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ORIGINAL RESEARCH

Complications associated with Percutaneous nephrolithotomy (PCNL)

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Abstract

Background: Percutaneous nephrolithotomy (PCNL) is a widely used minimally invasive procedure for the management of large, complex, or staghorn renal calculi. It offers higher stone-free rates compared to extracorporeal shock wave lithotripsy (ESWL) and ureteroscopy. However, PCNL is associated with complications such as bleeding, infection, and organ injury, which may impact patient outcomes. This study aims to evaluate the frequency, nature, and severity of complications associated with PCNL and identify potential risk factors.

Methods: A prospective observational study was conducted in the Department of Urology and Renal Transplant Surgery, including 22 patients undergoing PCNL. Data on patient demographics, stone burden, operative details, and postoperative outcomes were collected. The incidence of complications was systematically analyzed, and findings were compared with existing literature.

Results: The mean age of the study population was **46.27 years**, with **59.10%** of stones located in the left kidney. The most common stone location was the **renal pelvis (45.45%)**. The majority of patients underwent **26Fr tract dilation (54.55%)**, with **86.36%** requiring PCN placement. Postoperative fever (**13.64%**) and bleeding (**4.55%**) were the most common complications. Most patients (**68.18%**) were discharged on **postoperative day 3 (POD 3)**.

Conclusion: PCNL remains a safe and effective treatment for large renal stones with a low complication rate. Optimizing preoperative imaging, **early nephrostomy removal**, and **selective use of mini-PCNL** can improve patient outcomes. Further research is needed to refine perioperative protocols and minimize complications.

Keywords: PCNL, renal stones, complications, bleeding, infection, nephrostomy, mini-PCNL.

Introduction

Percutaneous nephrolithotomy (PCNL) is a widely used minimally invasive surgical procedure for the removal of large, complex, or staghorn renal calculi. Since its introduction in the 1970s, PCNL has revolutionized the management of kidney stones, offering a superior stone clearance rate compared to extracorporeal shock wave lithotripsy (ESWL) and ureteroscopy for large renal stones.[1] Despite its high efficacy, PCNL is associated with various intraoperative and postoperative complications that can impact patient outcomes. These complications range from minor issues, such as transient hematuria and fever, to major complications, including significant hemorrhage, organ injury, and sepsis[2]. Understanding these complications is crucial for surgeons to minimize risks and improve patient safety.

Renal stone disease is a significant global health concern, contributing to substantial morbidity and healthcare burden. With advancements in minimally invasive surgical techniques, percutaneous nephrolithotomy (PCNL) has emerged as the preferred treatment modality for large and complex renal calculi, offering high stone-free rates with relatively low morbidity compared to other interventions such as extracorporeal shock wave lithotripsy (ESWL) and ureteroscopy. Despite its effectiveness, PCNL is not devoid of complications, and certain major adverse events, though infrequent, can lead to prolonged hospitalization, additional interventions, and increased healthcare costs.

One of the most frequent and significant complications of PCNL is bleeding, which occurs due to injury to the renal vasculature during access creation or tract dilatation. Studies report that

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postoperative hemorrhage requiring blood transfusion occurs in 5-12% of cases[3]. In rare instances, arteriovenous fistulas or pseudoaneurysms may develop, necessitating angiographic embolization[4]. Factors influencing bleeding include tract size, access location, number of punctures, and operative time.

PCNL can lead to urinary tract infections (UTIs), pyelonephritis, and even sepsis, especially in patients with pre-existing infections or untreated bacteriuria[5]. Postoperative fever is observed in approximately 23-35% of patients, while severe sepsis occurs in 0.3-1% of cases[6]. Proper preoperative urine culture screening and antibiotic prophylaxis are critical in preventing infectious complications.

During percutaneous access, renal collecting system injury is a potential complication, leading to urinary extravasation, urinoma formation, or prolonged nephrostomy drainage[7]. Injury to adjacent organs such as the colon, pleura, liver, and spleen can also occur, though rare (less than 1%)[8]. Colonic injury is more common in patients with retro-renal colon anatomy, emphasizing the importance of preoperative imaging and careful tract selection.

The size of the nephrostomy tract plays a significant role in postoperative outcomes. Larger tracts (≥30Fr) are associated with higher bleeding risks, whereas mini-PCNL (≤20Fr) techniques have been developed to reduce complications while maintaining stone clearance efficiency[9].

