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Risk Factors for Intra-operative Bleeding in Percutaneous Nephrolithotomy in an Academic Center: A Retrospective Study

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Abstract

Background: Percutaneous nephrolithotomy (PNL) is the treatment of choice for renal stones as a safe, effective, and minimally invasive method. However, bleeding remains a major concern in the procedure.
Objectives: This study aimed to investigate the risk factors of bleeding in PNL.
Methods: This retrospective descriptive cross-sectional study was conducted in the Urology department of Razi hospital. The data of patients with urinary calculi staghorn type who underwent PNL in a prone position under general anesthesia were recorded. A checklist including patients' demographics, surgical characteristics, and outcomes was filled out for each patient.
Results: The data from 151 complete files were gathered. The mean age of the cases was 47.89 $\pm$ 12.41 years. The mean hemoglobin (Hb) drop was 1.92 $\pm$ 1.56 mg/dL. At least 1 mg/dL Hb drop was observed in all cases. The highest Hb drop was 3 mg/dL.). There was no significant relationship between stone bulk, age, BMI, GFR, surgery duration, and the number of tracts, and Hb drop during PNL ($P > 0.05$). But there was a positive correlation between Urinary Tract Infection (UTI) history ($P = 0.01$) and transfusion ($P = 0.0001$) and Hb drop during PNL. Also, the history of open kidney surgery ($P = 0.031$), nephrostomy insertion ($P = 0.003$), and extracorporeal shock wave lithotripsy therapy (ESWL) ($P = 0.041$) were correlated with the increased risk of Hb drop.
Conclusions: Urinary tract infection, history of open surgery, nephrostomy implantation, and ESWL were significantly associated with more bleeding in PNL.

Keywords: Bleeding, Risk Factors, Percutaneous Nephrolithotomy, Intraoperative Complications

1. Background

Percutaneous nephrolithotomy (PNL) is an effective, safe, and minimally invasive treatment method with low complications for renal and ureteral calculi refractory to extracorporeal shock wave lithotripsy therapy (ESWL) and in patients with anatomic variations (1-4). In fact, this method has been known as the gold standard of care for treating renal stone diseases (5). Despite the success rate of over 90%, there are inherent complications such as adjacent organs, sepsis, fistulas, stenosis of excretory way, fluid overload, serum electrolytes imbalance, hypothermia, irreversible renal lesion, and even death (6, 7). Although various pharmacological interventions exist, significant blood loss during or after the surgery remains a major concern for both surgeons and anesthesiologists (8), which may lead to various unwanted complications, including hemodynamic instability, need for transfusion and embolization, inability to safely remove stones, prolonged hospital stay, and rarely death (9).

Studies have shown a drop in hemoglobin (Hb) levels of 2.1 - 3.3 g/dL in cases undergoing PLN (10, 11) and the need for transfusion in 1% to 34% of them (12). Bleeding following this surgery is almost always controlled by conservative intervention, although selective embolization and arteriography are required in about 0.8% of cases (13-15). The available studies' results are inconsistent, and there is no agreement on the issue (16). Some have demonstrated that hypertension, site of puncture, and duration of surgery significantly affect the reduction of Hb during PCNL, while operative position (supine/prone), the number of punctures, and tract dilatation size have no significant effect (17). In other studies, stone size, the number of tracts, the

size of Amplatz sheath, and the number of stones were reported as influencing factors (18).

In contrast, Ramon de Fata et al. found that only multiple percutaneous tracts ($\geq$ 2) and middle calyx puncture were associated with lower blood loss and did not confirm the others reported by previous studies (4). This study was planned due to the mentioned discrepancies. Certainty, a preoperative workup is crucial to restrict the risk factors for bleeding associated with this surgery (8).

2. Objectives

This retrospective study aimed to identify the risk factors of intraoperative bleeding in patients undergoing percutaneous nephrolithotomy.

3. Methods

First, the study protocol was approved by the Ethics Committee of the Guilan University of Medical Sciences (GUMS). This retrospective study was conducted at the urology department of Razi hospital, an academic and referral center. The files of patients who underwent PNL were sorted out and screened for eligibility.

Inclusion criteria: Patients with urinary calculi staghorn type, aged 18 - 85 years, who had undergone elective PNL in the prone position were included.

Exclusion criteria: Files with incomplete data, cases with long-term use of anticoagulant agents or coagulopathy disorders like hemophilia, and emergency cases were excluded.

The responsible medical student completed a checklist including patient demographics and surgical outcomes. The eligible patients had intravenous urography, preoperative anesthesia visits as elective surgery, ultrasonography, and Computed Tomography (CT). The operation was performed under general anesthesia in the prone position. The same access site for the operation was determined based on intravenous urography and CT. Urinary ultrasound evaluated the degree of hydronephrosis, and CT measured the stone size. Urine culture and analysis were used to detect Urinary Tract Infection (UTI) that was treated before surgery. All the operations were performed by a single surgeon with 10 years of experience.

