International Journal of Life Sciences, Biotechnology and Pharma Research Vol. 13, No. 12, December 2024 Online ISSN: 2250-3137
Print ISSN: 2977-0122

DOI: 10.69605/ijlbpr_13.12.2024.159

Original Research

Retrospective analysis to study the Complications of Percutaneous Nephrolithotomy Under Regional Anesthesia

[1]Dr. Anubhav Raj, [2]Dr. S K Singh, [3]Dr. Kapil Rastogi, [4]Dr. Gyan Prakash, [5]Dr. Kruthika Prakash

[1]Associate Professor, [2]Professor, [4]Assistant Professor, [5]Junior Resident, Department of Surgery, Integral Institute of Medical Science and Research (IIMS&R) Lucknow, U.P., India
[3]Associate Professor, Department of Anesthesia, Integral Institute of Medical Science and Research (IIMS&R) Lucknow, U.P., India

Corresponding Author
Dr. Anubhav Raj
Associate Professor, Department of Surgery, Integral Institute of Medical Science and Research (IIMS&R) Lucknow, U.P., India

Received Date: 22 November, 2024 Accepted Date: 25December, 2024

Abstract

Aim: This study aims to analyze the complications associated with Percutaneous Nephrolithotomy (PCNL) performed under Spinal Anesthesia Block (SAB) using a retrospective descriptive design.

Material and Methods: This retrospective study included 100 patients who underwent PCNL under SAB from January 2020 to May 2023. Data were collected from medical records, including demographics, stone characteristics, anesthesia details, operative data, and post-operative outcomes. Complications were graded using the Clavien-Dindo Classification System, and statistical analysis was performed using SPSS version 25.0, with a p-value <0.05 considered statistically significant.

Results: The mean age was 47.5 ± 11.8 years, and 60% were male. The mean BMI was 25.8 ± 3.4 kg/m², and comorbidities were present in 32% of patients. The mean stone size was 18.4 ± 4.7 mm, with upper pole stones being most common (38%). The mean surgery duration was 88.2 ± 15.6 minutes, and blood loss was 150.6 ± 30.5 mL. Post-operative complications occurred in 28% of patients, with Grade I (12%) and Grade II (10%) being most frequent. Regression analysis revealed age, BMI, stone size, surgery duration, blood loss, and comorbidities as significant predictors of complications ($R^2 = 0.62$, $p < 0.001$).

Conclusion:PCNL under SAB is a safe and effective procedure, with most complications being minor and manageable. Predictive factors for complications include age, BMI, stone size, surgery duration, blood loss, and comorbidities, emphasizing the importance of thorough preoperative assessment, intraoperative vigilance, and postoperative care to optimize outcomes.

Keywords: Percutaneous Nephrolithotomy, Spinal Anesthesia, Complications, Clavien-Dindo Classification, Predictive Factors.

Introduction

Percutaneous Nephrolithotomy (PCNL) is a minimally invasive surgical procedure widely used for the removal of large or complex renal calculi. Since its introduction, PCNL has revolutionized the management of kidney stones by offering high stone clearance rates and reduced morbidity compared to open surgeries. Traditionally, PCNL has been performed under general anesthesia (GA) due to the perceived benefits of complete muscle relaxation, airway control, and reduced patient movement during the procedure. However, regional anesthesia, specifically spinal or epidural anesthesia, has emerged as a viable and increasingly preferred alternative in selected patients due to its distinct advantages, including reduced systemic anesthetic side effects, improved postoperative analgesia, and lower complication rates in high-risk patients.[1,2]Regional anesthesia for PCNL, particularly spinal anesthesia, involves blocking nerve signals at specific spinal levels, effectively numbing the lower half of the body while allowing the patient to remain conscious or mildly sedated. This approach has gained traction, especially in patients with significant comorbidities such as cardiovascular or pulmonary diseases, where general anesthesia poses higher risks. Regional anesthesia is also favored in resource-limited settings where anesthetic equipment for general anesthesia might be scarce. Despite these advantages, the shift towards regional anesthesia in PCNL raises important

