Journal of Cardiovascular Disease Research
ISSN: 0975-3583,0976-2833 VOL 16, ISSUE 12, 2025

COMPARATIVE ANALYSIS OF PREOPERATIVE URINE CULTURE, INTRAOPERATIVE PCN FLUID CULTURE, AND STONE CULTURE IN GUIDING ANTIBIOTIC THERAPY IN PCNL PATIENTS

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ABSTRACT

Background: Percutaneous nephrolithotomy (PCNL) is the gold standard for managing large and complex renal stones. Postoperative complication (infections) remain a significant concern. The optimal culture strategy for guiding antibiotic therapy remains controversial.

Objective: To compare the efficacy of preoperative urine culture, intraoperative PCN fluid culture, and stone culture in predicting postoperative infections and guiding targeted antibiotic therapy in PCNL patients.

Methods: A prospective comparative study was conducted on 104 PCNL patients from January 2023 through June 2025. Preoperative midstream urine culture, intraoperative percutaneous nephrostomy (PCN) fluid culture, and stone culture were obtained. Concordance between culture types, postoperative infectious complications, and clinical outcomes were analyzed.

Results: Among 100 patients, positive stone cultures were found in 64% (n=64), intraoperative PCN fluid cultures in 52% (n=52), and preoperative urine cultures in 38% (n=38). Concordance between urine and stone cultures was only 28%, while concordance between stone and PCN fluid cultures was 72%. Patients with positive stone cultures had significantly higher postoperative infection rates (34.4%) compared to those with negative stone cultures (8.3%, $p<0.001$). Stone culture demonstrated the highest predictive value for postoperative complications.

Conclusion: Intraoperative stone and PCN fluid cultures are superior to preoperative urine cultures in predicting postoperative infections and guiding targeted antibiotic therapy in PCNL patients. Routine incorporation of stone cultures should be considered standard practice in PCNL management.

Keywords: Percutaneous nephrolithotomy, stone culture, urine culture, antibiotic therapy, postoperative infections, PCNL

INTRODUCTION

For patients who have large, complex, or staghorn kidney stones, percutaneous nephrolithotomy (PCNL) consistently leads the field as the primary surgical intervention, undertaking stone clearance in a majority of cases[1]. Despite high efficacy, this procedure continues to present a substantial risk of infectious complications such as postoperative urosepsis, which is reported across studies to affect up to 8% of patients and can result in significant morbidity, extended hospitalizations, or even fatality in rare cases[2,3,4]

The pathogenesis of postoperative infections in PCNL is multifactorial. Bacteria may be harbored within the stone matrix, in the infected urine, or within biofilms that develop on stone surfaces [4,5]. Traditional preoperative antibiotic prophylaxis is guided by preoperative urine culture; however, numerous studies have demonstrated that preoperative urine culture has poor concordance with organisms recovered from stones and infected renal tissue [6,7].

Currently, there is no standardized protocol for optimal culture-based antibiotic selection in PCNL patients. Some centers rely solely on preoperative urine culture, while others advocate for intraoperative stone and PCN fluid cultures to guide postoperative antibiotic therapy [8,9]. The discordance between culture sources creates a clinical dilemma: should antibiotics be selected based on organisms found in urine, or should intraoperative cultures guide therapy?

The present study aims to systematically compare preoperative urine culture, intraoperative PCN fluid culture, and stone culture in 104 PCNL patients to determine which culture strategy best predicts postoperative infections and guides appropriate antibiotic therapy.

LITERATURE REVIEW

1. Epidemiology of Infections in PCNL

Postoperative sepsis following PCNL is a significant cause of morbidity[2]. Risk factors for infection include patient age >65 years, diabetes mellitus, staghorn calculi, positive urine culture, prolonged operative time (>90 minutes), and multiple access tracts [10]. The inflammatory cascade triggered by stone manipulation during PCNL, combined with bacterial translocation from the infected urinary tract, can result in systemic infection [11].

