Original Article

Factors predicting infectious complications following percutaneous nephrolithotomy

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Abstract

Objective: To determine the predictors of infectious complications following percutaneous nephrolithotomy (PCNL) in a prospective study.

Materials and Methods: A total of 332 patients with renal or upper ureteric calculi who underwent PCNL between January 2013 and June 2014 were included in the study. Infectious complications included febrile urinary tract infection and septicemia. The patients were divided into Group A and B depending on whether they developed or did not develop infectious complications. Patient, stone, renal, and procedure-related factors were compared between the two groups.

Results: There was no significant ($P > 0.05$) correlation among age (37.03 ± 16.24 vs. 36.72 ± 14.88), sex, and body mass index (21.00 ± 1.77 vs. 21.03 ± 2.25) between Group A and B. The patients in Group A were found to have significantly higher incidence of renal failure (39.5% vs. 9.2%, $P = 0.0001$), diabetes mellitus (12 [31.5%] vs. 33 [11.2%], $P = 0.0001$), previous percutaneous nephrostomy (PCN) tube placement (11 [28%] vs. 21 [7.1%] $P = 0.0001$), moderate to severe hydronephrosis (HDN), larger stone surface area (812.68 ± 402.07 vs. 564.92 ± 361.32, $P = 0.0001$), mean number of punctures (1.57 ± 0.50 vs. 1.20 ± 0.47, $P = 0.002$), and mean duration of surgery (94.28 ± 18.23 vs. 69.12 ± 21.23, $P = 0.0001$) than Group B.

Conclusion: Post-PCNL infectious complications were found to be more common in patients with renal failure, diabetes mellitus, preoperative PCN placement, staghorn calculi, severe HDN, multiple punctures, and prolonged duration of surgery.

Key Words: Diabetes mellitus, febrile urinary tract infection, hydronephrosis, percutaneous nephrolithotomy, septicemia

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INTRODUCTION

Currently, percutaneous nephrolithotomy (PCNL) is a favored treatment for large, multiple, complex, and lower calyceal stones.[1] There are predictive tables and scoring systems to predict stone clearance, but there is limited

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literature on the prediction of complications during PCNL.

The rate of complications in PCNL can vary according to the complexity of stone disease as well as patient and procedure-related factors. Complication rates reported by various studies range from 3% to 83%.[2,3] Postoperative fever is a frequent occurrence with reported rates between 15% and 30%.[4-7] While urosepsis has been reported to occur in 0.9–4.7% of PCNL procedures.[8]

Duration of procedure, bacterial load in the urine, severity of obstruction, and presence of infected stone directly affect the incidence of febrile urinary tract infection (UTI) and/or urosepsis.[9,10] Despite the high index of suspicion, it is not possible to predict preoperatively the source of infection with certainty.[9] Hence, there is intense need to evaluate patient, stone and procedure-related factors in details as there are limited studies on this issue in literature. Current study is aimed to determine predictors of infectious complications following PCNL.

MATERIALS AND METHODS

After ethical clearance from Institutional Review Board, patients with renal or upper ureteric calculi undergoing PCNL between January 2013 and June 2014 were included in study. Written informed consent was taken from all patients. Patients undergoing simultaneous bilateral PCNL, second look PCNL, concomitant other procedures such as endopyelotomy or retrograde ureterorenoscopy were excluded from study.

In patients' demographics, a detailed clinical history including past renal surgery, percutaneous nephrostomy (PCN) tube placement were recorded; blood investigations including complete blood count, renal function test, and blood sugar were done in all patients. X-ray, kidney-ureter-bladder (KUB), ultrasound KUB, intravenous urogram, and/or computed tomography with or without contrast were done to evaluate anatomical and functional status of kidney as well as stone parameters.

Febrile UTI was defined as a temperature >38°C on 2 consecutive postoperative days or >39°C on any one postoperative day.[11] Urosepsis implies clinically evident severe infection of the urinary tract with features consistent with systemic inflammatory response syndrome.[12]

Degree of hydronephrosis (HDN) was ascertained with ultrasound KUB. Mild HDN was defined as enlargement of the calices with preservation of the renal papillae; moderate HDN was defined as rounding of the calices with obliteration of the renal papillae; and severe HDN was defined as caliceal ballooning with cortical thinning.[13]

Preoperatively, sterile urine culture was ensured, and culture specific antibiotics were given whenever needed. PCN tube was placed in patients with pyonephrosis. Prophylactic antibiotics were given in all patients. The second generation cephalosporins or culture specific antibiotics were given at the induction of anesthesia.

