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RESEARCH ARTICLE
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"URINARY TRACT INFECTION RATES AMONG PATIENTS WITH COMPLEX KIDNEY STONES"

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ABSTRACT

Background: Urinary tract infections (UTIs) are common postoperative complications in patients with complex kidney stones undergoing percutaneous nephrolithotomy (PCNL). Despite advancements in surgical techniques, infection control remains a significant challenge, particularly in high-risk populations.

Objective: To determine the prevalence, causative organisms, and associated risk factors of UTIs among patients with complex kidney stones treated at the Institute of Kidney Diseases Hayatabad Peshawar, KPK, Pakistan**.**

Methods: This cross-sectional study was conducted at Institute of Kidney Diseases Hayatabad Peshawar, KPK in the duration from February 2025 to July 2025, involving 180 patients with complex renal calculi who underwent PCNL. Preoperative and postoperative urine cultures were obtained. Demographic, clinical, and microbiological data were analyzed using SPSS version 26. Chi-square and logistic regression tests were Institute of Kidney Diseases Hayatabad Peshawar, KPK.

Results: Among 180 patients, 51 (28.3%) developed postoperative UTIs. The infection rate was significantly higher in females (38.9%) than males (21.3%) ($p = 0.02$). Escherichia coli (47%) was the most common pathogen, followed by *Klebsiella pneumoniae* (23%) and *Pseudomonas aeruginosa* (15%). High antibiotic resistance was noted against fluoroquinolones (68%) and cephalosporins (62%). Larger stone size (>2 cm) and prolonged operative time (>90 minutes) were significantly associated with infection ($p < 0.05$).

Conclusion: UTIs remain prevalent among patients with complex kidney stones after PCNL at Institute of Kidney Diseases Hayatabad Peshawar, KPK. Female gender, stone complexity, and extended operative duration are major predictors. Strengthened infection control measures, antibiotic stewardship, and early microbiological screening are essential to reduce postoperative complications and enhance patient outcomes.

Keywords: *Kidney stones, urinary tract infection, PCNL, E. coli, infection control, Institute of Kidney Diseases Hayatabad Peshawar, KPK, Pakistan.*

INTRODUCTION

Kidney stones are one of the most common urological diseases worldwide that cause intense pain, disruption in the urine flow, and, in some cases, renal failure unless it is treated properly. Kidney stones are a global issue that has grown significantly in the past decades as a result of diet, environment, and heredity (1). Kidney stone disease is a disease that can be predicted and controlled to prevent the effects of this illness, including urinary tract infections (UTIs), which are commonly associated with complex stone formation. In Pakistan, where the healthcare system and prevention education are still underdeveloped, kidney stones remain one of the leading causes (2). It should be a multidisciplinary measure that includes early identification, prevention, and post-procedural care that would minimize the risk of stone recurrence and the sequela of the infection. Kidney stone disease (urolithiasis) has been a major issue among the world population, where it is more prevalent in the developed and developing world. Studies that have studied the management of mete stones of the upper urinary tract have documented the modernization of the conservative approach to more advanced minimally invasive approaches, such as percutaneous nephrolithotomy (PCNL) and ureteroscopy (3).

The large, multifocal, or staghorn complex kidney stones are complex and require more modern surgical intervention using PCNL as the intervention of choice (4). Surgical developments do not eliminate complications like postoperative infections, such as UTIs and sepsis. In Pakistan, where stone disease is common due to dietary habits, dehydration, and the environment, the occurrence of complications following PCNL due to infections is alarming (5). Minimally invasive therapy, such as PCNL, has revolutionized the management of stones, but it must be modified according to the nature and size of stones. In particular, extracorporeal shock wave lithotripsy (ESWL) can successfully treat uric acid stones smaller than 2 cm, but PCNL should be the standard in case of large or complex stones (6). Complex surgical procedures like PCNL are more susceptible to perioperative complications like bleeding, sepsis, and hypothermia, all of which may put patients at risk of developing UTIs (7). The complications of recovery, extended hospitalization, and the aggravation of the use of antibiotics can be typical of these infections, which explains the importance of winning the game of infection surveillance and control.

