Published Online: 2025 September 8 **Research Article**

Investigating the Factors Related to the Amount of Bleeding Due to Percutaneous Nephrolithotomy (PCNL)

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Received: 15 July, 2025; **Revised:** 19 August, 2025; **Accepted:** 30 August, 2025

Abstract

Background: Hemorrhage remains a major concern during percutaneous nephrolithotomy (PCNL). The present study focused on determining the contributing factors to blood loss throughout the procedure.

Methods: In this prospective study, we assessed 412 individuals who underwent PCNL at our center from June 2020 to June 2024. Hemoglobin drop post-surgery, adjusted for transfused blood volume, was used to estimate total blood loss. A stepwise multivariate regression model was applied to explore the correlations between bleeding volume or transfusion requirement and multiple patient-specific or procedural variables.

Results: The average hemoglobin reduction observed was 1.57 ± 2.43 g/dL. Significant predictors of blood loss included Body Mass Index (BMI) ($P < 0.05$), stone dimensions ($P < 0.05$), presence of multiple stones ($P < 0.05$), upper calyceal stone location ($P < 0.05$), insertion of two or more nephrostomy tubes ($P < 0.05$), surgery duration ($P < 0.05$), and diabetes ($P < 0.05$). A transfusion was required in 3.5% of patients.

Conclusions: Increased intraoperative blood loss following PCNL was significantly associated with higher BMI, greater stone burden, multiple stones, upper calyceal location, prolonged surgical time, multiple nephrostomy insertions, and diabetes mellitus.

Keywords: Blood Loss, Risk Factors, Percutaneous Nephrolithotomy, PCNL Complications

1. Background

Since the initial report of renal stone extraction via nephrostomy by Rupel and Brown in 1941, substantial progress has been achieved in both technique and equipment. The introduction of percutaneous nephrolithotomy (PCNL) by Fernstrom and Johansson in 1976 marked a pivotal advancement, later enhanced by Alken et al. through the development of renal endoscopes and ultrasonic lithotripters. While extracorporeal shock wave lithotripsy (ESWL) and flexible ureteroscopy are common modalities for treating nephrolithiasis, PCNL remains the preferred option in specific scenarios determined by stone size, location, morphology, and composition (1-3).

The PCNL is associated with complication rates ranging from 29% to 83%, including hemorrhage, renal system injury, infection, gastrointestinal tract perforation, vascular trauma, and pneumothorax (4). Among these, renal hemorrhage post-surgery is a particularly frequent and concerning complication, with perioperative bleeding reported in 7.5% to 23% of cases (5-7). Although most bleeding events can be

How to Cite: Mousapour E, Jafari S, Haghiabi H, Alishushtari A, Karimi A, et al. Investigating the Factors Related to the Amount of Bleeding Due to Percutaneous Nephrolithotomy (PCNL). Nephro-Urol Mon. 2025; 17 (4): e164152. https://doi.org/10.5812/numonthly-164152.

managed conservatively, approximately 0.8% of patients require invasive hemostatic interventions (8). Consequently, surgeons must be prepared to identify and address both intraoperative and postoperative complications effectively.

Several studies have identified potential bleeding risk factors, such as diabetes, staghorn calculi, dilation method, and stone burden (5, 9). Additionally, variables like Body Mass Index (BMI), stone location, surgery duration, presence or absence of hydronephrosis, and the number of access tracts have also been implicated, though findings remain inconsistent (10, 11).

2. Objectives

The present study aimed to clarify the predictive variables associated with bleeding in patients undergoing PCNL at Imam Khomeini Hospital, affiliated with Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran, through a retrospective analysis.

