Research Article / Araştırma Makalesi

Comparison of Supine and Prone Positions in PCNL Operations Performed in Isolated Kidney Upper Pole Access

İzole Böbrek Üst Pol Akses Yapılan PCNL Operasyonlarında Supin ve Prone Pozisyonlarının Karşılaştırılması

Yusuf ARIKAN [1], Serhat BEYAN [1], Ömer KORAS [1], Mert GÜROĞLU [1], Büşra EMİR [2], Ferhat DEMİRCİ [3], Yavuz Onur DANACIOĞLU [4], Mehmet Zeynel KESKİN [1]

[1]Izmir Tepecik Training and Research Hospital, Department of Urology, Izmir, TÜRKİYE
[2]Izmir Katip Celebi University Faculty of Medicine, Department of Biostatistics, Izmir, TÜRKİYE
[3]Izmir Tepecik Training and Research Hospital, Department of Medical Biochemistry, Izmir, TÜRKİYE
[4]University of Health Sciences, Istanbul Bakirkoy Dr. Sadi Konuk Training and Research Hospital, Department of Urology, İstanbul, TÜRKİYE

Abstract

Background: Renal stones larger than 2 cm in the upper pelvical system are usually managed with Percutaneous Nephrolithotomy (PCNL) operation, but there are unclear as to which position should be used. In our study, we aimed to compare the preoperative-peroperative and postoperative data of patients who underwent PCNL with isolated renal upper pole access in supine and prone position.
Materials and Methods: The study included 20 Supine PCNL and 45 Prone PCNL cases who underwent isolated renal upper pole access for renal calculi. Age, gender, body mass index (BMI) were evaluated from demographic data. Radiological findings such as stone-skin distance, stone density, stone size and volume were recorded. Total operation time, access time and fluoroscopy time were recorded from peroperative data. In the postoperative period, the duration of hospital stay and complications according to Clavien Dindo classification were recorded. Non-contrast computed tomography was performed at the 1st postoperative month and the stone-free status of the patients was evaluated.
Results: There was no statistical difference in demographic data in terms of age, gender, BMI, ASA scores in both groups. The total operation time was 75.95±28.7 min in supine PCNL group and 92.48±23.4 min in prone PCNL group (p<0.001). Access time was 11.6±5.12 min in supine PCNL group and 9.2±3.7 min in prone PCNL group (p<0.001). Fluoroscopy time was 3.6±1.2 min in the supine PCNL group and 2.5±1.1 min in the prone PCNL group and was statistically longer (p<0.001). There was no difference in complications between the groups. Grade>2 complications according to Clavien Dindo classification were more frequent in supine PCNL patients (p:0.03). Stone-free status was 70% in supine PCNL patients and 77.7% in prone PCNL patients and was higher in the prone PCNL group (p:0.01).
Conclusions: In patients undergoing PCNL for isolated upper pol stone, the operation time is longer when prone PCNL is performed, but higher stone-free rates are obtained in these patients. Grade >2 complications are less common in prone PCNL for renal upper pole calculi.

