Original article

Infectious complications during the initial 225 cases of standard PCNL: A single center experience

Kushal Karki, Narayan Bhusal

Abstract

Introduction

Percutaneous nephrolithotomy(PCNL) has emerged as the treatment of choice for medium to large urinary stones. Infection is a life threatening complication and is the most common cause of death following PCNL. This study aimed to examine different predictors of infective complications in PCNL.

Methods

This retrospective study was done on patients who underwent PCNL between 2016 and 2020 at a tertiary level medical college hospital. Medical records were reviewed for study variables.

Results

Two hundred and twenty five cases were included out of which 121 were male. A total of 151 complications were recorded among which 27(17.88%) were major complications. Infectious complications were seen in 67 (29.77%) patients among which 39 cases (17.33%) were febrile urinary tract infections. Urosepsis developed in four patients and one patient died due to urosepsis related complication. Female (p=0.003), Diabetes mellitus (p=0.002), positive urine culture (p=0.0001), stone location (p=0.01), degree of hydronephrosis (p=0.001), duration of surgery (p=0.001), number of access tracts (p=0.0001), and initial 100 cases (p=0.001) were associated with post PCNL infections.

Conclusion

Female, Diabetes mellitus, preoperative urine culture positivity, stone location, degree of hydronephrosis, duration of the operation, number of access tracts and surgeon experience are risk factors for post PCNL infections. Surgeons should be extra vigilant during their initial period. Urinary tract infection should be treated and extra care should be taken when operating in female patients giving ample attention to preoperative investigations.

Keywords: PCNL; sepsis; Urinary tract infection; urosepsis.

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Introduction

Kidney stone is one of the most common urological condition in Nepal.[1] The increasing adaptation to modern lifestyle, growing metabolic disease and infection has significantly contributed to increase in its prevalence.[2] Health and economic burden due to stone disease is enormous[3] and its management in developing countries like Nepal is a challenging task. The recent advancement and innovative technology have revolutionized the treatment of urinary stones.[4] The mainstream treatment of stone disease has largely shifted to minimally invasive techniques. Percutaneous nephrolithotomy (PCNL) has emerged as the treatment of choice for medium to large stones located mainly in the kidney and the proximal ureter. It offers high success rate and excellent stone clearance rate. But PCNL is associated with significant morbidity,[5,6] and septicemia remains one of the major complications associated with PCNL. Infective complication has been reported to occur in 21-39% cases of PCNL.[7] Infective complication depends upon the infective status of urine, status of stone harboring bacteria, skill and experience of surgeon and case volume of the center.[8,9]

Kidney stones obstruct the pelvicalyceal system and bacteria may enter into the circulation during stone manipulation. Bacteria present in renal stone and colonizing various catheters and stents are additional sources of infection.[10] Various factors related to patient and surgeon also play important roles for the occurrence of complications in PCNL. Moreover, PCNL has a stiff learning curve and is prone to various complications during the initial period.[11] Despite higher prevalence rate of urolithiasis and PCNL being adopted in different medical facilities in Nepal, we lack a comprehensive and large-scale study that provides a clear picture of the infective complications occurring during PCNL. Thus, the purpose of this single center study was to analyze the predictors of the infective complications and present an update of this dreadful complication.

Methods

This was a retrospective study. Patients who underwent PCNL from July 2016 to April 2020 at KIST Medical College Teaching Hospital, Imadol, Lalitpur, Nepal were included in the study. Medical records were studied, and the study variables (sex, location of stone, status of hydronephrosis, urine culture status, duration of surgery and number of access to kidney) were recorded in a proforma. Patients above 18 years of age were included in the study. Patients who underwent conversion to open procedure and whose medical records were incomplete were excluded from the study. All the perioperative complications were documented according to modified Clavien Dindo system. Complication of grade III, IV and V were termed as major complications.[12] Approval was taken from the institutional review board.

Procedure

Pre-operative baseline investigations including computed tomogram (CT) urogram was performed. If urine culture was positive, antibiotics were given. The procedure was performed only after urine culture became negative.

All patients were admitted one day prior to surgery and prophylactic antibiotic was started on the same day. Intravenous antibiotic was continued till second post-operative day. Intravenous Amikacin was administered to urine culture negative patients while in patients who were treated for positive urine culture the antimicrobial choice was directed by the sensitivity pattern.