Given the variability in complication rates reported in the literature, it is essential to systematically evaluate and quantify the overall and specific complications associated with PCNL in different patient populations. Identifying risk factors and trends in complications can help refine surgical techniques, enhance patient safety, and optimize postoperative management. Furthermore, a clearer understanding of the complication profile is crucial for patient counseling, informed consent, and setting realistic expectations regarding surgical outcomes.

This study aims to analyze the frequency, nature, and severity of complications associated with PCNL in order to contribute to the ongoing refinement of surgical care. By identifying key predictors of adverse events, this research can provide valuable insights for risk stratification, improving perioperative protocols, and ultimately enhancing patient outcomes and surgical success rates.

MATERIAL AND METHODS

Methods: This study was conducted in the Department of Urology and Renal Transplant Surgery to evaluate the overall and specific complication rates in patients undergoing percutaneous nephrolithotomy (PCNL) for renal stones. The study focused on assessing perioperative and postoperative outcomes and comparing institutional data with international standards.

Study Design

This was a prospective observational study conducted over a defined period, including 22 patients who met the inclusion criteria. A structured proforma was used for each patient to collect relevant clinical, intraoperative, and postoperative data. The study aimed to systematically document complications and evaluate their severity and potential risk factors.

Inclusion Criteria

Patients were eligible for inclusion in the study if they met the following criteria:

- Adults (≥18 years) diagnosed with renal calculi requiring PCNL.
- Patients with single, multiple, or complex renal stones based on imaging studies (ultrasound, CT, or IVU).
- Patients fit for surgery based on preoperative evaluation.
- Patients who provided informed consent for participation in the study.

Exclusion Criteria

Patients were excluded from the study under the following conditions:

- Patients with bleeding disorders or coagulopathy that contraindicate PCNL.
- Pregnant women, due to the risks associated with radiation exposure and surgical stress.
- Patients with active urinary tract infections (UTI) or sepsis at the time of surgery.
- Patients with severe cardiopulmonary comorbidities rendering them unfit for the procedure.
- Patients who were lost to follow-up or had incomplete medical records preventing thorough analysis.

Data Collection & Analysis

Data was collected on patient demographics, stone burden (size, number, location), and preoperative comorbidities. Intraoperative details, such as access tract size, operative time, and need for multiple tracts, were recorded. Postoperative outcomes, including length of hospital stay, stone-free rates, need for auxiliary procedures, and occurrence of complications, were analyzed.

Statistical Analysis

The data collected was subjected to statistical analysis to identify patterns and potential risk factors contributing to complications. The study aimed to provide insights into predictors of morbidity, helping refine surgical techniques, enhance patient safety, and improve postoperative management. The findings are expected to contribute to evidence-based modifications in perioperative protocols for better patient care.

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Results and observation

Table 1: Demographics

Characteristic	Value
Average Age (years)	46.27

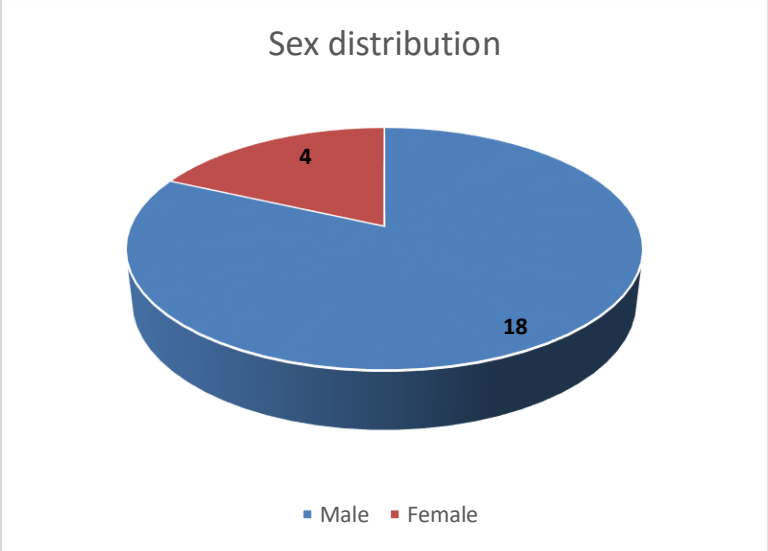

Figure 1: sex distribution

Table 2: Distribution of patients according to stone location, site and puncture site