Keywords: PCNL, Supine position, Prone position, Renal calculi, Stone surgery

Öz

Amaç: Üst pelvikalsiyel sistemde 2 cm'den büyük böbrek taşları genellikle Perkütan Nefrolitotomi (PCNL) operasyonu ile tedavi edilir ancak hangi pozisyonda olması gerektiği konusunda belirsizlikler vardır. Çalışmamızda supin ve prone pozisyonunda izole böbrek üst pol aksesi ile PCNL yapılan hastaların preoperatif-peroperatif ve postoperatif verilerinin karşılaştırılması amaçlanmıştır.
Materyal ve Metod: Çalışmaya böbrek taşı için izole böbrek üst polüne akses yapılan 20 Supin PCNL ve 45 Prone PCNL vakası dahil edildi. Hastaların demografik verilerinden yaş, cinseiyet, vücut kitle indeksi (VKI) değerlendirildi. Radyolojik bulgulardan taş-cilt mesafesi, taşın dansitesi, taşın büyüklüğü ve volümü kaydedildi. Peroperatif verilerinden total operasyon süresi, akses süresi ve floroskopi süresi kaydedildi. Postoperatif süreçte ise hastaların hastanede kalış süresi, Clavien Dindo sınıflamasına göre komplikasyonları belirtildi. Operasyon sonrası 1. ay Non-kontrast Bilgisayarlı Tomografi çekilerek hastaların taşsızlık durumu değerendirildi.
Bulgular: Her iki grupta demografik verilerden yaş, cinsiyet, VKİ, ASA skorları açısından herhangi bir istatistiksel fark izlenmedi. Peroperaif verilerden operasyon süresi supin PCNL grubunda 75.95±28.7 dk, prone PCNL grubunda 92.48±23.4 dk olup daha kısaydı (p<0.001). Akses süresi Supin PCNL grubunda 11.6±5.12 dk , Prone PCNL grubunda ise 9.2±3.7 dk idi (p<0.001). Floroskopi süresi ise Supin PCNL grubunda 3.6±1.2 dk, prone PCNL hastalarında ise 2.5±1.1 dk olup istatistiksel olarak daha uzundu (p<0.001). Gruplar arasında komplikasyonlar açısından fark izlenmedi. Clavien Dindo sınıflamasına göre Grade>2 komplikasyonlar Supin PCNL hastalarında daha sıktı (p:0.03). Taşsızlık durumu supin PCNL hastalarında %70, prone PNCL hastalarında %77.7 olup Prone PCNL grubunda daha yüksek izlendi (p:0.01).
Sonuç: İzole üst pol taşı nedeniyle PCNL uygulanan hastalarda prone PCNL uygulandığında operasyon süresi daha uzundur ancak bu hastalarda daha yüksek taşsızlık oranları elde edilmektedir. Böbrek üst pol taşı için PCNL operasyonunda Prone PCNL'de Grade >2 komplikasyonlar daha az görülmektedir.

Anahtar Kelimeler: PCNL, Supin pozisyon, Prone pozisyon, Böbrek taşı, Taş cerrahisi

Corresponding Author / Sorumlu Yazar

Dr. Serhat BEYAN
Izmir Tepecik Training and Research Hospital, Department of Urology, Izmir, TÜRKİYE

E-mail: drserhatbeyanq@gmail.com

Received / Geliş tarihi: 11.02.2025

Accepted / Kabul tarihi: 24.05.2025

DOI: 10.35440/hutfd.1637397

Introduction

Renal stone disease is a common urological problem worldwide (1). Percutaneous Nephrolitotomy (PCNL), which is one of the renal stone surgical methods, is performed especially for stones larger than 2 cm (2). In PCNL operations, supine or prone positions are used according to the surgeon's preference (3). In PCNL procedures for upper pol stones, both positions have their own advantages and disadvantages (4). Prone position provides a wider operation area by keeping the renal system in a stable position, and the supracostal and intracostal access are more feasible in this position (5).

In the supine position, simultaneous interventions with combined retrograde intrarenal surgery (RIRS) can be performed more easily. However, nephroscopic manipulation may be limited due to the mobility of the renal cavity for upper pol stones in the supine position (6).

There are limited studies in the literature on the success and complications of PCNL operations for isolated upper pole stones. In this study, we aimed to evaluate which position has a higher stone free rate (SFR), which position has fewer complications and which position is more applicable in clinical practice in isolated upper pole kidney stones.

Materials and Methods

This study was approved by our institutional ethical review committee (Decision No: 2024/05-11, Date: 04.06.2024).). All patients gave their written consent before participating in the study. We retrospectively reviewed the cases of PCNL between January 2018 and January 2024.

The exclusion criteria were as follows: Renal stones other than isolated upper pole, patients with stones <2 cm, history of neuromuscular disease, congenital renal anomaly, coagulopathy, morbid obesity and skeletal deformity. After the exclusion criteria, the study was designed with 20 supine PCNL and 45 prone PCNL cases with access to the upper pole of the kidney.

