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Percutaneous nephrolithotomy; alarming variables for postoperative bleeding

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KEYWORDS

Percutaneous nephrolithotomy;
Bleeding;
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Complications

ABBREVIATIONS

BMI, body mass index;
GSS, Guy's Stone Score;
Hb, haemoglobin;
KUB, plain abdominal radiograph of the kidneys, ureters and bladder;

Abstract ***Objectives:*** To evaluate factors contributing to bleeding after percutaneous nephrolithotomy (PCNL) and ways of managing this complication, as bleeding is a serious sequela that requires prompt management.

Patients and methods: The demographic and procedural data of 200 patients, who underwent unilateral PCNL during a 20-month period, were prospectively collected. Preoperative, operative, and postoperative details were recorded. The preoperative variables analysed included: age, sex, body mass index (BMI), the presence of hypertension, diabetes mellitus, serum creatinine, degree of hydronephrosis, previous ipsilateral open renal surgery, stone size and complexity. The operative variables analysed included: number of tracts, operative time, size of Amplatz sheath, type of anaesthesia, and complications such as calyceal and pelvic perforation.

Results: The variables of age, sex, BMI, diabetes, hypertension, and a preoperative creatinine level of >1.4 mg/dL had no significant effect on blood loss (all $P > 0.05$). However, the rate of bleeding was significantly higher ($P \leqslant 0.05$) in patients who had a history of previous open renal surgery, intraoperative pelvicalyceal perforations, and Guy's Stone Score (GSS) grade 3 and 4 complex stones;

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OR, odds ratio;
PCNL, percutaneous nephrolithotomy;
US, ultrasonography

however, absence of hydronephrosis, larger stone size, operative time (> 83 min), more than one puncture, and size of the Amplatz sheath (26–30 F) did not maintain their significance in multivariate analysis.

Conclusion: According to our present results stone complexity (GSS grade 3 and 4), history of ipsilateral renal stone surgery, and occurrence of intraoperative pelvicalyceal perforation are alarming variables for post-PCNL bleeding.

Introduction

Percutaneous nephrolithotomy (PCNL) has now largely surpassed open surgical techniques for renal stone management. Following technical improvements in PCNL, it has now become the standard procedure for the management of most large stones [1]. Despite recent advances, complications are still common occurring about a quarter of patients (23.3%) [2]. Bleeding in particular is a serious sequela that requires prompt control and management. Although a conservative approach suffices to control most bleeds after PCNL, a proportion of patients (0.8%) have been shown to have severe haemorrhage that necessitates surgical intervention, such as angiographic embolisation [3]. Also, a wide variation in the rate of blood transfusion for bleeding has been described in the literature ranging from 1% to 55% [4].

Haemorrhage after PCNL can occur immediately or after several days or weeks so called 'delayed bleeding' [5]. Certain patient, stone, and procedure-related factors are of value in predicting bleeding after PCNL, among these factors are body mass index (BMI), diabetes mellitus, stone size, degree of hydronephrosis, dilatation approach, and operative time [6,7]. Akman et al. [8] and others found that multiple access tracts, staghorn calculi, presence of diabetes, and prolonged operative time significantly increased blood loss during PCNL, while others concluded that stone size is the sole predictive factor of bleeding after PCNL [9]. The aim of the present study was to evaluate factors contributing to bleeding after PCNL and the ways of managing this complication.

Patients and methods

After approval of the study protocol by the Ethics Committee of the Sulaymaniyah Teaching Hospital, this study was conducted on patients who underwent unilateral PCNL during a 20-month period. The demographic and procedural data of 200 patients were collected prospectively using Microsoft Excel and analysed for factors that might have the potential to impact on post-PCNL bleeding. Preoperative informed consent was obtained. All patients were evaluated by history, physical examination, and haematological and biochemical investigations including: complete blood count, blood glucose, blood urea, and serum creatinine. All patients had a definitive preoperative diagnosis by plain abdominal radiograph of the kidneys, ureters and bladder (KUB), IVU, ultrasonography (US) and/or abdominal CT.