3. Methods

This retrospective study analyzed 412 patients who underwent PCNL at Imam Khomeini Hospital in Ahvaz between January 2020 and January 2024. All procedures were conducted by a single experienced surgeon to ensure consistency. The average stone size was calculated by measuring the surface area of each patient's renal calculi. All participants received prophylactic intravenous antibiotics 24 to 48 hours before surgery. A 5-French balloon catheter was positioned at the ureteropelvic junction to prevent the migration of stone fragments into the ureter during the procedure. Nephrostomy access was established using a guidewire, and lithotripsy was subsequently performed to fragment and remove the stones. The median intraoperative blood loss was determined to be 476.2 mL.

Patients were stratified into two groups:

- Group 1 (n = 206): Blood loss below the median

- Group 2 (n = 206): Blood loss above the median

Blood loss was estimated by evaluating postoperative hemoglobin decline, adjusted for any transfused blood volume. A stepwise multivariate regression model was used to explore associations between blood loss or transfusion requirements and several patient and procedural variables.

3.1. Statistical Analysis

Data analysis was performed using SPSS version 16. A Student's *t*-test was utilized to compare continuous variables such as stone size and BMI, while categorical variables were assessed using the chi-square test. For multivariate analysis, logistic regression was applied. A P-value less than 0.05 was considered statistically significant.

4. Results

Out of the total 412 participants, 285 were male (69.17%) and 127 were female (30.83%), with an average age of 47.6 years (range, 26 - 77 years). The mean stone burden across all patients was 401.09 ± 198.13 mm^2 (Table 1).

The average age in group 1 was 47.43 ± 18.72 years, while in group 2 it was 49.41 ± 19.21 years. This difference was not statistically significant (P = 0.36). Group 1 included 183 male and 23 female patients, whereas group 2 consisted of 178 male and 28 female patients. The mean estimated blood loss was 250.21 ± 161.32 mL in group 1 and 698.56 ± 203.19 mL in group 2. Additionally, BMI was significantly higher in group 2 (25.11 ± 2.48 kg/m^2) compared to group 1 (22.32 ± 2.11 kg/m^2), with a P-value of 0.02.

Stone size averaged 242.12 ± 197.34 mm^2 in group 1 and 529.44 ± 211.56 mm^2 in group 2, indicating a significantly larger stone burden in the latter group (P = 0.01). The frequency of stones located in the upper calyces was also significantly higher in group 2 (P = 0.03). When comparing stone multiplicity, group 1 had 113 patients with single stones and 93 with multiple stones. In contrast, group 2 had 65 patients with single stones and 141 with multiple stones. The difference was statistically significant (P = 0.01), suggesting a greater bleeding risk with multiple calculi.

Surgical duration was considerably longer in group 2, averaging 134.75 ± 39.18 minutes, as opposed to 67.54 ± 21.94 minutes in group 1 (P = 0.01). Furthermore, the incidence of multiple nephrostomy accesses was significantly higher in group 2 (P = 0.01). Underlying medical conditions, including diabetes mellitus, were more prevalent in group 2, with a statistically significant difference observed between the two groups. Additionally, patients with a prior history of PCNL were more frequently represented in group 2, also with a significant difference (Table 2).

5. Discussion

Our findings demonstrated a mean reduction in hemoglobin of 2.43 ± 1.57 g/dL following PCNL. Several variables showed a statistically significant association with increased intraoperative bleeding. These included

Table 1. Patients' Characteristics [a]

Characteristics	Values
Number of patients	412
Male	285 (69.17)
Female	127 (30.83)
Stone size (mm^2)	401.09 ± 198.13
BMI (k/m^2)	25.32 ± 3.09
Blood loss (mL)	
Mean ± SD	505.87 ± 276
Median	476.2

Abbreviation: BMI, Body Mass Index.

[a] Values are expressed as No. (%) or mean ± SD, unless otherwise indicated.