Technique of percutaneous nephrolithotomy

Under general/spinal anesthesia, retrograde ureteric catheterization was done on the ipsilateral side. Patient was turned prone, and percutaneous access was obtained under fluoroscopic guidance by the operating surgeon using a diamond tip 18-G puncture needle. A hydrophilic guide wire was passed, over which tract dilatations were done using Alken metal dilators and a Amplatz sheath was placed into system. Stones were fragmented using pneumatic lithoclast and removed. Intraoperative stone clearance was accessed using fluoroscopy. A JJ stent/ureteric catheter/nephrostomy tube was placed in most of the cases.

Patients were divided into two groups: Group A includes patients who developed febrile UTI and Group B includes patients who did not develop febrile UTI.

Statistical analysis

Assuming 80% power, 5% significance level with 95% confidence interval and 25% margin of error, the minimum sample size[14] required was 245 calculated on basis of study by Michel *et al.*,[8] in which the incidence of febrile UTI was 3.5%.

The results are presented in mean ± standard deviation and percentage. The categorical variables were compared using Chi-square test. The unpaired *t*-test was used to compare the continuous variables between the groups. The multivariate binary logistic regression was carried out to find the significant factors associated with different outcomes. The $P < 0.05$ was considered significant. All the analysis was carried out using SPSS 16.0 version (Inc., Chicago, USA).

RESULTS

A total of 332 patients were included in this study. The basic characteristics of the patients are presented in Table 1.

Complications were seen in 93 (28%) patients. Many patients had more than one complication; thus, overall 154 complications were seen [Table 2].

Comparisons of the patient, stone, renal, and procedure-related characteristics of both groups are shown in Table 3.

Table 1: Basic characteristics of the patients

Parameter	Number (*n*=332)
Age (mean±SD) (range)	36.76±15.01 (4-80)
Right/left	172/160
Male/female	215/117
Mean BMI in kg/m^2 (range)	21.03±2.20 (12.5-35.0)
Mean stone surface area in mm^2	593.28±373.73
Mean puncture tracts, (range)	1.25±0.48 (1-4)
Mean duration of surgery (min)	72.02±32.21
Mean hospital stay (days)	4.79±3.06

SD: Standard deviation, BMI: Body mass index

Table 2: Complications of PCNL classified according to modified Clavien system

Grade/complications	Number (*n*=154)	Percentage of total patients
Grade I		
Fever	18	5.4
Decreased urine output (<30 ml/h) requiring diuretics	5	1.5
Hydropneumothorax managed by watchful waiting	3	0.09
Grade II		
Blood transfusion	53	15.9
Urine leakage <12 h	10	3.0
Wound infection	4	1.2
Febrile urinary tract infection	33	10
Hyposaturation requiring oxygen after surgery	5	1.5
Grade IIIa		
Double-J stent replacement for urine leakage >24 h	4	1.2
Stent migration needed reposition	2	0.6
Hydropneumothorax needed chest tube	7	2.1
Grade IIIb		
Arterio-venous fistula requiring angioembolization	2	0.6
Uncontrolled bleeding due to A-V fistula requiring nephrectomy	1	0.3
Grade IVa		
Neighboring organ injury	0	0.0
Myocardial infarction	0	0.0
Creatinine elevation with dyselectrolytemia requiring dialysis	2	0.6
Grade IVb		
Urosepsis	5	1.5
Grade V		
Death	0	0.0

PCNL: Percutaneous nephrolithotomy

There was no significant ($P > 0.05$) difference among age (37.03 ± 16.24 versus 36.72 ± 14.88), sex, and body mass index (BMI) (21.00 ± 1.77 vs. 21.03 ± 2.25) between both the groups. The patients in Group A were found to have significantly higher incidence of renal failure (39.5% vs. 9.2%, $P = 0.0001$), diabetes mellitus ([12 (31.5%) vs. 33 (11.2%), $P = 0.0001$]), previous PCN tube placement (11 [28%] vs. 21 [7.1%] $P = 0.0001$), moderate to severe HDN, larger stone surface area (812.68 ± 402.07 vs. 564.92 ± 361.32, $P = 0.0001$), mean number of punctures (1.57 ± 0.50 vs. 1.20 ± 0.47, $P = 0.002$), and mean duration of surgery (94.28 ± 18.23 vs. 69.12 ± 21.23, $P = 0.0001$) than Group B. A significantly longer hospital stay was observed in Group A patients which signifies morbidity of febrile UTI.

