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### Endourology

Original article

# Factors determining perioperative complications of percutaneous nephrolithotomy: A single center perspective



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Factors affecting PCNL

#### Abstract

**Objective:** To determine factors affecting perioperative complications of percutaneous nephrolithotomy (PCNL) at a tertiary care academic center.

**Patients and methods:** Data from medical records of all patients who had undergone PCNL and matched the selection criteria in a tertiary care center between March 2010 and March 2015 were retrospectively reviewed. The demographic data, stone parameters, and stone free rate were addressed. Factors affecting perioperative complications of PCNL were evaluated and classified according to the modified Clavien classification (MCC) using different statistical methods.

**Results:** A total of 518 patients undergoing 575 PCNL procedures were enrolled in this study. Complications were detected in 148 patients (28.6%); the most serious complication was peri-operative bleeding in 53 patients (10.2%), which required conversion to open surgery in 12 cases (2.3%). Mortality occurred in 2 patients (0.4%). Grade I, II, IIIa, IIIb, IVa, IVb, V complications represented (14.1%), (15.4%), (7.5%), (2.3%), (0.6%), (0%), (0.4%), respectively. Complications of PCNL were significantly associated with tract numbers, tract location, method of stone extraction, and surgeon experience ( $P < 0.05$ ), while gender, stone shape and location, stone burden, degree of hydronephrosis, previous surgery, position of PCNL (supine vs. prone) and comorbidity did not impact perioperative complications ( $P > 0.05$ ).

**Conclusion:** Perioperative complications of PCNL were significantly affected by surgeon experience, number of PCNL tracts, accessed calyx as well as method of stone extraction. However, patient gender, stone characteristics (configuration, location and burden), degree of hydronephrosis, previous renal surgery, surgical position (supine vs. prone) did not impact the outcome of PCNL.

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## Introduction

Urolithiasis is one of the most common urinary tract disorders which is associated with human and financial burdens. Currently, there is a trend towards minimally invasive surgeries in management of large and recurrent renal stones [1].

The development of percutaneous renal surgery, as well as technical advancements in the available modalities for intracorporeal lithotripsy had led to a revolution in the manner in which urinary stone disease is managed surgically [2]. PCNL is the current gold standard for the management of large renal stones. Although PCNL is generally safe and minimally invasive technique, some serious complications such as bleeding and even death may occur for many reasons. The complications may occur during any step of the PCNL procedure from puncturing up to stone removal [2,3]. The rate of perioperative complications in the literatures varied from around 20% up to 50%. Despite most of the PCNL complications were minor, some serious complications were reported by different authors due to multiple factors [3,4].

Different scoring systems have been previously tested to improve the quality of reporting the perioperative complications of PCNL. Recently, the European Association of Urology (EAU) recommended the modified Clavien Classification (MCC) as a standardized system for reporting and grading the complication [4–7]. However, most of these studies focused only on reporting the complications of PCNL. There is a paucity of the literature describing the factors affecting the peri-operative complications of PCNL. Herein, we used the MCC system for the purpose of standardization.

Studying the factors which affect the complications of PCNL is important to identify the parameters affecting the severity of complications in order to reduce the rate of complications and to improve the quality of service. Therefore, the objective of the present study was to quantify and address the factors affecting perioperative complications of PCNL in a university teaching hospital over a period of five years.

## Patients and methods

We retrospectively reviewed the data of 650 patients undergoing PCNL at a high-volume tertiary stone center from March 2010 to March 2015. The medical records of 518 patients were available for this study after exclusion of patients with incomplete data. Those patients underwent 575 PCNL procedures. The protocol of the study was approved by the local ethical committee. The PCNL technique was performed by professors, lecturers, and residents. The data collection tool was a master sheet filled from the patients' medical files. The subjects were limited to the patients undergoing PCNL with good written perioperative follow up during the study period.

Patient's pre-operative assessment included medical history, physical examination, urine analysis, complete hemogram, coagulation profile, kidney function test and liver function test. Intra-operative notes and complications were considered. Post-operatively, all patients had complete blood count and serum creatinine level tests. On the day +1 KUB plain X-ray film and ultrasound were performed. A second session of PCNL was performed in cases of residual stones larger than 10 mm or if they were 4 mm–10 mm and accessible through the present tracts. Pre and postoperative serum

creatinine as well as imaging study results were compared. Intra and post-operative complications were classified according to the modified Clavien classification system into five grades [8].