Table 2. Comparison of Clinical Findings Between Higher and Lesser Bleeding Groups [a]

Variables	Group 1	Group 2	P-Value
Blood loss (mL)	250.21 ± 161.32	698.56 ± 203.19	0.00
Sex			0.87
Male	183	178	
Female	23	28	
Age (y)	47.43 ± 18.72	49.41 ± 19.21	0.36
BMI	22.32 ± 2.11	25.11 ± 2.48	0.02
Stone position			
Staghorn	40 (19.4)	35 (17.0)	0.97
Upper ureter	65 (31.6)	24 (11.7)	0.89
Renal pelvis	43 (20.9)	36 (17.5)	0.93
Calyceal	31 (28.1)	111 (53.9)	0.03
Diabetes	6 (2.9)	21 (10.2)	0.02
Stone size (mm^2)	242.12 ± 197.34	529.44 ± 211.56	0.01
Number of stone			0.01
Single	113 (54.9)	65 (31.6)	
Multiple	93 (45.1)	141 (68.4)	
Multiple access tracts	23 (11.16)	65 (31.55)	0.01
Previous PCNL	6 (2.9)	17 (8.3)	0.02
Operative time (min)	67.54 ± 21.94	134.75 ± 39.18	0.01

Abbreviations: BMI, Body Mass Index; PCNL, percutaneous nephrolithotomy.

[a] Values are expressed as No. (%) or mean ± SD.

elevated BMI, larger and multiple stones, upper calyceal location, use of multiple nephrostomy tracts, prolonged operative time, previous history of PCNL, and comorbid diabetes. The PCNL remains the standard treatment modality for renal stones larger than 20 mm, although recent miniaturized techniques have extended its application to smaller calculi as well. Despite its effectiveness, PCNL carries the risk of complications, with hemorrhage being one of the most critical. In our cohort, the transfusion rate was 3.5%, aligning with previously reported ranges of 3% to 23% (4, 12-17).

Diabetes mellitus, with a national prevalence of 18% in Malaysia (18), has been implicated in increased bleeding during PCNL. Akman et al. (9) previously reported a significant correlation between diabetes and transfusion requirements. However, subsequent studies have presented conflicting evidence (13, 19). In our study, diabetic patients exhibited greater hemoglobin deficits, supporting the association between this comorbidity and heightened bleeding risk.

In complex stone cases, multiple access tracts are often necessary for adequate stone clearance. However,

creating several percutaneous entries may lead to renal parenchymal damage and vascular injury, thereby increasing the potential for hemorrhage. Our analysis corroborated findings from prior investigations identifying multiple access tracts as an independent risk factor for bleeding (8, 13, 20), although some studies have failed to show this association (14, 21). Furthermore, our results indicated that prolonged surgery duration and a history of prior PCNL procedures were linked to greater blood loss. These findings mirror those of Loo et al. (22), who highlighted stone characteristics — such as size, number, and anatomical position — as influential in predicting bleeding severity.

5.1. Conclusions

In summary, factors such as higher BMI, larger stone size, multiple stones, upper calyceal location, use of multiple nephrostomy tubes, extended operative duration, and the presence of diabetes mellitus significantly contributed to increased blood loss during PCNL. Recognizing these predictors can aid clinicians in risk stratification and perioperative planning to minimize hemorrhagic complications.

Acknowledgements

The authors sincerely thank the Research Council of Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran, for their financial support.

Footnotes

Authors' Contribution: Study concept and design: E. M.; Acquisition of data: S. J.; Analysis and interpretation of data: H. H.; Drafting of the manuscript: S. R. A.; Critical revision of the manuscript for important intellectual content: S. R. A. and A. K. B. A.; Statistical analysis: A. A.; Administrative, technical, and material support: AJUMS; Study supervision: S. R. A. and E. M.

Conflict of Interests Statement: The authors declare no conflict of interests.

Data Availability: The dataset presented in the study is available on request from the corresponding author during submission or after publication.

Ethical Approval: IR.AJUMS.REC.1402.095 .

Funding/Support: The present study was financially supported by Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran.

Informed Consent: The research is based solely on the information in the file and no intervention is made in the patient's treatment process. In addition, the patient's information will remain confidential. The patient's information and identity will remain completely confidential. No costs will be paid by the patient.

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