Risk factors for hemorrhage requiring embolization after percutaneous nephrolithotomy

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Abstract

Introduction: Percutaneous nephrolithotomy (PCNL) is the primary surgical intervention in kidney stone management. Even though it is performed quite often, the complication rates are also high. Arteriovenous fistulas following extended hemorrhages after PCNL are one of the most serious complications of this operation. Our main objective was to review the data of patients who required angiography and embolization.

Methods: In total, we included 1405 patients who underwent PCNL between 2007 and 2014. All patient data were retrospectively reviewed. All patients went under PCNL using fluoroscopy. Following informed consent, all hemorrhagic patients underwent angiography in the interventional radiology department and embolization was performed in patients with a hemorrhage focus point.

Results: A total of 147 patients (10.4%) required transfusion for post-PCNL hemorrhages. Of them, 14 (0.99%) underwent angiography and embolization (9 [64.2%] were male and 5 [35.8%] were female, with a mean age of 39.4 ± 10.2). The remaining 133 patients were conservatively managed (81 [60.9%] males and 52 [39.1%] females, with a mean age of 42.3 ± 12.4). When the predicting factors for angiography and embolization were reviewed, renal abnormalities and the mean size of stones were significant in both univariate and multivariate analysis ($p < 0.001$).

Conclusion: Patients with extended and intermittent hematuria should be monitored closely for hemodynamics; if there is an ongoing necessity for transfusion, angiography should be considered.

Introduction

Percutaneous nephrolithotomy (PCNL) is a safe and reliable method in kidney stone surgery.[1] Lately, the efficacy and reliability of this operation improved due to advancements in technology and increased experience on this field. However, there are still related complications. Hemorrhage is one of the most dangerous complications that can be seen after PCNL. One of the most important reasons for bleeding is arteriovenous fistulas and pseudoaneurysms. Angiographic embolization can be used to treat the arteriovenous fistulas and post-PCNL hemorrhages.[2] With conservative treatment, the need for angiographic embolization following PCNL drops below 1%.[3,4] There is no consensus about the management of hemorrhages that develop following PCNL.[5,6] Selective and super-selective angiography can be used in massive or continuous post-PCNL hemorrhage cases.[7] Superselective embolization is defined as a reliable and safe procedure in renal vascular injury.[8] Arteriovenous fistulas that might develop following extended hemorrhage in PCNL patients should be diagnosed and treated as early as possible.[9] For this reason, defining the risk factors for arteriovenous fistulas is crucial.

In this study, our main aim was to research risk factors for post-PCNL hemorrhages that require embolization.

Methods

Study design

We reviewed patients treated with PCNL at a single centre between 2007 and 2014. In total, 1405 patients with complete set of data necessary for the study were included. All recorded patient data were retrospectively reviewed. Hemogram, coagulation profile, creatinine, urine culture antibiogram, total abdominal computed tomography imaging studies were performed on all patients before the surgery. Hemorrhages in patients were diagnosed with persistent hematuria, low hemoglobin levels, and disturbance in hemodynamic parameters. Hemorrhages that develop within 4 weeks after surgery were investigated.

PCNL technique

All patients went under PCNL using fluoroscopy. Amplatz dilatation, balloon dilatation or micro percutaneous methods were used according to indications on the patients. Laser and ultrasonic lithotripters were used to break up the stones. Except for the micro percutaneous surgery patients, all patients were fitted with re-entry catheters.

Embolization technique

Following informed consent from all patients, all hemorrhagic patients underwent angiography in the interventional radiology department and embolization was performed in patients with a hemorrhage focus point. For angiography, a vascular sheath of 7F thickness was inserted from right or left femoral artery. A 5F renal double curve diagnostic catheter (Boston Scientific Inc.) and 0.035″ guidewire (Radiofocus, Terumo) were used to selectively catheterize the renal artery that showed complications. Using 5 cc, non-ionic, iso-osmolar contrast matter, an angiography was performed. The main renal artery, segmental, interlobar arteries and distal branches were reviewed (Fig. 1). After pinpointing the hemorrhage location, guidance angiography images were retrieved. With these images, through the initial diagnostic catheter, a 2.4F microcatheter and guidewire (Progreat, Terumo) were used to superselecitvely catheterize the interlobar artery (the hemorrhage point) (Fig. 2). Beginning from the fistula level, embolization was performed towards the proximal end of interlobar artery using detachable coils sent from the micro catheter. Control angiography was done following coil embolization. After seeing that the fistula line (the hemorrhage point) was closed, the intervention was finalized (Fig. 3). The entry point in the main femoral artery was closed using the 6F vascular closure device (Angioseal, St. Jude). No patients required re-embolization.