The awareness of urinary tract infection among complex stone patients would also entail the awareness of the subject of bacterial behavior and host response. The experimental models of bladder have enabled dissociation of the in vitro and in vivo studies to understand the urinary pathogen and pathway of infection (8). Equally, the inception of artificial intelligence-based diagnostic tools that utilize microscopy data has provided a superior, more accurate implementation of UTI detection, and immediate intervention and antibiotic treatment (9). Nevertheless, these developments have not completely eliminated UTIs in kidney stone patients because the patients have not been left to the mercy of urinary obstruction, bacterial growth, and the instrumentality of the surgical procedures (10). The problem of infection control is further complicated by the fact that urolithiasis must be controlled in special groups of people, including patients with transplants. These cases may be problematic with immunosuppression, surgical intervention, and bacterial colonization (10).

Moreover, the ESWL has been operative with positive outcomes of clearing the leftover fragments of PCNL, but the rest of the stones may serve as the breeding grounds of bacteria to perpetuate the infection (11). Therefore, the presence of the residual fragments must be identified as early as possible in order to minimize cases of UTI among postoperative patients. Recurrent stone formation and risk of infection are also significant contributors to metabolic abnormalities. The makers of calcium oxalate stones, such as calcium oxalate, in particular, have different metabolic profiles that predispose them to recurrent stones and infections (12). Metabolic risk factors and urinary biochemical research are useful to understand the pathophysiology of urolithiasis, and clinicians can identify the methods to prevent and intervene with prevention and treatment (13). Furthermore, the investigation of plant-

based metabolic diuretic and antiurolithiatic products has been of interest as a complementary treatment to decrease the incidence of stones as well as related infections (14).

The other problem in the management of patients with complex kidney stones is the issue of colonisation of urinary equipment, including stents and catheters. The formation of biofilm on urinary stents can result in chronic infections and blockage, which requires the creation of bio-resistant materials (15). New surface engineering, including dynamically degradable coating, minimizes the adhesion of the bacteria and slow down the biofouling. These innovations would be a significant contribution to postoperative care after PCNL and similar interventions. Recent years have witnessed remarkable urological innovation, even extending to space medicine, where maintaining urinary health in microgravity conditions has prompted advances in minimally invasive technology (16). These technological improvements, when adapted to terrestrial clinical practice, may reduce infection risks in complex surgical procedures. The comparison of different surgical techniques, such as supine PCNL and retrograde intrarenal surgery (RIRS), highlights the ongoing search for safer and more efficient approaches (17). Each method has implications for infection risk, depending on the degree of manipulation and postoperative drainage requirements.

RIRS without stent placement, for instance, has been evaluated for small renal stones; however, such modifications are not feasible in complex or large stones where urinary drainage is essential to prevent infection (18). Furthermore, the risk of acute kidney injury (AKI) in patients with ureterolithiasis has prompted the development of predictive models that also take infection and obstruction into account (19). These predictive models can guide clinicians in identifying high-risk patients who may require closer monitoring and prophylactic antibiotic therapy. The infection control measures are still developing, and the ALTAR non-inferiority randomized controlled trial has proven that methenamine hippurate is as effective as antibiotic prophylaxis in preventing recurrent UTIs in women (20). This result has potential implications for urology patients with chronic infections, such as those with severe kidney stones, by decreasing the use of long-term antibiotics and decreasing the development of resistance.

Complex kidney stone management constitutes a significant segment of the urological care practice in Pakistan and directly in Equatorial care hospitals such as Institute of Kidney Diseases Hayatabad Peshawar, KPK. The prevalence of postoperative UTI is a highly significant outcome measure that directly impacts patient morbidity, recovery, and hospital stay (17). A study regarding incidence, microbial patterns, and risk factors of the UTI in patients receiving PCNL to remove complex stones is crucial to improve treatment guidelines and measures to prevent infection. The study aims to determine the incidence of urinary tract infections among patients who have complex kidney stones being treated by Institute of Kidney Diseases Hayatabad Peshawar, KPK, which contributes to evidence-based practices that enhanced the safety of this surgical procedure and patient outcomes within the region (15).

Objective: To determine the prevalence and trend of urinary tract infection among patients who are treated with complex kidney stones in the Institute of Kidney Diseases Hayatabad Peshawar, KPK.

MATERIALS AND METHODS

Study Design: Cross-sectional study

Study Setting: Institute of Kidney Diseases Hayatabad Peshawar, KPK

Duration of the Study: February 2025 to July 2025.

