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ORIGINAL PAPER

Factors associated to hemoglobin decrease after percutaneous nephrolithotomy: A retrospective study

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Summary *Objective: This study aims to determine the preoperative and perioperative risk parameters associated with a decrease in hemoglobin (Hb) in patients undergoing percutaneous nephrolithotomy (PCNL).*
Methods: We collected prospective data of consecutive patients who underwent PCNL from January 2018 to December 2022. The median decrease in post-operative hemoglobin levels compared to pre-operative was found to be 1.5 g/dl. This value was the cut-off value that divided the sample into two groups. Group 1 has a decrease in Hb levels that is higher or equal to the cut-off, group 2 has a decrease in Hb levels that is lower than the cut-off. All preoperative, stone characteristics and perioperative factors were recorded.
Results: A total of 273 patients were included in the study, 141 in Group 1 and 132 in Group 2. The mean age of Group 1 was significantly higher (55.48 ± 8.73 vs 45.9 ± 10.75 years, $p < 0.05$). The mean bleeding of Group 1 was significantly higher (285.85 ± 113.68 vs 135 ± 77.54 ml, $p < 0.05$). There was a significant difference in mean operation time between groups (86.35 ± 32.05 vs 64.89 ± 27.83 min, $p < 0.05$). Multivariate analysis showed that the variables age, comorbid diabetes mellitus, intraoperative bleeding amount, and operation time had a significant relationship with Hb reduction in patients undergoing PCNL ($p < 0.05$).
Conclusions: Older age, comorbid diabetes mellitus, large amounts of intraoperative bleeding, and longer operating time are factors associated with PCNL-related postoperative hemoglobin decrease.

KEY WORDS: Bleeding; Hemoglobin; Stone; Percutaneous nephrolithotomy (PCNL).

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INTRODUCTION

Percutaneous nephrolithotomy (PCNL) is an effective, safe, and minimally invasive treatment method with low rate of renal and ureteral calculi complications (1, 2). Indications for PCNL were determined as the presence of larger than 2 cm stones in the upper urinary tract or stones larger than 1.5 cm in the renal lower pole resistant to extracorporeal shock wave lithotripsy (3). High success rates that exceed 90% have been reported with percutaneous nephrolithotomy. However, despite the high success rate, several complications still often occur due to PCNL procedures (4).

Complications from PCNL can arise due to various factors. Stone characteristics are among the factors contributing to complications. In fact, size, location, and complexity of the kidney stones can increase the risk of complications during PCNL. Larger stones may require more extensive procedures, increasing the chances of complications. Other risk factors are related to patient characteristics, such as obesity, older age, or pre-existing medical conditions like diabetes or hypertension, that can increase the risk of complications during PCNL (5, 6). Bleeding is still one of the most common and significant morbidities, with reports showing an average hemoglobin drop ranging from 2.1 to 3.3 g/dL (7-12).

Bleeding complications are one of the potential risks associated with PCNL. Sources of bleeding during PCNL can be multifactorial including injury to the renal vessels during the procedure, bleeding at the puncture site, trauma to surrounding tissue when crushing and removing kidney stones. It is important to identify the factors associated to intraoperative bleeding and massive post-operative hemoglobin reduction so that transfusion therapy can be prepared if necessary (5, 6, 13).

In this study, we aim to determine the factors associated with PCNL-related hemoglobin decrease.

MATERIALS AND METHODS

This research is a retrospective analytical observational study of patients undergoing PCNL at *Siloam Hospital Makassar, South Sulawesi, Indonesia*. This study used secondary electronic medical records on patients who underwent PCNL from January 2018 to December 2022. The inclusion criteria in this study were being patients aged 23-78 years who underwent unilateral PCNL and had complete medical record data, while the exclusion criteria were being patients with complete staghorn stones, chronic kidney disease, anatomical or functional abnormalities of the urinary tract system, receiving a transfusion before or during the surgical procedure, being on anti-coagulant therapy, being submitted another surgical procedure or to bilateral PCNL surgery in the same session. All patients who met the exclusion criteria were removed from the research sample.