## Statistical analysis

Data was analyzed using the SPSS (Statistical Package for the Social Sciences, version 20.0). The comparisons between variables in the qualitative data were done using Fisher exact test. The comparisons between quantitative variables of the same group were done using student t test. Two tailed P values less than 0.05 were considered statistically significant.

## Results

The study consisted of 518 patients (Table 1), including 312 (60.2%) males and 206 (39.8%) females, with the mean age of 39.6 years (range, 5–75 years), and mean postoperative hospital stay was 4.6 days (range, 2–25 days). The right and left kidneys were affected in 245 (47.3%) and 273 (52.7%) patients, respectively. Twelve cases (2.3%) were converted to open surgery to control the massive bleeding. Complications occurred in 148 (28.6%) patients; peri-operative bleeding in 53 (10.2%), secondary hemorrhage in 10 (1.9%), fever required antibiotics 26 (5%) renal collecting system injury in 36 (6.9%), colon perforation in 5 (0.96%), pneumothorax in 1 (0.2%), and hemothorax in 1 (0.2%), pneumonia in 2 (0.4%) patients. Mortality occurred in 2 patients (0.4%).

Regarding stone free rate results; 296 (57.1%) out of the 518 cases were rendered stone free after first stage PCNL. Among the remaining procedures, 76 cases (14.7%) had clinically insignificant residual fragments (CIRFs), and 125 cases (24.1%) had significant residual fragments (SRFs) after the first stage of PCNL, 57 cases (11%) with SRFs underwent second stage of PCNL and 42 (8.1%) cases were rendered stone free after second stage PCNL. Eighteen cases (3.5%) with significant residual radiolucent stones (urate stones) received chemolysis using potassium citrate and 8 cases (1.5%) of them were stone free at the end of three months follow-up. Forty nine cases (9.5%) completed the treatment with extracorporeal shock wave lithotripsy (ESWL). The overall success rate at the end of three months follow-up was 81.5% (422/518).

As regards to the stratification of the PCNL according to modified Clavien grading system: 73 cases (14.1%) had grade I, 80 cases (15.4%) had grade II, 39 cases (7.5%) had grade IIIa, 12 cases (2.3%) had grade IIIb, 3 cases (0.6%) had grade IV complications, and two cases (0.4%) of mortality (grade V) (Table 3).

In our study, there was statistically significant difference between the mean pre-operative and post-operative hemoglobin ( $P=0.001$ ). There was a strong relation between number of tract and perioperative complications as in multiple tract procedures the complications occurred in 44%, while in single and double tracts occurred in 28% which was statistically significant ( $P=0.04$ ). Upper and middle access had about 35.4% complication rate while the lower calyx had the lowest complication rate (25%) despite the large number of the patients (340) (Table 2).

Regarding method of stone extraction, the highest complication rate was observed when the stone was staged about 70%, while with fragmentation and extraction was 28.9% (in 466 patients), where

**Table 1** Patient demographic, stone, and PCNL procedure related data.

Mean age (SD, range), year	39.6 ± 4.14 (5–75)
Male/female ratio, n (%)	312 (60.2%)/206 (39.8%)
Mean postoperative hospital stay (SD, range), day	4.9 ± 2.98 (2–25)
Side of the procedure Rt./Lt. n (%)	245 (47.3%)/273 (52.7%)
Stone opacity radio-opaque/radiolucent n (%)	430 (83%)/88 (17%)
Mean stone burden (SD, range), cm	4.4 ± 2.02 (1.3–11.7)
Hypertension, n (%)	38 (7.3%)
Diabetes mellitus, n (%)	43 (8.3%)
Chronic liver disease, n (%)	36 (6.9%)
Ischemic heart disease, n (%)	8 (1.5%)
Tract number (single/multiple), n (%)	398 (76.8%)/120 (23.2%)
Accessed calyx (upper–middle–lower), n (%)	40 (7.7%)–138 (26.6%)–340 (65.6%)
Tubeless PCNL approach, n (%)	38 (7.3%)
Number of PCNL stages:	
One stage, n (%)	461 (89%)
Two stage, n (%)	57 (11%)
Radiological degree of hydronephrosis:	
No hydronephrosis, n (%)	102 (19.7%)
Mild hydronephrosis, n (%)	256 (49.4%)
Moderate hydronephrosis, n (%)	111 (21.4%)
Severe hydronephrosis, n (%)	49 (9.5%)
Auxiliary procedure after PCNL:	
ESWL, n (%)	49 (9.5%)
Double J stent insertion, n (%)	24 (4.6%)
Ureteroscopy, n (%)	8 (1.5%)
Angioemolization, n (%)	2 (0.4%)
Stone-free result:	
Stone-free after first stage PCNL, n (%)	305 (58.9%)
CIRFs	76 (14.7%)
Significant residual fragments, n (%)	125 (24.1%)
Conversion to open surgery, n (%)	12 (2.3%)
<b>Success</b> (stone-free or residual fragments <4 mm) at the end of 3 months follow up, n (%)	378 (81.5%)
Solitary kidney patients, n (%)	12 (2.3%)
Mean preoperative hemoglobin (SD, range), g/dL	12.9 ± 1.35 (11–17)
Mean postoperative hemoglobin (SD, range), g/dL	11.2 ± 1.57 (6–16.5)
Mean preoperative serum creatinine (SD, range), mg/dL	0.97 ± 0.33 (0.2–3.6)
Mean postoperative serum creatinine (SD, range), mg/dL	1.09 ± 0.35 (0.4–2.5)