SPSS 20.0 for Windows was used in the statistical analysis. Percentages, means, and standard deviation values were calculated. Student's t-test and chi-square tests were used in the univariate analysis. Logistic regression analysis was used in the multivariate analysis and p values below 0.05 were deemed significant.

Results

Of the 1405 patients who underwent PCNL, 147 (10.4%) developed hemorrhaging that required transfusion. These 147 patients were divided into 2 groups: (1) patients with angiography and embolization; and (2) patients without angiography and embolization (i.e., treated conservatively). Of the 147 patients, 14 (9.5%) patients with persistent hematuria and hemodynamic disturbance underwent angiography and embolization. The remaining 133 patients (90.5%) were conservatively treated. No deaths were reported in both groups during the study period.

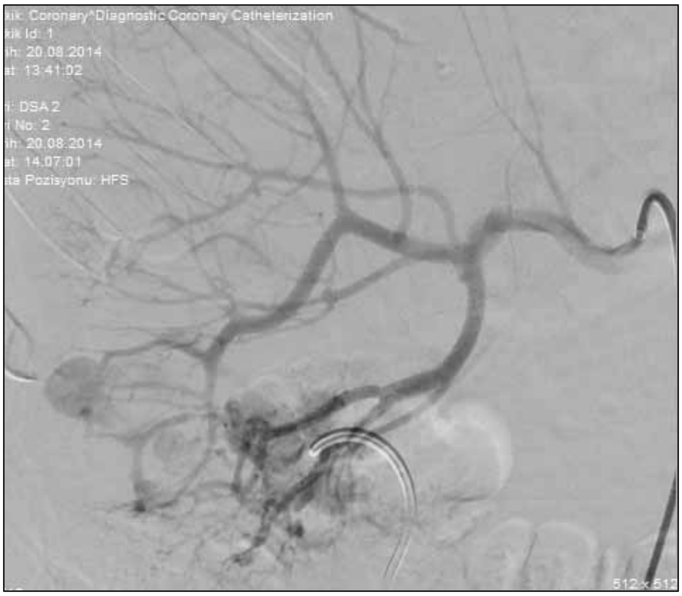

Fig. 1. The main renal artery, segmental, interlobar arteries and distal branches were reviewed.

From the embolization group, the technical success rate was 100% in viewing the hemorrhage point and treatment embolization. Only one patient showed partial loss in renal parenchyma due to a wide hemorrhagic area, even though he went under target embolization. However, the technical success rate of embolization using detachable coils was 100%. The mean intervention period was 68.5 ± 21.0 minutes. All stones were unilateral in embolization patients. Two (14.3%) patients had a horseshoe kidney and 2 (14.2%) had rotation

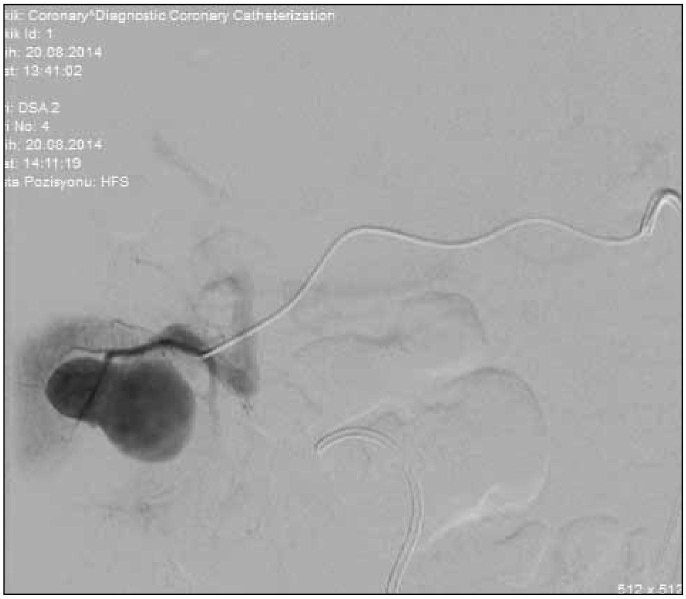

Fig. 2. A microcatheter (2.4F) and guidewire (Progreat, Terumo) were used to superselecitvely catheterize the interlobar artery (the hemorrhage point.

Fig. 3. Control angiography following coil embolization.

abnormalities. Other patients had no renal abnormalities. No patient had retrorenal colon. Of these 14 patients, 4 (28.6%) developed hemorrhage within the first 24 hours (Table 1, Table 2).

