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The Role of Stone Culture from Pelvic and Bladder Urine in Predicting Urosepsis Among Patients Undergoing Percutaneous Nephrolithotomy in a Rural Center Catering to A Rural Population

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ABSTRACT

Background: Percutaneous nephrolithotomy (PCNL) has evolved significantly since its inception, becoming the preferred treatment for large and complex renal calculi. Despite advancements, postoperative infectious complications like urosepsis remain a major concern. Emerging evidence suggests that intraoperative cultures, particularly from pelvic urine and stone specimens, may predict urosepsis more reliably than preoperative bladder urine cultures.

Objective: This study aimed to evaluate the predictive value of stone culture from pelvic and bladder urine in identifying the risk of urosepsis among patients undergoing PCNL in a rural healthcare setting. Secondary objectives included analyzing sex-based differences and the influence of comorbidities on urosepsis development.

Materials and Methods: In this prospective observational cohort study, 100 patients undergoing PCNL were evaluated over 18 months. Bladder urine, pelvic urine, and stone fragments were cultured intraoperatively. Patients were monitored postoperatively for signs of urosepsis. Data on demographics, comorbidities, and stone characteristics were collected. Statistical analyses included Chi-square tests and logistic regression to determine predictors of urosepsis.

Results: Among 100 patients (mean age 38.4 years; 50 males, 50 females), urosepsis occurred in 22% of those with positive bladder urine cultures and 50% with positive pelvic urine cultures, a statistically significant difference (p=0.0068). Middle-aged females with diabetes mellitus demonstrated the highest incidence of urosepsis in pelvic urine-positive cases. Logistic regression confirmed pelvic urine positivity as a strong independent predictor of postoperative urosepsis.

Conclusion: Pelvic urine cultures provide superior predictive value for postoperative urosepsis compared to bladder urine cultures, particularly in diabetic, middle-aged female patients. Routine intraoperative collection and culture of pelvic urine during PCNL could enable early identification of high-risk individuals, guiding prompt prophylactic and therapeutic interventions to mitigate infectious complications in resource-limited rural healthcare settings.

1. INTRODUCTION

Percutaneous nephrolithotomy (PCNL) has undergone significant evolution since its inception, becoming the preferred treatment for large and complex renal calculi. In 1976, Fernström and Johansson first described the technique of extracting renal stones through a percutaneous nephrostomy under radiological guidance. This minimally invasive approach marked a departure from the more invasive open surgical procedures previously employed[1].

Subsequent advancements in the 1980s, including improved renal access methods, tract dilation techniques, and the development of specialized nephroscopes, enhanced the efficacy and safety of PCNL. Innovations in fluoroscopy and lithotripsy devices further refined stone fragmentation and removal processes. These technological strides have solidified PCNL's role as a cornerstone in urological surgery[2].

Despite these advancements, infectious complications such as urosepsis remain a concern post-PCNL. Identifying predictors of urosepsis is crucial for improving patient outcomes. Recent studies suggest that cultures from renal pelvic urine and stone specimens may be more reliable indicators of potential urosepsis than preoperative midstream urine cultures. Mariappan et al[3]. demonstrated that positive stone and pelvic urine cultures were associated with a fourfold increased risk of urosepsis, whereas bladder urine cultures did not reliably predict such infections. Similarly, a systematic review and meta-analysis by Liu et al[4]. found that stone culture positivity was significantly associated with post-PCNL systemic inflammatory response syndrome (SIRS), underscoring the importance of intraoperative cultures in anticipating infectious complications.

In rural healthcare settings, where resource limitations may impact the availability of advanced diagnostic tools, the role of stone and pelvic urine cultures becomes even more pertinent. Implementing routine intraoperative culture analysis in these environments could enhance the early detection and management of potential urosepsis, thereby improving patient care and outcomes.

2. OBJECTIVES

Primary Objective

- To evaluate the predictive value of stone culture from pelvic and bladder urine in identifying the risk of urosepsis in patients undergoing percutaneous nephrolithotomy (PCNL) in a rural healthcare setting.

Secondary Objective

- To assess the occurrence of the above findings separately in male and female patients.
- To evaluate the influence of associated comorbidities on the occurrence of the above findings.

3. MATERIALS & METHODOLOGY

This study is a Prospective Observational Cohort Study. After getting approval from the Institutional Ethics Committee and informed consent was obtained from all participants. The study was conducted over 18 months in the Department of Urology at Karpaga Vinayaga Institute of Medical Sciences & Research Centre, Chengalpattu District. A minimum of 100 patients, calculated based on the expected incidence of post-PCNL urosepsis (approximately 10-20%) with a confidence level of 95% and power of 80%.

