; renal stone; postoperative outcomes.

Perkütan Nefrolitotomide Supine ve Prone Pozisyonları: Operasyon Etkinliği ve Hasta Konforundaki Rolleri

ÖZ

Amaç: Bu çalışma, perkütan nefrolitotomi (PCNL) sırasında supine ve prone pozisyonlarının operasyon özellikleri, hasta sonuçları ve postoperatif iyileşme kalitesi üzerindeki etkilerini karşılaştırmayı hedeflemiştir.

Gereç ve Yöntemler: Aralık 2022 ile Ağustos 2024 tarihleri arasında tek bir merkezde renal taş (>2 cm) nedeniyle PCNL uygulanan 78 hastanın retrospektif analizi yapılmıştır. Hastalar, mini-PCNL (mPCNL) supine pozisyonunda tedavi edilen 41 hasta ve standart PCNL (sPCNL) prone pozisyonunda tedavi edilen 37 hasta olmak üzere iki gruba ayrılmıştır. Demografik veriler, operasyon süresi, hastanede yatış süresi, komplikasyon oranları, postoperatif ağrı ve analjezik gereksinimi ile iyileşme kalitesi skorları (QoR) karşılaştırılmıştır. Tedavi etkinliği, ameliyat sonrası 2. ayda taşsızlık (<2 mm rezidü taş) oranı üzerinden değerlendirilmiştir.

Bulgular: Operasyon ve akses süreleri supine grubunda anlamlı olarak daha kısa bulunmuş ve bu grup hastalarında hastanede yatış süresi daha kısa olmuştur. Supine grubunda iyileşme kalitesinde daha belirgin bir iyileşme gözlenmiş, postoperatif ağrı ve analjezik gereksinimleri daha az olmuştur. Ayrıca, supine pozisyonda tedavi edilen hastalarda rezidü taş oranı prone grubuna kıyasla daha düşük bulunmuş ve bu durum tedavi etkinliğinin artmış olduğunu göstermektedir.

Sonuç: mPCNL'de supine pozisyonu, operatif verimlilik, hasta konforu ve postoperatif yaşam kalitesi açısından prone pozisyonuna göre avantajlar sunmaktadır. Bu faydalar göz önünde bulundurulduğunda, PCNL prosedürleri için supine pozisyonu tercih edilebilir bir seçenek olabilir. Daha geniş hasta popülasyonlarında bu bulguların doğrulanması için çok merkezli çalışmalar önerilmektedir.

Anahtar Kelimeler: Perkütan nefrolitotomi; supine pozisyon; pronepozisyon; yaşam kalitesi; iyileşme kalitesi; renal taş; postoperatif sonuçlar.

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INTRODUCTION

Percutaneous nephrolithotomy (PCNL) has been a reliable surgical option for the treatment of large kidney stones for many years with high success rates and low risk of complications (1,2). Although PCNL performed in the prone position provides wide surgical access, it has certain limitations in terms of patient positioning and anesthesia management. Therefore, in recent years, there has been a growing interest in the supine position and its advantages, such as easier access to the patient by the anesthesia team and easier management of patient ventilation, have attracted attention (3,4).

Supine PCNL, first introduced into clinical practice by Valdivia and colleagues in 1998, has been described as a technique that improves operative ergonomics for surgeons and anesthesiologists (5). The modified supine position, known as Galdakao-modified supine Valdivia (GMSV), also allows endoscopic combined intrarenal surgery (ECIRS) to be performed during the operation and has become a preferred option for surgeons, especially in complex cases (6,7). However, there is limited data on the effects of prone and supine positions on patient comfort, operative time, complication rates and postoperative quality of life (8).

The existing literature suggests that the supine position shortens the operation time compared to the prone position and reduces the risk of position related injury by eliminating the need for position change (9). However, there is no comprehensive and clear data on which position contributes more positively to patient quality of life. In this study, we aimed to compare the supine and prone positions used in PCNL operations in terms of patient comfort, treatment efficacy and safety and to examine the effects of both positions on postoperative quality of recovery. The results obtained are expected to provide important information that will guide clinical practice in position selection.

