Analysis of factors related with bleeding in percutaneous nephrolithotomy using balloon dilatation

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Introduction: *The aim of the present study is to determine the preoperative and operative factors associated with bleeding in percutaneous nephrolithotomy (PNL) operations where tract dilatation was formed by balloon dilators.*

Material and methods: *A total of 378 patients underwent PNL in our department between 2003 and 2008. After excluding missing data 310 patients were included in the study in whom nephrostomy tract dilatation was performed using balloon dilators. The amount of blood loss was estimated by calculating the change in hemoglobin (Hgb). Preoperative and operative factors were assessed for association with the change in Hgb levels.*

The preoperative factors were age, sex, hypertension, diabetes mellitus (DM), smoking, ipsilateral pyelonephritis, body mass index, serum creatinine level, stone localization and burden, previous ipsilateral renal stone surgery and extracorporeal shock wave lithotripsy and degree of hydronephrosis. Operative factors were operation time, calyx of puncture and tract number. The possible effect of surgical experience was also taken into consideration. Univariate and stepwise multiple linear regression analysis were performed.

Results: *The average Hgb drop was 1.9 g/dL (range: 0.1 g/dL-8.8 g/dL). Ancillary procedures were performed due to the residual calculi in 23% of patients. The stone free rates increased from 77% to 94% after the secondary interventions.*

Prolonged operation time and presence of diabetes mellitus (DM) had a significant association with the decrease in Hgb levels ($p < 0.05$). However the remaining factors analyzed did not have any association with the change in Hgb values ($p > 0.05$). Previous ipsilateral open renal stone surgery was not associated with a change in Hgb levels ($p > 0.05$). Staghorn stones and operation expertise were the factors related with operation time ($p < 0.05$).

Conclusions: *In patients where tract dilatation is gained by balloon dilators prolonged operation time and DM are the major risk factors related with a higher incidence of blood loss. Surgical expertise is highly related with operation time. It would be wise to operate staghorn stones when a high surgical experience is gained.*

Key Words: percutaneous nephrolithotomy, bleeding, tract dilatation, surgical complications

Introduction

The management of renal calculi with percutaneous modalities became a part of the medical practice in the late 1970's[1] and is continuously evolving as a minimal invasive technique. Treatment with percutaneous nephrolithotomy (PNL) is limited to those cases likely to have a less favorable outcome after extracorporeal shock wave lithotripsy (SWL) and is the first line of treatment in staghorn calculi.[2,3] Even though PNL is generally accepted to be a minimal invasive technique with low complication rates, serious complications still do occur.[4,5] Injury of the neighboring organs (spleen, liver, colon, pleura, and lung), infection and bleeding are the major complications. The degree of bleeding may vary between patients and the management may become challenging. Although bleeding is usually managed by conservative treatments such as monitorization and blood transfusion, some patients require angioembolization to control intractable bleeding.

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In our center balloon dilatation is employed for dilatation of the access formed to the collector system. In this study we aimed to identify the risk factors associated with bleeding in patients where balloon dilatation was employed as a form of tract formation.

Material and methods

A total of 378 patients underwent PNL in our center between January 2003 and November 2008. After excluding patients with missing data, 310 primary PNL procedures patients with a mean age of 44 years (18 to 80) were retrospectively reviewed. In eight patients, whom previously underwent open renal stone surgery, mechanical dilatation was employed due to unsuccessful balloon dilatation and these patients were excluded. The remaining 302 patients were included in the study. Diagnostic work up included medical history, physical examination, definition of stone size (kidney-ureter-bladder (KUB) and USG) and anatomy of collecting system (intravenous pyelogram), multiple serum analysis (including clotting profile work up), urine dipstick tests, urine culture, blood coagulation parameters and isotope renogram if indicated. Evaluation of the stone position and burden (stone area = length x width x 0.25 x π) was done by using a KUB and an excretory urogram.[6]

The preoperative 24 hour, postoperative 24 and 48 hour hematocrit (Htc) and hemoglobin (Hgb) values were recorded. The amount of blood loss was predicted by calculating the decrease in Hgb levels. The amount of blood transfusion was also taken into consideration. The approximation that a 1-U blood transfusion increases the hematocrit by 3% and hemoglobin by 1 value was used. The change in Hgb was calculated using the following formula: Preoperative Hgb – Postoperative Hgb + Blood transfusion units *1.