DOI: 10.69605/ijlbpr_13.12.2024.159

questions regarding its safety profile, complication rates, and overall clinical outcomes compared to general anesthesia.[3]Complications during and after PCNL can arise from various factors, including patient characteristics, stone burden, surgical techniques, and anesthesia type. While PCNL is generally considered safe, it is not without risks. Complications associated with the procedure can range from minor issues, such as transient fever and hematuria, to severe life-threatening complications, including sepsis, massive hemorrhage, and multiorgan dysfunction. The type of anesthesia used plays a pivotal role in influencing these outcomes. With regional anesthesia, there are specific challenges, including hemodynamic instability, inadequate analgesia, and potential complications related to spinal or epidural techniques, such as post-dural puncture headache, nerve injury, or rarely, epidural hematoma.[4]One of the most frequently encountered complications of PCNL, regardless of anesthesia type, is bleeding. The risk of significant hemorrhage arises from vascular injury during renal access or stone fragmentation. Under regional anesthesia, intraoperative monitoring and management of blood loss become critical, as hypotension caused by spinal anesthesia can mask early signs of significant blood loss. Furthermore, prolonged surgical duration under spinal anesthesia can exacerbate hemodynamic instability, increasing the risk of adverse outcomes.[5]Another common complication is infection, which may present as fever, urinary tract infection (UTI), or sepsis. Stone fragments, prolonged operative times, and pre-existing infections are key risk factors for sepsis after PCNL. Under regional anesthesia, the ability to detect early signs of infection, such as increased heart rate or systemic inflammation, might be delayed, adding an additional layer of complexity to patient monitoring and management.[6]Postoperative pain management is another area where anesthesia type can influence outcomes. Regional anesthesia provides excellent pain control during the early postoperative period; however, its analgesic effects diminish over time, necessitating supplemental analgesia. Inadequate postoperative pain management can lead to delayed mobilization, increased hospital stay, and higher chances of thromboembolic complications. Additionally, complications such as post-dural puncture headache and transient neurological symptoms, though rare, can occur with spinal anesthesia, impacting patient recovery and satisfaction.[7]Patient positioning during PCNL under regional anesthesia also presents challenges. The prone position, often required for renal access, can compromise ventilation and hemodynamic stability, particularly in obese patients or those with compromised respiratory function. While regional anesthesia avoids the airway complications associated with general anesthesia, inadequate ventilation in prone positioning remains a concern that must be addressed through vigilant monitoring and patient selection.The incidence of complications can also be influenced by surgeon experience, operative time, stone characteristics, and intraoperative imaging techniques. Long operative durations, complex stone burden, and repeated attempts at renal access are associated with a higher likelihood of complications. Under regional anesthesia, these factors gain added importance, as prolonged procedures may exceed the effective duration of spinal anesthesia, requiring additional doses or conversion to general anesthesia, both of which carry their own set of risks.[8]In the postoperative period, delayed recovery, prolonged hospital stays, and reintervention for residual stones or complications can significantly impact patient outcomes and healthcare costs. Effective communication between the surgical and anesthesia teams is essential to address complications promptly and optimize clinical outcomes.The complications associated with PCNL under regional anesthesia are multifactorial, arising from patient-specific factors, anesthesia-related issues, and surgical challenges. A thorough understanding of these complications, along with meticulous patient selection, preoperative preparation, intraoperative monitoring, and postoperative care, is essential to minimize risks and ensure favorable outcomes. Future studies comparing regional and general anesthesia in PCNL are needed to further refine best practices and improve patient safety in this increasingly popular approach to kidney stone management.

Material and methods

This study was designed as a retrospective descriptive study aimed at analyzing the complications associated with Percutaneous Nephrolithotomy (PCNL) performed under Spinal Anesthesia Block (SAB). The data was collected from patients who underwent the procedure between January 2020 and May 31, 2023.Based on the calculation, a total sample size of 100 patients.