Demographic data including age, gender, body mass index (BMI), American Society of Anaesthetists (ASA) score; preoperative evaluations including degree of hydronephrosis, stone characteristics on Kidney-Ureter-Bladder (KUB) graphy , stone density, stone volume, stone-skin distance (SSD); intraoperative data including access, fluoroscopy, total operation time; postoperative data including length of hospital stay (LOS), residual stone status and complications, need for additional treatment at 1-month follow-up, and SFR were obtained from electronic patient files and recorded in a database. All patients received prophylactic antibiotherapy with second generation cephalosporins. Patients with growth in preoperative urine culture were treated with antibiotics until sterile urine culture results were obtained. In axial NCCT, 3 distances were measured from the centre of the stone to the skin surface: horizontal, vertical and 45° between the first 2 measurements. The average of these 3 measurements was accepted as the SSD. Stone density (HU) was calculated by the point value at the centre of the stone. Stone volume was determined using the ellipsoid formula ($0.167 \times \pi \times L \times W \times W \times H$) (7).

In both methods, a 5f ureteral catheter was inserted into the ureter and the anatomy of the pelvis and calyx structures was better demonstrated by fluoroscopy-guided retrograde pyelography with contrast material. After pyelography, fluoroscopy-guided puncture needle (18 gauge, Boston Scientific Corporation, Natick, MA) was used to access the appropriate upper calyx. After placement of the guide wire (SensorTM Guide Wire, Boston Scientific), the tract was dilated using amplatz dilators and a 30 Fr amplatz sheath (Karl Storz, Tutlingen, Germany) was inserted. Renal access time was defined as the time from retrograde pyelography to puncture of the desired calyx, expansion of the tract with fascial dilators, and placement of the Amplatz sheath. Fluoroscopy time was measured as the total fluoroscopy time used during the operation. Operative time was measured as the time from the sterile draping of the patient to the insertion of the nephrostomy tube or Double J catheter. SFR was defined as the absence of residual stones on Non-Contrast Computer Tomography (NCCT) 1 month after the operation or the largest stone size of the residual stone <4 mm. Clavien-Dindo Classification was used for complications (8).

Operation Tecnique

Supin Percutan Nephrolitotomy

After induction of general anaesthesia, a 5 Fr ureteral catheter was inserted into the renal pelvis with fluoroscopy, in Modified Galdakao Valdivia position. Renal access was obtained through the renal calyx with a fluoroscopy-guided puncture needle (18 Gauge, Boston Scientific Corporation, Natick, MA). After placement of the guide wire (SensorTM Guide Wire, Boston Scientific), the tract was dilated using amplatz dilators and a 30 Fr amplatz sheath (Karl Storz, Tutlingen, Germany) was inserted. A 28 Fr nephroscope was inserted through the amplatz. Stone was directly identified and fragmented into smaller parts using a 3.4-Fr Pneumatic Lithotriptor (Vibrolity, Elmed, Ankara, Turkey). Large fragments of fragmented stones that could fit into the Amplatz sheath were removed with stone forceps. After the decision to end the operation, an 8 f nephrostomy tube was placed in all patients. A 4.8 Fr JJ catheter was placed according to the surgeon's preference.

Prone Percutan Nephrolitotomy

The patient was given general anesthesia and the patient was placed in the lithotomy position and cystoscopy was performed. Preferably, open-ended 5 Fr ureteral catheter was placed in the ureter on the planned side of the operation. After the ureteral catheter was left in the pelvis, the urethral catheter was inserted and the ureteral catheter was fixed to the catheter. Then, the patient was carefully placed in the prone position. When the patient was placed in the prone position, silicone pillows were placed on the

chest area, both flank areas, and under the feet, especially to prevent lung compression. Renal access was obtained through the renal calyx with a fluoroscopy-guided puncture needle (18 Gauge, Boston Scientific Corporation, Natick, MA). After placement of the guide wire (SensorTM Guide Wire, Boston Scientific), the tract was dilated using amplatz dilators and a 30 Fr amplatz sheath (Karl Storz, Tutlingen, Germany) was inserted. A 28 Fr nephroscope was inserted through the amplatz. Stone was directly identified and fragmented into smaller parts using a 3.4-Fr Pneumatic Lithotriptor (Vibrolity, Elmed, Ankara, Turkey). Large fragments of fragmented stones that could fit into the Amplatz sheath were removed with stone forceps. After the decision to end the operation, an 8 f nephrostomy tube was placed in all patients. A 4.8 Fr JJ catheter was placed according to the surgeon's preference.