Preoperatively, all patients with positive urine culture were treated with culture sensitive specific antibiotics for their infection. All operations were performed either directly or by the supervision of three surgeons experienced in endourology and trained PNL operations in different centers. A guide wire and ureteral catheter was placed in the ipsilateral ureter in a supine position under general anesthesia. Percutaneous access was performed at the posterior axillary line by the operating urologist under biplane C-arm fluoroscopic guidance through the posterolateral plane of the kidney after retrograde opacification via the ureteral catheter in prone position. After gaining access into the collecting system a guide wire was inserted. Fascial dilatation was done over the guide wire by using an 8/10F co-axial dilator and a stiff guide wire was placed. Nephrostomy tract dilatation was performed using a balloon dilator over the second stiff guide wire. Nephrostomy tract dilatation was performed using a high pressure 30F nephrostomy balloon catheter kit dilator over the second stiff guide wire. After successful tract dilatation the 30F Amplatz sheath was positioned. Using a 26F rigid nephroscope through the established tract, small stones were extracted directly with graspers or baskets and bigger stones were first disintegrated by pneumatic lithotriptors and then extracted. After completion of the procedure a 14Ch Malecot nephrostomy tube was placed and secured to the skin with a 2-0 silk suture.

To identify the factors associated with the decrease in Hgb levels; preoperative and operative factors were analyzed. The preoperative factors analyzed were age, sex, presence of hypertension (HT), diabetes mellitus (DM), tobacco smoking habits, history of ipsilateral pyelonephritis, body mass index (BMI), serum creatinine level, stone localization, stone burden, previous ipsilateral renal stone surgery, previous ipsilateral extracorporeal shock wave lithotripsy and degree of hydronephrosis. The operative factors analyzed were operation time, calyx of puncture, dilatation technique (balloon and mechanical) and tract number. We also analyzed the possible effects of the surgical experience.

The body mass index was calculated by body weight divided by the square of height. Patients were stratified into four groups according to the World Health Organization classification of BMI: < 25 (average), 25-29.9 (overweight), 30-39.9 (obese) and > 40 kg/m^2 (morbidly obese). Smoking habits were recorded as pack year and this was calculated by multiplying the number of packs of cigarettes smoked per day by the number of years the person has smoked. Hydronephrosis was graded as either nil/mild or moderate/severe.

Statistical Package for Social Sciences, version 15 (SPSS 15) was used for statistical analysis. The association of the previously defined parameters with Hgb changes was studied using univariate (Student's t test, ANOVA) and multiple regression stepwise analysis in the group of patients where only balloon dilatators were used for tract formation.

Results

Three hundred and two patients in whom tract dilatation was formed by balloon dilators were included in the study, 196 were males and 106 were females with a mean age of 44 years (range 18-80).

Of the 302 patients, 96 had a history of open surgical stone intervention. In six patients a horseshoe kidney was diagnosed and the operation was performed in accordance. In all patients the tract size was 30F and the balloon dilatation was ceased when a 15 atm pressure was reached. In eight patients, whom previously underwent open renal stone surgery, mechanical dilatation was employed due to unsuccessful balloon dilatation and the Hgb change was similar with the remaining patients ($p > 0.05$). Mean operation time was 120 minutes (range 30 to 290). The mean interval to nephrostomy tube removal was 2 days (range 0 to 9). In 23% of the patients an ancillary procedure (SWL 68.9%, PNL 24.13%, ureterorenoscopy 5.17%, open surgery 1.7%) was performed due to residual calculi after the first operation. The stone free rates increased from 77% to 94% after the secondary interventions. In 2.4% of the patients a double-J stent was administered either due to prolonged urinary leakage or formation of stone street.

The mean decrease in Hgb was 1.9 g/dL (range: 0.1 g/dL-8.8 g/dL). In 61 patients (20%) blood transfusion was carried out and the mean transfusion rate was 669 cc (range 400 cc to 2000 cc). In one patient a pseudoaneurysm and in another patient A-V fistula occurred and was treated with angioembolization. These patients underwent super selective renal angiography to identify the site and type of vascular injury. Embolization of the injured vessels was performed using microcoils. In one patient another embolization session was needed due to recanalization of the occluded vessel.

Univariate analysis revealed that gender, age, presence of HT, stone side, single kidney patients, previous ipsilateral pyelonephritis, stone localization, previous ipsilateral renal stone surgery, previous ipsilateral SWL and calyx of puncture did not have any association with the change in Hgb levels ($p > 0.05$).

