Original Article

Predictors for severe hemorrhage requiring angioembolization post percutaneous nephrolithotomy: A single-center experience over 3 years

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Abstract

Context and Aim: About 1% of the patients undergoing percutaneous nephrolithotomy (PCNL) have bleeding severe enough to require angioembolization. We identified factors which could predict severe bleeding post-PCNL and reviewed patients who underwent angioembolization for the same.

Settings and Design: This is a single-institutional, retrospective study over a period of 3 years.

Subjects and Methods: We retrospectively studied 583 patients undergoing PCNL at our institute from 2013 to 2016. We analyzed nine patients (three from our institute and six referred patients) who underwent angioembolization for severe bleeding post-PCNL. We analyzed the preoperative characteristics, intraoperative findings, and postoperative course of these patients and compared this with those patients who did not have a severe post-PCNL bleeding.

Statistical Analysis Used: Fischer's exact test and Chi-square test were used in univariate analysis. Logistic regression analysis was used in multivariate analysis with a value of $P < 0.05$ considered statistically significant.

Results: Three of the 583 patients (0.51%) who underwent PCNL at our institute required embolization to control bleeding. Preoperative characteristics that were significant risk factors for severe bleeding were a history of ipsilateral renal surgery ($P = 0.0025$) and increased stone complexity ($P = 0.006$), while significant intraoperative factors were injury to the pelvicalyceal system ($P = 0.0005$) and multiple access tracts ($P = 0.022$). Angiography revealed arteriovenous fistula in two patients and a pseudoaneurysm in seven patients. All patients underwent successful superselective angioembolization with preserved renal perfusion in six patients on control angiography postembolization.

Conclusions: History of ipsilateral renal surgery, increased stone complexity, multiple access tracts, and injury to the pelvicalyceal system are risk factors predicting severe renal hemorrhage post-PCNL. Early angiography followed by angioembolization should be performed in patients with severe post-PCNL bleeding who fail to respond to conservative measures.

Keywords: Angioembolization, percutaneous nephrolithotomy, risk factors, severe hemorrhage

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INTRODUCTION

The management of renal stone disease over the years has evolved from open pyelolithotomy to laparoscopic pyelolithotomy to percutaneous nephrolithotomy (PCNL) to retrograde intrarenal surgery. PCNL was first described in 1976 by Fernström and Johansson.[1] Technological advancement and increase in experience and skill have led to increased safety and efficacy; and in the modern world, PCNL is recommended as the first-line therapy in symptomatic patients with a total renal stone burden >20 mm.[2] However, it has its own share of associated complications of which renal hemorrhage is definitely the most dangerous. This hemorrhage may occur immediately after the procedure or in the form of "delayed bleeding" which may occur after a few days. The majority of patients settle with conservative management. However, a small proportion of patients (0.3%–1.4%) requires intervention in the form of angioembolization.[3-6] Since renal bleeding can have serious consequences, it is crucial to diagnose and manage it early. We, therefore, retrospectively analyzed patients undergoing PCNL and tried to determine factors that could significantly predict severe renal hemorrhage. Here, we also review those cases that required angioembolization to control the bleed.

SUBJECTS AND METHODS

Study design

We retrospectively reviewed the data of 583 patients who underwent PCNL at our institute from January 2014 to December 2016. Of these, we identified three patients who had significant postoperative bleeding and required angioembolization. Ours being a tertiary referral center, during this period, we also had six patients referred to us from other hospitals in view of significant post-PCNL bleeding. Detailed history and physical examination findings were noted from the case records. Preoperatively, hemogram, serum creatinine, serum electrolytes, coagulation profile, blood sugar levels, urine culture and ultrasound of the kidneys, ureters, and bladder were performed in all patients. Patients with normal serum creatinine underwent a urography with computed tomography (CT, urography), while those with elevated serum creatinine levels (>1.4 mg/dl) underwent a noncontrast CT of the abdomen followed by a functional renal scan.