Statistical Analysis

The data were evaluated in the statistical package program IBM SPSS Statistics 25.0 (IBM Corp., Armonk, New York, USA). The normal distribution of the data of numerical variables was evaluated with the Shapiro Wilk normality test and *Q-Q* graphs. Categorical variables were given as frequency and percentage. Descriptive statistics are given as Mean ± Standard Deviation and Median (*IQR*) values. The mean differences between two related groups of normally distributed data were compared by independent ttest, and the Mann Whitney U test was used to compare non-normally distributed data. The relationship between categorical variables was evaluated with the Pearson Chi-Square test in *r* x *c* tables. A value of $p<0.05$ was considered statistically significant.

Results

There was no statistical difference in demographic data in terms of age, gender, BMI, ASA scores in both groups. The mean age was 51.1±18.4 years in supine PCNL patients and 47.2±17.5 years in prone PCNL patients. There was no difference between the groups in terms of stone structure, degree of hydronephrosis, localisation of the stone, laterality of the stone, volume and density of the stone, and stone-skin distance between the findings obtained in preoperative radiological evaluations with KUB graphy and NCCT. The stone volume was 6715.7±1647.6 mm3 in the supine PCNL group and 7132.8±1881.5 mm3 in the prone PCNL patients, which was higher in the prone PCNL patients, although there was no statistical difference. Quantitative data related to demographic and radiological findings of the patients are shown in Table 1.

Table 1. Comparison of demographic data and radiological features of the stone between both groups

	Group 1 (Supin PCNL) (*n*=20)	**Group 2 (Prone PCNL) (*n*=45)**	
	Mean±SD	*Mean±SD*	*p* value
Age (years)	51.1±18.4	47.2±17.5	0.217
BMI (kg/m²)	23.1±4.8	25.2±5.7	0.109
Sex (M/F) *n* (%)	15 (75) / 5 (25)	32 (71.1) / 13 (28.9)	0.872
ASA Class *n* (%)			
1	4 (20)	9 (20)	
2	11 (55)	26 (57.7)	0.982
3	5 (25)	10 (22.2)	
Structure of the stone			
Opaque	15 (75)	33 (73.3)	
Semi opaque	4 (20)	9 (20)	0.741
Non-opaque	1 (5)	3 (6.6)	
Stone Side (Left/Right)	11 (55) / 9 (45)	21 (46.6) / 24 (53.4)	0.091
Stone Volume (mm³)	6715.7±1647.6	7132.8±1881.5	0.079
Stone density (HU)	978.1±401.7	1014.8±489.89	0.111
Stone skin distance (cm)	11.8±3.1	10.9±2.9	0.816

Among the peroperative data, the operation time was 75.95±28.7 min in the supine PCNL group and 92.48±23.4 min in the prone PCNL group ($p<0.001$). Access and fluoroscopy time were statistically longer in the supine PCNL group (11.6±5.12 min and 3.6±1.2 min) than in the prone PCNL group (9.2±3.7 min and 2.5±1.1 min) ($p<0.001$). There was no difference between the groups in terms of d-j stent placement rates and complications. Grade>2 complications were more frequent in supine PCNL patients (p:0.01). SFR was 70% in supine PCNL patients and 77.7% in prone PCNL patients (p:0.03). There was no statistical difference between the groups in terms of length of hospital stay and additional treatment of residual stones. Data on the comparison of peroperative and postoperative values of the patients are shown in Table 2.