SD: standard deviation of the mean; PCNL: percutaneous nephrolithotomy; n: number of cases; ESWL: extracorporeal shock wave lithotripsy.

NB: some patients had more than one comorbidity.

extraction in-toto had less complications (6 out of 42 patients) about 14.2% (Table 2).

The surgeon experience affection on the complications was realistic as the lowest one with professors and lecturers (about 27%) while they reached 40% with the residents. Renal pelvic stones (127 patients) had perioperative complication in 29.1% of the patients, while 34.6% of 60 patients with complete staghorn stone developed complications which was also insignificant ( $P = 0.08$ ).

Regarding the patient position (prone vs. supine), it was statistically insignificant ( $P = 0.288$ ). No statistically significant difference were detected in complications of PCNL regarding stone burden, degree of hydronephrosis, previous surgery and comorbidity ( $P = 0.121$ ,  $P = 0.09$ ,  $P = 0.671$ ,  $P = 0.153$  respectively) (Table 2).

## Discussion

PCNL is the current gold standard for management of large kidney stone >2 cm due to its relative safety compared to the open

stone surgery. Consequently, it was incorporated in the European and American guidelines for treatment of renal stones [4,5]. However, it was associated with some serious complications such as bleeding and even death. Therefore, the present study was designed to evaluate factors affecting perioperative complications of PCNL over a period of five years in a university teaching hospital.

In the present study, the overall complication rate was 28.6%, which is higher than the 21.5% that has been previously reported in an international multi-center study of 5803 patients [5]. This difference can be partially explained by positive correlations between surgeon experience and the complications, despite it is weak positive correlation, but it is significant ( $P = 0.04$ ), and it is intuitive that the complications are higher during the learning phase. Some surgeons have a broad experience and others such as residents are acquiring it [9]. The incidence of complications after PCNL performed by professors, lecturer and residents in the present study were 27.2% (70/262), 26.8% (54/196), and 40% (24/60), respectively. Such results not only reflect the impact of surgeons' experience, but also denote the management of difficult and complicated cases by professors.

**Table 2** Relation between different characteristics and complications in 518 patients.

Variable		N	Complications N (%)	P value
Gender	Male	312	98 (31.4%)	0.755
	Female	206	60 (29.1%)	
Stone shape and location	Complete staghorn	81	28 (34.6%)	0.08
	Partial staghorn	116	30 (25.9%)	
	Pelvic	127	37 (29.1%)	
	Pelvic and lower calyx	52	16 (30.8%)	
	Multiple calyceal stones	70	23 (32.9%)	
	Upper calyx only	10	4 (40%)	
	Middle calyx only	21	5 (23.8%)	
	Lower calyx only	41	5 (12.2%)	
Stone burden	Staghorn stone	81	28 (34.6%)	0.121
	Less than 2 cm	106	27 (26.4%)	
	More than 2 cm	331	92 (27.8%)	
Degree of hydronephrosis	No HN	102	26 (25.5%)	0.09
	Mild HN	256	73 (28.5%)	
	Moderate HN	114	34 (29.8%)	
	Marked HN	46	15 (32.6%)	
Surgeon experience	Professors	257	70 (27.2%)	<b>0.03</b>
	Lecturers	201	54 (26.8%)	
	Residents	60	24 (40%)	
Tract number	Single tract	398	110 (27.6%)	<b>0.04</b>
	Two tracts	102	30 (29.4%)	
	Three tracts	18	8 (44.4%)	
Tract location	Upper calyx	40	15 (37.5%)	<b>0.03</b>
	Middle calyx	138	48 (34.8%)	
	Lower calyx	340	85 (25%)	
Position of PCNL	Prone	487	139 (28.5%)	0.288
	Supine	31	9 (29.1%)	
Side of PCNL	Rt.	245	71 (28.9%)	0.165
	Lt.	273	77 (28.2%)	
Method of stone extraction	Staged	10	7 (70%)	<b>0.009</b>
	Extraction in toto	42	6 (14.3%)	
	Fragmentations	466	135 (28.9%)	
Pervious surgery	Open surgery	75	22 (29.3%)	0.671
	PCNL	45	15 (33.3%)	
Comorbidity	Diabetes mellitus	43	25 (58.1%)	0.153
	Hypertension	38	20 (52.6%)	
	Liver disease	36	22 (61.1%)	
	IHD	8	4 (50%)	

