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# THE ASSOCIATION BETWEEN RENAL STONE COMPLEXITY AND THE AMOUNT OF POSTOPERATIVE BLEEDING FOLLOWING PERCUTANEOUS NEPHROLITHOTOMY

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## ABSTRACT

**Background:** Percutaneous Nephrolithotomy (PCNL) is the primary therapy for large or complex kidney stones. Although effective, postoperative bleeding remains one of the most frequent major complications, with hemoglobin reduction (ΔHb) serving as an objective indicator of blood loss. Kidney stone complexity is suspected to play a significant role in determining the severity of bleeding. **Objective:** To evaluate the association between kidney stone complexity and the degree of bleeding following PCNL.
**Methods:** This analytical observational study employed a cross-sectional design involving 58 nephrolithiasis patients undergoing PCNL at RSUP Prof. Ngoerah, RS Surya Husadha, and RS Bali Royal Hospital in 2024. Stone complexity was classified as staghorn and non-staghorn. Bleeding severity was determined based on ΔHb, with ≤1 g/dL categorized as mild bleeding and >1 g/dL as severe bleeding. The Chi-Square test was used to assess the association, with statistical significance set at $p < 0.05$.
**Results:** Most patients had non-staghorn kidney stones (53.4%), and severe bleeding was observed in 62.1% of subjects. A significant association was found between stone complexity and bleeding severity ($p = 0.021$). Patients with staghorn stones demonstrated a higher proportion of severe bleeding (77.8%), whereas mild bleeding was more commonly observed in the non-staghorn group (51.6%).
**Conclusion:** Kidney stone complexity is significantly associated with increased bleeding severity following PCNL. Stone complexity should therefore be considered an important factor in operative planning and risk management strategies for bleeding.

**Keywords: Bleeding, hemoglobin reduction, kidney stone complexity, nephrolithiasis, PCNL, staghorn stone**

## INTRODUCTION

Kidney stones, medically referred to as nephrolithiasis, were defined as the formation of solid, stone-like masses within the kidneys resulting from the crystallization of salts or other minerals contained in the urine.[1] Kidney stones generally did not cause symptoms when the stones were small and could be passed spontaneously. Clinical symptoms usually developed when the diameter of the stone exceeded that of the downstream urinary tract, particularly the ureter.[2] When large kidney stones migrated from the kidney into the urinary tract system, such as the ureter, urinary bladder, and urethra, the risk of obstruction of normal urine flow increased, leading to pain, discomfort, and renal colic. This condition was referred to as urolithiasis.[3]

Kidney stone disease was a common condition worldwide. A study on global prevalence patterns reported an increasing trend in kidney stone prevalence over the past several decades. Current estimates indicated that the prevalence of kidney stones ranged from 5–10% in Europe, approximately 4% in South America, and 1–19% in Asia.[4] In Indonesia, kidney stones continue to be one of the most prevalent urological conditions following urinary tract infections and benign prostatic hyperplasia (BPH). To date, no study had described the national prevalence of kidney stones in Indonesia. However, data from the 2013 Basic Health Research (Riskesdas) reported a prevalence of urinary tract stones of 0.6% in the general population, with the highest prevalence observed in Yogyakarta at 1.2%.[5] These findings indicated that kidney stones

continued to represent a significant public health problem in Indonesia.

The management of kidney stones varied according to multiple parameters and was individualized for each patient, generally involving a combination of conservative management, medical intervention, and surgical procedures. More specific treatment strategies depended on factors such as stone size, stone location, stone composition, patient symptoms, and the overall medical history of the patient.[6] According to the latest guidelines from the American and European Urological Associations, symptomatic patients with stones measuring 20 mm or larger and with complex stone characteristics were recommended to undergo minimally invasive intervention using percutaneous nephrolithotomy (PCNL), which was considered the first-line treatment for this condition (Ibrahim et al., 2018). Compared with other treatment modalities, PCNL was substantially more effective for managing kidney stones larger than 20 mm. In addition, PCNL has come to be as the favored treatment choice due to its impressive success rate, minimal recurrence rate, and comparatively lower cost.[7] Over the past 25 years, PCNL had remained the primary treatment choice for kidney stones because of its benefits in preserving optimal renal function.[8,9]