Surgical procedure and equipment

The entire procedure was performed in the Urology Department with the patient under general anaesthesia in 171 patients and using spinal anaesthesia in 29 patients. Prophylactic antibiotics were given according to the local guidelines of the hospital. After placing the patient in the lithotomy position, retrograde ureteric catheterisation with a 5-F open-ended ureteric catheter was performed under fluoroscopy guidance using a rigid cystoscope. All other parts of procedures were completed in the prone position. The selected calyx was accessed by the attending urologist using C-arm fluoroscopy (Siemens, Berlin, Germany). The 18-G coaxial needle (Cook Medical Inc., Bloomington, IN, USA) was placed in the preferred calyx. The floppy tipped guidewire (Boston Scientific, Quincy, MA, USA) was then passed into the collecting system through the needle. A working channel was established using a serial plastic or metallic dilator system under fluoroscopy control to 20–30 F. The Amplatz sheath (Boston Scientific) was placed over the dilated tract. A 20-F nephroscope (Karl-Storz, Tuttlingen. Germany) was then placed directly into the kidney through the Amplatz. The stones were fragmented using a pneumatic lithotripter (NidhiLith, Nidhi Medical systems, Delhi, India). Forceps and irrigating fluid were used to remove stone fragments. The number and types of accesses depended on the size of the treated stones (staghorn stone vs single stone) and localisation (upper or lower pole). Surgery was terminated and a nephrostomy tube fixed in patients with pyonephrosis at the initial puncture during the procedure.

At the end of the procedure, the ureteric stent was replaced by a JJ stent in cases of pelvic perforation, bleeding, irrigating fluid extravasation and residual stones, while in the absence of the aforementioned events the ureteric stent was removed without JJ-stent insertion. A Foley catheter (20–24 F) was placed as a nephrostomy tube in all patients and clamped for 8 h. In those who had JJ stents these were removed 3 weeks later.

Postoperative follow-up

In all patients, the haemoglobin (Hb) level was checked immediately after PCNL, repeated after 24 h, and re-checked if indicated later. The urethral catheter was removed after 24–48 h and the nephrostomy tube was removed after 2–6 days. On the first postoperative day, all patients had a complete blood count and KUB was routinely done. Abdominal US and sometimes KUB and urine analysis were done at the first postoperative outpatient visit at 2 weeks. Preoperative, operative, and postoperative details were recorded and analysed. Patients with persistent severe haematuria for >24 h postoperatively and occurrence of bleeding after nephrostomy tube removal were regarded as postoperative bleeding and analysed accordingly. We analysed the following preoperative factors: age, sex, BMI, the presence of hypertension, diabetes mellitus, serum creatinine level, degree of hydronephrosis, previous open renal surgery, stone size (diameter) and stone complexity. The operative factors analysed were: number of access tracts, mean duration of operation (minutes), size of Amplatz sheath, and complications such as calyceal and pelvic perforation. Postoperatively, the total Hb drop calculated for all patients and those transfused were identified. Patients were categorised by BMI: underweight <18.5 kg/m^2, ideal body weight <25 kg/m^2, overweight 25–29.9 kg/m^2, obese 30–34.9 kg/m^2, and morbidly obese $\geqslant 35$ kg/m^2. The operative time was documented as the time from positioning and ureteric stenting until the final placement of the nephrostomy tube. Hydronephrosis was graded as no hydronephrosis, mild (blunting of the calyceal fornices and enlargement of the calyces), moderate (rounding of the calyces with obliteration of the papillae) and severe (ballooning of the calyces with or without parenchymal thinning) based on US criteria [10]. The number of the access tracts was decided according to the position and complexity of the stone. Stones were classified based on the size and location and complexity to determine stone burden. The greatest diameter of measured stone was taken. For patients with multiple stones the summation of the greatest diameter of all stones was calculated. Patients were categorised according to stone size: patients with a kidney stone <20 mm (42 patients with failure of ESWL), kidney stone 20–30 mm (74 patients), and kidney stone >30 mm (84 patients). Stone burden and location was classified based on the Guy's Stone Score (GSS) system, which is comprised of four grades [11]. Changes in Hb concentration were defined as the difference between preoperative and 24-h postoperative Hb concentrations and prior to discharge, and patients receiving blood transfusion were identified.