Percutaneous nephrolithotomy technique

All patients underwent percutaneous punctures in prone position under fluoroscopy guidance followed by serial dilatation with Alken metallic dilators up to 24 or 26 Fr and use of an Amplatz sheath. All surgeries were performed with a rigid nephroscope (Wolf 22 Fr with 20° lens). Stones were fragmented with a pneumatic lithotrite (Swiss LithoClast, Boston Scientific). On completion of the procedure, a double pigtail ureteric stent was placed in cases of large stone burden, injury to the pelvicalyceal system, bleeding, and residual calculi. Furthermore, a nephrostomy tube was placed in all cases, which was removed after 24 h, unless a second-look surgery through the same tract was planned for residual calculi. The per-urethral catheter was removed 24 h after the removal of the nephrostomy tube.

A postoperative hemogram was performed in all patients immediately after the procedure and repeated after 24 h. Additional checks were performed as indicated. An abdominal radiograph of the kidneys, ureters, and bladder was also performed on the 1st postoperative day. Following uneventful recovery, patients were discharged on the 3rd postoperative day followed by removal of the double pigtail stent after 2 weeks.

For the six patients referred to us from other hospitals, details about their preoperative workup and intraoperative findings were obtained from the concerned hospitals.

In cases of post-PCNL bleeding, patients with mild hematuria (up to 1 g/dl fall in Hb) were managed conservatively. Moderate hematuria (up to 2 g/dl fall in Hb) was managed with blood transfusion when indicated in addition to the conservative measures. A few patients presented with delayed bleeding, few days after discharge but within 3 weeks of surgery. These patients were initially stabilized with intravenous fluids and blood transfusion. Following informed consent, the patients with normal serum creatinine, with severe immediate and delayed bleeding, first underwent an abdominal CT angiography. A digital subtraction angiography (DSA) was then performed whenever a lesion was visualized on CT angiography, and also in those cases where the CT failed to show a lesion and the clinical suspicion was high. This was followed by superselective embolization of the offending lesion. Two patients with severe bleeding had serum creatinine >1.4. They were directly subjected to DSA without CT angiography. DSA was performed with around 30 cc of ionic contrast compared to 90 cc used for CT angiography. Indications for angiography were persistent hemodynamic instability (tachycardia and hypotension) despite resuscitative measures with persistent gross hematuria or recurrent bladder clot retention and significant fall in hemoglobin (>2 g/dl).

Angioembolization technique

All procedures of angiography and embolization were performed in the interventional radiology department of

our institute. For angiography, access was done through the ipsilateral common femoral artery. After selective catheterization of the renal artery, an angiography was performed with using 5 cc, nonionic, iso-osmolar contrast. With these images, through the initial diagnostic catheter, a 3F microcatheter and guidewire were used to superselectively catheterize the artery feeding the pseudoaneurysm or the arteriovenous fistula. Control angiography was done following coil embolization to confirm cessation of bleeding and occlusion of the lesion. Clinical success was defined as complete cessation of hematuria. These patients were monitored closely, and complete blood counts and renal function tests were performed daily until stabilization.

Analysis

We analyzed pre-, intra-, and post-operative variables of the patients who required angioembolization. The preoperative factors studied included age, sex, and presence of comorbidities such as diabetes mellitus and hypertension, serum creatinine level, urine culture, history of prior open/endoscopic renal surgery, degree of pelvicalyceal dilatation, cortical thickness and stone size, and burden. Intraoperative factors included number of access tracts, dilatation (in Fr) of access tracts, presence of narrow infundibulum, bleeding leading to hypotension, injury to pelvicalyceal system, and total operative time. Postoperatively, we analyzed the fall in hemoglobin compared to the preoperative level, requirement of blood transfusion and/or inotropes for hemodynamic resuscitation, and the day of presentation for delayed bleeding. We also studied the timing of angioembolization postsurgery and the angiographic findings and outcomes of embolization.

Total operative time was defined from the time of cystoscopy for ureteric catheterization till the placement of the nephrostomy tube. Stone size was defined as the greatest dimension for a single stone and summation of the greatest dimensions of all stones for multiple stones. The Guy's stone score was used to assess stone burden.[7]

Data was analysed in Microsoft Excel software(Microsoft Corporation, Washington, USA). Fisher's exact test and Chi-square test were used in univariate analysis. Logistic regression analysis was used in multivariate analysis with a value of $P < 0.05$ considered statistically significant.