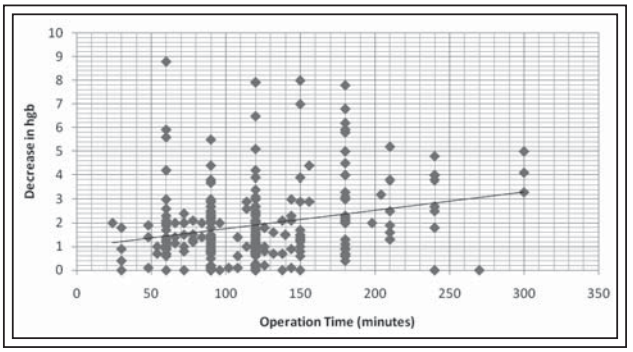

Figure 1. Correlation between operation time and decrease in Hgb values.

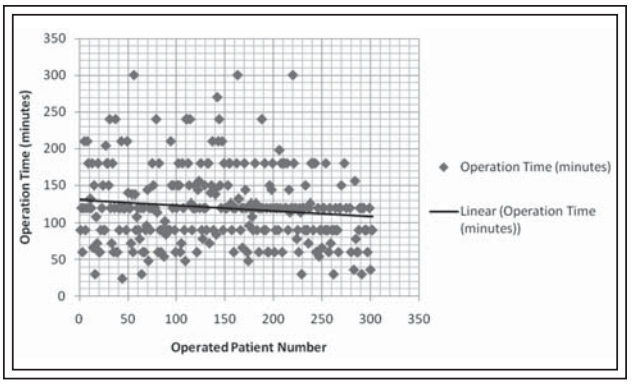

Figure 2. Relationship between operation time and operation expertise.

On the other hand presence of DM showed a significant association ($p < 0.05$) with the change in Hgb levels in univariate analysis. BMI, smoking rate, tract number, degree of hydronephrosis, serum creatinine levels and operator expertise did not show any association ($p > 0.05$) with the change in Hgb levels in linear regression analysis. Operation time had a significant effect on Hgb decrease in linear regression analysis ($p < 0.05$), Figure 1.

Stepwise multiple regression analysis showed that operation time ($p = 0.001$) was significantly associated with drop in Hgb levels. Further analysis was carried out to determine the factors associated with an increased operation time. Stepwise multiple regression analysis revealed that stone burden (correlation co-efficient: 0.3, $p < 0.05$) and operator expertise (correlation co-efficient: -0.12, $p < 0.05$) were significant predictors of operation time. A statistical difference was found between staghorn stones and other stone types in the mean operation time (ANOVA $p < 0.05$). The operation time, Figure 2, significantly decreased as the learning curve progressed while the operated mean stone burden had a

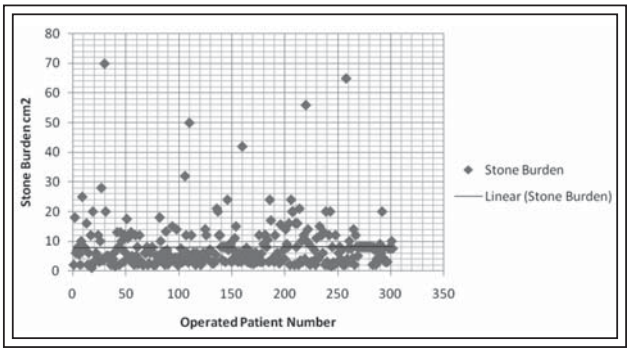

Figure 3. Stone burden versus operated patient number.

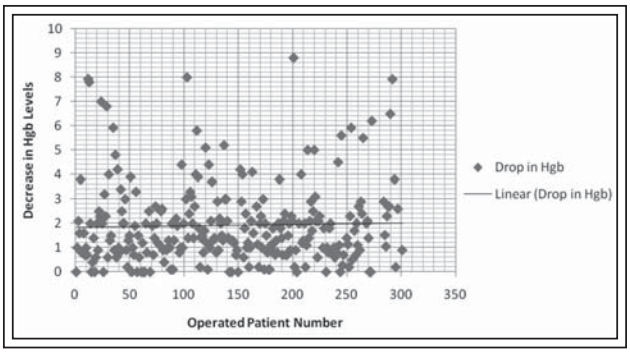

Figure 4. Decrease in Hgb as the learning curve progresses.

uniform distribution within the whole group of patients, Figure 3. The Hgb levels decrease did not change as the learning curve progressed ($p > 0.05$), Figure 4.

The detailed explanation of the statistical analysis results are shown in Table 1.

