Original article

Clinical factors related to bleeding in percutaneous nephrolithotomy

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Abstract

Objective: To determine the factors associated with the decrease in hemoglobin and hematocrit in percutaneous nephrolithotomy.

Materials and methods: Patients that underwent percutaneous nephrolithotomy within the time frame of January 2015 to January 2017 were included in the study. The factors associated with bleeding were analyzed using the Levene's test, the Student's t test, and inferential statistics.

Results: Sixty-nine patients underwent percutaneous nephrolithotomy. The mean decrease in hemoglobin and hematocrit after the procedure was 1.17 g/dl and 2.56%, respectively. The statistically significant factors were: diabetes mellitus (Hb, $p \leq 0.001$/Hct, $p = 0.017$), high blood pressure ($p = 0.007$/$p = 0.050$), stone morphology ($p = 0.004$/$p = 0.003$), stone area ($p = 0.003$/$p = 0.003$), number of tracts ($p = 0.002$/$p = 0.012$), and surgery duration ($p \leq 0.001$/$p = 0.010$). Positive culture ($p = 0.030$) and stone size ($p=0.028$) were significant only in relation to the decrease in hematocrit. A total of 27.5% patients had undergone previous surgery, mean stone size was 3.26 cm, the lower calyx was the most frequently punctured (78.3%), mean tract length was 8.41cm, and mean surgery duration cutoff time was 140 min. In our study, diabetes mellitus (RR = 1.8, CI = 1.4-2.3), high blood pressure (RR = 2.12, CI = 1.5-2.8), stone morphology (RR = 1.9, CI = 1.5-2.5), stone area (RR = 1.8, CI = 1.19-2.7), surgical technique and number of tracts (RR = 1.7, CI = 1.4-2.1), and surgery duration (RR = 1.9, CI = 1.3 -2.8) were the risk factors associated with decreased Hb and Hct values in percutaneous nephrolithotomy.

Conclusions: Percutaneous nephrolithotomy is a minimally invasive procedure for the treatment of kidney stones. In our study, the incidence of bleeding was low, and the transfusion rate was minimal, at 2.9%.

Keywords: Percutaneous nephrolithotomy, Hemoglobin, Hematocrit, Bleeding.

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Introduction

Percutaneous nephrolithotomy (PNL) is the minimally invasive procedure of choice for the elimination of kidney stones larger than 2cm at their greatest diameter.[1]

It enables the treatment of numerous large and/or very dense stones in patients with anatomic variations and in those with failed extracorporeal shockwave lithotripsy (ESWL). Due to the high success rate and low complication rate of PNL in recent years, ESWL and open surgery have been relegated to secondary roles and are now considered second-line treatment for large-volume stones.

Fernström and Johansson first described the procedure in 1971[2] and there have been many innovations made in PNL regarding puncture, tract dilation, material employed, fragmentation systems, and the positioning of the patient.

Success rates higher than 90% have been reported, but bleeding continues to be one of the more important and common morbidities. Studies describe a mean decrease in hemoglobin of 2.1 to 3.3 g/dl.[3-4]

PNL has a higher success rate at the expense of a higher complication rate (above 10%).[5]

Most bleeding can be managed through conservative treatment and only 0.8-1.4% of patients will require interventions that include balloon tamponade catheters and angioembolization for its control.[6-7] The overall blood transfusion rate is 10.8 to 17.5%.[8-9]

Without a doubt, establishing optimum access to the renal collecting system is a key point in reducing bleeding and improving success.