All procedures were done under general anesthesia. Following the successful placement of the ureteric catheter in lithotomy position, the patient was positioned to prone and radiopaque dye was injected retrograde. Puncture was done with 18G needle by triangulation technique under the guidance of fluoroscope. Straight-tip 0.036 inch Terumo (Termo Co, Tokyo, Japan) guidewire was negotiated through the needle to the ureter. If not successful, the guidewire was allowed to coil in pelvis or calyx. All the procedures were done with 26fr nephroscope and a 30fr Amplatz sheath. Pneumatic lithotripter was used for stone fragmentation and 6fr ureteric catheter was kept at the end of the procedure if ureteropelvic junction [UPJ] and /or ureter were normal. In case of injury to UPJ or pelvicalyceal system, a 5fr Double J stent was deployed. Routinely, a 20fr nephrostomy tube was placed at the completion of each procedure.

X-ray kidney ureter bladder (KUB) was done on the second postoperative day. If no residual stone was seen, the nephrostomy tube was removed. Foley catheter was removed the next day. Routinely, the double J stent was removed two weeks after the procedure, but removed immediately if DJ stent related fever was observed. Clinically Insignificant Residual Fragments (CIRF) are those residual calculi which are <4mm in size, asymptomatic, non-obstructive and non-infectious.[13]

Postoperative fever was defined as temperature >38°C. Febrile urinary tract infection (UTI) was defined as a temperature >38°C on two consecutive postoperative days or >39°C on any one postoperative day with postoperative positive urine culture.[10] Urosepsis implies clinically evident severe infection of the urinary tract with features consistent with systemic inflammatory response syndrome.[11] Postoperative fever with pus cells in urine >4/HPF, febrile urinary tract infection [UTI] and urosepsis were taken as infectious complication of PCNL.[14]

Statistical analysis

Descriptive analyses comprising the mean and standard deviation were used for continuous variables and proportions were used for discrete variables. Comparative tests included the chi square test and fisher exact test for qualitative variables where appropriate and the Student t test and Mann-Whitney test for continuous variables. A P value 0.05 was considered significant. All the analysis was carried out in IBM SPSS Statistics Base, version 20.0, (SPSS Inc., Chicago, IL, USA).

Results

Two hundred and fifty patients underwent PCNL during the study period. Twenty five patients were excluded from the study. Among the patients excluded from the study, seven were converted to open surgery, nine patients were less than 18 years of age and in nine patients the required information were missing in the medical record. Demographic data are presented in **Table 1**. Of the total cases, 121[53.77%] were male and 104[46.22%] were female. Mean age was 32.3±12.14 years for male and35.6±10.31 years for female participants. Stone size ranged from 1.2cm to 4.3cm with a mean stone size of 1.73cm. PCNL was conducted in 114 right kidneys and 111 left kidneys. Regarding stone location, 73 stones were located in the pelvis, 51 in the calyx, 81 in the Pelvicalyx and 20 stones were found in the upper ureter. The CT Hounsfield unit ranged from 512 to 1532 HU.

Table 1. Baseline characteristics and operative data

Parameters		N=225
Age mean (years)± SD [range]		32.41±12.14[18-67]
Male: female n [%]		121[53.77%]:104[46.22%]
Left kidney: right kidney n[%]		105[46.66%:115[51.11%]
Location of stone, n [%]		
	Pelvis	73[32.44%]
	Calyx	51[22.66%]
	Pelvicalyx	81[36%]
	Upper Ureter	20[8.8%]
Stone size [mm] range		17.3[11 -52]
Hounsfield unit stone ±SD [range]		934.4±14.23[510-1624]
Hydronephrosis, n [%]		
	No HDN	101[44.88%]
	Mild	82[36.44%]
	Moderate	31[13.77%]
	Severe	11[4.88%]
UTI		37[16.44%]
Duration of surgery in min ± (range)		71.3±8.2[40-118]
Mean hospital stay [day] ± SD[range]		4.23±2.17 [3-65]
Approach, n[%]		
	Subcoastal	157[69.77%]
	Supracoastal	45[20%]
	Supra and subcoastal	23[10.22%]
Number of access, n[%]		
	One	173[81.77%]
	Two	41[18.22%]
	Three	11[4.8%]

SD = Standard deviation HDN = Hydronephrosis UTI = Urinary Tract Infection

A total of 151 complications were recorded. Among them 27 (17.88%) were major complications. Infectious complications were seen in 67 (29.77%) patients among which febrile urinary tract infection was seen in 39 cases (17.33%). Urosepsis developed in five patients and one patient died due to related complication. Escherichia coli 29(69.23%) was the most common bacteria grown, followed by Klebsiella spp in 5(12.82%), Enterococcus spp in 3(7.68%), Citrobacter spp in 2(5.12%) and Proteus spp in 2(5.12%) during the postoperative period. Stone free status without CIRF was achieved in 167 (74.22%) patients which was up to 192 (85.33%) cases considering CIRF <4mm. In modified Clavien-Dindo system, 32 grade I, 92 grade II, 18 grade IIIa, 2 grade IIIb, 2 grade IVa ,4 grade IVb and 1 grade V complications were recorded (**Table 2**). Stone analysis reports were available only in 65 cases. Fourty-two were calcium oxalate monohydrate stones, nine calcium oxalate dihydrate, eight uric acid stones and six struvite stones.