Inclusion Criteria:

Patients eligible for the study included those who:

1. Underwent **PCNL under SAB** during the study period.
2. Were available for follow-up for **three months post-operatively**.

Exclusion Criteria:

Patients were excluded if they:

1. Did not complete **three months of follow-up** post-operatively.
2. Underwent **PCNL under General Anesthesia (GA)**.
3. Required **conversion from SAB to GA** during the procedure.

DOI: 10.69605/ijlbpr_13.12.2024.159

Data Collection:
The data was meticulously extracted from patient medical records and surgical reports. The collected data included:

- **Patient Demographics:** Age, sex, BMI, and comorbidities.
- **Stone Characteristics:** Stone size, location, and composition.
- **Anesthetic Details:** Type and technique of SAB, and anesthesia duration.
- **Operative Details:** Duration of surgery and intraoperative complications.
- **Post-Operative Outcomes:** Complication rates, stone-free rate, recovery time, and length of hospital stay.

Complication Assessment:
Complications were systematically classified using the **Clavien-Dindo Classification System**, an internationally accepted framework for surgical complication grading. The system categorizes complications as follows:

- **Grade I:** Minor deviation from normal recovery without pharmacological intervention.
- **Grade II:** Requires pharmacological treatment.
- **Grade IIIa:** Requires surgical, endoscopic, or radiological intervention without general anesthesia.
- **Grade IIIb:** Requires surgical, endoscopic, or radiological intervention under general anesthesia.
- **Grade IVa:** Life-threatening complication requiring ICU management (single organ dysfunction).
- **Grade IVb:** Life-threatening complication requiring ICU management (multi-organ dysfunction).
- **Grade V:** Death of the patient.

The classification allows contraction into **five broad grades (I, II, III, IV, V)** depending on the focus of the study and the sample size. This system ensures an objective and reproducible assessment of complications.

Statistical Analysis
Data analysis was performed using **SPSS version 25.0**. Descriptive statistics, including mean, median, and standard deviation, were used to summarize continuous variables, while categorical variables were presented as frequencies and percentages. Inferential statistics, including the **Chi-square test** for categorical data and the **independent t-test** for continuous data, were applied to identify significant associations. A **p-value <0.05** was considered statistically significant.

Results
Patient Demographic Characteristics (Table 1)
The study included 100 patients who underwent PCNL under SAB. The mean age was 47.5 ± 11.8 years, and age was significantly associated with complications ($p = 0.014$). A higher age tended to correlate with an increased risk of complications, emphasizing age as an important factor in predicting post-operative outcomes.There was a male predominance (60%), with males constituting the majority of the sample, though the sex distribution was not statistically significant ($p = 0.221$). The mean BMI was 25.8 ± 3.4 kg/m², and it was significantly associated with complications ($p = 0.031$). Patients with a higher BMI were more prone to complications, reflecting the potential impact of obesity on surgical and post-operative outcomes.Comorbidities were present in 32% of the patients, with hypertension (18%), diabetes mellitus (14%), and smoking history (22%) being the most common. The presence of comorbidities showed a significant association with complications ($p = 0.017$). These findings highlight the need for thorough pre-operative evaluation and optimization of comorbid conditions in patients undergoing PCNL.

Stone Characteristics (Table 2)
The mean stone size was 18.4 ± 4.7 mm, and larger stone sizes were significantly associated with complications ($p = 0.002$). Stone size remains a crucial factor, as larger stones typically require longer surgical durations and may result in higher intraoperative blood loss.Regarding stone location, stones were most frequently located in the upper pole (38%), followed by the middle pole (35%) and lower pole (27%). The association between stone location and complications was significant ($p = 0.041$), with upper pole stones generally being easier to access and manage.In terms of stone composition, calcium oxalate stones (55%) were the most common, followed by uric acid stones (30%) and struvite stones (15%). Stone composition did not show statistical significance concerning complications, but calcium oxalate stones remain the predominant type observed in clinical practice.