All patients included in our study were in-patients at our clinic. Conservative treatment was performed as a first step in all of the patients. Patients with persistent hematuria and hemodynamic disturbances were transferred to the Radiology Department for angiography. The mean clinic follow-up period was 54.32 ± 17.2 hours after the development of the postoperative hemorrhage. There was a statistically significant difference between patients who were managed conservatively and patients who underwent angiography and embolization in terms of mean hemoglobin drop, hospitalization period, transfusion volume, and postoperative bleeding periods (Table 3).

When the predicting factors for angiography and embolization were reviewed, we found that renal abnormalities and mean size of stones were significant in univariate and multivariate analysis ($p < 0.001$) (Table 4).

Table 1. Patient data

		n	%
Localization	Right	8	57.1
	Left	6	42.9
Sex	Male	9	64.2
	Female	5	35.8
ESWL	ESWL +	10	71.4
	ESWL -	4	38.6
Renal abnormality	Horseshoe kidney	2	14.3
	Rotation abnormal	2	14.3
Stone count	Single	10	71.4
	Multiple	4	28.6
Stone location	Pelvis	6	42.8
	Lower calyx	4	28.6
	Pelvis + upper calyx	4	28.6
Access number	1	12	85.7
	2	2	14.3
Access entrance	Subcostal	12	75
	Intercostal (11–12 rib)	4	25
Access location	Lower calyx	12	75
	Middle calyx	2	12.5
	Upper calyx	2	12.5
Dilatation type	Amplatz one shot	8	50.0
	Amplatz sequential	4	25
	Balloon	4	25
Dilatation diameter	30 French	10	62.5
	24 French	4	25
	Micro percutaneous	2	12.5
Residual stones	Stone free	9	64.3
	<4 mm	4	28.6
	>4 mm	1	7.1
Hemorrhage time	First 12 hours	2	14.3
	12–24 hours	2	14,3
	>24 hours	8	71.4
Angiography result	Arteriovenous fistula	10	71.4
	Arteriolocated fistula	2	14.3
	Pseudoaneurysm	2	14.3
Previous surgeries	PCNL	1	7.1
	Open renal surgery	1	7.1

ESWL: Extracorporeal shock wave lithotripsy; PCNL: percutaneous nephrolithotomy.

Discussion

Complication rates which require transfusion following PCNL are between 3% and 23%.[9-11] Hemorrhages are usually caused by segmental arteries and controlled using conservative management methods.[12] Hemorrhages that require embolization are between 0.3% and 1.4%.[9,10]

Since the arterial system runs on the increased pressure principle, the risk of developing an arteriovenous fistula (blood flowing from injured arteries' high pressure towards adjacent injured vein) or pseudoaneurysm (blood pooling under parenchyma) is relatively high.[13] The hemorrhage source might not be clearly seen using slice-view imaging studies in patients with hemorrhagic complications and hemodynamic abnormality following PCNL. Therefore, the catheter angiography plays an important role in detecting the hemorrhage source and in embolizing the hemorrhage.[14] Fistulas that develop from the arterial towards the venous system, pseudoaneurysm from the arterial system, or fistulas from the arterial system towards the calyx system can all be seen using contrast angiography through the renal artery.[15] During embolization, instead of push-type coils we used mechanically detachable coils to avoid non-target

Table 2. Patient surgical data

Mean stone size (cm)	4.2 ± 1.35
Mean operation time (minute)	57.8 ± 18.6
Fluoroscopy period (second)	68.5 ± 21.0
Mean hemoglobin drop (g/dL)	2.8 ± 0.9
Mean hospitalization period (days)	8.2 ± 2.1
Mean age (years)	39.4 ± 10.2
Mean preoperative creatinine (mg/dL)	1.02 ± 0.2
Mean pre-embolization creatinine (mg/dL)	1.25 ± 0.5
Mean post-embolization creatinine (mg/dL)	1.13 ± 0.3

embolization risk. With push-type coils, the risk for non-target embolization increases and the renal unit loss also increases.[16]

In our study, we found that 28.6% of our cases developed hemorrhage within the first 24 hours, similar to reported rates.[10,17] Hemorrhages that require angiography and embolization are usually seen 24 hours after the operation and are characterized by the drop of hemoglobin values against transfusion. Therefore, patients hemorrhaging after 24 hours and requiring transfusion should be referred to angiography immediately. In cases with postoperative intermittent hemorrhages which disrupt hemodynamic balance, close monitoring and angiography can be considered. In some cases, hemorrhages develop 13 weeks post-surgery.[17] In our study, we also have a similar patient who developed hemorrhage 4 weeks after surgery. In late-term intermittent hematuria cases, vascular pathologies should be considered. Since patients will experience a small loss in renal units during embolization, creatinine levels should be closely monitored. We did not see a significant difference in mean creatinine levels during these steps. However, patients should be followed for hypovolemic symptoms and they should be supported with hydration and transfusion.