Female sex, positive urine culture in preoperative sample, upper ureteric stone, severe hydronephrosis, multiple tract access, diabetic patient, longer duration of surgery and initial 100 cases were statistically significant for the development of infective complications (**Table 3**).

Discussion

Infection is a life-threatening complication associated with PCNL. Cause for infection after PCNL can be divided into patient related and surgeon related factors. Endotoxin is found in high level particularly in infectious stone.[15] During lithotripsy these lipopolysaccharides are released into the systemic circulation which subsequently leads to the cascade of inflammatory response and sepsis. This phenomenon is more prominent in obstructed pelvicalyceal system.[16] In our study 28 patients (12.44%) had transient rise in temperature but had negative urine culture. This rise in temperature after PCNL cannot be solely attributed to PCNL. Inflammatory response to surgical trauma, absorption of hematoma and extravagated fluid may cause transient rise in temperature.

We found that, fever was strong indicator of urinary tract infection in culture positive cases. Those patients who were treated for documented urine infection preoperatively had higher postoperative infectious complications. Despite achieving negative urine culture for bacterial growth, it was not possible to eliminate all the bacteria from obstructed system and stone.[17] Urine culture is a widely used noninvasive preoperative investigation. But stone culture is recommended as a more appropriate method to predict the incidence of sepsis after endourological procedures.[15] Despite standard treatment of preoperative urinary infections, infected urine at percutaneous nephrolithotomy may be present, thus renal pelvic urine and stone cultures may be more useful to identify the causative agent and direct the treatment.[18] Aborting the procedure in case of turbid urine from the puncture site, draining with a DJ

Table 2. Complication according to modified Clavien grading system (n=151)

Complications		n (%)
Grade I	Fever	28 (12.44)
	Decreased urine output requiring diuretics	5 (2.22)
	Hydropneumothorax managed by watchful waiting	7 (3.11)
	Bleeding that requires a single episode of nephrostomy clamping	3 (1.33)
	Renal pelvic perforation managed by watchful waiting	7 (3.11)
Grade II	Blood transfusion	5 (2.22)
	Urine leakage	9 (4.0)
	Wound infection	7 (3.11)
	Febrile urinary tract infection	39 (17.33)
	Postoperative ileus managed by nasogastric decompression	2 (0.88)
	Hyposaturation requiring oxygen after surgery	5 (2.22)
	Minor atelectasis requiring medical management	7 (3.11)
Grade IIIa	Double J stent replacement for urine leakage >24 h	4 (1.77)
	Bleeding requiring multiple bladder washouts/irrigations	5 (2.22)
	Stent migration needed reposition	4 (1.77)
	Urine leakage managed by ureteric stenting without GA	3 (1.33)
	Hydropneumothorax needed chest tube	2 (0.88)
Grade IIIb	Arteriovenous fistula requiring angioembolization	1 (0.44)
	Perirenal abscess managed by open drainage	1 (0.44)
Grade IVa	Bowel injury	1 (0.44)
	Hyposaturation requiring ICU management	1 (0.44)
Grade IVb	Urosepsis	4 (1.77)
Grade V	Death	1 (0.44)

stent or percutaneous nephrostomy tube and staging the procedure may decrease the risk of septic complications.

Earlier studies investigating the cause of infectious complication have reported significant gender difference, with female more prone to septic complications.[19,20] Our result showed that female patients had significantly higher incidence of fever and progressed to sepsis. The single mortality noted in our study was also a female patient who died due to septic shock. Urinary stone and infective stone are more common in females which may increase the incidence of septic complication in female. Patients with diabetes mellitus (DM) are at risk of developing urinary tract infection and fever. We also noted that DM was associated with postoperative septic complication and was in line with previous study.[21]

Surgeon experience plays an important role in the development of post-operative complications.[22] Ideal access track placement is crucial for easy access, increase stone clearance and decreasing complications.[16] Non papillary puncture and torque during the procedure are common challenges faced during early attempts. These may cause bleeding and compromise vision. Use of standard size tract provides better vision, stone disintegration and minimizes the intrapelvic pressure.[23] We used 30fr Amplatz sheath and 26fr nephroscope during our initial stage for easy access and to avoid unnecessary complications. With experience we have shifted to mini-PCNL.