All PCNL procedures in this study sample were performed using a 24 F Amplatz sheath for renal calculi; surgery was performed in complete supine position under subarachnoid spinal block; the tract was dilatated using serial metallic dilatators and stone fragmentation was done by *Lithoclast® Master* (*EMS, Nyon, Switzerland*); residual fragments were cleared using a flexible nephroscope; experience of surgeons was more than five year. At the end of the procedure, a 18 Fr Foley urethral catheter with the balloon inflated was placed. Operative time was considered from the beginning of the cystoscopy for ureteral catheter insertion to the end of the placement of nephrostomy catheter. A non-contrast *Computerized tomography* (CT scan) and routine serum exams were performed during the first postoperative day in all cases. The success rate was defined as the absence of residual symptomatic fragments > 4 mm in the CT of the first postoperative day.

Characteristic data collected included age, gender, *body mass index* (BMI) (normal value: 18.5-25.0), stone characteristics (stone side and location, degree of hydronephrosis, stone burden, and stone complexity using *Guy's Stone Score* (GSS) based on preoperative CT scan analysis).

Intraoperative factors include operative time and amount of bleeding. The amount of bleeding was calculated by the anesthesiologist team from the initial flank incision to access the kidney to the closure of the incision site with sutures or adhesive strips. The amount was calculated by the total blood volume collected in the suction canister (taking into account the fluid used for irrigation) and the estimated bleeding from the gauze/sponge used during the operation.

Comorbidities including hypertension and diabetes mellitus were also registered.

Hemoglobin (Hb) levels (normal value: male 13-17 g/dl; female 12-16 g/dl) of all patients were tested 3-5 days before the surgery. After PCNL is carried out, hemoglobin measurement was carried out again 2 hours after surgery. The decrease in hemoglobin levels was assessed by the difference between hemoglobin before and after surgery. The median reduction of hemoglobin level was 1.5 g/dl; this value was accepted as the cut-off value. Patients were divided into two groups based on the threshold value. Patients with reductions in hemoglobin levels by more than 1.5 g/dl were assigned to Group 1, and patients with reductions by less than the cut-off value were assigned to Group 2.

Statistics

Variables with categorical data are reported as frequencies and percentages.

Meanwhile, continuous data variables are reported in the form of mean and standard deviation. The data normality test was carried out using the Kolmogorov-Smirnov test. The chi-square test was performed to assess the association of categorical variables. Alternatively, Fisher's exact test was used if chi-square requirements were not met. To test comparisons of numerical data, an independent t test was carried out for normally distributed data and the Mann-Whiteney test for non-normally distributed data. The Pearson correlation test was carried out if the data were normally distributed, while the Spearman correlation test was carried out if the data were not normally distributed.

Ethical approval

This research has received ethical approval from the *Health Research Ethics Committee Siloam Hospital, Makassar* (No. 068/KE-RS/SHMK/IX/2023).

RESULTS

A total of 368 electronic medical records were collected, 95 of which met one of the exclusion criteria, leaving 273 samples who met the criteria and were included in this study. Of the 273 samples, 141 samples were in group 1 and 132 samples were in group 2. The average decrease in post-operative Hb in the total study sample was 1.5 g/dl. The average age in the total study sample was 50.85 years. The majority of patients were males (74.4%). A total of 37.4% of patients had comorbid hypertension and 9.2% diabetes mellitus. The average *body mass index* (BMI) was 26.45 kg/m^2. The average total bleeding during surgery was 212 ml and the average operative time was 75.97 minutes. Data characteristics of this research sample are available in Table 1. Several variables were found to have a significant relationship with post-operative Hb reduction, namely age, comorbid diabetes mellitus, comorbid hypertension, intraoperative amount of bleeding and operation time. The mean age of Group 1 was significantly higher than in Group 2 (55.48 ± 8.73 *vs* 45.9 ± 10.75 years, p < 0.001). Mean bleeding amount in Group 1 was significantly higher than Group 2 (285.85 ± 113.68 *vs* 135 ± 77.54 ml, p < 0.001). There was a significant difference also in mean operation time between groups (Group 1 86.35 ± 32.05 *vs* Group 2 64.89 ± 27.83 minutes, p < 0.001).

The characteristics of stones and their distribution are presented in Table 2. Most stones were found in the right urinary tract (56%) and the majority of patients were accompanied by moderate hydronephrosis (41.4%). Stone location was most commonly reported at the lower pole (42.9%). In most patients, stone burden was around 30-50 mm^2 (58.2%). Stone complexity was most commonly reported as grade 2 (51.6%). Bivariate analysis showed that of all stone characteristics, only stone burden was reported

Table 1.
Clinical characteristics of patients and distribution according to decreases of Hb.