\*N: number of cases HN: hydronephrosis IHD: ischemic heart disease.

NB: some patients had more than one comorbidities.

Persistent urine leakage was encountered in 30 cases (5.8%). Six out of the thirty patients had stone fragments in the ureter and underwent ureteroscopic stone extraction and insertion of a double-J stent. The remaining 24 (4.6%) patients with persistent urine leakage were treated by insertion of double-J stents. The rate of persistent urine leakage in our study was lower than that reported by Taylor et al. (15%) [10], this complication may be underestimated in several studies and sometimes not mentioned in the complications [5,11]. However, the incidence of urine leakage after PCNL in the literature ranged from 0.4% to 8% [10]. Our rate of persistent urine leakage lies within that range.

Fever was encountered in 20.9% of our cases; most of them were transient fever (15.9%) which improved spontaneously or with only

antipyretics and 5% of cases required antibiotics according to the antibiogram, which is consistent with the 22.4%, which was reported by Lee et al. [13]. However, other studies reported a rate of only 1–1.2% of postoperative fever [12,14].

The most commonly reported major perioperative complication of PCNL is bleeding [10]. In our experience, there was a significant decrease in the mean post-operative hemoglobin, consistent with what has been reported by Falahatkar et al. [4]. With refinement of techniques and equipment, the overall transfusion rate for PCNL has fallen significantly from 6.9% in early series, to less than 2% in contemporary reports [10]. In the present study, bleeding occurred in 65 (12.5%) cases during PCNL procedures and open surgery was

**Table 3** Clavien grading score of complications of 518 Patients.

Grade	N	%	Complications (N)*	Management
Grade I	73	14.1%	– Transient low grade fever and transient leak (63) – Bleeding not dictating blood transfusion (10)	Conservative management for low grade fever and leak—watchful waiting for bleeding without blood transfusion
Grade II	80	15.4%	– Bleeding dictating blood transfusion(51) – Fever with UTI (26) – DVT (1) – Pneumonia (2)	Blood transfusion for bleeding and Antibiotics shifting according to antibiogram for UTI-anticoagulants for DVT-antibiotics for pneumonia
Grade IIIa	39	7.5%	– Colonic injury(3) – AV fistula (2) – Hemothorax(1) – Pelvic perforation (33)	Conservative management for colonic injury by tube drain- angioembolization for AV fistula-chest tube insertion for hemothorax-JJ insertion for pelvic injury
Grade IIIb	12	2.3%	– Conversion to open (11) – Nephrectomy(1) – Colonic injury(1)	Open surgery to control bleeding—required colostomy for colonic injury
Grade IVa	3	0.6	– Impaired renal functions with hemodialysis (2)	Hemodialysis
Grade IVb	0	0%	Not observed	
Grade V	2	0.4	– Death (2)	ICU management and death

NB: Some patients had more than one complication.

\* (N) number of procedures.

needed for 12 cases (2.3%) of them in order to control the massive bleeding, including one patient where nephrectomy was indicated.

In the review of Taylor et al. [10], applying modified Clavien classification system, the majority of complications were minor; 11.1% and 5.3% for respectively grades I, and II, and 3.6%, 0.5% and 0.03% for grades III, IV and V, respectively. In the current cohort, most of postoperative complications were of low grads, including 14.1% and 15.4% for grades I and II, respectively. Grades III, IV and V were detected in only 9.8%, 0.6%, and 0.4%, respectively (Table 3).

In the present study, PCNL complications were significantly associated with location of the tract. The risk of pleural injury increases if the puncture is above the 12th rib. The incidence of pleural injury in our study was only 0.4%, which was consistent with the 0.7–0.14%, that have been previously reported [12,14].