Table 2. Comparison of Perioperative and Postoperative Data between both groups

	Group 1 (Supin PCNL) (*n*=20)	Group 2 (Prone PCNL) (*n*=45)	
	Mean±SD	***Mean±SD***	***p* value**
Access time	11.6±5.12	9.2±3.7	<0.001
Fluoroscopy screening time (min)	3.6±1.2	2.5±1.1	<0.001
Operation time (min)	75.95±28.7	92.48±23.4	<0.001
Access Location **-Supracostal** **-Infrakostal**	 14 (70) 6 (30)	 37 (82.2) 8 (17.7)	<0.001
DJ stent insertion *n* (%)	7 (35)	18 (40)	0.802
Clavien Dindo , *n* (%)			
1	3 (15)	6 (13.3)	
2	2 (10)	4 (8.8)	0.102
3A	2(10)	2 (4.4)	
3B	1 (5)	1 (2.2)	
Grade >2 Complications, *n* (%)	3 (15)	3 (6.6)	0.03
Length of stay in hospital (days)	1.7±0.8	1.8±0.9	0.463
Stone Free Rate *n* (%)	14 (70)	35 (77.7)	0.01
Additional treatment (*n* (%)	4 (20)	8 (17.7)	0.239
Additional type of treatment *n* (%)			
ESWL	1 (5)	2 (4.4)	
F-URS-URS	3 (15)	5 (11.1)	0.184
PCNL	0 (0)	1 (2.2)	

Discussion

In this study, the different aspects of supine and prone positions in patients undergoing PCNL with isolated upper pole access for renal calculi were analysed in detail.

Upper calyx access for PCNL is generally used for stones with special anatomy such as staghorn stones, large upper calcial stones, and stones in anomalous kidneys (9). The first step of successful PCNL is to establish a properly placed nephrostomy tract (10). The advantage of upper pole access is direct access to most of the intrarenal collecting system and upper ureter, so upper pole access is one of the ways to ensure good stone clearance (11). Upper pole access can be performed by both supracostal and infracostal approaches. Although supracostal access provides direct access to the stones in the upper pole of the kidney, it may increase the risk of pleural injury and haemothorax (12). In the prone position, the advantages of supracostal access include a steeper nephroscopic angle and an optimal field of view for a larger stone load (13-14). In our study, supracostal access was performed in 82.2% of patients in the prone position and 70% in the supine position for upper pol stones, and it was observed that more supracostal access was provided in the prone position.

The most important indicator of success in PCNL operations is the SFR (15). In the literature, Astroza et al. (16) used upper pol access more frequently in the prone position in staghorn stones and the SFR was 59.2% in the prone position and 48.4% in the supine position in staghorn stones. Tefekli et al. (12) reported an SFR of 77.1% in patients who underwent isolated upper pol access. Soares et al. (5) found an SFR of 84.8% with supracostal access and 84.4% with infracostal access in their series of 329 isolated upper pole accesses. In a study by Bulut et al. (17) on the comparison of supine and prone PNL during the learning curve period, SFR rates were found to be 80% in the supine position and 64% in the prone position. In the literature, it is obvious that the surgical success varies according to the position in PCNL operation performed to isolated upper pol stones. In our study, SFR in isolated upper pole stones was 77.7% in prone PCNL and 70% in supine PCNL patients and this difference was clinically significant. In our opinion, this difference is due to the fact that supracostal access can be performed more easily in the prone position.

Although the main aim of PCNL operations is to provide stone-free operation, short surgical time and fewer complications in the per-postoperative period are also important points (18). Surgical time in PCNL operations consists of 3 parts as access time, fluoroscopy time and total operation time. Oner et al. (19) found a total operation time of 37.5 min and a fluoroscopy time of 3.4 min in their PCNL series in which they applied isolated upper pole accessory. Sofer et al. (20) reported an operation time of 90 min in supine position and 110 min in prone position in patients in whom they performed PCNL by reaching the upper calyx. Kumar et al. (21) reported an operation time of 51.8 min in the supine position in patients who underwent isolated upper pol access in the supine position. In our study, the duration of access, fluoroscopy and total operation time in the supine and prone positions were 11.6, 3.6, 75.9 and 9.2, 2.5, 92.4, respectively. Total operative time was longer in the prone position, whereas access and fluoroscopy time were shorter. In addition, Desoky et al. (22) compared the supine and prone PCNL methods and found that the operative time was statistically significantly shorter in the supine position, but there was no significant difference in SFR, postoperative complication rates, postoperative pain, and hospital stay. Also, Jamil et al. (23) reported that supine PCNL

required shorter operating time, shorter hospital stay, and less analgesia treatment than percutaneous nephrolithotomy performed in the prone position. We think that the change of the patient's position affects the duration of the operation in the prone position.