3.1. Statistical Analysis

The data analysis was performed by SPSS 16.0 (SPSS, Chicago, IL, USA). Data are presented as the mean and standard deviation (SD) or the median and range. The Chi-square test was applied for univariate analysis. Finally, multivariate logistic regression was performed. Spearman's rho correlation coefficient test was also used. A P-value less than 0.05 was considered significant.

4. Results

A total of 180 files were examined, and finally, the data of 151 patients were analyzed with a mean age of 47.89 $\pm$ 12.41 years (range 16 - 81). Of them, 75% were above 40. Patients' demographics, medical history, and surgery characteristics are presented in Table 1. The mean drop in Hb levels was 1.92 $\pm$ 1.56 mg/dL, and 24.8% required transfusions. None of them underwent nephrectomy to control bleeding. Only one patient needed postoperative angiography and embolization. Surgery outcomes are presented in Table 2. In this study, we found that all cases had at least a 1 mg/dL drop in Hb levels and the highest drop was 3 mg/dL (Table 2). By using Spearman's rho correlation coefficient, borderline significant values were observed in terms of stone bulk and Hb drop ($P < 0.069$), but not regarding other variables, including age, BMI, GFR, surgery duration, and the number of tracts ($P > 0.05$). A significant association was observed between UTI ($P = 0.01$) and transfusion ($P = 0.0001$) and Hb levels drop. However, no meaningful association was observed regarding other variables ($P > 0.05$) (Table 3). According to logistic regression, the history of open kidney surgery ($P = 0.031$), nephrostomy insertion ($P = 0.003$), and ESWL ($P = 0.041$) were correlated with the increased risk of Hb drop (Table 4).

5. Discussion

In this study, we found that at least a 1 mg/dL drop in Hb levels was observed in all cases, and the highest drop was 3 mg/dL. A significant association was observed between UTI and transfusion and Hb drop. The history of open kidney surgery, nephrostomy insertion, and ESWL were correlated with the increased risk of Hb dropping. A similar study conducted by Said supports our results (12). Li et al., in a meta-analysis, found that hypertension, diabetes, stone type, and multiple tracts were significantly associated with severe bleeding and the need for embolization after PLN. They strongly recommended that the exact correlations must be evaluated by further studies (19).

Percutaneous nephrolithotomy is the standard and successful treatment for renal stones; however, complications occur in approximately 15% of cases. It is estimated that 9.4% develop intraoperative bleeding with different predisposing factors (10, 11). Akman et al. reported that diabetes was a significant risk factor for bleeding in these patients. They found it to be expected because diabetes

Table 1. Patients' Baseline Demographics and Surgery Characteristics

Variables	Values [a]
Mean body mass index (kg/m^2)	28.0904 ± 4.69695
Mean age (y)	47.89 ± 12.41
Gender	
Male	78 (51.7)
Female	73 (48.3)
History of hypertension	
No	103 (68.2)
Yes	48 (31.8)
History of diabetes mellitus	
No	119 (78.8)
Yes	32 (21.2)
History of active urinary tract infection	
No	141 (93.37)
Yes	10 (6.623)
Kidney involved	
Right	71 (47.02)
Left	80 (52.98)
Multifocal stone	
One place	47 (30.7)
More than one place	104 (69.3)
Renal secretion in pyelography	
Normal	128 (84.1)
Decreased	23 (15.9)
Thickness of renal parenchyma	
Increased	2 (1.32)
Normal	135 (89.41)
Decreased	14 (9.27)
Previous ESWL	
No	85 (56.3)
Yes	66 (43.7)
Previous open surgery	
No	129 (85.4)
Yes	22 (14.6)
History of kidney involvement PNL	
No	136 (90.1)
Yes	15 (9.9)
Degree of hydronephrosis	
No or mild	90 (59.60)
Moderate	48 (31.79)
Severe	13 (8.61)
Mean duration of operation (min)	48.53 ± 22.375
Calyx undergoing puncture	
Upper	14 (9.27)
Middle	17 (11.26)
Lower	120 (79.47)
Number of tracts	
1	142 (94.03)
2	9 (5.7)
Nephrostomy implantation	
No	75 (49.67)
Yes	76 (50.33)
Transfusion	
No	114 (75.49)
Yes	37 (24.51)

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

Table 2. Surgery Outcomes

Outcome	Value
Mean duration of hospitalization (days)	3.25 ± 1.46
Mean drop in hemoglobin (g/dL)	1.92 ± 1.56
Mortality	0
Need for angiography and embolization to control postoperative bleeding	1
Need for laparotomy due to postoperative colon perforation	0
Postoperative urosepsis after the operation	1
Postoperative pulmonary complications	1
Perforation of the collecting urinary tract after surgery	0
Postoperative urethra-pelvic junction injury	1
Postoperative large hematoma	1
Need for nephrectomy to control postoperative bleeding	0
Need to re-PNL	2

leads to atherosclerosis and microangiopathy (13). Kukreja et al. found a positive relationship between hypertension and intraoperative bleeding, which was explained by arteriosclerosis (20).