The rates of the colonic injury reported in the previous studies were quite low [15,16]. In the present cohort, only five cases (0.97%) of colonic injury were detected, including two adult males and one adult female. These patients were managed conservatively by double-J insertion and tube drains fixation with parenteral broad spectrum antibiotics, but one patient died with sepsis whereas colostomy was indicted in a female child.

Mortality after PCNL is rare, ranging from 0.1 to 0.7% [10]. Only two (0.03%) Clavien grade V complications were reported by de la Rosette et al. [5]. We had two mortalities (0.4%) after PCNL in the current study. The first was a female patient, 63 years old who died on the 3rd postoperative day. She had several comorbidities including diabetes, hypertension, and hepatitis C virus. Intra-operatively, two punctures were performed, but after dilatation of first tract, bleed-

ing was observed so a nephrostomy tube was fixed and bleeding was controlled. The other tract was dilated and the procedure was continued. After 40 min, the patient developed severe hypotension, that necessitated termination of the procedure, fluid replacement, blood transfusion and the patient was transferred to the intensive care unit where she received inotropics for a day then she suffered from hypotension, disturbed conscious level, oliguria, elevation of serum creatinine and eventually deceased.

The second patient was a 42-year old thin man, with 3.2-cm left renal pelvic stone. The PCNL procedure was done successfully. On the 3rd postoperative day, the patient developed abdominal pain and picture of peritonitis, then a colonic injury was discovered and laparotomy was done for creation of colostomy. The Patient was transferred to the intensive care unit, where he died after 4 days from sepsis.

To define risk factors associated with the increased incidence of complications, we found no significant correlation between gender, stone shape and location, stone burden, degree of hydronephrosis, positioning during PCNL (supine vs. prone), history of previous surgery or associated comorbidities and the incidence of complications ( $P > 0.05$ ). Despite the complication rate was high with associated comorbidities, it was not statistically significant. However, there were significant correlations ( $P < 0.05$ ) between surgeon experience, number of punctures, accessed calyx, as well as method of stone extraction, and the complications of PCNL.

The use of auxiliary interventions such as ESWL may be necessary to achieve stone free status and the surgeon should explain to the patients with staghorn stones the possibility of needing such auxiliary procedures to achieve a satisfactory outcome. In our study, ESWL was required in 9.4% of cases, second session PCNL in 11%

of cases, double-J stent in 4.6% of cases, ureteroscopy in 1.5% of cases while angioembolization was indicated in 0.4%. Mousavi-Bahar et al. reported that ESWL was needed in 5% and second session PCNL was needed in about 3% and angioembolization was done in 0.15% [14].

The main limitation of the present study was its retrospective nature. However, the results of the current study might help to emphasize the challenge of the increased financial costs associated with the need for long postoperative hospital stay as well as for the auxiliary procedures to render the patients stone free after PCNL in a university teaching hospital. It also points to the potential perioperative risk factors which should be considered with the PCNL procedure in such training centers. The potential confounders which might impact the outcome of the study could be compensated by the large sample size of the current cohort.

### Conclusion

The perioperative complications of PCNL were significantly associated with surgeon experience, number of PCNL tracts, accessed calyx as well as method of stone extraction. On the other hand, there was no significant correlation between perioperative complications of PCNL and patients' gender, stone configurations, degree of hydronephrosis, previous surgery, position of PCNL and comorbidity. Randomized trials are definitely warranted for proper evaluation of the risk factors.

### Ethical Committee Approval

This research was conducted in accordance to the Ethical and Moral stipulations set by the Faculty of Medicine, Al-Azhar University following the standers of the "World Medical Association Declaration of Helsinki" and "The Council for international organization of Medical Science in collaboration with the World Health Organization and The Islamic Organization for Medical Science, Geneva 2004".

### Conflict of interest

None declared.

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This study was self-funded retrospective study extracted from patient's medical records. The follow-up of patients is the standard of care and it was not require any additional resources.

### Authors Contributions

**Ahmed Ibrahim (Ibrahim A)**, MD, MSc; first author, creating the research idea, collecting the data, preparing the manuscript, reviewing the statistical analysis.

**Ibrahim elsothi (Elsotohi A)**, MD, PhD; data collection and revision.

**Sami Mahjoub (Mahjoub S)**, MD, PhD; data collection and assisting in manuscript writing and revision of the statistical analysis.

**Adel Elatreisy (Elatreisy A)**, MD, data collection.

**Khaled Soliman (Soliman Kh)**, MD, PhD; data collection and revision.

**Mohamed Mabrouk (Mabrouk M)** MD, PhD; Senior Author.

**Ismail Khalaf (Khalaf I)**, MD, PhD, Senior Author, the supervisor of the research team.

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