Operative and Anesthesia Details (Table 3)
The mean duration of surgery was 88.2 ± 15.6 minutes, and this duration was significantly associated with complications ($p = 0.003$). Prolonged surgeries increase the likelihood of complications, possibly due to extended tissue exposure and increased blood loss.The mean duration of anesthesia was 102.4 ± 18.3 minutes, and it also showed a significant association with complications ($p = 0.005$). Longer anesthesia duration may indicate more challenging surgical cases and potentially increased anesthesia-related complications.The mean blood loss during surgery was 150.6 ± 30.5 mL, which was statistically significant ($p = 0.002$). Increased blood loss often correlates with prolonged procedures and larger stone burden, contributing to higher complication rates.Intraoperative complications occurred in 12% of patients, with a significant association with other

DOI: 10.69605/ijlbpr_13.12.2024.159

operative factors (p = 0.045). This highlights the importance of intraoperative vigilance and preparedness to address unforeseen complications.

Post-Operative Outcomes (Table 4)

The mean length of hospital stay was 4.5 ± 1.7 days, and it was significantly associated with complications (p = 0.004). Longer hospital stays often indicate post-operative complications or delayed recovery.The mean recovery time was 12.3 ± 3.5 days, which also showed a significant association with complications (p = 0.010). Patients with complications required more time to resume normal activities.The stone-free rate was an impressive 92%, reflecting the effectiveness of the procedure, and it was statistically significant (p = 0.015). Achieving high stone clearance rates is a key indicator of procedural success.Post-operative complications were observed in 28% of patients (p = 0.023), with infections (14%), bleeding requiring transfusion (7%), and reintervention (5%) being the most common complications. These findings suggest that while PCNL is generally safe, complications do occur and must be carefully managed.

Complication Assessment Using Clavien-Dindo Classification (Table 5)

Using the Clavien-Dindo Classification, most complications were classified as Grade I (12%) and Grade II (10%), representing minor complications managed conservatively or with pharmacological interventions.Severe complications, including Grade IIIa (3%), Grade IIIb (2%), and Grade IVa (1%), were relatively rare. No cases of Grade IVb or V (death) were reported.These findings emphasize the overall safety of PCNL under SAB, with most complications being minor and manageable without invasive interventions.

Multiple Regression Analysis (Table 6)

The multiple regression analysis revealed that several independent variables were significantly associated with complications in patients undergoing **Percutaneous Nephrolithotomy (PCNL) under Spinal Anesthesia Block (SAB)**. The model was statistically significant (**$p < 0.001$**) with an **R^2 value of 0.62**, indicating that these variables explained **62% of the variation in complications**. Age was identified as a significant predictor, with older patients showing a higher risk of complications. Similarly, a higher BMI was positively associated with an increased likelihood of complications. Stone size emerged as the strongest predictor, with larger stones significantly increasing the risk. Surgery duration also played a key role, as longer procedures were linked to a higher chance of complications. Increased blood loss during surgery was another contributing factor, reflecting the impact of intraoperative hemodynamic changes on patient outcomes. Furthermore, the presence of comorbidities, such as diabetes or hypertension, was associated with an elevated risk of complications. These findings emphasize that age, BMI, stone size, surgery duration, blood loss, and comorbidities are independent and significant predictors of complications, highlighting the need for meticulous preoperative assessment, procedural efficiency, and vigilant post-operative care to minimize risks and improve patient outcomes.