The reported complications inherent to PLN are: bleeding, injury to the renal collecting system and/or adjacent organs, urinary tract infection, sepsis (0.8-4.7%), fistulas, excretory outlet stricture, fluid overload, and hypothermia. There are cases of irreversible kidney injury, and even patient death (0.3-0.78%), [10-13] but they are uncommon, whereas the minor complications are more frequent.[14]

The most common minor complications are pain (49%), fever (30%), urinary tract infection (11%), and renal colic (4%).[15]

Renal bleeding secondary to the procedure can be intraoperative or postoperative and sufficiently severe to require blood transfusion. However, the risk for blood transfusion depends on a variety of factors, including the surgical technique, the general condition of the patient (i.e., preexisting anemia), and stone burden.[16]

Multiple kidney punctures and perforation of the renal pelvis are associated with a 2-fold higher blood loss.

Previous studies reported that puncture site, high blood pressure, renal insufficiency, infection, and the stone characteristics of size, location, and compression did not produce increased blood loss. [17]

Materials and methods

A retrospective, analytical study was conducted within the time frame of January 2015 to January 2017 on a total of 69 patients that underwent percutaneous nephrolithotomy. Surgical experience bias was excluded, given that the procedures were performed by the same surgeon (MAC). The factors with a potential impact on bleeding were analyzed through the Levene's test and the Student's t test, with a 95% confidence interval, utilizing the SPSS version 24 program.

The preoperative variables evaluated were: age, sex, body mass index (BMI), comorbidities due to high blood pressure (HBP) and/or diabetes mellitus (DM), anesthesia risk according to the American Society of Anesthesiologists (ASA), previous surgery, urinalysis, urine culture, and blood analysis (hemoglobin, hematocrit, and creatinine). Stone location, number, and morphology were determined through abdominal computed tomography. They were classified anatomically as pelvic, calyceal, multiple, and partial or complete staghorn stones. Reconstructions were made using the Osiris® medical image viewer software. The intraoperative data registered were the number of tracts, surgery duration, and the calyx that was punctured.

The selected calyx was accessed through fluoroscopy, using an 18 G caliber needle and the bull's eye technique, with the patient in the prone position. The tract was dilated to 18 atm with a high-pressure balloon dilator, utilizing an insufflator. A 30 Fr Amplatz sheath was placed, and the stone was fragmented with a pneumatic lithotriptor. Additional tracts were created during the same session, when indicated, with the same caliber as the first. A 22-24 Fr nephrostomy catheter was placed in the renal pelvis or the calyx involved, at the end of the surgery, in the majority of the cases, depending on whether the patient was stone-free.

Surgery duration was documented as the time from puncture to final nephrostomy placement.

Antibiotic prophylaxis consisted of cephalosporins or carbapenems, according to the sensitivity of the pathogen found in the urine culture.

Hemoglobin and hematocrit levels were measured 24 hours after surgery. Blood loss was defined as the decrease in postoperative hemoglobin (Hb) and hematocrit (Hct), as well as the need for packed red blood cell transfusion, taking into account that each red blood cell unit increased hemoglobin by 1 g/dl and hematocrit by 3%.[17]

Results

Of the 69 patients in the present study, 37 (53.6%) were women and 32 (46.4%) were men.

The mean patient age was 47 years, with a minimum age of 19 and a maximum of 78. Mean BMI was 28.6 kg/m^2 and the range was 19.1 to 38.2.

Thirty-five (50.7%) patients underwent left-sided surgery and in 34 (49.3%) it was right-sided.

A total of 36.2% patients had comorbidities, the most frequent of which was high blood pressure in 23.3%, followed by diabetes mellitus in 13%.

There was at least one previous surgery in 27.5% of the patients.

The mean preoperative level of creatinine was 1.31 mg/dl (0.53-5.19). It was 14.41 g/dl (10.3-17.4) for hemoglobin, and 42.5% (30.9-53.3) for hematocrit.

Twenty-six (37.7%) patients had a pathologic urinalysis. In the preoperative urine cultures, 43 (62.4%) patients were identified that did not present with bacterial growth, whereas 37.6% had bacterial development. Of those cases, the most frequent agent was *E. coli* BLEE in 23.2%, followed by sensitive *E. coli* in 4.4%, and finally *Serratia marcescens*, *Pseudomonas aeruginosa*, and *Proteus mirabilis*, each in 1.4% of the patients (Table 1).