It was considered that a 1 unit blood transfusion increased the Hb level by 1 g/dL and haematocrit by 3%. Therefore, drops in Hb and haematocrit were calculated as following: (preoperative Hb – postoperative Hb) + (number of units transfused $\times$ 1 g/dL Hb per unit transfused) [12].

The mean (SD) postoperative Hb drop after 24 h was 1.5 (1) g/dL [median (range) 1.3 (0.0–4.8) g/dl]. The indication for blood transfusion was decided using a Hb concentration threshold of 10 g/dL [13], thus postoperatively patients with a Hb concentration <10 g/dL were transfused. Patients with a Hb concentration >10 g/dL but clinically showing symptoms of anaemia underwent further follow-up, those who persisted with anaemic symptoms were transfused. Patient with intractable bleeding, persistent gross haematuria or haemodynamic instability were candidates for angiographic intervention. Those patients who developed bleeding through the tract during removal of the nephrostomy tube were treated by immediate re-insertion of the nephrostomy tube and kept for another 3 days [14].

Statistical analysis

Data were first checked for consistency and validity. All data were then analysed using the Statistical Package for the Social Sciences (SPSS® version 20, IBM SPSS Statistics Inc., USA) computer program. Univariate analysis included the *t*-test and ANOVA test for quantitative variables, and the chi-square test for qualitative variables.

Logistic regression analysis was used for multivariate analysis. The purpose of the logistic regression analysis is to estimate the odds ratio (OR). The strength of association was examined using ORs and 95% CIs derived from the logistic regression. All P values were based on two-sided tests, with a $P < 0.05$ considered statistically significant.

Results

In all, 200 patients (125 male, 75 female) who underwent PCNL were analysed. A wide range of patient ages were included in the study, at mean (SD; range) of 37.5 (14.7; 5–75) years. Patients were categorised by their BMI: nine (4.5%) were underweight, 63 (31.5%) had a normal weight, 82 (41%) were overweight and 46 (23%) were obese. The pre- and perioperative variables assessed are shown in Table 1.

For postoperative variables, the mean (SD) Hb drop was 1.5 (1.0) g/dL. In all, 17 (8.5%) patients needed blood transfusions. Intraoperative perforations

Table 1 Preoperative and perioperative findings in the study population.

Variable	N (%)
Diabetes mellitus	23 (11.5)
Hypertension	39 (19.5)
Serum creatinine > 1.4 mg/dL	4 (2.0)
Previous renal surgery	73 (36.5)
Degree of hydronephrosis	
None	10 (5)
Mild	59 (29.5)
Moderate	88 (44)
Severe	43 (21.5)
Stone size, mm	
< 20	42 (21)
20–30	84 (42)
> 30	74 (37)
GSS grade	
1	70 (35)
2	93 (46.5)
3	12 (6)
4	25 (12.5)
Type of anaesthesia	
General	171 (85.5)
Spinal	29 (14.5)
Duration, min	
< 83	120 (60)
> 83	80 (40)
No. of working tracts	
1	171 (85.5)
2	25 (12.5)
3	4 (2)
Size of Amplatz sheath, F	
20–24	46 (23)
26–30	154 (77)

occurred in 32 (16%) patients and bleeding in 16 (8%) patients. The longest operative duration was 150 min and the shortest was 35 min. Most of the patients with postoperative gross haematuria responded to conservative treatment with bed rest and i.v. crystalloid with or without blood transfusion. However, one patient (0.5%) required angioembolisation after failure of conservative management.

Two patients developed bleeding through the tract after removal of the nephrostomy tube on the third postoperative day. Both of them were treated by immediate re-insertion of the nephrostomy tube and kept for another 3 days, which they responded well to.

Examining relevant perioperative factors and their correlation with blood loss and bleeding, a univariate analysis was performed. Age, sex, BMI, diabetes, hypertension, and a preoperative creatinine level of > 1.4 mg/dL had no significant impact on blood loss ($P > 0.05$). However, the rate of bleeding was significantly higher ($P = 0.024$) in those patients who had a history of previous open renal surgery (13.7%) compared with those

Table 2 Factors affecting blood loss assessed by univariate analysis.