Table 1: Patient Demographic Characteristics

Variable	Number (Mean ± SD)	Percentage (%)	p-Value
Age (years)	47.5 ± 11.8	-	0.014*
Sex (Male)	60	60%	0.221
Sex (Female)	40	40%	-
BMI (kg/m²)	25.8 ± 3.4	-	0.031*
Comorbidities	32	32%	0.017*
Hypertension	18	18%	-
Diabetes Mellitus	14	14%	-
Smoking History	22	22%	-

Table 2: Stone Characteristics

Variable	Number (Mean ± SD)	Percentage (%)	p-Value
Stone Size (mm)	18.4 ± 4.7	-	0.002*
Stone Location:			
Upper Pole	38	38%	0.041*
Middle Pole	35	35%	-
Lower Pole	27	27%	-
Stone Composition:			
Calcium Oxalate	55	55%	-
Uric Acid	30	30%	-
Struvite	15	15%	-

DOI: 10.69605/ijlbpr_13.12.2024.159

Table 3: Operative and Anesthesia Details

Variable	Number (Mean ± SD)	Percentage (%)	p-Value
Surgery Duration (mins)	88.2 ± 15.6	-	0.003*
Anesthesia Duration (mins)	102.4 ± 18.3	-	0.005*
Blood Loss (mL)	150.6 ± 30.5	-	0.002*
Intraoperative Complications	12	12%	0.045*

Table 4: Post-Operative Outcomes

Variable	Number (Mean ± SD)	Percentage (%)	p-Value
Length of Hospital Stay (days)	4.5 ± 1.7	-	0.004*
Recovery Time (days)	12.3 ± 3.5	-	0.010*
Stone-Free Rate	92	92%	0.015*
Post-Operative Complications	28	28%	0.023*
Infection (UTI/Sepsis)	14	14%	-
Bleeding (Transfusion)	7	7%	-
Reintervention Required	5	5%	-

Table 5: Complication Assessment Using Clavien-Dindo Classification

Grade (Clavien-Dindo)	Number (n)	Percentage (%)
Grade I	12	12%
Grade II	10	10%
Grade IIIa	3	3%
Grade IIIb	2	2%
Grade IVa	1	1%
Grade IVb	0	0%
Grade V	0	0%

Table 6: Multiple Regression Analysis of Factors Associated with Complications in PCNL Under Spinal Anesthesia Block (SAB)

Independent Variable	Regression Coefficient (β)	Standard Error	t-Value	p-Value	95% Confidence Interval
Age (years)	0.215	0.078	2.75	0.007*	(0.061, 0.369)
BMI (kg/m²)	0.183	0.069	2.65	0.010*	(0.047, 0.319)
Stone Size (mm)	0.298	0.085	3.51	0.001*	(0.130, 0.466)
Surgery Duration (mins)	0.256	0.080	3.20	0.002*	(0.098, 0.414)
Blood Loss (mL)	0.145	0.072	2.01	0.047*	(0.002, 0.288)
Comorbidities (Yes/No)	0.194	0.081	2.40	0.018*	(0.033, 0.354)
Constant (Intercept)	0.870	0.256	3.40	0.001*	(0.367, 1.373)

Discussion

This study provides a comprehensive analysis of factors contributing to complications in patients undergoing Percutaneous Nephrolithotomy (PCNL) under Spinal Anesthesia Block (SAB).

In terms of patient demographics, our study observed a mean age of 47.5 ± 11.8 years, with older age significantly associated with increased complications ($p = 0.014$). Similar findings were reported by Haloi et al. (2024), where age was also identified as a significant predictor of complications, suggesting that older patients are at higher risk due to reduced physiological reserves and increased comorbidities.[9]In our cohort, 60% of patients were male, aligning with Jamil et al. (2023), where males constituted 66.3% of the study population. This male predominance reflects the higher prevalence of kidney stones in men globally.10 The mean BMI in our study was 25.8 ± 3.4 kg/m², with higher BMI significantly linked to complications ($p = 0.031$).[10] This result is consistent with surgical outcomes observed in other studies, where higher BMI was associated with longer operative times, increased blood loss, and higher rates of infection. Comorbidities were present in 32% of our patients, primarily hypertension (18%), diabetes mellitus (14%), and smoking history (22%). The association between comorbidities and complications ($p = 0.017$) has also been reported by Mukherjee and Singh (2019), emphasizing the importance of preoperative optimization in patients with existing medical conditions.[11]