In terms of complications, both positions have their own advantages and disadvantages. Since upper pole access can be performed with a steeper angle in the prone position, complication rates have been reported to be lower compared to the supine position (24-25). Soares et al. (5) found a Clavien Grade 3-4 complication rate of 17.6% in patients who underwent supracostal upper pole access in the prone position and 1.9% in patients who underwent infracostal access. In addition, there were concerns about increased colonic injury due to more lateral access in the supine position, but Liu et al. showed that there was no significant difference between both methods in their meta-analysis (26). Kekre et al. (27) performed PCNL with supracostal access in a series of 102 patients, 79.5% of the patients were stone-free and 9.8% of the patients had intrathoracic complications such as hydrothorax, pneumothorax or hydropneumothorax requiring intercostal drainage. Radecka et al. (28) found a nephropleural fistula rate of 3.3% after supracostal PCNL. In our study, no difference was observed between all groups in terms of total complications. Grade>2 complications were observed in 3 patients in both patient groups with a rate of 15% in Prone patients and 6.6% in Supine PCNL patients. The higher rate of Grade>2 complications, especially in Prone patients, may be due to the surgeons attempting more supracostal access.

The main limitations of our study are its retrospective design, the fact that it was performed in a single centre and the small number of cases. Another limitation is the use of standard 30 F Amplatz in PCNL operations. Complication rates may be reduced with lower width Amplatz dilators.

Conclusion

In PCNL operations performed with upper pole access, although prone PCNL has a longer operation time, a higher stone-free rate is obtained. Grade >2 complications are less common in prone PCNL.

Ethical Approval: *The study was approved by The University of Health Sciences, Tepecik Training and Research Hospital Ethical Committee, Izmır, Turkey (Decision No: 2024/05-11, Date: 04.06.2024).*

Author Contributions:
Concept: Y.A. Y.O.D. S.B. F.D.
Literature Review: Y.O.D., Y.A., S.B., O.K., M.G.
Design : M.Z.K., Y.A., O.K., S.B.
Data acquisition: Y.A., S.B., F.D., M.G.
Analysis and interpretation: B.E:
Writing manuscript: Y.A., S.B., O.K., M.G.
Critical revision of manuscript: F.D. Y.O.D., M.Z.K., B.E., M.G.
Conflict of Interest: *The authors have no conflicts of interest to declare.*
Financial Disclosure: *Authors declared no financial support.*