Variable	Without bleeding, n (%)	With bleeding, n (%)	P
Age group, years			
< 15	14 (100.0)	0 (0.0)	0.515
15–49	130 (91.5)	12 (8.5)	
> 50	40 (90.9)	4 (9.1)	
Sex			
Male	116 (92.8)	9 (7.2)	0.243
Female	68 (90.7)	7 (9.3)	
BMI, kg/m^2			
Underweight (< 18.5)	7 (77.8)	2 (22.2)	0.274
Normal (< 25)	59 (93.7)	4 (6.3)	
Over weight (25–29.9)	74 (90.2)	8 (9.8)	
Obese (> 30)	44 (95.7)	2 (4.3)	
Diabetes mellitus			
No	165 (93.2)	12 (6.8)	0.094
Yes	19 (82.6)	4 (17.4)	
Hypertension			
No	151 (93.8)	10 (6.2)	0.066
Yes	33 (84.6)	6 (15.4)	
Preoperative creatinine level > 1.4 mg/dL			
No	181 (92.3)	15 (7.7)	0.206
Yes	3 (75.0)	1 (25.0)	
Previous renal surgery			
No (127)	121 (95.3)	6 (4.7)	0.024
Yes (73)	63 (86.3)	10 (13.7)	
Degree of hydronephrosis			
No	8 (80.0)	2 (20.0)	0.009
Mild	57 (96.6)	2 (3.4)	
Moderate	84 (95.5)	4 (4.5)	
Severe	35 (81.4)	8 (18.6)	
Stone size, mm			
< 20	42 (100.0)	0 (00.0)	0.001
20–30	82 (97.6)	2 (2.4)	
> 30	60 (81.1)	14 (18.9)	
Stone complexity (GSS grade)			
1	66 (94.3)	4 (5.7)	0.007
2	89 (95.7)	4 (4.3)	
3	10 (83.3)	2 (16.7)	
4	19 (76.0)	6 (24.0)	
Duration, min			
< 83	120 (100.0)	0 (0.0)	0.001
> 83	64 (80.0)	16 (20.0)	
Number of working tracts			
1	163 (95.3)	8 (4.7)	0.001
2	19 (76.0)	6 (24.0)	
3	2 (50.0)	2 (50.0)	
Size of Amplatz sheath, F			
20–24	46 (100.o)	0 (0.0)	0.001
26–30	138 (89.6)	16 (10.4)	
Intraoperative pelvicalyceal perforation			
No	162 (96.4)	6 (3.6)	0.001
Yes	22 (68.8)	10 (31.3)	

Table 3 Outcomes of multivariate binary logistic regression analysis of factors affecting bleeding.

Variable	Odds ratio (95% CI)	P
Intraoperative perforation		
No (reference)	1	0.002
Yes	3.22 (2.55–10.04)	
Stone complexity(GGS grade)		
1 (reference)	1	0.025
2	1.01 (0.26–3.29)	
3	1.83 (1.01–5.32)	
4	2.07 (1.78–10.66)	
Previous renal surgery		
No (reference)	1	0.011
Yes	1.81 (1.12–6.34)	

with no such history (only 4.7%). Bleeding was strongly associated with certain factors, such as the absence of hydronephrosis ($P = 0.009$), larger stone size ($P = 0.001$), and GSS grade 3 and 4 complex stones ($P = 0.007$).

For intra- and postoperative variables associated with bleeding after PCNL, operative time (> 83 min), number of working tracts (> 1 tract), large tract (Amplatz sheath 26–30 F), and intraoperative pelvicalyceal perforations were significant (all $P < 0.05$; Table 2). Among the aforementioned variables only stone complexity (GSS grade 3 and 4), history of previous ipsilateral renal surgery, and intraoperative pelvicalyceal perforation maintained their significance in multivariate analysis. Intraoperative perforations obviously increase the risk of bleeding and in the present study this increased the risk was by 3.22 times. Similarly, the risk of bleeding was increased by about twice with high stone complexity (GSS grade 4) and previous renal surgery (Table 3).