	Side	Count	Percentage (%)
Stone Side Distribution	Right	9	40.90%
	Left	13	59.10%
Stone Location	Upper Pole	1	4.55%
	Mid Pole	1	4.55%
	Lower Pole	2	9.09%
	Pelvis	10	45.45%
	PUJ	5	22.73%
	Upper Ureter	3	13.64%
Puncture Site	Upper Pole	2	9.09%
	Mid-posterior	12	54.55%
	Lower posterior	7	31.82%
	Dual	1	4.55%

Table 4: Distribution of patients according to dilation of Tract

Size	Count (n)	Percentage (%)
18Fr	4	18.18%
24Fr	6	27.27%
26Fr	12	54.55%

Table 5: Distribution of patients according to PCN Placement

PCN Placed	Count (n)	Percentage (%)
Yes	19	86.36%
No	3	13.64%

Table 6: Distribution of patients according to PCN Removal

Post-Operative Day	Count (n)	Percentage (%)
Day 2	16	72.73%
Day 3	5	22.73%
Day 4	1	4.55%

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Table 7: Distribution of patients according to Complications

Complication	Count (n)	Percentage (%)
P/O Bleeding	1	4.55%
P/O Fever	3	13.64%
PCS Injury	0	0.00%
Colonic Injury	0	0.00%
Thoracic Injury	0	0.00%

Table 8: Distribution of patients according to Discharge Timing

Post-Operative Day	Count (n)	Percentage (%)
POD 2	2	9.09%
POD 3	15	68.18%
POD 4	3	13.64%
POD 5	2	9.09%

Table 1 presents the demographic characteristics of the study population. The average age of the patients included in the study was 46.27 years, indicating a middle-aged population undergoing the procedure. Figure 1 illustrates the laterality of stone occurrence. Stones were found in the right kidney in 40.90% of cases and the left kidney in 59.10% of cases, suggesting a slight predominance of left-sided renal stones. Table 2 categorizes patients based on the anatomical location of the stones. The majority of stones were found in the pelvis (45.45%), followed by the PUJ (22.73%), upper ureter (13.64%), and other locations like the upper, mid, and lower poles. The mid-posterior calyx was the most common site (54.55%), followed by the lower posterior calyx (31.82%). The upper pole and dual punctures were used in fewer cases(table 3).The majority of patients underwent 26Fr dilatation (54.55%), followed by 24Fr (27.27%) and 18Fr (18.18%), indicating that larger dilatation sizes were preferred.(table 4) PCN was placed in 86.36% of patients, while 13.64% did not require it, indicating its widespread use for drainage.(table 5) The majority of patients had their PCN removed on Day 2 (72.73%), followed by Day 3 (22.73%), with only a few requiring PCN until Day 4 (4.55%)(table 6) .The most common complication was postoperative fever (13.64%), followed by postoperative bleeding (4.55%). No cases of PCS injury, colonic injury, or thoracic injury were reported(table 7). Majority of patients were discharged on POD 3 (68.18%), while smaller proportions were discharged on POD 2 (9.09%), POD 4 (13.64%), and POD 5 (9.09%)(table 8) .

Discussion

The present study provides insights into the demographic and procedural characteristics of patients undergoing percutaneous nephrolithotomy (PCNL), as well as its outcomes and complications. To place these findings in context, we compare them with previous studies using author citations.

Demographics and Laterality of Stones

The average age of the study population was 46.27 years, which is consistent with findings from Reddy et al. (2016)[10], where patients undergoing PCNL had a mean age of 45.67 ± 13.21 years. Similarly, Singh et al. (2019)[11] reported that the majority of PCNL patients were middle-aged, particularly those with chronic kidney disease (CKD).

Regarding laterality, our study found that 59.10% of stones were in the left kidney, which aligns with the observations of Nikic et al. (2014)[12], who noted a slight predominance of left-sided renal stones in their cohort. This supports the notion that anatomical and functional differences may contribute to left-sided stone formation.