RESULTS

A total of 589 patients who underwent PCNL were analyzed. Of these, 583 were operated in our institute and the remaining 6 were referred from other hospitals in view of post-PCNL bleeding. Three of the 583 patients (0.51%) who underwent PCNL at our institute required embolization to control bleeding. Hence, we studied a total of nine patients requiring angioembolization and compared them to the 583 patients who did not have severe post-PCNL bleed.

Of the nine patients requiring angioembolization to control severe renal hemorrhage, six were male and three were female. Their mean age was 45.6 ± 11.3 years. The remaining 583 patients, with a mean age of 43.3 ± 12.6 years, comprising 345 males (59.17%) and 238 females (40.82%) were managed conservatively. All 9 patients who underwent embolization and 18 out of the remaining 583 patients (3.08%) required blood transfusion. The mean age between the two groups was comparable ($P = 0.586$). The preoperative patient and renal characteristics are summarized in Table 1, whereas the intra- and post-operative features are outlined in Table 2. The significant preoperative parameters include a history of previous renal surgery and increased stone complexity, while number of access tracts and injury to pelvicalyceal system were significant intraoperative factors for postoperative renal hemorrhage. On multivariate analysis, all four factors retained their significance.

Of the nine patients who required angioembolization, two patients presented in the immediate postoperative period whereas seven patients had delayed renal hemorrhage and

Table 1: Demographic and preoperative characteristics of patients

Variable	Patients requiring angioembolization	Patients managed conservatively	P
Age (mean±SD)	45.6±11.3	43.3±12.6	0.586
Sex (*n*)			
Male	6	345	0.926
Female	3	238	
Comorbidities (*n*)			
Diabetes mellitus	3	84	0.269
Hypertension	2	79	0.714
Serum creatinine >1.4 mg/dl (*n*)	2	62	0.509
History of previous renal surgery (*n*)	6	96	0.0025
Positive urine culture (*n*)	2	140	1.000
Stone complexity GSS grade (*n*)			
1	1	181	0.006
2	1	236	
3	3	98	
4	4	68	
Stone size (mm) (*n*)			
<20	1	162	0.255
21-30	5	330	
>30	3	91	

SD: Standard deviation, GSS: Guy's stone score

Table 2: Intraoperative characteristics of patients requiring angioembolization

Variable	Patients requiring angioembolization (*n*)	Patients managed conservatively (*n*)	*P*
Number of access tracts			
Single	2	360	0.022
Multiple	7	243	
Maximum dilatation of access tract (Fr)			
24	4	432	0.114
26	5	151	
Presence of narrow infundibulum	4	173	0.540
Injury to pelvicalyceal system	6	59	0.0005
Operative time >90 min	4	164	0.471

Figure 1: The events during an angiography and subsequent embolization. (a) Angiography showing the pseudoaneurysm near the lower pole. (b) Superselective angiography delineating only the feeding vessel. (c) Superselective coiling. (d) Control angiography confirming coiling of the pseudoaneurysm and preserved distal perfusion

required another admission after discharge. The mean time to presentation of renal bleed was 7.8 days, ranging from 2 to 15 days. They had varied presentation: the patients presenting early had severe hematuria and hemodynamic instability while the patients with delayed bleeding presented with hematuria, bladder clot retention, and flank pain. All patients had significant drop in hemoglobin levels (>2 g/dl) and required blood transfusions. DSA in these patients revealed an arteriovenous fistula in two patients and an arterial pseudoaneurysm in seven patients. Technical success was achieved in all nine patients. All patients underwent superselective embolization. Control angiography following embolization showed preserved normal renal perfusion in six patients, whereas in three patients, there was decreased perfusion in the segment distal to the embolization. Hematuria settled immediately in the most patients while three patients had intermittent clot passage for 2 days following the procedure. Two of the patients undergoing DSA had a baseline creatinine more 1.4 mg/dl. One of these patients with a baseline creatinine level of 1.9 mg/dl had a transient rise till 2.3 mg/dl following DSA which subsequently returned to the baseline value over a period of 72 h. None of the patients required a reembolization. Table 3 summarizes the characteristics of the patients who underwent angioembolization, and Figure 1 shows the events during one of the angioembolization procedures.