Nevertheless, complications associated with PCNL could still occur. Based on an analysis of 31 studies, the lowest average complication rate was reported for PCNL at 13.8%, followed by shock wave lithotripsy (SWL) at 15.4%, while the highest complication rate was observed with retrograde intrarenal surgery (RIRS) at 18.3%. Reported complications included bleeding, infection, injury to surrounding organs, as well as procedure-specific complications such as urinary tract obstruction, pneumothorax, hematoma, and seroma.[10]

In a systematic study conducted by Antonio and colleagues, which analyzed 356 reported events, 13 intraoperative complications were identified, six of which were bleeding-related complications.[11] Despite recent advances in PCNL techniques, the risk of bleeding complications persisted due to potential blood loss during renal puncture, tract dilation, and stone fragmentation. Bleeding following PCNL could become a serious, life-threatening condition that required additional medical interventions.[12] A study by Bartoletti et al. concluded that stone burden was the only predictable factor associated with the risk of post-PCNL bleeding. This result was consistent with a retrospective study by Hu et al., which reported that staghorn stones contributed to nearly a threefold increase in the risk of severe bleeding following PCNL.[13] Therefore, this literature review was conducted to examine the association between kidney stone complexity and post-procedural bleeding following percutaneous nephrolithotomy.

## OBJECTIVE

The objective of this study was to evaluate differences in hemoglobin level reduction between patients with staghorn and non-staghorn kidney stones following percutaneous nephrolithotomy (PCNL), and to analyze the association between kidney stone complexity and the degree of post-PCNL bleeding.

## METHODS

An analytical observational study using a cross-sectional design was used in this study. Secondary data was gathered from medical records of patients who underwent percutaneous nephrolithotomy (PCNL) at RSUP Prof. Ngoerah, RS Surya Husadha Denpasar, and Bali Royal Hospital during the 2024 calendar year. The study procedures, data collection and analysis were performed between January and August 2025.

Medical records of adult patients (aged ≥18 years) who underwent PCNL during 2024 at the three participating hospitals comprised the study population. Records were eligible if they contained the essential preoperative and postoperative parameters required for the analysis (including pre- and post-operative hemoglobin values and radiologic documentation of stone morphology). Records from patients with documented coagulation disorders, a history of diabetes mellitus, or chronic kidney disease were excluded.

The minimum sample size was calculated using the Lemeshow formula for comparison of two proportions. Assuming a proportion of bleeding/transfusion of 40% in the staghorn group and 10% in the non-staghorn group, $\alpha = 0.05$ and power = 80%, the required sample size was 29 subjects per group (total n = 58). Purposive sampling was applied to select records that fulfilled the inclusion and exclusion criteria.

The independent variable of this study was renal stone complexity, which was determined based on preoperative radiological findings documented in the medical records. Stone complexity was classified into staghorn and non-staghorn stones. Staghorn stones were defined as calculi occupying the renal pelvis and extending into at least two calyces with a branching configuration, whereas non-staghorn stones included solitary or multiple renal calculi that did not exhibit a staghorn morphology.

The dependent variable was postoperative bleeding following percutaneous nephrolithotomy, which was assessed using the change in hemoglobin level (ΔHb). The hemoglobin difference was calculated by subtracting the postoperative hemoglobin value from the preoperative value (Hb_pre − Hb_post) and expressed in g/dL. Based on this value, postoperative bleeding was categorized into mild bleeding, defined as a hemoglobin decrease of ≤1.0 g/dL, and severe bleeding, defined as a hemoglobin decrease of >1.0 g/dL, in accordance with previously published criteria.

After obtaining institutional permissions and ethical approval, investigator(s) accessed hospital medical record units and extracted data using a standardized data extraction form. Extracted variables included demographic data, stone morphology from preoperative imaging, pre- and post-operative hemoglobin values, operative duration, and any documented transfusion events or intraoperative complications. Data were entered into Microsoft Excel, checked for completeness and consistency (editing and cleaning), coded, and subsequently imported into SPSS for analysis.

Descriptive statistics were applied to summarize sample characteristics: categorical variables were shown as frequency and percentage, while continuous variables were reported as mean ± standard deviation (or median and interquartile range if not normally distributed). The association between stone complexity (staghorn vs non-staghorn) and bleeding category (mild vs severe)

was evaluated using the Chi-square test. A two-sided p-value < 0.05 was considered statistically significant. Analyses were performed using IBM SPSS (version as available at the time of analysis).