In our study, most stones were located in the renal pelvis (45.45%), followed by the PUJ (22.73%) and the upper ureter (13.64%). This distribution is similar to findings by Taylor et al. (2012), who reported that renal pelvic and PUJ stones are the most common targets for PCNL.

Additionally, our study found that the mid-posterior calyx (54.55%) and lower posterior calyx (31.82%) were the most frequent sites of stone occurrence. Reddy et al. (2016)[10] observed a similar pattern, where 40.5% of stones were pyelocalyceal and 27.9% were calyceal, further supporting the high frequency of calyceal involvement.

The majority of patients in our study underwent 26Fr dilatation (54.55%), followed by 24Fr (27.27%) and 18Fr (18.18%), indicating a preference for larger tract sizes. Nikic et al. (2014)[12] also reported that larger tracts were commonly used in traditional PCNL, though mini-PCNL (tract size < 20Fr) is gaining popularity due to its reduced bleeding risk.

However, Singh et al. (2019)[11] demonstrated that in patients with solitary kidneys, mini-PCNL resulted in comparable stone clearance rates with fewer complications. This suggests that while larger tracts may facilitate stone retrieval, smaller tracts should be considered in selected patients.

Our study found that PCN was placed in 86.36% of patients, with most being removed on Day 2 (72.73%). Taylor et al. (2012)[13] reported similar findings, stating that nephrostomy tube placement is widely practiced to minimize complications such as urine extravasation.

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Furthermore, Nikic et al. (2014) emphasized the importance of early nephrostomy removal in reducing infection risk, which aligns with our finding that most tubes were removed by Day 2.

Postoperative Complications

Postoperative Fever (13.64%):Our study's postoperative fever rate is comparable to the 10-30% range reported by Taylor et al. (2012)[13] and Vorrakitpokatorn et al. (2006).Vorrakitpokatorn et al. (2006)[14] highlighted that postoperative fever correlates with increased blood transfusion rates and prolonged hospital stays.Nikic et al. (2014)[12]reported that 9.52% of patients experienced postoperative fever, reinforcing that fever is among the most common minor complications of PCNL.

Bleeding (4.55%):Our reported rate of postoperative bleeding is within the 2-5% range observed in Reddy et al. (2016)[10] and Taylor et al. (2012)[13].Nikic et al. (2014)[12] found that 7.9% of cases had minor bleeding, with 1.58% requiring additional intervention, suggesting that while bleeding is a concern, severe cases remain rare.

Sepsis and Infectious Complications: Sepsis was not reported in our study, but Vorrakitpokatorn et al. (2006)[14] found that 4.7% of patients developed septic shock, with a mortality rate of 0.78%.Singh et al. (2019) also noted that patients with CKD undergoing PCNL had a higher risk of sepsis and required more frequent postoperative dialysis.Taylor et al. (2012) emphasized the importance of preoperative antibiotics to minimize the risk of infectious complications.

The majority of patients in our study were discharged by postoperative day (POD) 3 (68.18%), which closely mirrors findings from Nikic et al. (2014)[12], where most patients were discharged between POD 3-5, depending on their recovery and the presence of complications. However, hospital stays can be significantly longer in certain cases. Vorrakitpokatorn et al. (2006)[14] reported an average stay of 7.3 days, with extended hospitalization linked to fever and sepsis. Similarly, Reddy et al. (2016)[10] found that patients who had undergone prior renal surgeries often required longer recovery times, reinforcing the idea that surgical history plays a role in postoperative outcomes.

Overall, our study aligns well with existing literature on PCNL, reinforcing its role as a safe and effective treatment for kidney stones. Our findings highlight a few areas where further optimization can improve patient outcomes. (1) Expanding the use of mini-PCNL in appropriate cases could reduce bleeding risks, as suggested by Singh et al. (2019). (2) Preoperative antibiotic protocols and early nephrostomy removal should be consistently implemented to minimize infection risks, as emphasized by Taylor et al. (2012)[13]. (3) More research on postoperative fever and sepsis risk factors, particularly in patients with chronic kidney disease (CKD), is needed to develop tailored treatment strategies, as suggested by Vorrakitpokatorn et al. (2006)[14].

Ultimately, our study reinforces the safety and efficacy of PCNL as a first-line treatment for kidney stones while identifying areas where further refinements can enhance patient outcomes.

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