There was a significant difference in terms of mean hemoglobin drop, mean hospitalization period, mean blood transfusion necessity and starting time of the hemorrhages between the conservative management and embolization groups ($p < 0.001$). These results are similar to the ones reported in the literature.[10,17]

In addition, stone size and renal anomaly presence were significant in both univariate and multivariate analysis in the conservative management and embolization groups ($p < 0.001$). Stone size and renal anomaly presence were considered risk factors for hemorrhage requiring embolization. Srivastava and colleagues found that stone size was also a risk factor.[9] Again, some studies indicate that the presence of staghorn stones are a risk factor for hemorrhage.[9,16] In our study, the presence of renal anomalies was not considered a risk factor,[10] likely due to our low number of cases.

Reviewing risk factors for vascular complications following PCNL is essential. In PCNL patients, knowing that there is a higher risk of developing hemorrhages enables us to take proper preoperative precautions. In addition, angiography must be considered as a first option in hemorrhage development during the postoperative period due to higher risk of developing vascular complications.

The main limitation of our study is its retrospective design. It is clear that prospective studies with more patients are needed.

Conclusion

PCNL is a commonly used method in kidney stone surgery. Patients with extended intermittent hematuria should be monitored closely for hemodynamic balance; if the transfusion necessity is still ongoing, angiography should be considered. Big-sized stones and renal abnormalities pose a risk for vascular complications. Early angiography for postoperative hemorrhage in high-risk patients should be considered the first option.

Competing interests: The authors all declare no competing financial or personal interests.

Table 3. Operative parameters

Parameter		Conservative management		Angiography + embolization		*p* value
Mean hemoglobin drop (g/dL)		0.9 ± 0.4		2.8 ± 0.9		<0.01
Mean hospitalization period (days)		4.2 ± 1.0		8.2 ± 2.1		<0.01
Mean blood transfusion (units)		1.02 ± 0.41		4.01 ± 1.30		<0.01
Mean operation time (minute)		61.2 ± 20.1		57.8 ± 18.6		0.472
Fluoroscopy period (second)		77.1 ± 18.1		68.5 ± 21.0		0.335
Residual stone	Stone free	102	76.7%	9	64.3%	0.312
	<4 mm	22	16.5%	4	28.6%	
	>4 mm	9	6.8%	1	7.1%	
Hemorrhage period	First 12 hours	109	82.0%	2	14.3%	<0.01
	12–24 hours	19	14.3%	2	14.3%	
	>24 hours	5	3.7%	6	71.4%	

Table 4. Predicting factors for angiography and embolization

Factor		Conservative management (n = 133)		Angiography and embolization (n = 14)		*p* value (univariate)	*p* value (multivariate)
Localization	Right	73	54.8%	8	57.1%	0.896	
	Left	60	45.2%	6	42.9%		
Sex	Male	88	66.1%	9	64.2%	0.785	
	Female	45	33.9%	5	35.8%		
ESWL	+	72	54.1%	10	71.4%	0.294	
	-	61	45.9%	4	38.6%		
Renal anomaly	+	11	8.2%	4	38.6%	<0.01	<0.01
	-	122	91.8%	10	71.4%		
Stone count	Single	91	68.4%	10	71.4%	0.648	
	Multiple	42	31.6%	4	38.6%		
Stone localization	Pelvis	54	40.6%	6	42.8%	0.784	
	Lower calyx	33	24.8%	4	38.6%		
	Multiple	46	34.6%	4	38.6%		
Access number	Single	101	75.9%	12	85.7%	0.365	
	Multiple	32	24.1	2	14.3%		
Access location	Subcostal	108	81.2%	10	71.4%	0.236	
	Intercostal (11–12 rib)	25	18.8%	4	38.6%		
Dilatation type	Amplatz one shot	68	51.1%	7	50.0%	0.661	
	Amplatz sequential	30	22.5%	4	38.6%		
	Balloon	35	26.4%	3	21.4%		
Dilatation diameter	30 French	100	75.2%	10	71.4%	0.430	
	24 French	23	17.3%	2	14.3%		
	Micro-percutaneous	10	7.5%	2	14.3%		
Past surgeries	PCNL	8	6.0%	1	7.1%	0.405	
	Open renal surgery	14	10.5%	1	7.1%		
Mean stone size (cm)		2.8 ± 0.92		4.2 ± 1.35		<0.01	<0.01
Mean age (year)		45.6 ± 7.8		39.4 ± 10.2		0.225	

This paper has been peer-reviewed.

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