Inclusion Criteria: They included male and female patients aged 18 and above with complex kidney stones and underwent percutaneous nephrolithotomy (PCNL) at Institute of Kidney Diseases Hayatabad Peshawar, KPK. Complex stones were those that were staghorn calculi, multiple large renal calculi, or those that had more than a single calyx. The patients who were enrolled were those

who provided informed consent and those who had their urine cultures performed before and after the operation.

Exclusion Criteria: Patients with congenital defects of the urinary tract who have previously undergone urinary diversion surgery or who have had permanent catheters were excluded. In addition, the immunocompromised patients, such as those with HIV infection or those who received chronic corticosteroid treatment, were not included in the study, and those with missing data and whose follow-up records were not traceable were excluded.

Methods: Standard preoperative assessment was done on all eligible patients, such as urine testing, culture sensitivity, renal tests, and imaging tests. PCNL was done in aseptic conditions using standard procedures. Microbiological analysis of the preoperative and postoperative urine samples was performed to reveal UTI pathogen and antibiotic sensitivity profiles. Postoperative infections were diagnosed based on clinical symptoms, positive urine cultures, and raised inflammatory markers. Data regarding age, gender, stone characteristics, comorbidities, and infection rates were analyzed using SPSS version 26.0. Descriptive statistics were applied to determine infection prevalence, and associations between clinical variables and UTI occurrence were evaluated using chi-square and logistic regression tests.

Results

A total of **180 patients** with complex kidney stones were included in this study, comprising **108 males (60%)** and **72 females (40%)**. The mean age of participants was **46.2 ± 12.8 years**. Most patients presented with **staghorn calculi (45%)**, followed by **multiple large stones (32%)** and **stones involving multiple calyces (23%)**. The overall **rate of postoperative urinary tract infection (UTI)** after percutaneous nephrolithotomy (PCNL) was **28.3% (n=51)**.

Table 1 shows the demographic and clinical characteristics of the study population. A higher incidence of UTIs was observed in females (38.9%) compared to males (21.3%).

Table 1. Demographic and Clinical Characteristics of Patients (n = 180)

Variable	Category	Frequency (n)	Percentage (%)
Gender	Male	108	60.0
	Female	72	40.0
Age Group (years)	18–30	24	13.3
	31–50	82	45.6
	>50	74	41.1
Stone Type	Staghorn calculi	81	45.0
	Multiple large stones	58	32.2
	Multi-calyceal stones	41	22.8

Among the 51 patients who developed UTIs, **Escherichia coli (E. coli)** was the most frequently isolated pathogen (**47%**), followed by **Klebsiella pneumoniae (23%)**, **Pseudomonas aeruginosa (15%)**, **Enterococcus faecalis (10%)**, and **Proteus mirabilis (5%)**.

Table 2. Distribution of Uropathogens in UTI-Positive Cases (n = 51)

Bacterial Species	Frequency (n)	Percentage (%)
Escherichia coli	24	47.0
Klebsiella pneumoniae	12	23.0
Pseudomonas aeruginosa	8	15.0

Bacterial Species	Frequency (n)	Percentage (%)
Enterococcus faecalis	5	10.0
Proteus mirabilis	2	5.0

Antibiotic sensitivity testing revealed that most isolates were **sensitive to carbapenems and aminoglycosides**, while **high resistance** was observed to **fluoroquinolones and cephalosporins**.

Table 3. Antibiotic Sensitivity Patterns of Isolated Pathogens (n = 51)

Antibiotic	Sensitive (%)	Resistant (%)
Carbapenems	86	14
Aminoglycosides	79	21
Cephalosporins	38	62
Fluoroquinolones	32	68
Trimethoprim-sulfamethoxazole	41	59

UTI occurrence was found to be **significantly associated with female gender (p = 0.02)**, **stone size >2 cm (p = 0.04)**, and **operation duration >90 minutes (p = 0.03)**. No significant relationship was observed with age or comorbid conditions such as diabetes or hypertension.