In contrast, Meng et al. found no association between diabetes and hypertension, and bleeding during PNL (21). A few studies have indicated that females were more prone to bleeding; however, it was not supported by other studies (22). The other risk factor was the stone size. Larger stones were associated with prolonged operation time and, as a result, increased bleeding (21, 23). Kallidonis et al. found that the type of stone was the other risk factor (24), which was supported by two other studies (22, 25). Studies have shown that patients with renal stones with nil or mild hydronephrosis are at higher risk of severe bleeding due to the thickness of the renal cortex. The distribution of kidney vessels is scattered in higher degrees of hydronephrosis. Therefore, the risk of vessel injury during surgery will be lower (26). Kim et al. found that correct renal puncture was a significant risk factor for severe hemorrhage requiring angioembolization (27). Ullah et al. reported that operating time, female gender, and stone size were the main risk factors (28).

As mentioned above, studies have reported different risk factors for bleeding in PLN, and their findings are often inconsistent, which can be explained by differences in instruments, surgeon's experience, and surgical technique, such as the need for multiple or large access tracts. In addition, measurement tools, bleeding estimation criteria, the accuracy of laboratories, and studied populations are not the same among studies. Also, the inclusion criteria of the studies as an influencing factor differ in terms of patients' characteristics, comorbidities, age, and preoperative status (12, 17, 18, 21, 27, 29).

Table 3. Correlation Between Hemoglobin Drop and Quantitative Variables

Quantitative Variables	Age (y)	BMI	GFR Before Operation (Kidney Function)	Bulk Rock	Duration of Operation (Min)	Number of Tracts
Decrease in hemoglobin (g/dL)						
Spearman's rho correlation coefficient	-0.061	-1.071	0.123	0.149	0.136	0.008
Significance level	0.457	0.392	0.139	0.069	0.101	0.925
Number	149	148	146	150	146	151

Table 4. Multivariate Binary Logistic Regression Analysis for Factors Affecting Hemoglobin Drop (g/dL)

Variables	B Regression Coefficient	S.E. Standard Deviation	Significance Level	Odds Ratio	Confidence Interval	
					Lower Limit	Upper Limit
Previous open kidney surgery	1.969	0.911	0.031	7.162	1.201	42.698
Step 4						
Nephrostomy implantation	1.898	0.632	0.003	6.676	1.935	23.038
Previous ESWL	1.162	0.569	0.041	3.198	1.048	9.759
Fixed value (effect of unknown factors)	-2.033	0.646	0.002	0.131		

5.1. Limitations

The nature of a retrospective study is different from prospective studies. Selection bias occurs in retrospective studies, and the reliability of the results is disturbed by incomplete files that need to be excluded. Furthermore, the investigated items should be restricted to those recorded in patients' medical files. A single-center study could be another limitation of this survey.

5.2. Conclusions

According to the findings of this study, PLN under general anesthesia in a prone position was performed successfully and safely in this center. Also, UTI, history of open surgery, nephrostomy implantation, and ESWL were the significant risk factors for the severity of bleeding in this procedure.

Footnotes

Authors' Contribution: Study concept and design, HN and GB; Drafting of the manuscript, SG and KG; Acquisition of data, SG and GM; Statistical analysis, EK; Analysis and interpretation of data, GB and KG; Critical revision of the manuscript for important intellectual content, HN and GM; Study supervision, GB and HN.

Conflict of Interests: We declare that one of our authors (Gelareh Biazar, Reviewer) is one of the editorial board. The journal confirmed that the mentioned author with CoI was completely excluded from all review processes. We also introduced this author with CoI during the submission as an opposed reviewer.

Data Reproducibility: The data presented in this study are openly available in one of the repositories or will be available on request from the corresponding author by this journal representative at any time during submission or after publication. Otherwise, all consequences of possible withdrawal or future retraction will be with the corresponding author.

Ethical Approval: The study protocol was approved by the Research Ethics Committee of the Guilan University of Medical Sciences. At the time of designing this research, which was also a medical student's thesis, a specific number was not considered for research as an ethical code. Therefore, the authors of this manuscript received a confirmation letter from the vice-chancellor for Research of Guilan University of Medical Sciences (GUMS).

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