MATERIAL AND METHODS

This study was conducted retrospectively using the data of 78 patients who underwent percutaneous nephrolithotomy between December 2022 and August 2024 in the Department of Urology, Düzce Faculty of Medicine. Grouping was performed based on the type of surgery. Sample size was calculation performed using G*Power software to determine the minimum number of patients required for statistical significance. Based on a power (1-β) of 80%, an effect size of 0.5, and a significance level (α) of 0.05, the minimum required sample size was calculated as 54 patients (18). However, to increase the robustness of the findings and account for potential dropouts, a total of 78 patients were included in the study.

The study was conducted in accordance with the Declaration of Helsinki and approval was obtained from Düzce University Clinical Research Ethics Committee. (Decision Num-ber:2024/161 Date:19/08/2024) The data of all patients were evaluated in compliance with confidentiality principles and personal information was protected and anonymized.

Operative Method

Supine mPCNL

The operation was performed under general anesthesia. After anesthesia, retrograde pyelography was performed by placing a 6 fr ureter catheter into the side where the operation would be performed through cystoscopy in lithotomy position. The ureter catheter was fixed to the urethral catheter placed in the bladder. On the side of the patient to be operated on, a line was drawn with a surgical pen from the patient's posterior axillary line, the 12th rib line, and the upper iliac bone area to the back. The kidney was accessed from the area between these three lines. Then, the patients were placed in the GMSV position. In this position, as described, the patient's ipsilateral lower extremity was brought into extension while the contralateral extremity was brought into abduction and flexion.

A silicone pad was placed under the lower part of the area to be accessed, and this area was raised approximately 25-30 degrees. The arm on the same side was fixed to the thoracic cage and a pillow was placed underneath to cross the thoracic cage. Retrograde pyelography was performed to determine the renal calyx to be accessed. An 18 gauge diamond-tipped aspiration needle was preferred for renal access. After access was obtained, a 12 fr and 17 fr dilator were placed over the guide wire inserted into the calyxand a 17.5 metal sheath was placed, followed by entry into the collecting system with a 12 fr nephroscope (Karl Storz). Laser lithotripsy was performed on the stones using Holmium Junior Fx laser lithotripter (8–10 Hz, 1500–2000 J). After confirming with fluoroscopy that no stone fragments remained, the collecting system and ureter transition were checked with antegrade pyelography. The procedure was completed by placing a 4.8 f 26 cm double J ureteral stent in the patients.

Prone sPCNL

The operation was performed under general anesthesia. After anesthesia, retrograde pyelography was performed by placing a 6fr ureter catheter on the side where the operation would be performed through cystoscopy in lithotomy position. The ureter catheter was fixed to the urethral catheter placed in the bladder.

Then the patient was placed in the prone position. When the patient was placed in the prone position, silicone pillows were placed on the chest area, both side areas and the soles of the feet. The entry area and genital regions of all patients were painted with antiseptics, sterile drapes were provided and the tip of the 6 fr ureteral catheter was sent from the urethra. Then, the contrast agent given in the 6 fr ureter catheter was used for retrograde pyelography and the appropriate calyx was determined accordingly. An 18 gauge diamond-tipped aspiration needle was preferred for renal access. After the entry, dilation was performed up to 28-30 fr using Amplatz dilators (Microvasive/Boston Scientific, Natick, MA) over the guide wire placed in the calyx and entry was made into the collecting system with a 26 fr nephroscope (Karl Storz). Pneumatic lithotripsy was performed on the stones. After confirming that no stone fragments remained with fluoroscopy the collecting system and ureter transition were checked with antegrade pyelography. The procedure was completed by placing a 12 fr nephrostomy catheter in the patients.