The multivariate binary logistic regression analysis revealed that patients with renal failure (serum creatinine >1.4 mg/dl), staghorn stone, severe preoperative HDN, higher number of puncture, and longer duration of surgery were found to be significant factors associated with infectious complications [Table 4].

DISCUSSION

Complication rates of PCNL have decreased to a great extent owing to improvement in technique and technical experience, development of special instruments, and better preoperative and perioperative monitoring.[8]

Septicemia could be caused by an infection introduced while obtaining access to the kidney or during manipulation of infected stones. Fever following PCNL is significantly more frequent in cases of infected stones (struvite or staghorn stones) in comparison to those with sterile stones.[15] The pathogenesis of urosepsis associated with PCNL has been attributed to high concentrations of endotoxins released in the systemic circulation during stone manipulation resulting in initiation of systemic inflammatory response. This process could be enhanced by an obstruction of the upper urinary tract which opens up the pyelolymphatic and pyelovenous channels.[9]

In current study, infectious complications were seen in 38 patients (11.4%). Among these, febrile UTI (managed by antibiotics, Clavien grade 2) was seen in 33 (10%) of patients, and urosepsis (managed by intensive care monitoring, Clavien grade 4) was seen in 5 (1.5%) patients. Others also found the incidence of fever following PCNL in the range of 21–32.1% of the cases[7,16] and septicemia in 0.9–4.7% of the cases.[8]

Urosepsis is medical emergencies with may have very high mortality rate (60–80%).[17,18] Therefore, determination of factors affecting infectious complications and risk stratification are critical to avoid serious postoperative events.

Escherichia coli was reported as the most common microorganism isolated from cultures in our study as in the previous reports.[19,20] *Pseudomonas aeruginosa* was the leading organism in patients who developed sepsis.

The presence of pus or cloudy urine on initial puncture was considered to be high-risk for the development of postoperative sepsis.[20,21] In such conditions, we placed nephrostomy tube and deferred the surgery until urine culture was rendered sterile.

We observed that patients who had PCN tube *in situ* were associated with higher incidence of febrile UTI (11 [28%] as

Table 3: Factors associated with infectious complications (febrile UTI and urosepsis)

	Patients with post-PCNL febrile UTI and urosepsis (Group A) (*n*=38)	Patients without febrile UTI and urosepsis (Group B) (*n*=294)	*P*
Age in years, mean±SD	37.03±16.24	36.72±14.88	0.90
Male/female	25/13	189/105	0.85
BMI, mean±SD	21.00±1.77	21.03±2.25	0.92
Patients with serum creatinine >1.4 mg/dl (%)	15 (39.5)	27 (9.2)	0.0001*
Patients with diabetes (%)	12 (31.5)	33 (11.2)	0.0001*
Previous PCN (%)	11 (28)	21 (7.1)	0.001
Mean preoperative hemoglobin (g/dl)	10.48±1.24	10.72±1.25	0.06
Previous renal operative history	5 (13.1)	27 (9.2)	0.41
Stone characteristic (%)			
Staghorn	21 (55.3)	21 (7.1)	0.0001*
Multiple	12 (31.6)	140 (47.6)	0.13
Pelvic/single calyceal/upper ureteric	5 (13.2)	133 (45.2)	1.00 (references)
Stone surface area (mm^2)	812.68±402.07	564.92±361.32	0.0001*
Preoperative HDN (%)			
Mild	12 (31.6)	180 (61.2)	0.0001*
Moderate	12 (31.6)	94 (32.0)	
Severe	14 (36.8)	20 (6.8)	
Mean number of punctures, mean±SD	1.57±0.50	1.20±0.47	0.002*
Supracostal/infracostal punctures	23/37	118/237	0.13
Duration of surgery (min), mean±SD	94.28±18.23	69.12±21.23	0.0001*
Hospital stay (days)	6.42±2.97	4.57±2.17	0.001*