The study used retrospective, anonymized medical record data. The institutional ethics committee granted ethical approval prior to data collection (ethical clearance number as recorded in the study documentation). Permissions were secured from each participating hospital to access and analyze de-identified patient records.

## RESULT

### Sample Profile

Based on the study design examining the association between renal stone complexity and postoperative bleeding following percutaneous nephrolithotomy (PCNL), data were obtained from the medical records of patients with nephrolithiasis who underwent PCNL at RSUP Prof. Ngoerah, RS Surya Husadha Denpasar, and Bali Royal Hospital during the year 2024. A total population of 114 individuals was identified. Of these, 58 individuals met the inclusion criteria and were included as study samples, while the remaining 56 individuals were excluded.

The study period and sample collection were conducted over five weeks, from October to November 2025. Data collection was performed periodically through the medical record systems of RSUP Prof. Ngoerah, RS Surya Husadha Denpasar, and Bali Royal Hospital, Bali. The study was conducted after obtaining ethical clearance approval (No. 1978/UN14.2.2.VII.14/LT/2025).

The variables collected in this study included sex, age, renal stone complexity classified as complex stones (staghorn or multiple stones) and non-complex stones (solitary stones) preoperative hemoglobin levels, postoperative hemoglobin levels, and operative duration. The collected data were recorded and organized using Microsoft Excel and subsequently analyzed using SPSS software to assess the distribution of each study variable.

### Descriptive Analysis of Study Variables

### Frequency Distribution of Participant Characteristics (Sex, Age, and Operative Duration)

Based on the data analysis presented in Table 1, most participants in this study were female (30 individuals, 51.7%). The majority of participants were classified as having non-staghorn stones (53.4%), which included solitary or multiple stones located in one or more renal calyces, while 46.6% of participants had staghorn renal stones. Regarding postoperative bleeding severity, 37.9% of participants experienced mild bleeding, whereas the majority of participants (62.1%) experienced severe bleeding.

**Table 1.** Frequency Distribution of Samples Based on Sex, Renal Stone Complexity, and Bleeding Severity

| Variable | n | % |
|---|---|---|
| **Sex** | 58 | 100.0 |
| Male | 28 | 48.3 |
| Female | 30 | 51.7 |
| **Renal Stone Complexity** | 58 | 100.0 |
| Staghorn | 27 | 46.6 |
| Non-staghorn | 31 | 53.4 |
| **Bleeding Severity** | 58 | 100.0 |
| Mild | 22 | 37.9 |
| Severe | 36 | 62.1 |

According to the data analysis shown in Table 2, the youngest participant was 23 years old and the oldest was 72 years old. The mean age of the participants was 49.07 years, with a standard deviation of 11.176 years.

The shortest operative duration was 20 minutes, while the longest operative duration reached 180 minutes. The mean operative duration among all participants was 74.55 minutes, with a standard deviation of 32 minutes.

Preoperative hemoglobin levels ranged from 10.20 g/dL to 16.80 g/dL, with a mean value of 12.76 g/dL and a standard deviation of 1.42 g/dL. Postoperative hemoglobin levels ranged from 8.10 g/dL to 16.0 g/dL, with a mean value of 11.31 g/dL and a standard deviation of 1.87 g/dL.

Based on these findings, the decrease in hemoglobin levels ranged from 1.0 g/dL to 4.0 g/dL. The mean hemoglobin reduction was 1.44 g/dL, with a standard deviation of 1.03 g/dL.

**Table 2.** Descriptive Statistics of Age, Operative Duration, and Hemoglobin Reduction


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| Variable | n | Minimum | Maximum | Mean | Standard Deviation |
|---|---|---|---|---|---|
| Age (years) | 58 | 23 | 72 | 49.07 | 11.176 |
| Operative duration (minutes) | 58 | 20.00 | 180.00 | 74.55 | 32.00 |
| Hemoglobin level | | | | | |
| Preoperative Hb (g/dL) | 58 | 10.20 | 16.80 | 12.76 | 1.42 |
| Postoperative Hb (g/dL) | 58 | 8.10 | 16.00 | 11.31 | 1.87 |
| Hemoglobin reduction (g/dL) | 58 | 0.10 | 4.00 | 1.45 | 1.03 |

**Bivariate Analysis (Chi-Square Test)**

Bivariate analysis was performed to determine whether a statistically significant association existed between renal stone complexity and postoperative bleeding among patients with nephrolithiasis who underwent percutaneous nephrolithotomy (PCNL) at RSUP Prof. Ngoerah, RS Surya Husadha Denpasar, and Bali Royal Hospital during the 2024 study period. Statistical analysis was conducted using crosstabulation followed by the Chi-square test, with a significance level set at 0.05.