Parameters Evaluated

Parameters such as preoperative and postoperative patient quality of recovery index, operation time, percutaneous access time, hospitalization time, complication rates, post-operative pain and analgesic requirement, catheter

requirement, perioperative hemoglobin loss, blood transfusion requirement and treatment efficacy were compared between the groups. Treatment efficacy was evaluated by measuring the residual stone size with Computed Tomography at the 2nd month postoperatively; stones above 2 mm were considered clinically significant residual stones, while stones below 2 mm were considered stone-free

In the primary outcome measures of our study, QoR score and stone-free status were evaluated. Other parameters were considered in the secondary outcome measures. Among these parameters, the S.T.O.N.E. nephrolithometry scoring system was used to determine stone disease severity (10,11).

Statistical Analysis

Data were analyzed using IBM SPSS Statistics v22. Skewness and Kurtosis tests were used for normality analysis. Independent t-test was used for normally distributed continuous variables, while Mann-Whitney U test was used otherwise. For parametric variables, mean and standard deviation were reported, whereas for non-parametric variables, median, minimum, and maximum values were provided in tables and text. Chi-square test was used for categorical variables. All results were evaluated at a 95% confidence interval, and $p<0.05$ was considered the significance level.

RESULTS

A total of 78 patients underwent percutaneous nephrolithotomy in either supine or prone positions, allowing for a comprehensive comparison of demographic characteristics, stone properties, perioperative and postoperative outcomes and quality of recovery measures. In comparing the supine and prone groups, statistically significant differences were found in operative time, access time and hospital stay duration. Patients in the supine group had a shorter median operative time (51 (30-130) minutes) compared to those in the prone group (90 (60-180) minutes, $p <0.001$). Similarly, access time was shorter in the supine group (supine group: 3.29 ± 2.55 minutes, prone group: 4.86 ± 2.11 minutes, $p=0.004$). Patients in the supine position also experienced a shorter hospital stay (4 (3-5) days) compared to the prone group (5 (3-14) days, $p <0.001$) (Table 1).

Table 1. Patient demographics and operative characteristics

Characteristics	Supine (n=41)	Prone (n=37)	Total (n=78)	p
Age (years) (Mean±SD)	47.43 ± 14.44	48.35 ± 17.40	47.88 ± 15.82	0.80
Male/Female	26/15	16/21	42/36	0.074
Operative Time (min) (Median, (min-max)	51 (30-130)	90 (60-180)	63.5 (30-180)	***<0.001***
Access Time (min) (Mean±SD)	3.29 ± 2.55	4.86 ± 2.11	4.04 ± 2.47	***0.004***
Hospital Stay (days) (Median,min-max)	4 (3-5)	5 (3-14)	5 (3-14)	***<0.001***

No statistically significant differences were found between groups regarding laterality, stone size or number of stones. However, stone density was greater in the supine group (1117.44 ± 279.2) compared to the prone group (917.51 ± 303.65), with a p-value of 0.03. When S.T.O.N.E. score was analyzed, no significant difference was observed between both groups, p value 0.41 (Table 2).

Table 2. Stone characteristics

Characteristics	Supine (n=41)	Prone (n=37)	Total (n=78)	p
Laterality (Right/Left)	20/21 (%49/%51)	23/14 (%62/%38)	43/35 (%55/%45)	0.235
Stone Size (mm) (Mean±SD)	24.8 ± 5.87	26.02 ± 4.4	25.38 ± 5.22	0.31
Number of Stones (Mean±SD)	1.41 ± 0.63	1.49 ± 0.8	1.45 ± 0.71	0.66
Stone Density (Hounsfield Unit) (Mean±SD)	1117.44 ± 279.2	917.51 ± 303.65	1022 ± 306.1	**0.03**
S.T.O.N.E. nephrolithometry score (Mean±SD)	9.2±1.44	8.92±1.50	9.06±1.46	0.41

In the chi-square test performed for calyx access, a statistically significant difference was observed between the supine and prone groups (p-value 0.045). Therefore, a post hoc analysis of the chi-square test was conducted, and adjusted residual values between-1.96 and +1.96 were considered insignificant. Upper calyx access was found to be statistically significantly higher in the supine group. These findings provide important insights into evaluating the effects of different positions for each category (Table 3).