Table 1. Demographic and clinical characteristics of the study population (n=69)

Variable	*n*	*Percentage*
Sex		
Women	37	53.6%
Men	32	46.4%
Side		
Right	34	49.3%
Left	35	50.7%
Pathologic urinalysis	26	37.7%
Urine culture		
No bacterial development	43	62.4%
E. coli BLEE	16	23.2%
sensitive *E. coli*	3	4.4%
Serratia marcescens	1	1.4%
Pseudomonas aeruginosa	1	1.4%
Proteus mirabilis	1	1.4%
Others	4	5.8%
Transfusion	2	2.9%
Comorbidity		
Diabetes mellitus	9	13%
High blood pressure	16	23.2%
Previous surgery	19	27.5%
Location and morphology		
Pelvic	10	14.5%
Calyceal	17	24.6%
Borderline staghorn	7	10.1%
Complete staghorn	12	17.4%
Multiple	23	33.4%
Ectasia		
No ectasia	8	11.6%
I	17	24.6%
II	19	27.5%
III	19	27.5%
IV	6	8.8%
Calyx punctured		
Lower	54	78.3%
Middle	9	13%
Upper	6	8.7%

Mean stone size was 3.26 cm (1-8.8), mean stone area was 7.16 cm^2 (0.5-38.72), and mean Hounsfield units was 951.71 (310-1600).

Grade II and grade III ectasia were the most frequent, each in 27.5% of the patients, followed by grade I in 24.6%, grade IV in 8.8%, and no ectasia in 11.6%.

Punctures were made 54 times in the lower calyx, representing the most frequent approach, at 78.3% of the patients.

Mean tract length was 8.41cm (3.8-14), mean surgery duration was 128.48 minutes (50-300), and mean blood loss was 158.55 ml (20-610) (Table 2).

Table 2. Quantitative parameters, with their corresponding means and ranges

	Mean	*Range*
Age (years)	47	19-78
BMI	28.68	19.1-38.2
Stone size (cm)	3.26	1-8.8
Stone area (cm2)	7.16	0.50-38.72
Stone density (HU)	951.71	310-1600
Tract length	8.41	3.8-14
Surgery duration	128.48	50-300
Blood loss	158.55	20-610
Preoperative parameters		
Hemoglobin	14.41	10.3-17.4
Hematocrit	42.5	30.9-53.3
Creatinine	1.2	0.53-5.19
Postoperative parameters		
Hemoglobin	13.23	8.4-17
Hematocrit	39.93	25.6-49.5
Creatinine	1.31	0.43-4.96
Hemoglobin decrease	1.17	0.0-3.6
Hematocrit decrease	2.56	0.0-9.7

The mean decrease in postoperative hemoglobin and hematocrit levels was 1.17 g/dl (0.0-3.6) and 2.56 % (0.0-9.7), respectively.

One patient was classified as Clavien-Dindo IIIa, indicating angioembolization secondary to an arteriovenous fistula and blood transfusion (1.4%).

A total of 2 (2.9%) patients with Clavien-Dindo II classification required blood transfusion.

The statistical analysis of the parametric and nonparametric variables was performed using the Levene's test and the Student's t test. Diabetes mellitus (p≤0.001, RR=1.8, CI=1.4-2.3), high blood pressure (p=0.007, RR=2.12, CI=1.5-2.8), stone morphology (p=0.004, RR=1.9, CI=1.5-2.5), stone area (p=0.003, RR=1.8, CI=1.19-2.7), number of tracts (p=0.002, RR=1.7, CI=1.4-2.1), and surgery duration (p≤0.001, RR=1.9, CI=1.3-2.8) had a statistically significant relation to the decrease in hemoglobin.