Inclusion Criteria:

- Patients undergoing percutaneous nephrolithotomy (PCNL) for renal calculi.
- Age ≥ 18 years.
- Willingness to participate and provide informed consent.

Exclusion Criteria:**

- Pre-existing urosepsis or active urinary tract infection at the time of surgery.
- Immunocompromised patients (e.g., HIV, long-term corticosteroid therapy).

- Patients with a history of recent urological intervention (<3 months).

Preoperative evaluation includes a thorough medical history, clinical examination, and baseline investigations, with a urine culture obtained directly from bladder urine. Intraoperatively, pelvic urine and stone fragments are collected after the initial puncture and sent promptly for culture and sensitivity testing. Postoperative monitoring involves close observation for signs of urosepsis such as fever, chills, hypotension, and tachycardia. If infection is suspected, blood and repeat urine cultures are performed to guide appropriate antimicrobial therapy and timely intervention.

The primary outcome of the study is the incidence of urosepsis following percutaneous nephrolithotomy (PCNL). Secondary outcomes include evaluating the correlation between positive stone culture and the development of urosepsis, assessing the correlation between pelvic urine culture and urosepsis, and comparing the predictive value of bladder urine culture versus stone culture in identifying postoperative infections.

Data collection included demographic details, comorbidities, and stone characteristics such as size, location, and composition. Culture results were obtained from bladder urine, pelvic urine, and stone fragments. Postoperative outcomes were monitored, focusing on the occurrence of urosepsis. Descriptive statistics were used to summarize patient demographics and clinical characteristics. Categorical variables were compared using the Chi-square test or Fisher's exact test, as appropriate. Logistic regression analysis was performed to identify independent predictors of urosepsis. Additionally, the sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of stone culture and pelvic urine culture were calculated to assess their diagnostic accuracy.

The expected outcomes of the study include determining the predictive value of stone and pelvic urine cultures compared to bladder urine cultures in anticipating the development of urosepsis. Additionally, the study aims to identify high-risk patients who would benefit from targeted prophylactic interventions, thereby improving patient outcomes and optimizing the management of infection risks associated with percutaneous nephrolithotomy.

4. RESULTS

Table 1: Demographic Characteristics of the Study Population

Parameter	Value	P Value
Age (years)	Mean: 38.4 years (Range: 18–60 years)	NS
Sex	Males: 50, Females: 50	NS
Surgical Procedure	PCNL Upper Pole (26), PCNL Mid Pole (20), PCNL Lower Pole (29), PCNL Multiple Puncture (25)	NS
Duration of Surgery (minutes)	Mean: 81.4 minutes (Range: 51–120 minutes)	NS

Table 1 - The study included 100 post-PCNL patients with a mean age of 38.4 years, ranging from 18 to 60 years. The sex distribution was equal, with 50 males and 50 females. Surgical procedures were categorized as PCNL Upper Pole (26 patients), Mid Pole (20 patients), Lower Pole (29 patients), and Multiple Puncture (25 patients). The mean duration of surgery was 81.4 minutes, with a range between 51 and 120 minutes. These demographic findings ensured a balanced patient representation across sex, surgical sites, and operative times, supporting the reliability of subsequent analyses related to urosepsis prediction following PCNL.

Table 2: Comparison of Urosepsis Between Bladder Urine and Pelvic Urine Cultures

Culture Site	Total Samples	Urosepsis (Yes)	Urosepsis (No)	Percentage Urosepsis (%)	P-Value	Significance
Bladder Urine	50	11	39	22.0	0.0068	Significant
Pelvic Urine	50	25	25	50.0	0.0068	Significant

Table 2 - Compares the incidence of urosepsis between samples collected from bladder urine and pelvic urine among 100 patients who underwent percutaneous nephrolithotomy (PCNL). Fifty samples each were obtained from bladder urine and pelvic urine. In the bladder urine group, urosepsis developed in 11 patients (22%), while 39 patients (78%) did not show evidence of urosepsis. In contrast, among pelvic urine samples, urosepsis occurred in 25 patients (50%), with the remaining 25 patients (50%) being free of infection.

A chi-square test was performed to determine the statistical significance of the difference in urosepsis rates between the two groups. The p-value obtained was 0.0068, which is below the conventional threshold of 0.05, indicating a statistically significant association between culture site and the development of urosepsis. Specifically, patients with positive cultures from pelvic urine were significantly more prone to developing urosepsis compared to those with positive bladder urine cultures.