Regarding stone characteristics, the mean stone size in our study was 18.4 ± 4.7 mm, with larger stones significantly associated with complications ($p = 0.002$). Kamal et al. (2017) similarly reported that larger stone size was linked to prolonged surgeries, increased blood loss, and higher rates of complications. In our study, 38% of stones were located in the upper pole, followed by 35% in the middle pole and 27% in the lower pole, with location

DOI: 10.69605/ijlbpr_13.12.2024.159

showing a significant association with complications (*p = 0.041*). Stones in the lower pole are known to be more difficult to access, often requiring prolonged surgical manipulation. In terms of composition, calcium oxalate stones (55%) were the most common, followed by uric acid (30%) and struvite stones (15%). Although stone composition did not show statistical significance with complications, similar findings regarding calcium oxalate predominance have been reported in global urolithiasis studies.[12]

The operative and anesthesia details revealed that the mean surgery duration was 88.2 ± 15.6 minutes, and longer operative times were significantly associated with complications (*p = 0.003*). Jamil et al. (2023) reported a shorter mean operative time of 65 ± 2.9 minutes in their cohort, suggesting that prolonged operative durations may increase risks due to extended anesthesia exposure and surgical manipulation. The mean anesthesia duration was 102.4 ± 18.3 minutes, with longer durations showing a significant association with complications (*p = 0.005*).[10] Increased anesthesia duration could indicate challenging surgical scenarios or prolonged hemodynamic instability. The mean intraoperative blood loss was 150.6 ± 30.5 mL, with higher blood loss significantly linked to complications (*p = 0.002*). This finding is consistent with Kamal et al. (2017), who noted that higher blood loss often necessitated transfusions and increased the risk of post-operative infections.[12] Intraoperative complications occurred in 12% of patients, aligning with Jamil et al. (2023), who reported a 3% hypotension rate and 1.56% nausea/vomiting rate during SAB.[10]

Post-operative outcomes in our study demonstrated a mean hospital stay of 4.5 ± 1.7 days, which was significantly associated with complications (*p = 0.004*). Longer hospital stays are often indicative of delayed recovery, infections, or other post-operative concerns. Mukherjee and Singh (2019) reported a mean hospital stay of 9 days, suggesting variability based on institutional protocols and patient populations. The mean recovery time was 12.3 ± 3.5 days, with complications significantly prolonging recovery (*p = 0.010*). Our study achieved an impressive stone-free rate of 92%, which was significantly associated with fewer complications (*p = 0.015*). This result is consistent with Kamal et al. (2017), who reported a 90% stone-free rate in their analysis.[12]Post-operative complications were observed in 28% of our patients, with 14% infections, 7% bleeding requiring transfusion, and 5% requiring reintervention. Jamil et al. (2023) reported comparable rates, with fever in 11.23% and transfusions in 3.5% of cases.[10]

Recent studies have extensively evaluated complications in Percutaneous Nephrolithotomy (PCNL) using the Clavien-Dindo Classification (CDC), and the results align closely with our findings. A study by Haberal et al. (2024) reported that the majority of complications following PCNL under regional anesthesia were categorized as Grade I (13%) and Grade II (9%), with severe complications, including Grade IIIa (4%) and Grade IIIb (2%), being relatively rare.[13] Similarly, Tian et al. (2024)analyzed complications in patients with complex renal stones and found a predominance of Grade I (15%) and Grade II (11%) complications, emphasizing that severe complications such as Grade IVa and Grade IVb remained uncommon. These findings align with our study, where Grade I (12%) and Grade II (10%) were the most frequently observed complications, and severe complications, including Grade IIIa (3%), Grade IIIb (2%), and Grade IVa (1%), were minimal. Importantly, no Grade IVb or V (death) complications were recorded, highlighting the overall safety and effectiveness of PCNL under regional anesthesia.[14]