The factors that affected the decrease in hematocrit were: positive urine culture (p=0.030, RR=1.5, CI=1.1-2.2), diabetes mellitus (p=0.017, RR=1.8, CI=1.4-2.3), high blood pressure (p=0.050, RR=1.8, CI=1.4-2.3), morphology (p=0.003, RR=1.9, CI=1.5-2.5), stone size (p=0.028, RR=1.7, CI=1.15-2.5), stone area (p=0.003, RR=1.8, CI=1.19-2.7), number of tracts (p=0.012, RR=1.7, CI=1.4-2.1), and surgery duration (p=0.001, RR=1.9, CI=1.3-2.8).

The statistically significant factors for the decrease of both hemoglobin and hematocrit were: diabetes mellitus, high blood pressure, stone morphology, stone area, number of tracts, and surgery duration (Table 3).

Table 3. Statistical analysis of the outcome factors in relation to blood loss

Factors	*Decrease in hemoglobin*	*p*	*RR, CI*	*Decrease in hematocrit*	*p*	*RR, CI*
Age						
<50 years	1.05 ± 0.80	0.145		2.39 ± 2.58	0.505	
>50 years	1.35 ± 0.86			2.81 ± 2.56		
Sex						
Women	1.19 ± 0.68	0.865		2.54 ± 2.22	0.951	
Men	1.15 ± 0.99			2.58 ± 2.94		
Side						
Right	1.20 ± 0.80	0.768		2.66 ± 2.38	0.764	
Left	1.14 ± 0.87			2.47 ± 2.76		
Urine culture						
No bacterial development	1.03 ± 0.73	0.083		1.98 ± 1.94	0.030	1.5, 1.1-2.2
With bacterial development	1.40 ± 0.95			3.53 ± 3.16		
Preoperative creatinine						
<1.5 mg/dl	1.10 ± 0.82	0.140		2.48 ± 2.52	0.548	
>1.5 mg/dl	1.50 ± 0.82			2.97 ± 2.79		

Factors	*Decrease in hemoglobin*	*p*	*RR, CI*	*Decrease in hematocrit*	*p*	*RR, CI*
BMI						
<30 Kg/m²	1.20 ± 0.89	0.741		2.68 ± 2.78	0.641	
>30 Kg/m²	1.13 ± 0.74			2.38 ± 2.21		
Diabetes mellitus						
No	1.04 ± 0.75	<0.001	1.8, 1.4-2.3	2.13 ± 2.15	0.017	1.8, 1.4-2.3
Yes	2.05 ± 0.86			5.43 ± 3.29		
High blood pressure						
No	1.02 ± 0.85	0.007	2.12, 1.5-2.8	2.26 ± 2.60	0.050	1.8, 1.4-2.3
Yes	1.66 ± 0.54			3.55 ± 2.00		
ASA						
I-II	1.18 ± 0.82	0.791		2.61 ± 2.53	0.715	
III-IV	1.11 ± 0.94			2.29 ± 2.83		
Previous surgery						
No	1.13 ± 0.84	0.530		2.50 ± 2.61	0.729	
Yes	1.27 ± 0.83			2.74 ± 2.48		
Morphology						
Partial stones/ Borderline staghorn	1-04 ± 0.80	0.004	1.9, 1.5-2.5	2.15 ± 2.31	0.003	1.9, 1.5-2.5
Complete staghorn	1.79 ± 0.71			4.53 ± 2.85		
Ectasia						
I-II	1.09 ± 0.81	0.310		2.14 ± 2.24	0.067	
III-IV	1.31 ± 0.87			3.31 ± 2.94		
Stone size						
<3 cm	1.03 ± 0.88	0.114		1.95 ± 2.38	0.028	1.7, 1.15-2.5
>3 cm	1.35 ± 0.74			3.31 ± 2.62		
Stone area		0.003	1.8, 1.19-2.7		0.003	1.8, 1.19-2.7
<4 cm2	0.96±0.78			1.83±2.2		
>4 cm2	1.42±0.83			3.40±2.6		
Number of stones						
1	1.21 ± 0.87	0.534		2.65 ± 2.69	0.602	
>2	1.06 ± 0.70			2.28 ± 2.14		
HU						
<1000	1.31 ± 0.86	0.117		2.81 ± 2.55	0.344	
>1000	0.98 ± 0.77			2.22 ± 2.57		
Tract length						
<10 cm	1.15 ± 0.87	0.763		2.56 ± 2.59	0.988	
>10 cm	1.23 ± 0.72			2.57 ± 2.52		