This finding highlights the clinical importance of collecting pelvic urine during PCNL procedures, as it appears to be a more sensitive predictor for postoperative infectious complications. Early identification and targeted management based on pelvic urine culture results may help reduce morbidity associated with urosepsis in high-risk patients.

Figure 1: Urosepsis Rates: Bladder vs Pelvic Urine Cultures Post-PCNL

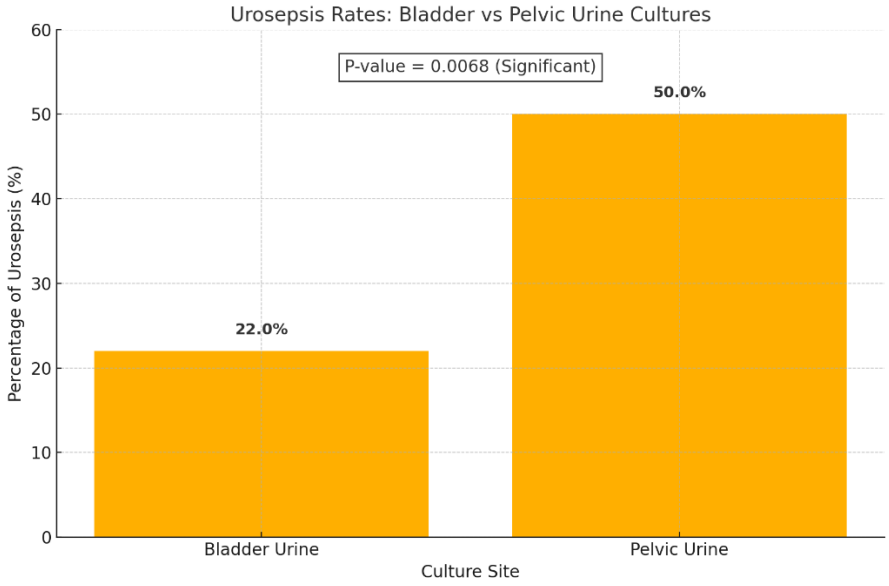

Figure 1 - Comparison of urosepsis rates between bladder urine and pelvic urine cultures in post-PCNL patients. The incidence of urosepsis was significantly higher in samples collected from pelvic urine (50%) compared to bladder urine (22%), with a p-value of 0.0068, indicating statistical significance.

Figure 2: Incidence of Urosepsis in Post-PCNL Patients Stratified by Culture Site, Age Group, Sex, and Diabetes Mellitus Status

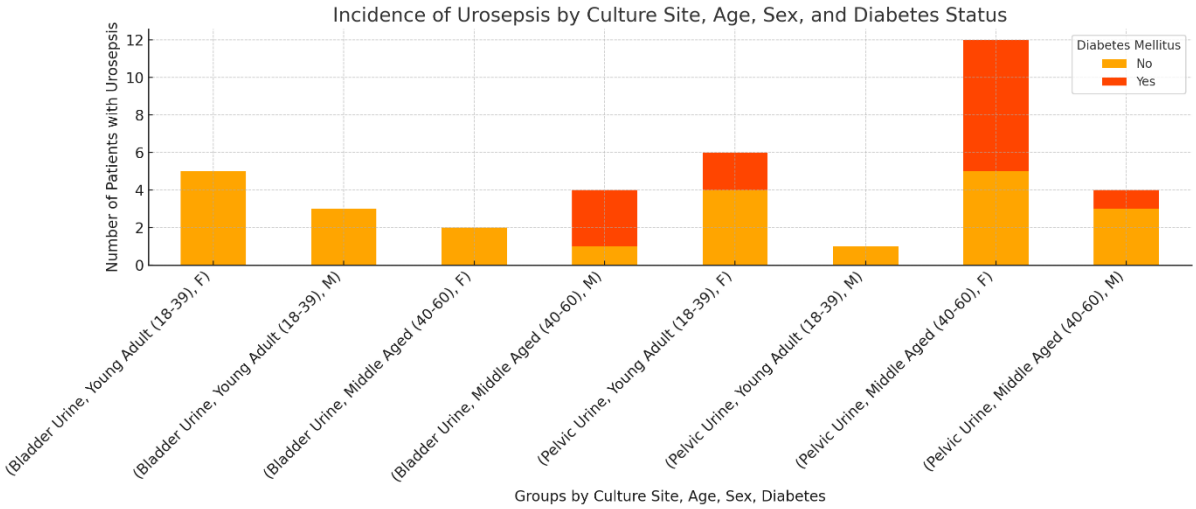

Figure 2 - Demonstrates the distribution of urosepsis incidence among post-percutaneous nephrolithotomy patients, categorized by culture site, age group, sex, and diabetic status. A notably higher incidence of urosepsis was observed in pelvic urine samples, particularly among middle-aged female patients with diabetes mellitus. This association highlights the increased vulnerability of this subgroup to infectious complications. The findings underscore the clinical importance

of early detection and aggressive management strategies in diabetic, middle-aged female patients following stone removal procedures.