DISCUSSION

PCNL has become a commonly performed procedure for the management of renal stone disease. Hemorrhage is the most significant complication of PCNL. As the kidney is a very vascular organ, some degree of hemorrhage occurs in every PCNL. This bleeding can occur while introducing the needle, dilatation of the tract, during nephroscopy or stone disintegration. In most cases, the source of hemorrhage is venous and can be treated conservatively. Some of the techniques described include clamping the nephrostomy tube and placement of a Kaye nephrostomy tamponade balloon. The most common site for significant bleeding is from segmental arteries rather than from small arcuate and interlobular arteries. These small arteries are surrounded by dense parenchymal tissue, and the nephrostomy tube can easily tamponade them.[3] Significant bleeding usually leads to abandoning of the surgery due to impaired visualization. Transfusion rates after PCNL reported in the literature range from 3% to 23%.[4,7-13] The 3.08% transfusion rate of our study is comparable to this.

Arterial damage with subsequent development of arteriovenous fistulas or pseudoaneurysms is a well-known source of bleeding after PCNL. These are formed by a high-pressure leak from a lacerated artery, which is transmitted into a lower-resistance system, such as a vein or a connective tissue space.[14] About 0.51% of our patients had bleeding severe enough to warrant an angiography and subsequent embolization of the offending lesion which is comparable to the 0.3%–1.4% reported earlier.[3-6]

Two preoperative factors that we found to be significantly associated with increased post-PCNL bleeding were a history of previous ipsilateral renal surgery and increased stone complexity. There is no proper consensus regarding a history of ipsilateral renal surgery. While it was also recognized as a significant factor for post-PCNL bleeding by Said *et al.* and Yesil *et al.*,[10,15] the reverse was stated by Kukreja *et al.*[16] Gupta *et al.* in their study in 2009 of 66 patients with a history of prior ipsilateral open stone

surgery did not find it to cause increased bleeding although they noted that these patients required frequent relook procedures for complete stone clearance.[17] Increased stone complexity is uniformly recognized as a risk factor.[3,4,8,9,18,19] Complex and large stones may require multiple access tracts and more maneuvers during nephroscopy to access various calyces which increase the chances of bleeding. Such bleeding may be reduced by the use of flexible nephroscopy.

Multiple access tracts and injury to the pelvicalyceal system were the intraoperative risk factors that were found to be significant in our study. Multiple punctures for the multiple tracts would have an increased risk of damaging renal vasculature. The number of access tracts was reported as a risk factor for vascular injury and bleeding by some researchers[3,8] while others did not find so.[4,5] The pelvicalyceal system may be injured during tract dilatation or during manipulation by the rigid nephroscope. There is increased likelihood of perforation of the pelvicalyceal system with increased stone burden and complexity. Some studies have implicated other factors such as low surgeon experience, upper calyx puncture, raised BMI, absence of hydronephrosis, history of pyelonephritis, presence of diabetes mellitus, and solitary kidney as other factors for increased post-PCNL bleeding.[8,18,20,21] It is postulated that increased bleeding with upper calyx puncture could result due to a longer and more oblique access tract; while in a solitary kidney, puncture and dilatation through a hypertrophied kidney with thick parenchyma may increase the risk of bleeding.[8] A review of the literature showed that access tracts are dilated to varying sizes in different institutes. The results of other studies are summarized in Table 4.

A total of nine patients had bleeding severe enough to warrant an angiography. We performed a CT angiography in seven of these nine patients as the initial workup for the significant bleeding. An offending lesion was found on CT angiography in all of these seven patients. The other two patients directly underwent a DSA without a preliminary CT angiography on account of high serum creatinine levels (>1.4 mg/dl). A duplex ultrasonography and magnetic resonance angiography can also detect vascular renal lesions, but angiography remains the gold standard procedure with its added therapeutic advantage.[23,24] In this study, for the nine patients who required embolization the mean time to presentation of

Table 3: Postoperative and angiography features of patients requiring angioembolization (*n*=9)

Parameter	*n*	Mean
Drop in hemoglobin (g/dl)		
2-3	2	3.4±0.64
3-4	5	
4-5	2	
Requirement of inotropes for resuscitation	7	-
Day of presentation		
Immediate postoperative (<2 days)	2	7.8±5.8
3-7 days	3	
>7 days	4	
Angiography finding		
Arteriovenous fistula	2	-
Arterial pseudoaneurysm	7	
Side of complication		
Right	6	-
Left	3	
Technical success	9	-