Table 3. Access location

Access Location (n)	Supine (n=41)	Prone (n=37)	Total (n=78)	p
Upper Calyx	18 (72%)	7 (28 %)	25 (100 %)	***0.045***
-Upper calyx udjested residual	***2,4***[a]	***-2,4***[a]		
Middle Calyx	14 (48,3%)	15 (51,7%)	29 (100 %)	
-Middle calyx udjested residual	-0,6	0,6		
Lower Calyx	9 (37,5%)	15 (62,5%)	24 (100 %)	
-Middle calyx udjested residual	-1,8	1,8		

Table 3: Statistically significant difference was observed between the supine and prone groups in the chi-square test (p-value: 0.045). Therefore, a post hoc analysis of the chi-square test was performed, and adjusted residual values between -1.96 and +1.96 were considered non-significant. The significant values were indicated in ***bold italics***

The supine group had a statistically significantly lower hemoglobin drop (0.4 (-0.4-2.4) g/dL) compared to the prone group (0.8 (-1.4-3.7) g/dL, $p = 0.026$). The need for narcotic analgesics postoperatively was also lower in the supine group, with only 5 (%12.1) (patients requiring it versus 15 (%40.5) in the prone group ($p = 0.004$). Additionally, the presence of residual stones greater than 2 mm was significantly lower in the supine group (3 patients, %7.3) compared to the prone group (9 patients, %24.3, $p = 0.038$) (Table 4).

Table 4. Perioperative and postoperative outcomes

Characteristics	Supine (n = 41)	Prone (n = 37)	Total (n = 78)	p
Hemoglobin Loss (g/dL) (Median, min-max)	0.4 (-0.4-2.4)	0.8 (-1.4-3.7)	0.4 (-1.4-3.7)	**0.026**
Transfusion Requirement (n)	3 (%7.3)	22 (% 5.4)	5 (%6.4)	0.89
Complications (n)	6 (%14.6)	4 (%10.8)	10(%12.8)	0.73
Narcotic Analgesic Requirement (n)	5 (%12.1)	15 (%40.5)	20 (%25.6)	**0.004**
Residual Stone Presence (>2 mm, n)	3 (%7.3)	9 (%24.3)	12 (%15.3)	**0.038**

Quality of recovery (QoR) scores improved statistically significantly postoperatively in both groups; however, the improvement was more pronounced in the supine group. The mean increase in QoR scores in the supine group was +62.76 ± 40.01, whereas the prone group showed an increase of +17.43 ± 28.92 ($p < 0.001$). This suggests that the supine position may provide a better quality of recovery outcome for patients postoperatively (Table 5).

Table 5. Quality of recovery (QoR) scores

Characteristics	Supine (n=41)	Prone (n=37)	Total (n=78)	p
Preoperative QoR Score (Mean±SD)	65.32 ± 32.03	92.27 ± 21.13	78.1 ± 30.42	**<0.001**
Postoperative QoR Score (Mean±SD)	128.07 ± 16	109.7 ± 23.13	119.36 ± 21.64	**<0.001**
QoR Score Change (Mean±SD)	+62.76 ± 40.01	+17.43 ± 28.92	41.26 ± 41.73	**<0.001**

DISCUSSION

Percutaneous nephrolithotomy has gained wide acceptance as a minimally invasive method for the treatment of large kidney stones (12). Traditionally performed in the prone position, PCNL provides a wide surgical access, but presents some limitations in terms of anesthesia access difficulties and patient comfort (13,14). In recent years, the supine position has emerged as an alternative to these limitations and offers advantages in terms of anesthesia management and patient ventilation. In this study, the effects of supine and prone positions on operative characteristics, patient outcomes and quality of life were evaluated, and it was found that the supine position provided significant advantages (15,16).