In the context of multiple regression analysis, our study identified age, BMI, stone size, surgery duration, blood loss, and comorbidities as significant predictors of complications, collectively explaining 62% of the variation ($R^2 = 0.62$). Zhang et al. (2024) similarly reported that stone size, surgery duration, and comorbidities were strong predictors of post-PCNL complications, with larger stones and prolonged operative times being associated with higher complication rates.[15] Another study by Qiu and Hu (2024) focused on predictors of significant bleeding during PCNL and identified operative duration, stone burden, and patient comorbidities as critical factors influencing intraoperative and postoperative outcomes. These findings mirror our results, where blood loss and surgery duration emerged as significant independent predictors of complications.[16]Additionally, Wang et al. (2023) found that patients with higher BMI and advanced age had a significantly increased risk of developing complications during and after PCNL, underscoring the importance of patient-specific risk stratification in clinical practice.[17]

Further supporting our findings, Lin et al. (2023) highlighted the role of intraoperative blood loss and stone size as major contributors to postoperative complications. Their study emphasized the importance of maintaining hemodynamic stability during prolonged surgical procedures to minimize adverse outcomes.[18] Moreover, Park et al. (2022)suggested that comorbidities such as diabetes and hypertension significantly increase the risk of post-PCNL complications, reinforcing our observation that these medical conditions independently elevate complication risks. The collective results from these studies strengthen our conclusion that age, BMI, stone size, surgery duration, blood loss, and comorbidities are robust predictors of complications in PCNL under regional anesthesia.[19]

Conclusion

In conclusion, this study highlights the safety and effectiveness of Percutaneous Nephrolithotomy (PCNL) under Spinal Anesthesia Block (SAB), with

DOI: 10.69605/ijlbpr_13.12.2024.159

most complications classified as minor (Grade I and II) and severe complications being rare. Independent predictors of complications included age, BMI, stone size, surgery duration, blood loss, and comorbidities, collectively explaining a significant proportion of outcome variability. These findings emphasize the importance of thorough preoperative assessment, intraoperative vigilance, and postoperative care to minimize risks and optimize patient outcomes. Future prospective studies with larger sample sizes are recommended to further refine risk prediction models and enhance patient safety protocols in PCNL under regional anesthesia.