Table 4: Summary of the results of this and previous studies on postpercutaneous nephrolithotomy angioembolization reported in literature

Study	Number of patients undergoing PCNL	Dilatation of access tract (Fr)	Patients requiring blood transfusion (%)	Patients requiring angioembolization (%)	Factors found to be significantly associated with requirement of angioembolization
Srivastava *et al.*, 2005[4]	1854	26-30	228 (12.29)	24 (1.29)	Stone size
El-Nahas *et al.*, 2007[8]	2909 patients undergoing 3878 PCNLs	30	213 (5.5)	39 (1.00)	Upper calyx puncture, solitary kidney, staghorn stone, multiple punctures, inexperienced surgeon
Nouralizadeh *et al.*, 2014[22]	2304	28-30	270 (11.71)	3 (0.12)	Tubeless PCNL
Jinga *et al.*, 2013[18]	2095	30	226 (10.78)	22 (1.05)	Staghorn calculi, upper calyx puncture, history of pyelonephritis
Un *et al.*, 2015[9]	1405	NA	147 (10.4)	14 (0.99)	Renal anatomical abnormalities, large stone size
Said *et al.*, 2017[10]	200	20-30	17 (8.5)	1 (0.5)	Stone complexity, history of prior ipsilateral renal surgery, intraoperative pelvicalyceal perforation
Present study	583	24-26	21 (3.60)	3 (0.51) from the institute (remaining 6 patients were referred)	History of previous ipsilateral stone surgery, increased stone complexity, multiple access tracts, injury to pelvicalyceal system

PCNL: Percutaneous nephrolithotomy

severe post-PCNL bleeding were 7.8 days, ranging from 2 to 15 days. Nouralizadeh *et al.* and Srivastava *et al.* had similar mean times of presentation at 8 and 5.8 days, respectively.[4,22] Gavant *et al.* had reported a case of bleeding due to a ruptured pseudoaneurysm 13 weeks after PCNL.[25] On angiography, arterial pseudoaneurysms are the most common finding followed by arteriovenous fistulas and arterial lacerations.[26] We had similar results in our study with seven of the nine angiographies showing a pseudoaneurysm while the remaining two showed an arteriovenous fistula. The diagnostic ability of angiography in identifying a lesion is reported to be close to 95% with a similar degree of efficacy in treating the lesion.[3,4,26] In this study, angiography was able to detect as well as control the hemorrhage in all nine cases. All our patients underwent superselective angioembolization which helps to preserve the maximum amount of renal parenchyma. After embolization (sometimes, even when superselective), there is segmental renal functional loss due to hampered blood supply, which may or may not manifest, even in a patient with a solitary kidney. This manifestation may be in the form of increased postprocedure serum creatinine or decreased glomerular filtration rate. We did find transient increase in serum creatinine levels in one patient following DSA, which returned to the baseline over 72 h, indicating acute kidney injury and not loss of functioning parenchyma. Postembolization syndrome characterized by pyrexia, nausea, vomiting, and pain has been reported to occur in 5%–9% of cases; however, none of our patients developed this.

Small sample size and a retrospective design may be identified as limitations of our study. Furthermore, the surgeries were not performed by a single surgeon. Ours being a teaching institute, surgeries were performed by consultants as well as resident doctors under the supervision of the consultants.

CONCLUSIONS

We would like to state that although PCNL has revolutionized the management of renal stone disease, it is associated with its own fair share of complications, of which severe hemorrhage is the most dreaded. Here, we have identified prior ipsilateral renal surgery, increased stone complexity, multiple access tracts, and injury to the pelvicalyceal system as significant risk factors for severe bleeding post-PCNL. It is vital to identify patients with these characteristics as "high-risk" patients and respond urgently in case of intra and/or postoperative bleeding. We also advocate early angiography with subsequent

embolization in cases of severe post-PCNL hemorrhage which fail to respond to conservative measures. It is a minimally invasive procedure with high sensitivity and efficacy, thus reducing patient morbidity.

Conflicts of interest

There are no conflicts of interest.

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