Parameters (Mean ± SD)	Total (n = 273)	Group 1 (n = 141)	Group 2 (n = 132)	p-value
Decrease in Hb (g/dl)	1.5 ± 1.24	2.3 ± 1.10	0.8 ± 0.35	< 0.001 *
Age (year)	50.85 ± 10.85	55.48 ± 8.73	45.9 ± 10.75	< 0.001 *
Gender (Male)	203 (74.4%)	105(74.46%)	98 (74.24%)	1.000 *
Comorbidities				
HT	102 (37.4%)	61 (43.26%)	41 (31.06%)	0.045 #
DM	25 (9.2%)	19 (13.47%)	6 (4.54%)	0.012 #
HT + DM	12 (4.4%)	8 (5.67%)	4 (3.03%)	0.380 #
BMI (kg/m^2)	26.45 ± 4.62	26.18 ± 4.49	26.73 ± 4.76	0.391 *
Bleeding Amount (ml)	212 ± 123.49	285.85 ± 113.68	135 ± 77.54	< 0.001 *
Operation time (min)	75.97 ± 31.89	86.35 ± 32.05	64.89 ± 27.83	< 0.001 *

**t-independent test; #chi-square test.*
SD: Standard deviation; Hb: Hemoglobin; DM: Diabetes mellitus; HT: Hypertension; BMI: Body mass index.

Table 2.
Stone characteristics and distribution according to decreases of Hb.

Parameters (Mean ± SD)	Total (n = 273)	Group 1 (n = 141)	Group 2 (n = 132)	p-value
Laterality (n; %)				0.179 #
Right	153 (56%)	85 (60.28%)	68 (51.51%)	
Left	120 (44%)	56 (39.72%)	64 (48.49%)	
Hydronephrosis (n; %)				0.847 #
None	11 (4%)	5 (3.55%)	6 (4.54%)	
Mild	90 (33%)	47 (33.34%)	43 (32.57%)	
Moderate	113 (41.4%)	61 (43.26%)	52 (39.39%)	
Severe	59 (21.6%)	28 (19.85%)	31 (23.48%)	
Stone Location (n; %)				0.082 #
Upper Pole	14 (5.1%)	12 (8.51%)	2 (1.51%)	
Mid Pole	5 (1.8%)	4 (2.83%)	1 (0.75%)	
Lower Pole	117 (42.9%)	54 (38.29%)	63 (47.7%)	
Pelvic-ureteric Junction	12 (4.4%)	6 (4.25%)	6 (4.54%)	
Pelvic	44 (16.1%)	22 (15.6%)	22 (16.67%)	
Multiple Location	81 (29.7%)	43 (30.5%)	38 (28.78%)	
Stone Burden (n; %)				< 0.001 #
< 30 mm^2	47 (17.2%)	14 (9.93%)	33 (25%)	
30-50 mm^2	159 (58.2%)	76 (53.9%)	83 (62.8%)	
> 50 mm^2	67 (24.5%)	51 (36.17%)	16 (12.2%)	
Stone Complexity (GSS Grade)				0.384 #
Grade 1	94 (34.4%)	54 (38.3%)	40 (30.3%)	
Grade 2	141 (51.6%)	69 (48.9%)	72 (54.5%)	
Grade 3	38 (13.9%)	18 (12.8%)	20 (15.2%)	
Grade 4	-	-	-	

 # chi-square test.
SD: Standard deviation; GSS: Guy's Stone Score.

to have a significant relationship with post-operative Hb reduction, because patients with a higher stone burden tended to have a greater decrease in Hb ($p < 0.05$).
The results of multivariate analysis showed that the variables age, comorbid DM, bleeding amount, and operation time significantly influenced the reduction in post-operative Hb ($p < 0.05$) (Table 3). Next, a correlation test was carried out to assess the strength and direction of the correlation between Hb decrease and age, intraoperative bleeding amount and operation time. The results showed that age had a weak positive correlation with decrease in Hb (R: 0.337, $p < 0.001$), intraoperative bleeding amount had a strong positive correlation with decrease in Hb (R: 0.669, $p < 0.001$), and operation time had a moderate positive correlation. with decrease in Hb (R: 0.432, $p < 0.001$) (Table 4). These results show that older age, greater amount of bleeding, and longer operation time are associated with a higher decrease in post-operative Hb levels.

Table 3.
Multivariate analysis of factors associated with hemoglobin decrease.