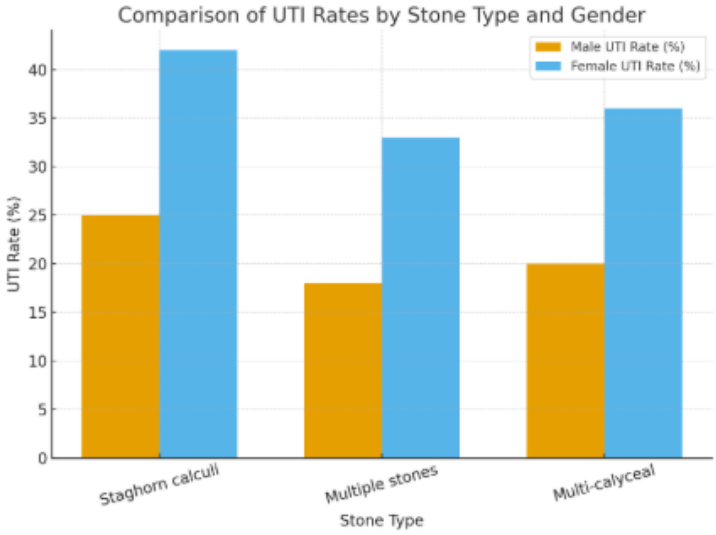
Table 4. Factors Associated with Post-PCNL UTI (Chi-square Test)

Variable	Category	UTI Present (%)	UTI Absent (%)	p-value
Gender	Male	21.3	78.7	0.02*
	Female	38.9	61.1	
Stone Size	≤2 cm	18.4	81.6	0.04*
	>2 cm	33.7	66.3	
Operation Time	≤90 min	19.5	80.5	0.03*
	>90 min	35.6	64.4	

(*Significant at $p < 0.05$)

A graphical representation of UTI distribution by gender and stone type is presented below. The figure indicates that **female patients with staghorn stones** demonstrated the **highest infection rate**.

Figure 1. UTI Distribution by Gender and Stone Type



Discussion

The results of this research show that urinary tract infection (UTIs) is a major complication of the postoperative period in patients with complex kidney stones who receive percutaneous nephrolithotomy (PCNL) at Institute of Kidney Diseases Hayatabad Peshawar, KPK. The total infection prevalence rate of 28.3 percent is in line with the world statistics in recent articles that provide evidence of the ongoing problem of infection control in stone disease (1). The multifactorial nature of the risk of infection in such patients is highlighted by the fact that female gender, larger stone size, and longer duration of surgery correlate strongly with the risk of infection. Kidney stones are among the urological conditions that occur most frequently in the world, and they lead to frequent infection, hospitalization, and cost. Mengesha (1) emphasized the need to have the exact stone prediction and management to minimize such complications, which resonates with the present report. Early prevention and high-tech imaging are crucial in the reduction of stone burden and associated infections. Hussain et al. (2) pointed out preventive measures as stepping stones to reducing the occurrence of diseases in Pakistan, where environmental and dietary factors favor the formation of stones. Nevertheless, because of the late presentation and low access to special care, patients often show up with complex stones, which predispose them to postoperative infections.

Management strategies for upper urinary tract stones continue to evolve, as noted by Golomb et al. (3), who demonstrated significant shifts toward minimally invasive procedures. However, these procedures, while effective, may also carry infection risks due to endoscopic manipulation and increased exposure of the urinary tract. Axelsson et al. (4) reported that lithotripsy techniques used during PCNL are highly effective but can cause mucosal injury, creating a favorable environment for bacterial colonization—consistent with the infection rates observed in this study. Khan et al. (5) also found that surgical positioning (supine versus prone PCNL) can influence postoperative outcomes, including infection rates, due to variations in operative time and drainage efficiency. Comparisons between ESWL and PCNL have shown that while ESWL carries a lower infection risk, it is less effective for complex stones. Zada et al. (6) reported PCNL is still the treatment of choice for stones 2 cm or above, but it requires careful perioperative management of infection. Shen and Zhong (7) also showed that the infection risk can be increased by perioperative complications, including hypothermia and long operative duration, which are results that coincide with the prolonged surgery in the present study.