Discussion

PNL is currently a safe treatment for the removal of large, multiple and complex renal stones. Although PNL is minimally invasive, it is still a surgical procedure and thus it is associated with a low but specific major complication rate.[5] According to different investigators the general complication rates are variable.[5,7-9] Fortunately in most cases minor complications are encountered. In a recently published review of the literature the frequency of major complications was 0.9%-4.7% for septicemia and 0.6%-1.4% for renal hemorrhage requiring intervention.[4] In our series the ratio of major complications was 1.6% (AV fistula 0.8%, septicaemia 0.8%).

Blood loss during PNL operations may occur during renal puncture, tract dilatation, nephroscopy and stone removal. The vascular related complications may range from clinically insignificant bleeding to severe AV fistulas. Clinically insignificant bleeding, one of the most common minor complication of PNL, is managed with conservative measures. On the other hand clinically significant bleedings are rare and may become life threatening. AV fistula, one of the most serious complications of PNL, is managed by selective embolization treatment.

Bleeding related complications are usually assessed with the incidence of blood transfusion. In our study we used the change in Hgb levels even though we recorded both Htc and Hgb levels. We only used Hgb levels since there are studies in the literature delineating that Hgb and Htc are identical parameters and there is no need to determine both in the evaluation of patients.[10]

Previously systematic analysis of the risk factors for bleeding in PNL operations has been elucidated by Stoller et al, Kukreja et al and Turna et al.[11-13] In these studies stone burden, staghorn calculi, multiple tract operations and DM were found as the major risk factors related with post PNL bleeding. In our study increased blood loss was related with DM and increased operation time. In some studies the number of tracts has been related with bleeding.[8,11-14] Even though it seems logical that the chances of bleeding will increase as the number of tracts increases this was not the case in our study. However this may be due to the small number of patients with more than two tracts in the groups we accepted as multiple tracts. When the results are assessed in that manner we could say that performing PNL with two tracts does not cause bleeding, however we do not have sufficient data to discuss three or more tracts. Strivasta et al and Martin et al also did not find any significant correlation with the puncture number and bleeding.[15,16] Information regarding the calyx of puncture related bleeding complications is conflicting. While upper calyx puncture was identified as a risk factor in the study of Nahas et al, this has not been confirmed either by our study or by Turna et al.[13,17]

The effect on the outcome of percutaneous renal surgery of previously performed open renal surgery has been debated by various studies. The possible local effects of a previous open renal surgery may result in difficulties of access and requires careful preoperative planning. Bleeding however has not been seen to increase in this subset of patients.[18-20] In a previous study conducted by our group has also suggested that the necessity and amount of blood transfusion is not higher in patients who previously underwent open renal surgery.[18] In our current study the Hgb change was analyzed and the results corroborate the previous studies. However in these cases balloon dilatation may be challenging due to the scar tissue on the access route. In our series balloon dilatation was unsuccessful in eight (8.3%) cases that all were patient's previously undergone open renal stone surgery.

SWL treatment has well described reversible (mild tubular necrosis, vacuolar changes of tubular lumen etc) and irreversible (disruption of nephrons, large hematomas of cortex and medulla etc) effects on kidney tissue.[21] However previous SWL treatment had no effect on the Hgb change in our study. Even though both HT and DM have systemic effects, like atherosclerosis, in the study of Turna et al only DM had a significant effect on post PNL Hgb decreases.[13] However, due to the small number of patients with

TABLE 1. **Preoperative and operative analyzed factors for the association with blood loss**