References

1. Zhang J, Luo H, Wu H, Qian Y, Tang Z, Wang J et al. The association between domestic water hardness and kidney stone disease: a prospective cohort study from the UK Biobank. Int J Surg. 2024 Dec 31. doi: 10.1097/JS9.0000000000002198. Epub ahead of print. PMID: 39784501.
2. Cui D, Chen G, Luo J, Ma Q, Wang G, Yang Z, et al. Comparison of percutaneous nephrolithotripsy combined with retrograde intrarenal surgery and multi-tract percutaneous nephrolithotripsy for octopus stone: A propensity score-matching study. Medicine (Baltimore). 2024 May 31;103(22):e38311. doi: 10.1097/MD.0000000000038311. PMID: 39259108; PMCID: PMC11142782.
3. Gelmis M, Caglar U, Esmeray A, Gunay NF, Dizdaroglu C, Meric A et al. Comparison of supine and prone mini percutaneous nephrolithotomy in obese patients: a retrospective study. Aktuelle Urol. 2024 Sep 12. English. doi: 10.1055/a-2382-8423. Epub ahead of print. PMID: 39265637.
4. Zoeir A, Mamdoh H, Moussa A, Abdel-Raheem A, Gameel T, Elsherbeny A, et al. Which is easier for beginners: supine or prone position percutaneous nephrolithotomy? Assessment of the learning curve in novice urologists through a randomized clinical trial. Minerva Urol Nephrol. 2024 Dec;76(6):748-758. doi: 10.23736/S2724-6051.24.05974-3. PMID: 39831856.
5. Soares RMO, Zhu A, Talati VM, Nadler RB. Upper Pole Access for Prone Percutaneous Nephrolithotomy: Advantage or Risk? Urology. 2019 Dec;134:66-71. doi: 10.1016/j.urology.2019.08.031. Epub 2019 Sep 2. PMID: 31487511.
6. Bulut EC, Aydın U, Coşkun Ç, Çetin S, Ünsal A, Polat F, et al. Which Position for Novice Surgeons? Effect of Supine and Prone Positions on Percutaneous Nephrolithotomy Learning Curve. Medicina (Kaunas). 2024 Aug 10;60(8):1292. doi: 10.3390/medicina60081292. PMID: 39202573; PMCID: PMC11356003.
7. Heidar NA, Labban M, Nguyen DD, El-Achkar A, Mansour M, Bhojani N et al. Does volume matter? Incorporating estimated stone volume in a nomogram to predict ureteral stone passage. Can Urol Assoc J. 2022 Mar;16(3):E150-E154. doi: 10.5489/cuaj.7364. PMID: 34672936; PMCID: PMC8923883.
8. Dindo D, Demartines N, Clavien PA. Classification of surgical complications: a new proposal with evaluation in a cohort of 6336 patients and results of a survey. Ann Surg. 2004 Aug;240(2):205-13. doi: 10.1097/01.sla.0000133083.54934.ae. PMID: 15273542; PMCID: PMC1360123.
9. Huang T, Jiao BB, Luo ZK, Zhao H, Geng L, Zhang G. Evidence of the outcome and safety of upper pole vs. other pole access single puncture PCNL for kidney stones: which is better? Eur Rev Med Pharmacol Sci. 2023 May;27(10):4406-4420. doi: 10.26355/eurrev_202305_32446. PMID: 37259721.
10. Memik Ö, Karslı O. Assessment of complications and success rates of Percutaneous nephrolithotomy: single tract *vs*. multi tract approaches. PeerJ. 2025 Jan 16;13:e18450. doi: 10.7717/peerj.18450. PMID: 39830965; PMCID: PMC11742455.
11. Lojanapiwat B, Prasopsuk S. Upper-pole access for percutaneous nephrolithotomy: comparison of supracostal and infracostal approaches. J Endourol. 2006 Jul;20(7):491-4. doi: 10.1089/end.2006.20.491. PMID: 16859462.
12. Tefekli A, Esen T, Olbert PJ, Tolley D, Nadler RB, Sun YH et al. Isolated upper pole access in percutaneous nephrolithotomy: a large-scale analysis from the CROES percutaneous nephrolithotomy global study. J Urol. 2013 Feb;189(2):568-73. doi: 10.1016/j.juro.2012.09.035. Epub 2012 Dec 20. PMID: 23260552.
13. Stening SG, Bourne S. Supracostal percutaneous nephrolithotomy for upper pole caliceal calculi. J Endourol. 1998 Aug;12(4):359-62. doi: 10.1089/end.1998.12.359. PMID: 9726403.
14. Golijanin D, Katz R, Verstandig A, Sasson T, Landau EH, Meretyk S. The supracostal percutaneous nephrostomy for treatment of staghorn and complex kidney stones. J Endourol. 1998 Oct;12(5):403-5. doi: 10.1089/end.1998.12.403. PMID: 9847059.
15. Khalil MAU, Patujo YH, Ullah F, Ibrar U, Adil R, Inam QA et al. An Analysis of Percutaneous Nephrolithotomy (PCNL) Performed at the