The shorter operation time in PCNL procedures performed in the supine position indicates that this position is a more practical and faster option in surgical practice. The absence of the need for a change of position and the ability of the patient to remain fixed in a single position is considered to be a factor that optimizes the operation time, especially in obese patients or patients with restricted mobility. In addition, shorter hospitalization time in the supine position is an important finding supporting patient comfort and rapid postoperative recovery (5,17,18).

In the literature, it is known that pelvically located stones and stones with low density decrease the operation time (19,20). The patients in our study had 5 pelvic stones each supine and prone. It was observed that the stone location was not statistically different between the two groups. In addition, although stone densities are statistically lower in the prone method, the supine method seems more advantageous according to the results of our study. This may be due to better accessibility to the stone, lithotripsy angle and stone manipulation in the supine method.

Also, supine mPCNL is a safe and effective method in the treatment of pediatric kidney stones and its important advantage is that it provides easier access, especially from the lower calyx to the upper calyx (21).

There are studies in the literature that investigate the quality of life after percutaneous kidney stone treatment by trying to develop various standard criteria and investigating the success of surgery as well as morbidity and complication rates (22). In studies evaluating the quality of life in kidney stone treatment, it is known that double-J stents placed after the procedure seriously disturb patients. Therefore, informing patients about stent irritation before the procedure is important (23). In our study, the observed improvement in recovery associated with double-J stents may be attributed to comprehensive patient education regarding stent management or the inherently higher intensity of pain associated with stone disease itself. Postoperative quality of life assessments show that the supine position improves patient satisfaction. A significant improvement in patients' quality of life was observed in operations performed in this position, which accelerated the return to daily life after the operation (24). The improvement in quality of life scores reflect the direct contribution of the supine position to patient comfort. At the same time, less narcotic analgesia was required in the supine position, indicating that this position also offers an advantage in terms of postoperative pain management (25).

In terms of treatment efficacy, the lower residual stone rate in the supine position demonstrates the potential of this position to improve stone-free rates. It is known that the S.T.O.N.E score is used to predict stone free rates. In our study, there was no difference between the stone scores between the groups. However, the stone free rate was higher in the supine group. This finding suggests that the supine position may be a more effective option for complete stone removal. This position may improve patient outcomes, especially in the treatment of more complex and larger stones (26).

In the literature, different complication rates during surgery have been reported based on the accessed calyces. Upper calyx access provides easier entry to the renal pelvis and UPJ, facilitating improved stone clearance, particularly for branched stones, but carries a higher risk of thoracic complications. In contrast, lower calyx access poses a lower complication risk but can make it challenging to reach adjacent calyces or the UPJ, potentially increasing the risk of torque and kidney injury (27,28). In our study, a statistically significant higher rate of upper calyx access was observed in the supine group compared to the prone group. Although studies have reported higher complication rates for upper calyx access, no such difference was observed in our study. Therefore, we can suggest that the supine method may be preferred for upper calyx access (29).

This study has some limitations. Due to its retrospective nature, there may be limitations such as missing data and incomplete records. The single-center nature of the study limits the generalizability of the results. In addition, there

are small differences in characteristics such as stone density, size and location between the groups; this may affect the results. Another limitation of our study is that although general anesthesia was performed in both patient groups, perioperative monitorized findings of the patients were not evaluated. Future multicenter and prospective studies will increase the accuracy and generalizability of the findings.

CONCLUSIONS

This study demonstrates that the supine position offers significant advantages in terms of operative time, patient comfort, quality of recovery and treatment efficacy in PCNL procedures. The short operative time, rapid recovery and low pain level provided by the supine position have the potential to increase patient satisfaction. In clinical practice, the supine position should be considered as an effective option to improve patient outcomes in PCNL procedures. Multicenter studies with large patient populations will contribute to confirm these findings on a larger scale.

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