References

1. Li S, Zeng F, Li Z, Wang Y, Chen J, Liu H. Comparison of the Efficacy and Safety of Percutaneous Nephrolithotomy under Spinal versus General Anesthesia: A Meta-Analysis. *Int J Clin Exp Med*. 2017;10(2):2932-2942.
2. Aksoy Y, Gülpınar MT, Gümüş E, Arslan M, Özkaya F, Arslan B, Karaoğlu S. Percutaneous Nephrolithotomy under Regional versus General Anesthesia: Efficacy and Safety in Geriatric Patients. *Urol Int*. 2018;100(1):77-83. doi:10.1159/000484606.
3. Kumar A, Gupta V, Sinha RJ, Kapoor R, Singh V, Pandey A. Prospective Randomized Comparison of Spinal versus General Anesthesia for Percutaneous Nephrolithotomy: Evaluation of Complications, Recovery Parameters, and Stone Clearance Rates. *J Endourol*. 2018;32(5):371-376. doi:10.1089/end.2017.0865.
4. Yadav R, Jain S, Tomar V, Mishra P, Gupta A, Singh S. Comparative Study of Percutaneous Nephrolithotomy under Spinal and General Anesthesia: A Single-Center Experience. *Urol Ann*. 2019;11(3):276-281. doi:10.4103/UA.UA_4_19.
5. El-Husseiny T, Moraitis K, Maan Z, Ghani KR, Saad S, Khattab A. Safety and Efficacy of Percutaneous Nephrolithotomy under Regional Anesthesia: A Comparative Study. *Urolithiasis*. 2020;48(1):69-75. doi:10.1007/s00240-019-01150-1.
6. Basiri A, Kashi AH, Mehrabi S, Mokhtari G, Zare S, Dadkhah F. Regional Anesthesia in Percutaneous Nephrolithotomy: A Randomized Clinical Trial. *Urol J*. 2021;18(1):1-6. doi:10.22037/uj.v18i.6100.
7. Gonen M, Cenker A, Goktas C, Demirci D, Kara O, Sancar B. Comparison of Spinal and General Anesthesia in Percutaneous Nephrolithotomy: A Matched-Pair Analysis. *J Endourol*. 2022;36(4):467-472. doi:10.1089/end.2021.0845.
8. Patel HD, Okhunov Z, Clayman RV, Ramaswamy K, Ramasamy S, Smith A. Nephrolithotomy Techniques: An Update on Outcomes and Complications. *Curr Opin Urol*. 2023;33(2):120-126. doi:10.1097/MOU.0000000000000901.
9. Haloi M, Biswas R, Bora A, Devi S. Efficacy of Thoracic Segmental Spinal Anaesthesia in Percutaneous Nephrolithotomy: A Retrospective Observational Study. J Clin Diagn Res. 2024;18(4):UC31-UC35.
10. Jamil MN, Asif M, Ashraf H, Islam E, Azam A, Bibi R. Supine Percutaneous Nephrolithotomy Under Spinal Anaesthesia: Our Experience of 365 Cases. Pak J Med Health Sci. 2023;17(3):189.
11. Mukherjee A, Singh A. Assessment of Surgical Outcomes and Complications between Spinal and General Anesthesia for Patients Undergoing Percutaneous Nephrolithotomy: A Comparative Study. Int J Urol Sci. 2019;11(2):75-80.
12. Kamal BA, Anwar K, Bhat MA, et al. Percutaneous Nephrolithotomy under Spinal Anesthesia: A Study of 300 Cases. J Endourol. 2017;31(5):520-523.
13. Haberal T, Yilmaz B, Demir O, Aydin C, Korkmaz I, Yildirim A. Analysis of Complications Following Percutaneous Nephrolithotomy Under Regional Anesthesia Using Clavien-Dindo Classification. Urol Int. 2024;112(2):145-152. doi:10.1159/000530245.
14. Tian Y, Xu J, Li Y, Zhang K, Huang Q, Wang P. Complications and Outcomes of Percutaneous Nephrolithotomy for Complex Renal Stones Under Regional Anesthesia: A Prospective Study. World J Urol. 2024;42(1):67-74. doi:10.1007/s00345-023-04287-0.
15. Zhang H, Chen S, Liu Q, Li J, Huang T, Wang X. Predictors of Complications in Percutaneous Nephrolithotomy: A Comprehensive Analysis Using Regression Models. J Endourol. 2024;38(3):325-332. doi:10.1089/end.2023.0934.
16. Qiu X, Hu Z. Predictive Factors for Major Bleeding in Patients Undergoing Percutaneous Nephrolithotomy: A Clinical Prediction Study. Int J Urol. 2024;31(2):148-155. doi:10.1111/iju.15035.
17. Wang J, Luo Y, Zhang Z, Li S, Chen W, Zhou H. Risk Stratification and Prediction of Complications Following Percutaneous Nephrolithotomy Under Regional Anesthesia: A Prospective Cohort Study. Asian J Urol. 2023;10(3):221-228. doi:10.1016/j.ajur.2023.05.002.
18. Lin F, Zhao Y, Wang Q, Jiang Y, Zhang H, He X. The Impact of Intraoperative Blood Loss and Stone Size on Postoperative Complications in Patients Undergoing PCNL Under Regional Anesthesia. Urolithiasis. 2023;51(4):413-420. doi:10.1007/s00240-023-01560-6.
19. Park Y, Kim D, Choi S, Lee J, Jeon J, Lim S. Influence of Comorbidities on Postoperative Outcomes and Complications in Percutaneous Nephrolithotomy Under Regional Anesthesia. Urol Ann. 2022;14(2):151-157. doi:10.4103/UA.UA_112_21.