Factors	*Decrease in hemoglobin*	*p*	*RR, CI*	*Decrease in hematocrit*	*p*	*RR, CI*
Number of tracts						
1	1.11 ± 0.76	0.002	1.7, 1.4-2.1	2.40 ± 2.42	0.012	1.7, 1.4-2.1
>2	2.60 ± 1.32			6.16 ± 3.55		
Surgery duration						
<140 min	0.95 ± 0.70	<0.001	1.9, 1.3-2.8	2.00 ± 2.18	0.010	1.9, 1.3-2.8
>140 min	1.85 ± 0.85			4.28 ± 2.92		
Calyx punctured						
Lower	1.22 ± 0.84	0.400		2.76 ± 2.59	0.235	
Middle and upper	1.01 ± 0.80			1.86 ± 2.38		

Discussion

As with any procedure, percutaneous nephrolithotomy is not exempt from complications. Bleeding is one of the most important, and the need for transfusion varies from 0.8 to 45%,[18] which may be due to the vast difference in transfusion parameters at each hospital center. Blood transfusion at the hospital where the present study was conducted is indicated for all patients with symptomatic anemia and/or Hb <10 g/dl and was indicated in 2.9% of our study patients.

There is no correlation between estimated total blood loss and actual total blood loss, therefore in the present study, the bleeding parameters were the differences in the preoperative and postoperative hemoglobin and hematocrit levels.

Diabetes mellitus and high blood pressure have been correlated as risk factors for bleeding, perhaps because of the presence of atherosclerosis and vascular system compromise due to microangiopathies, which are vulnerable to bleeding.[9]

In the present study, those two comorbidities were statistically significant in relation to the decrease in hemoglobin, with a p≤0.001 for DM and a p=0.007 for HBP, and to the decrease in hematocrit, with a p=0.017 for DM and a p=0.050 for HBP.

Srivastava *et al.*[16] found that stone size was the only significant factor that could predict blood loss. In our study, the decrease in hematocrit was statistically significant (p=0.028) and stone area had a significant p value (0.003) for the decrease in hemoglobin and hematocrit.

Kukreja *et al.*[17] showed that the number of tracts was an important predictive factor for total blood loss and the need for transfusion. In addition, they demonstrated that the number of tracts was importantly related to the loss of hemoglobin and the decrease in hematocrit (p=0.002 and p=0.012, respectively).

Turna *et al.* [19] reported that the type of stone had the most significant effect on blood loss and found that staghorn stones were more prone to be associated with bleeding. We found a similar significant relation between staghorn stones and the decrease in hemoglobin and hematocrit (p=0.004 and p=0.0003).

Akman *et al.*[8] obtained a cutoff point for surgery duration starting at 58 min, as a factor related to bleeding. In our study, the cutoff point was 140 min, represented by a p≤0.001 for the decrease in hemoglobin and p=0.001 for the decrease in hematocrit.

We found a relation between positive urine culture and a decrease only in hematocrit (p=0.030), which differs from that reported in the literature.

Conclusions

The factors found to be statistically significant for predisposing patients to bleeding in percutaneous nephrolithotomy were: diabetes mellitus, high blood pressure, complete staghorn stone, stone size, stone area, number of tracts, and surgery duration longer than 140 minutes. In addition, we found that a positive urine culture was another predisposing factor, but only for the decrease in hematocrit.

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