Discussion

PCNL is a safe and effective procedure for removing large, complex, and/or multiple renal calculi. However, a dangerous and life-threatening complication that can occur during or after PCNL is bleeding, which can occur during needle passage, tract dilatation, or nephrostomy. It is mostly due to injury to the segmental arteries rather than from smaller intrarenal vessels, while acute bleeding due to injury to the main renal vessels is uncommon [9,15]. There is no standard classification for post-PCNL bleeding, which has different presentations from early to delayed and from mild to severe [16–18]. The rate of bleeding in the present study was 8.5%, which is comparable with that reported by Mousavi-Bahar et al. [15] in their series of 671 patients with a bleeding rate of 6.5%.

There are three different strategies available for drainage of the collecting system after PCNL: placement of nephrostomy tube, JJ-stent insertion without a nephrostomy tube, and totally tubeless in which neither nephrostomy tube nor a stent is left *in situ*. However, certain factors such as operative course, procedural complexity, stone burden, and the clinical status of the patient should be considered when choosing the method of drainage. We used a nephrostomy tube in all patients for simultaneous drainage and haemostasis. Despite that, we routinely inserted a JJ stent in most of the cases except in patients with small stone burden, minimal bleeding, a single working tract and complete stone clearance, in which placement of either a nephrostomy tube or JJ stent is sufficient [14,19].

There is controversy regarding the risk factors for post-PCNL bleeding [7,15,20] and in particular relating to previous ipsilateral renal surgery as a risk factor. Yesil et al. [21] divided 360 patients into four groups: Group 1 consisted of primary PCNL patients, Group 2 of patients whose stones were removed by open surgery from the same side, Group 3 of patients with previous PCNL surgery, and Group 4 of patients with previous ESWL. They found that previous ipsilateral open surgery increased the risk of postoperative bleeding, while Kukrej et al. [12] suggested the reverse. In this study, a history of ipsilateral renal operation increased the risk of bleeding with an OR of 1.81. However, more studies with higher statistical power are necessary to provide stronger evidence for this correlation.

The occurrence of intraoperative pelvicalyceal perforations and complex stones are recognised as risk factors for post-PCNL bleeding. Turna et al. [6] reported that partial (GSS grade 3) and complete staghorn (GSS grade 4) stones are more vulnerable to bleeding because they need more manoeuvres to completely clear the calyces of stone fragments, hence increasing the chance of more parenchymal and pelvicalyceal injury, which can lead to bleeding [22]. The present study confirmed that association.

Most bleeding during PCNL will respond to appropriate treatment, e.g. placement of a larger nephrostomy tube, clamping of the nephrostomy tube, hydration and mannitol administration, and Kaye balloon tamponade. In most cases bleeding is venous in origin and easily controlled by such manoeuvres [18]. In our present series, in most of the cases, bleeding responded well to conservative treatments and only one patient (0.5%) required angioembolisation.

The present study has several limitations including a small sample size and missing important variables, e.g. surgical experience, which may have impacted on the rate of vascular complications. Estimation of blood loss by measuring pre-and postoperative Hb is another source of bias.

Conclusion

Although PCNL is a safe and effective method of treating large and complex stones, life-threatening complications like bleeding can still occur. According to the result of the present study, stone complexity (GSS grade 3 and 4), history of ipsilateral renal stone surgery, and occurrence of intraoperative pelvicalyceal perforation are alarming variables for post-PCNL bleeding. Further studies are recommended as extensive controversies regarding predictors of post-PCNL bleeding exist. Most bleeding complications respond well to conservative therapy; however, angioembolisation is indicated on rare occasions.

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None.

Conflicts of interest

The authors have no conflicts of interest to disclose.

References

[1] Al-Kohlany KM, Shokeir AA, Mosbah A, Mohsen T, Shoma I, Eraky I, et al. Treatment of complete staghorn stones: a prospective randomized comparison of open surgery versus percutaneous nephrolithotomy. *J Urol* 2005;**173**:469–73.

[2] Jessen JP, Honeck P, Knoll T, Wendt-Nordahl G. Percutaneous nephrolithotomy under combined sonographic/radiologic guided puncture: results of a learning curve using the modified Clavien grading system. *World J Urol* 2013;**31**:1599–603.

[3] Kessaris DN, Bellman GC, Pardalidis NP, Smith AG. Management of hemorrhage after percutaneous renal surgery. *J Urol* 1995;**153**:604–8.

[4] Keoghane SR, Cetti RJ, Rogers AE, Walmsley BH. Blood transfusion, embolisation and nephrectomy after percutaneous nephrolithotomy (PCNL). *BJU Int* 2013;**111**:628–32.