5. DISCUSSION

In line with Mariappan et al[3], our study demonstrated that positive pelvic urine cultures significantly predicted urosepsis risk post-PCNL, whereas bladder urine cultures were less reliable. This reinforces the value of intraoperative pelvic urine sampling, particularly in high-risk groups, to enable early intervention and reduce infectious complications. Our study also supports Liu et al[4] meta-analysis, which concluded that intraoperative stone and pelvic urine cultures are superior predictors of postoperative SIRS and urosepsis compared to preoperative bladder urine cultures. The significantly higher sepsis rates from pelvic urine in our cohort reinforce the clinical value of intraoperative sampling.

Our study is consistent with the findings of Li et al[5], whose meta-analysis of 19 studies involving 4,829 patients revealed that stone culture positivity was significantly superior to preoperative midstream and pelvic urine cultures in predicting post-PCNL systemic inflammatory response syndrome (SIRS). Similarly, we found that pelvic urine cultures were more predictive of urosepsis than bladder urine cultures, particularly among middle-aged diabetic females, highlighting the essential role of intraoperative culture sampling in infection risk assessment and management.

Our study findings were similar to Devaraj et al[6], who demonstrated that stone culture and sensitivity are more reliable predictors of urosepsis than pelvic or midstream urine cultures. Similarly, Singh et al[7], a prospective analytical study, highlighted the superior predictive value of intraoperative renal stone cultures for post-PCNL urosepsis and SIRS over bladder urine cultures. The notably higher incidence of urosepsis from pelvic urine samples in our cohort reinforces the critical role of intraoperative culture sampling.

Teh et al[8], who emphasized that positive intraoperative cultures serve as significant predictors of post-PCNL sepsis. In line with their Northern Malaysian experience, we observed that pelvic urine cultures demonstrated a stronger association with the development of urosepsis compared to bladder urine cultures. Notably, middle-aged female patients with diabetes mellitus exhibited a higher risk of sepsis, underscoring the importance of targeted prophylactic strategies in this vulnerable subgroup.

The findings of Korets et al[9], who demonstrated that postoperative SIRS was significantly associated with positive stone and renal pelvic urine cultures. Like their observations, our results highlight that pelvic urine cultures are superior predictors of urosepsis compared to bladder urine cultures in post-PCNL patients.

Walton-Diaz et al[10], who demonstrated that renal stone cultures had superior predictive value for postoperative sepsis compared to preoperative midstream urine cultures. Similarly, we observed a significantly higher incidence of urosepsis associated with positive pelvic urine cultures, reinforcing the importance of intraoperative culture analysis in PCNL patients.

Sen et al[11], concluded that positive stone cultures significantly predict postoperative SIRS and urosepsis. This reinforces the critical role of intraoperative pelvic urine and stone cultures in early identification of high-risk patients, enabling timely intervention and improving postoperative outcomes following percutaneous nephrolithotomy.

Our study findings were parallel with Tang et al[12], who identified positive intraoperative cultures and patient comorbidities, especially diabetes mellitus, as significant predictors of systemic infection post-PCNL. The strong association between pelvic urine cultures and urosepsis in middle-aged diabetic females reinforces the necessity for tailored perioperative infection control strategies.

Mishra et al[13], who observed that positive stone cultures were significantly associated with higher postoperative infectious complications, which was similar to our study. The higher urosepsis rates linked to pelvic urine cultures, particularly among diabetic middle-aged females, reinforce the predictive value of intraoperative cultures in anticipating and managing post-PCNL infections.

6. CONCLUSION

Our study confirms that pelvic urine cultures are significantly more predictive of postoperative urosepsis than bladder urine cultures in patients undergoing PCNL, particularly among middle-aged female patients with diabetes mellitus. Routine intraoperative collection and analysis of pelvic urine samples can enable early identification of high-risk patients, allowing timely antimicrobial intervention and improving postoperative outcomes. These findings emphasize the critical role of targeted infection control strategies, especially in resource-limited rural healthcare settings, to reduce morbidity associated with urosepsis.

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