	Exp (B)	Multivariate 95% CI	p-value
Age	0.923	0.889 - 0.958	< 0.001
HT	1.454	0.706 - 2.994	0.309
DM	3.574	1.089 - 11.728	0.036
Stone Burden	0.232	0.034 - 1.579	0.136
Bleeding Amount (ml)	0.986	0.982 - 0.990	< 0.001
Operation time (min)	0.985	0.974 - 0.996	0.011

CI: Confidence Interval; DM: Diabetes mellitus; HT: Hypertension.

Table 4.
Correlation analysis between factors associated with hemoglobin decrease.

Variable	Mean ± SD	Pearson correlations	
		R	p-value
Age	50.85 ± 10.85	0.337	< 0.001+
Bleeding Amount (ml)	212 ± 123.49	0.669	< 0.001+
Operation time (min)	75.97 ± 31.89	0.432	< 0.001+

+ Pearson correlations; R: Correlation coefficient.

Discussion

Despite the efficacy of *percutaneous nephrolithotomy* (PCNL), bleeding complications remain a concern, leading to decreased hemoglobin levels. Factors associated with bleeding consist of age, diabetes mellitus, operation time and intraoperative bleeding amount (14).
A study by *Taylot et al.* found that patients with diabetes mellitus had a higher risk of bleeding complications during PCNL due to impaired platelet function and altered coagulation factors (15). The significant association between diabetes mellitus and increased blood loss during PCNL leads to a greater decrease in hemoglobin level. Furthermore, diabetes mellitus affects the entire vascular system, causing microangiopathies and an increased tendency for bleeding. In univariate analyses in their study, *Tefekli et al.* found that diabetes mellitus and hypertension correlated with decreased hemoglobin levels (14, 16). The multivariate regression analysis revealed that diabetes mellitus is an independent risk factor for bleeding. Our study also found diabetes mellitus as a significant risk factor in multivariate regression analysis.
Significant correlations were found between advanced age and increased risk of bleeding complications and subsequent hemoglobin decrease in PCNL procedures (14). Reduced ability to recover after injury and changes in cardiovascular system may be possible mechanisms for increased bleeding (17). Therefore, age has to be considered an high-risk factor for decreasing hemoglobin after PCNL.
There are several studies indicating that stone burden is another risk factor for decreasing hemoglobin after PCNL. In their study, *Kukreja et al.* demonstrated that a larger stone burden was associated with an increased risk of bleeding complications during PCNL, resulting in a greater decrease in hemoglobin levels. *Syahputra et al.*, suggested that the size of the kidney stone positively correlated with the amount of blood loss during PCNL (18, 19). However, in our study, multivariate regression showed no significant correlation between stone burden and decrease of hemoglobin. A study by *Wilson et al.* found that longer operation

times were associated with a higher risk of bleeding complications during PCNL, leading to a more significant decrease in hemoglobin levels. Chen et al. reported a positive correlation between operation duration and blood loss during PCNL (20, 21). and *Lee et al.* demonstrated a significant correlation between the amount of blood loss during PCNL and the decrease in hemoglobin levels postoperatively. *Kumar et al.* also reported that higher blood loss during PCNL was associated with a greater decrease in hemoglobin levels (22, 23).

The analysis of the selected studies revealed several significant findings. Firstly, advanced age was consistently associated with an increased risk of bleeding complications and subsequent hemoglobin decrease in PCNL procedures. Secondly, patients with a history of hypertension demonstrated a higher incidence of bleeding and greater hemoglobin decrease than normotensive individuals. Furthermore, diabetes mellitus was found to be an independent risk factor for bleeding complications. Stone size, operative duration, and blood loss significantly influenced bleeding in PCNL procedures.

The present research has several advantages, including a fairly large sample size and an analysis which was carried out comprehensively and sequentially. However, apart from that, this study also has limitations, including using secondary data from medical records and considering PCNL carried out by different surgeons with different experience so that this could be a confounding factor in this study.

Conclusions

This comprehensive study highlights the importance of considering various factors associated with bleeding complications and hemoglobin reduction in PCNL procedures. Older age, comorbid diabetes mellitus, more perioperative bleeding, and long operative time are significantly associated with decreasing Hb post-PCNL surgery. These findings emphasize the need for careful patient selection, careful surgical technique, and appropriate precautions to minimize bleeding complications in PCNL procedures.

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