**Table 3.** Association Between Renal Stone Complexity and Postoperative Bleeding

| Renal Stone Complexity | Bleeding Severity | | Total | *p* value |
|---|---|---|---|---|
| | Mild | Severe | | |
| **Staghorn** | 6 (22.2%) | 21 (77.8%) | 27 (100.0%) | 0.021 |
| **Non-staghorn** | 16 (51.6%) | 15 (48.4%) | 31 (100.0%) | |
| **Total** | 22 (37.9%) | 36 (62.1%) | 58 (100.0%) | |

Based on the crosstabulation analysis, of the 27 participants with staghorn renal stone complexity, the majority (77.8%) experienced severe postoperative bleeding. In contrast, among the 31 participants with non-staghorn renal stone complexity, 51.6% experienced mild postoperative bleeding.

The Chi-square test yielded a p value of 0.021. As the p value was less than 0.05, the association between the variables was statistically significant. Therefore, it was concluded that renal stone complexity, categorized based on staghorn and non-staghorn morphology, was significantly associated with the degree of hemoglobin reduction following percutaneous nephrolithotomy.

## DISSCUSION

### Participant Characteristics

The participant characteristics obtained in this study indicated that the majority were female (51.7%), while males accounted for 48.3% of the sample. The participants' average age was 49.07 years, with the youngest participant being 23 and the oldest being 72 years. This distribution reflected the general demographic characteristics of patients with nephrolithiasis, as kidney stone disease was commonly observed in individuals of productive age through to the elderly population.[14] These findings were also consistent with a previous study conducted by Tondok et al. at RSUP Kandou Manado in 2014, which reported that the 36–50-year age group constituted the largest proportion of patients with kidney stones.[15]

Most participants had non-staghorn renal stones (53.4%), whereas 46.6% had staghorn stones. Nevertheless, severe postoperative bleeding following PCNL predominated, accounting for 62.1% of cases, indicating that blood loss remained a relatively frequent complication of the procedure.

When bleeding severity was assessed based on hemoglobin reduction (ΔHb), the majority of patients experienced a hemoglobin decrease of more than 1 g/dL (62.1%). This finding illustrated that a considerable proportion of patients undergoing PCNL experienced a clinically relevant decline in hemoglobin levels. These results emphasized that postoperative bleeding was a common complication after PCNL and required careful clinical attention.

This condition highlighted the importance of postoperative hemoglobin monitoring, particularly in patients with staghorn stones, as this group exhibited a higher risk of significant blood loss and a potential need for transfusion if not optimally managed. Statistical analysis demonstrated a mean hemoglobin reduction of 1.449 g/dL, suggesting that, overall, PCNL procedures in this study were performed effectively with adequate bleeding control, as most blood loss remained below the clinically significant


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threshold of a hemoglobin decrease of 2 g/dL.[16] These findings may also reflected the application of meticulous surgical techniques, appropriate visual guidance, and operator expertise, all of which played a critical role in maintaining procedural safety.

**Association Between Renal Stone Complexity and Bleeding Severity**

Based on the Pearson Chi-square analysis, a p value of 0.021 was obtained. As this value was less than 0.05, it was statistically concluded that a significant association existed between renal stone complexity and the degree of blood loss, as assessed by postoperative hemoglobin reduction following PCNL. These findings indicated that stone complexity constituted one of the factors influencing the extent of blood loss during and after the procedure.

Clinically, this result was supported by the pattern observed in Table 3, in which patients with non-staghorn stones predominantly experienced mild bleeding (51.6%), whereas patients with staghorn stones demonstrated a substantially higher risk of severe bleeding (77.8%), characterized by a hemoglobin reduction exceeding 1 g/dL.

This pattern suggested that increasing stone complexity, in terms of both morphology and stone burden, was associated with a higher likelihood of significant bleeding, attributable to a wider intervention area and more extensive instrument manipulation.