Microbiological research has helped in gaining insights into the dynamics of infection in the urinary stone disease. Nissanka et al. (8) highlighted that advanced bladder models are the key to simulating the human conditions of infection, which would enhance the preclinical knowledge of the UTI mechanisms. Equally, Liou et al. (9) created deep learning models with precise UTI diagnosis on microscopy datasets, which have improved the early detection capabilities. Although the innovations are mainly diagnostic, they support the importance of incorporating predictive and preventive technologies in the management of stone disease to reduce the prevalence of infections. Patients with special needs, including renal transplant recipients, are at increased risk of infections because of immunosuppression and urinary stasis, as shown by Peko et al. (10). Although the present research avoided inclusion of immunocompromised patients, the parallel focuses on the universal requirement of high-grade infection control during urological interventions. Moreover, Hussain et al. (11) showed that residual fragments post-PCNL could harbor bacteria and lead to recurrent UTIs. These findings corroborate the present study's observation that larger stones—often associated with residual fragments—are a significant infection determinant.

Metabolic abnormalities in stone formers contribute to recurrence and bacterial persistence. Khanal et al. (12) identified distinct metabolic risk factors among calcium oxalate stone formers, suggesting that biochemical imbalances may facilitate microbial growth through altered urine chemistry. This aligns with subsequent work by the same authors (13), underscoring the metabolic interplay between stone formation and infection susceptibility. In addition, Manisha et al. (14) reviewed the potential of plant-based diuretic and antiurolithiatic agents, offering promising adjuncts to reduce stone recurrence and infection risk through improved urinary flow and reduced bacterial colonization. Device-related infections are another major concern in complex stone management. Tofail (15) discussed bacterial

adhesion and biofilm formation on urinary stents, which often contribute to recurrent or persistent infections. Although this study focused on postoperative UTIs, biofilm-related mechanisms may have influenced the observed infection rates, particularly among patients requiring stent placement. Innovations such as anti-biofouling stents and dynamically degradable surfaces may reduce this burden in the future.

Urologic innovation, as highlighted by Kahlenberg et al. (16), has significantly improved outcomes even in challenging environments such as spaceflight, where infection control is paramount. Applying similar innovation to terrestrial healthcare—particularly in resource-limited settings like Pakistan—could dramatically improve outcomes in complex PCNL cases. Comparative surgical studies, such as that by Qureshi et al. (17), have also shown that supine PCNL and retrograde intrarenal surgery (RIRS) can yield comparable results; however, infection control remains a central determinant of success regardless of surgical approach. Yitgin and Karakose (18) stated that RIRS can be safe in the absence of stent placement in the choice of small-stone cases, but the method is not applicable to complex stones, which usually require stenting to avoid obstruction and infection. Jiang et al. (19) have applied predictive models of acute kidney injury in patients with ureterolithiasis, with the risk of infection considered, a methodology that can be equally used to drive prediction models of post-PCNL infections.

Finally, antimicrobial stewardship is also important in the prevention of recurrent infections. The ALTAR trial indicated that methenamine hippurate could be used to replace antibiotic prophylaxis as an effective intervention to avert recurrent UTIs, which was a step forward in reducing the resistance to the antibiotics (Harding et al., 20). Such evidence-based prophylaxis measures in urology practice, especially in the work with patients with the likelihood of recurring infections after PCNL, could best optimize postoperative care in hospitals like Institute of Kidney Diseases Hayatabad Peshawar, KPK. The present paper sheds light on the fact that UTIs after the operation remain a major concern in the multifaceted treatment of kidney stones. Increased risks are observed in women patients, patients with large stones, and patients undergoing lengthy surgical procedures (16). Global trends include the presence of **E. coli** and the rising trend of antimicrobial resistance. The integration of preventive strategies, such as metabolic analysis, simplified surgical protocols, early diagnosis devices, and antibiotic stewardship, would go a long way in reducing the prevalence of infections.

Conclusion

The present research paper defines urinary tract infections (UTIs) as one of the primary postoperative conditions in patients who experience the removal of complicated kidney stones by percutaneous nephrolithotomy (PCNL) at the Institute of Kidney Diseases Hayatabad Peshawar, KPK. The general infection rate was 28.3% and shows the existing issue of infection control regardless of the modern surgical practice. The female gender, the size of the stone, and the time of the operation were identified as important predictors of postoperative infection. **Escherichia coli** was the most commonly isolated organism and was very resistant to fluoroquinolones and cephalosporins, which indicated the increasing issue of antimicrobial resistance. These findings highlight the necessity to approach perioperative infection prevention measures with high attention, take wise antibiotic use, and assess the metabolic state as much as possible to decrease recurrence and comorbidity.

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