Institute of Kidney Disease, Pakistan: Stone Clearance and Complications. Cureus. 2024 Dec 9;16(12):e75430. doi: 10.7759/cureus.75430. PMID: 39791059; PMCID: PMC11711708.
16. Astroza G, Lipkin M, Neisius A, Preminger G, De Sio M, Sodha H, et al. Effect of supine vs prone position on outcomes of percutaneous nephrolithotomy in staghorn calculi: results from the Clinical Research Office of the Endourology Society Study. Urology. 2013 Dec;82(6):1240-4. doi: 10.1016/j.urology.2013.06.068. Epub 2013 Sep 21. PMID: 24063939.
17. Bulut EC, Aydın U, Coşkun Ç, Çetin S, Ünsal A, Polat F, et al. Which Position for Novice Surgeons? Effect of Supine and Prone Positions on Percutaneous Nephrolithotomy Learning Curve. Medicina (Kaunas). 2024 Aug 10;60(8):1292. doi: 10.3390/medicina60081292. PMID: 39202573; PMCID: PMC11356003.
18. Zhou G, Zhou Y, Chen R, Wang D, Zhou S, Zhong J, Zhao Y, Wan C, Yang B, Xu J, Geng E, Li G, Huang Y, Liu H, Liu J et al. The influencing factors of infectious complications after percutaneous nephrolithotomy: a systematic review and meta-analysis. Urolithiasis. 2022 Dec 14;51(1):17. doi: 10.1007/s00240-022-01376-5. PMID: 36515726; PMCID: PMC9750925.
19. Oner S, Karagozlu Akgul A, Demirbas M, Onen E, Aydos M, Erdogan A. Upper pole access is safe and effective for pediatric percutaneous nephrolithotomy. J Pediatr Urol. 2018 Apr;14(2):183.e1-183.e8. doi: 10.1016/j.jpurol.2017.12.013. Epub 2018 Feb 2. PMID: 29459134.
20. Sofer M, Giusti G, Proietti S, Mintz I, Kabha M, Matzkin H, et al. Upper Calyx Approachability through a Lower Calyx Access for Prone Versus Supine Percutaneous Nephrolithotomy. J Urol. 2016 Feb;195(2):377-82. doi: 10.1016/j.juro.2015.07.101. Epub 2015 Aug 6. PMID: 26254723.
21. Kumar N, Somani B. Supine tubeless upper pole PCNL under spinal anaesthesia: Safety, feasibility and outcomes from a tertiary endourology centre. Arab J Urol. 2024 Jan 26;22(3):159-165. doi: 10.1080/20905998.2024.2309780. PMID: 38818256; PMCID: PMC11136457.
22. Desoky EAE, Sakr AM, ElSayed ER, Ali MM. Ultra-Mini-Percutaneous Nephrolithotomy in Flank-Free Modified Supine Position *vs* Prone Position in Treatment of Pediatric Renal Pelvic and Lower Caliceal Stones. J Endourol. 2022 May;36(5):610-614. doi: 10.1089/end.2021.0557. Epub 2022 Mar 9. PMID: 34861776.
23. Jamil MN, Haq FU, Islam EU, Shaheen R, Farooq U. Comparison Between Supine Position Versus Prone Position In Percutaneous Nephrolithotomy: A Single Centered Analysis Of 623 Cases. J Ayub Med Coll Abbottabad. 2022 Oct-Dec;34(Suppl 1)(4):S1003-S1007. doi: 10.55519/JAMC-04-S4-11259. PMID: 36550663.
24. Yuan D, Liu Y, Rao H, Cheng T, Sun Z, Wang Y et al. Versus Prone Position in Percutaneous Nephrolithotomy for Kidney Calculi: A Meta-Analysis. J Endourol. 2016 Jul;30(7):754-63. doi: 10.1089/end.2015.0402. Epub 2016 May 11. PMID: 27072075.
25. Birowo P, Tendi W, Widyahening IS, Rasyid N, Atmoko W. Supine versus prone position in percutaneous nephrolithotomy: a systematic review and meta-analysis. F1000Res. 2020 Apr 2;9:231. doi: 10.12688/f1000research.22940.3. PMID: 33014345; PMCID: PMC7509599.
26. Liu L, Zheng S, Xu Y, Wei Q. Systematic review and meta-analysis of percutaneous nephrolithotomy for patients in the supine versus prone position. J Endourol. 2010 Dec;24(12):1941-6. doi: 10.1089/end.2010.0292. Epub 2010 Sep 21. PMID: 20858062.
27. Kekre NS, Gopalakrishnan GG, Gupta GG, Abraham BN, Sharma E. Supracostal approach in percutaneous nephrolithotomy: experience with 102 cases. J Endourol. 2001 Oct;15(8):789-91. doi: 10.1089/089277901753205753. PMID: 11724115.
28. Radecka E, Brehmer M, Holmgren K, Magnusson A. Complications associated with percutaneous nephrolithotripsy: supra- versus subcostal access. A retrospective study. Acta Radiol. 2003 Jul;44(4):447-51. doi: 10.1080/j.1600-0455.2003.00083.x. PMID: 12846698.