[5] Nouralizadeh A, Ziaee SA, HosseiniSharifi SH, et al. Delayed post percutaneous nephrolithotomy hemorrhage: prevalence, predictive factors and management. *Scand J Urol* 2014;**48**:110–5.

[6] Turna B, Nazli O, Demiryoguran S, Mammadov R. Percutaneous nephrolithotomy: variables that influence hemorrhage. *Urology* 2007;**69**:603–7.

[7] Lee JK, Kim BS, Park YK. Predictive factors for bleeding during percutaneous nephrolithotomy. *Korean J Urol* 2013;**54**:448–53.

[8] Akman T, Binbay M, Sari E, Yuruk E, Tepeler A, Akcay M, et al. Factors affecting bleeding during percutaneous nephrolithotomy: single surgeon experience. *J Endourol* 2011;**25**:327–33.

[9] Srivastava A, Singh KJ, Suri A, Dubey D, Kumar A, Kapoor R, et al. Vascular complications after percutaneous nephrolithotomy: are there any predictive factors? *Urology* 2005;**66**:38–40.

[10] Lin EP, Bhatt S, Dogra VS, Rubens DJ. Sonography of urolithiasis and hydronephrosis. *Ultrasound Clin* 2007;**2**:1–16.

[11] Thomas K, Smith NC, Hegarty N, Glass JM. The Guy's Stone Score grading the complexity of percutaneous nephrolithotomy procedures. *Urology* 2011;**78**:277–81.

[12] Kukreja R, Desai M, Patel S, Bapat S, Desai M. Factors affecting blood loss during percutaneous nephrolithotomy: prospective study. *J Endourol* 2004;**18**:715–22.

[13] Liumbruno G, Bennardello F, Lattanzio A, Piccoli P, Rossetti G. Recommendations for the transfusion of red blood cells. *Blood Transfusion* 2009;**7**:49–64.

[14] Wang Y, Jiang F, Wang Y, Hou Y, Zhang H, Chen Q, et al. Post-percutaneous nephrolithotomy septic shock and severe hemorrhage: a study of risk factors. *Urol Int* 2012;**88**:307–10.

[15] Mousavi-Bahar SH, Mehrabi S, Moslemi MK. Percutaneous nephrolithotomy complications in 671 consecutive patients: a singlecenter experience. *Urol J* 2011;**8**:271–6.

[16] El-Nahas AR, Shokeir AA, El-Assmy AM, Mohsen T, Shoma I, Eraky I, et al. Post-percutaneous nephrolithotomy extensive hemorrhage: a study of risk factors. *J Urol* 2007;**177**:576–9.

[17] Nuño de la Rosa I, Palmero JL, Miralles J, Amorós A, Ferrer E, Esteban E. Treatment of hemorrhagic complications of EurRadiol percutaneous nephrolithotomy in Galdakao position. *Actas Urol Esp* 2013;**37**:587–91.

[18] Galek L, Darewicz B, Werel T, Darewicz J. Haemorrhagic complications of percutaneous lithotripsy: original methods of treatment. *Int Urol Nephrol* 2000;**32**:231–3.

[19] Srinivasan AK, Herati A, Okeke Z, Smith AD. Renal drainage after percutaneous nephrolithotomy. *J Endourol* 2009;**23**:1743–9.

[20] Anil Kumar N, Venkata Chaitanya S, Bezawada S, Sree Gouri SR. Post percutaneous nephrolithotomy massive hematuria: our experience. *Int J Contemp Med Res* 2016;**3**:1499–502.

[21] Yesil S, Ozturk U, Goktug HN, Tuygun C, Nalbant I, Imamoglu MA. Previous open renal surgery increased vascular complications in percutaneous nephrolithotomy (PCNL) compared with primary and secondary PCNL and extracorporeal shock wave lithotripsy patients: a retrospective study. *Urol Int* 2013;**91**:331–4.

[22] Zehri AA, Biyabani SR, Siddiqui KM, Memon A. Triggers of blood transfusion in percutaneous nephrolithotomy. *J Coll Physicians Surg Pak* 2011;**21**:138–41.