PCNL is commonly used procedure but beginners have to overcome the stiff learning curve. During the initial learning phase, higher complication rate is observed.[11] Moreover, semi-blind nature of the procedure itself is prone to multiple complications. Identification of appropriate puncture site and ideal direction to the target are crucial initial steps for successful procedure. Additionally, track dilation and lithotripsy may result in unwanted injury to pelvicalyceal system. With increase in number of cases and surgeons experience the rate of complication decreased gradually. Most of the complications encountered were grade I (32) and grade II (92) type as recorded in the modified Clavien-Dindo system. Fever was common postoperatively, among the first 100 cases, 38 patients experienced fever (p=0.001) but gradually reduced to 29(23.2%) in the remaining cases. To avoid adverse outcomes, it is recommended to complete PCNL with a desirable operative time.[24] Sugihara et al concluded that there is significant increase in complication rate after prolong PCNL.[25] In the current study, the procedure which took more than 70 min was significantly associated with fever [p=0.001%]. Routinely, the maximum time for each PCNL in our center is limited to two hours. Any procedure exceeding the time limit is carried out in the next setting. Longer single setting PCNL increases the absorption of significant amount of fluid from PCS.[24] Pressure irrigation during the procedure increases renal pelvic pressure and increases likelihood of post-operative fever.[23] There have been several comparisons between single and multiple-tract PCNL. Authors have argued its potential adverse outcomes like bleeding and decreased kidney function.[26] We found that risk of infective complication increased with increase in number of tracks placed. Increased need of number of tracts depends on anatomy of PCS, and size and location of stone. For experienced surgeon, multiple track may be effective[27] but beginners should remain vigilant.

Composition of the stone plays an important role in the occurrence of infective complications.[28] Urinary stone itself harbor bacteria that get released during the stone breaking process. Therefore, stone analysis and culture are helpful in the identification and culture sensitivity of

Table 3. Factors associated with septic complication

Factors associated with septic complications		Post-PCNL patient with septic complications [N=67]	Post-PCNLpatient without septic complications [N=158]	P Value
Age in years ±SD		33.44±11.23	31.32±10.56	0.31
Sex	Male	26	95	0.9
	Female	41	63	0.003*
Urine culture	Positive	29	8	0.0001*
	Negative	38	150	0.5
Location of stone	Pelvis	21	52	0.4
	Calyx	12	39	0.8
	Pelvicalyx	27	54	0.5
	Upper ureter	7	13	0.01*
Hydronephrosis preop	None	32	93	0.8
	Mild	24	50	0.9
	Moderate	5	10	0.4
	Severe	6	5	0.001*
Number of tracts:	Single	46	127	0.7
	Multiple	21	31	0.0001*
DM patient n [%]		11	12	0.002*
Duration of surgery	>70min	41	98	0.001&
	≤70min	26	60	0.4
	Initial 100 cases	38	62	0.001*
	Later	29	86	0.2

DM = Diabetic Mellites *= significant

the bacteria. But in our study stone analysis was available in only 65 cases. The limited number of analysis reports available makes it difficult to make a final conclusion but calcium oxalate stone was seen in the majority. HU can predict stone hardness during preoperative assessment.[29] Hard stone consume relative longer time and energy during fragmentation that may increase the risk of potential complications.[29] Use of different types of energy source during stone disintegration and the amount of mechanical force imparted during pneumatic lithotripter should also be considered. The associated injury to the pelvicalyceal system causes extrarenal migration of the stone fragments. All these factors increase the risk of hemorrhage and sepsis. Stone free rate is a common indicator used to access the clinical success of the procedure and is evaluated either using ultrasonography or X-ray KUB.[30] In our cohort, in the first 100 cases, 81 patients acquired stone free status [CIRF(<4mm)]. In the remaining next 125 cases stone free status was achieved in 111 [88.88%] patients. With the gradual increase in the number of procedures, the surgeons experience enhances greatly allowing a greater stone free status. CT scan is recommended for the assessment of residual stone[30] but because of financial constrains the stone clearance in our study was assessed with ultrasonography or X-ray KUB.

This study has certain limitations. Relation of pelvicalyceal system pressure and infective complication were not examined. Sending urine culture from puncture aspirate and stone culture would have been better guide to the management in postoperative period.[31] Post-operative pain, use of analgesic was not included in the analysis and reports of stone analysis of all the participants were not available in all patients. Apart from being single-centered the results are also limited due to the retrospective nature of the study. The positively identified variables can be validated with a large, well designed multi-centered prospective study.

Conclusion

Female, DM, preoperative urine culture positivity, stone location, degree of hydronephrosis, duration of the operation, number of access tracts and surgeon experience are risk factors for post PCNL infection. Surgeons should be extra vigilant during their initial learning period, keep a close eye on the operative times and be careful when operating in female patients giving ample attention to preoperative investigations.

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