*Significant. PCNL: Percutaneous nephrolithotomy, UTI: Urinary tract infection, HDN: Hydronephrosis, SD: Standard deviation, BMI: Body mass index

Table 4: Significant factors associated with febrile UTI-multivariate logistic regression analysis

	Adjusted OR	95% CI	*P*
Patients with renal failure	3.46	1.13-6.78	0.002*
Patients with diabetes			
Stone surface area	2.36	1.28-9.17	0.001*
Stone characteristic			
Staghorn	23.22	8.04-73.10	0.001*
Multiple	2.18	0.66-5.14	0.14
Pelvic/single calyceal	1.00 (references)		
Preoperative HDN			
Mild	1.00 (references)		
Moderate	1.00	0.67-1.21	1.00
Severe	1.15	1.08-3.15	0.003*
Number of puncture	1.11	1.05-3.24	0.004*
Duration of surgery	2.10	1.11-7.35	0.01*

*Significant. CI: Confidence interval, HDN: Hydronephrosis, OR: Odds ratio

compared to Group B (21 [7.1%] $P = 0.0001$). This could be either due to infected stone which initially lead to pyonephrosis or the biofilm formation and subsequent dissemination of bacteria during PCNL.

Patients with renal failure (39.5% in Group A vs. 9.2% in Group B, $P = 0.0001$) as well as diabetes mellitus (12 [31.5%] vs. 33 [11.2%], $P = 0.0001$) had significant higher incidence of febrile UTI, probably due to low immunity. Renal insufficiency and diabetes mellitus as a risk factor for postoperative fever and sepsis have been identified by other studies also.[8]

Staghorn calculus is associated with infection, which could disseminate and ultimately lead to postoperative fever and sepsis. Besides, making the operation more complex, it was also shown that the stones >20 mm have greater risk of carrying infectious agents as compared to 20 mm or less.[22] In current study, we found similar findings with Mariappan *et al*.,[22] in terms of stone size and Staghorn calculus association.

In our study, severe HDN was associated with higher incidence of febrile UTI (14 [36.8%] in Group A vs. 20 [6.8%] in Group B, $P = 0.0001$). HDN has been proposed to be associated with increased risk of postoperative infectious complications by other authors.[22,23] HDN is a manifestation of poor drainage of the renal collecting system; therefore, it is possible to assume that a renal unit with impaired drainage is more likely to experience infection.

Duration of surgery was significantly ($P = 0.0001$) longer in Group A (94.28 ± 18.23) as compared to Group B (69.12 ± 21.23). Longer duration of operation implies greater quantities of irrigation fluid used as well as greater maneuvering which leads to higher chances of sepsis. The risk of infection is proportional to the amount of irrigation fluid used and the duration of surgery.[6]

Multiple punctures will increase the probability of introducing more infective organism into system and will understandably increase the probability of septic complications. Mean number of puncture was higher in those who developed febrile complication (1.57 ± 0.50 in Group A vs. 1.20 ± 0.47 in Group B, $P = 0.002$). Instrumentation of the urinary tract is not uncommon to cause bacteremia.[24]

Intestinal and colonic injuries could result in septic complications such as peritonitis or severe UTI. Previous bowel surgery predisposes to duodenum or colonic injury, and a urologist

should proceed with special care.[25] Colonic perforation has been observed in <1% of PCNLs.[8] In current study, we did not encountered any bowel injury.

Our study has some limitations such as small sample size and also we did not assess the intrapelvic pressure directly. PCNL through 28 French Amplatz and 24 French nephroscope is a low pressure system, and it was probably not a significant factor in the current study. We did not analyze tubeless and with tube PCNL separately regarding the incidence of febrile UTI.

The strengths of our study include a prospective design, use of standard criteria defined, especially to identify the infection-related events and evaluation of considerably a high number of variables.

CONCLUSION

Post-PCNL infectious complications were found more common in patients with renal failure, diabetes mellitus, preoperative PCN placement, staghorn calculi, severe HDN, multiple puncture, and prolong duration of surgery. This was not related to age, sex, BMI, preoperative hemoglobin, and previous operative history.

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Conflicts of interest
There are no conflicts of interest.

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