Clinically, these findings were consistent with a study conducted by Ingratoeboen et al, which reported that among 49 patients with renal stones larger than 20 mm, six patients experienced a reduction in hemoglobin levels following PCNL.[17] The increased bleeding severity observed in patients with complex renal stones could be explained by several factors related to stone characteristics and PCNL technical aspects. In cases involving complex staghorn or multiple stones, the extensive stone surface area and branching into multiple renal calyces necessitated longer operative times and more intensive instrument manipulation. These conditions increased the risk of renal parenchymal trauma and subsequently elevated the likelihood of intraoperative bleeding.[18]

Furthermore, complex renal stones often required a greater number of percutaneous access tracts compared with solitary stones. Each additional access tract potentially created further injury to renal tissue and surrounding blood vessels, thereby increasing the risk of bleeding. This observation was consistent with the study by Esmaeil Mousapour et al, which reported a positive association between renal stone complexity, operative duration, number of access tracts, and bleeding volume.[19]

These results were further supported by additional statistical tests, including the Likelihood Ratio Test ($p = 0.020$) and Fisher's Exact Test ($p = 0.030$), both of which yielded p values below 0.05. The consistency across these tests strengthened the validity of the conclusion that renal stone complexity was significantly associated with postoperative bleeding.

**Comparison of Study Findings with Previous Studies**

**Significance of Stone Complexity**

This study demonstrated a statistically significant association between renal stone complexity and bleeding severity based on the Chi-square test ($p = 0.021$). These findings were consistent with multiple previous studies reporting that increased stone complexity or stone burden, such as in cases of staghorn or multiple stones, was associated with a higher risk of bleeding during PCNL. Prior clinical studies indicated that complex renal stones required wider percutaneous access, prolonged instrument manipulation, and were frequently associated with an increased risk of intraoperative bleeding.[12]

Complex stone cases generally required more than one percutaneous access tract or wider tract dilation to achieve complete stone clearance. Each additional access tract potentially caused further trauma to the renal parenchyma and surrounding vasculature, thereby increasing blood loss during the procedure.[18] Prolonged operative duration also represented an important contributing factor. In this study, the mean operative duration was 74.55 minutes, indicating variability between simple and complex cases.[19] A study by Hongyan Niu and Wei Li reported that procedures lasting more than 90 minutes doubled the risk of severe bleeding compared with operative durations of less than 90 minutes.[20] Longer operative times increased tissue exposure to instrument manipulation and hydraulic pressure, thereby elevating the risk of bleeding. These findings were consistent with previous reports demonstrating a positive correlation between stone complexity, operative duration, and intraoperative blood loss.

**Clinical Implications**

Clinically, the findings of this study underscored the significance of renal stone complexity in PCNL procedural planning. The anticipated procedural difficulty, as predicted by stone complexity, influenced the selection of operative strategies and the preparedness of the medical team in anticipating bleeding risks, both intraoperatively and postoperatively.

Therefore, in patients with complex renal stones, comprehensive preoperative planning was essential, including preparation for blood transfusion availability Syahputra et al, coordination with interventional radiology teams for potential selective embolization, and the selection of efficient yet safe access tracts to minimize tissue trauma and bleeding-related complications.[21,22]

These findings provided a strong clinical rationale for urologists to tailor technical approaches and risk management strategies on an individual basis according to renal stone complexity. Consequently, patient safety and the overall success of PCNL procedures could be optimally enhanced.

## CONCLUSION AND RECOMMENDATION


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This study demonstrated a significant association between renal stone complexity, particularly staghorn stones, and postoperative bleeding following percutaneous nephrolithotomy. Patients with complex renal stones undergoing PCNL tended to experience a greater reduction in hemoglobin levels compared with those with non-staghorn stones. This finding may be explained by the larger stone burden and wider calyceal distribution in complex stones, which require multiple access tracts and prolonged tissue contact, thus raising the risk of intraoperative bleeding and subsequent postoperative hemoglobin decline.

The mean postoperative hemoglobin reduction observed in this study was 1.449 g/dL, which remained below the 2 g/dL threshold commonly used to define severe bleeding. This result suggested that operative management at RSUP Prof. Ngoerah, RS Surya Husadha Denpasar, and Bali Royal Hospital Denpasar was generally effective in controlling perioperative bleeding. Clinically, renal stone complexity should be considered an important predictor for preoperative bleeding risk stratification, and patients with complex stones should receive stricter perioperative bleeding management, including early blood typing and transfusion preparedness. Future studies are recommended to include blood transfusion requirements as a primary outcome in addition to hemoglobin reduction to provide a more comprehensive clinical assessment of severe bleeding complications following PCNL.

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