Preoperative factors		**Change in hemoglobin (g/dL)**	
HT	(+) n: 82-27% (-) n: 220-73%	1.97 (std deviation: 1.6) 1.91 (std. deviation: 1.57)	p > 0.05 (t-test, and stepwise multiple regression analysis)
DM	(+) n: 37-12% (-) n: 265-88%	2.4 (std. deviation: 2.2) 1.8 (std. deviation: 1.5)	p < 0.05 (t-test) p = 0.03 (stepwise multiple regression analysis)
SWL	(+) n: 69-23% (-) n: 233-77%	1.9 (std. deviation: 1.3) 1.8 (std. deviation: 1.7)	p > 0.05 (t-test and stepwise multiple regression analysis)
Previous ipsilateral open stone surgery	(+) n: 96-32% (-) n: 206-68%	1.9 (std. deviation: 1.6) 1.9 (std. deviation: 1.6)	p > 0.05 (t-test and stepwise multiple regression analysis)
Smoking	Smokers: 89 patients (32%) Smokers mean pack/years: 1.7		p > 0.05 (stepwise multiple regression analysis)
Stone burden	Range: 114 Mean: 8.21 Median: 6 Min: 1 Max: 115		p > 0.05 (stepwise multiple regression analysis)
BMI	Range: 114 Mean: 28.39 Median: 28.08 Min: 18 Max: 41		p > 0.05 (stepwise multiple regression analysis)
Hydronephrosis	No hydronephrosis n = 41 13.5% Grade 1 n = 66 22% Grade 2 n = 120 40% Grade 3 n = 66 22% Grade 4 n = 7 2.4%	1.4 (std. deviation: 1.2) 2 (std. deviation: 1.6) 2 (std. deviation: 1.7) 2 (std. deviation: 1.6) 0.9 (std. deviation: 0.6)	p > 0.05 (ANOVA and stepwise multiple regression analysis)
Stone location	Solitary caliceal stones: Lower calyx: n = 60 19.9% Upper calyx: n = 19 6.3% Multiple stones: n = 60 19.9% Solitary pelvis stones: n = 95 31.4% Staghorn: n = 54 17.8% Partial staghorn: n = 14 4.6%	 1.8 (std. deviation: 1.7) 1.4 (std. deviation: 1) 2.1 (std. deviation: 1.5) 1.7 (std. deviation: 1.3) 2.2 (std. deviation: 2) 2.2 (std. deviation: 2)	 p > 0.05 (ANOVA and stepwise multiple regression analysis)
Operative factors			
Operation time	Range: 271 Mean: 119 minutes Median: 120 minutes Min: 29 minutes Maxi: 300 minutes		p = 0.001 (stepwise multiple regression analysis)
Tract number	Single: n = 260 86% Multiple: 2 tracts: n=36 11.9% More than 2 tracts: n = 6 1.9%	1.8 (std. deviation: 1.6) 2 (std. deviation: 1.4)	p > 0.05 (t-test and stepwise multiple regression analysis)
Calyx of puncture	Single: Lower calyx: n = 229 76% Mid calyx: n = 24 7.9% Upper calyx: n = 7 2.3% Multiple: Lower + mid calyx: n = 25 8.3% Low + upper calyx: n = 8 2.7% Mid + upper calyx: n = 3 0.9% Lower + mid + upper calyx: n = 6 1.9%		p > 0.05 (ANOVA and stepwise multiple regression analysis)

DM they could not provide sufficiently convincing data. Our study revealed that DM has a significant effect on bleeding in all statistical analysis which is in accordance with Turna`s and Kukreja's findings.[12,13]

Recently studies about the effect of aging on the complications of PNL have been published. These studies have demonstrated the safety and feasibility of PNL operations in the elderly.[22,23] On the other hand Stoller and associates found a higher transfusion rate in the elderly despite similar preoperative hemoglobin levels.[24] In our study no such association between aging and blood transfusion rates and Hgb changes have been shown. Smoking related operative complications are usually related to ischemia and pulmonary problems. In our study the drop of Hgb levels had no relationship with smoking.

Obesity has been associated with increased surgical morbidity and mortality.[25] El-Assmy et al described their experience of PNL in 1121 patients.[26] They found that obesity had no significant effect on hospital stay, auxiliary procedures, complications including bleeding, hemoglobin loss, stone free rates and operation time. Even though there are no morbidly obese patients in our study group, no significant Hgb change has been observed between obese and normal body weight patients.

Our study revealed that prolonged operation time was related with a decrease in Hgb levels. In the study of Tanriverdi et al, operation time decreased as the experience of the surgeon increased.[27] Another possible factor that may increase operation time would be difficulties of the case it's self. In our study also operation time was associated with the experience of the surgeon. The operation time significantly decreased with the increase in the experience of the surgical team. Previous studies and the American Urological Association nephrolithiasis guideline panel have stated that staghorn stones and high stone burden are parameters associated with blood loss in PNL operations.[3,13,15,17] Even though our results have not shown any association with blood loss and stone burden and staghorn stones these two parameters were highly related with operation time. If less blood loss is aimed it would be wise not to operate large stones and staghorn stones at the beginning of the surgical experience.

Conclusions

In patients where tract dilatation is gained by balloon dilators prolonged operation time and DM are the major risk factors related with a higher chance of blood loss. A history of previous open renal surgery is not related with a higher chance of blood loss however it has its own difficulties in forming the tract with a balloon dilator. Operation time may be kept short by operating complicated stones when a higher surgical experience is gained. □

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