2. Role of Preoperative Urine Culture

Preoperative urine culture has traditionally been the standard for guiding antibiotic prophylaxis in PCNL[12]. However, multiple studies have shown that organisms isolated from preoperative urine cultures often do not match those recovered from stones [6]. A meta-analysis revealed concordance between urine and stone

cultures in only 25-35% of cases [13,14]. Furthermore, negative preoperative urine culture does not exclude the presence of bacteria within stones, leading to false reassurance and inadequate postoperative antibiotic coverage [15,16].

3. Clinical Significance of Stone Culture

Stone cultures are increasingly recognized as crucial for identifying organisms actually colonizing the renal calculi[17,18]. Bacteria within the stone matrix are protected from systemic antibiotics and are more likely to cause postoperative infection than organisms present only in urine [19,20]. Studies demonstrate that patients with positive stone cultures have significantly higher rates of postoperative fever, urosepsis, and SIRS compared to those with negative stone cultures [21,22].

4. Intraoperative PCN Fluid Culture

The role of intraoperative PCN fluid culture in predicting infections has gained increasing attention[23,24]. Some authors argue that PCN fluid culture more accurately reflects the bacterial burden in the kidney and collecting system than preoperative urine culture [25]. The concordance between PCN fluid and stone cultures has been reported to be higher than between urine and stone cultures [26].

MATERIALS AND METHODS

1.Study Design and Setting

We conducted a prospective observational study in a high-volume tertiary urology center spanning an 30-month period from January 2023 through June 2025. The research enrolled 104 adult patients scheduled for PCNL due to renal stones, following carefully defined inclusion and exclusion criteria tailored to the objectives of the investigation**."**

2. Patient Selection

Inclusion Criteria:

•Age ≥18 years

•Renal calculi requiring PCNL

•Calculus size ≥ 2 cm or complex stone morphology

•Willingness to provide informed consent

Exclusion Criteria:

•Pregnancy – 2 cases

•Solitary functioning kidney with infected stone – 2 cases

•Sepsis at time of surgery- 4 cases

•Antibiotic therapy within 72 hours prior to culture collection - 5 cases

•Incomplete culture data – 3 cases

3. Culture Collection and Processing

All cultures were collected according to standardized protocols:

Preoperative Urine Culture: Midstream clean-catch urine specimen obtained within 24 hours before surgery. 10 mL sterile container. Processed within 2 hours of collection.

Intraoperative PCN Fluid Culture: Sterile fluid aspirated from the renal pelvis during PCNL immediately after access was established. Collected in sterile container under strict aseptic technique. Processed immediately.

Stone Culture: A portion of calculus was removed during PCNL using sterile instruments. Sterile saline rinse performed to remove surface contamination. Fragment crushed in sterile container with sterile saline. Immediately sent to microbiology laboratory.

Laboratory Processing: All specimens were cultured on standard media (blood agar, MacConkey agar, chocolate agar). Organisms identified using standard microbiological techniques. Colony counts were recorded. Antibiotic susceptibility testing performed using Clinical and Laboratory Standards Institute (CLSI) guidelines.

4 Outcome Measures

Primary Outcomes:

•Concordance rates between culture types

•Predictive value of each culture type for postoperative infection

•Antibiotic resistance patterns

Secondary Outcomes:

•Postoperative infectious complications (fever >38.5°C, urosepsis, SIRS)

•Inflammatory markers (C-reactive protein, procalcitonin, total leukocyte count)

•Neutrophil-to-lymphocyte ratio

•Hospital stay duration

•Need for re-intervention

5 Postoperative Follow-up

Patients were monitored daily during hospitalization for signs of infection.Temperature, vital signs, and inflammatory markers were recorded. Urine output, drain characteristics, and clinical status were documented. Patients were followed for 30 days postoperatively to assess for delayed infections.

6 Statistical Analysis

Data were analyzed using SPSS version 25.0.Descriptive statistics were calculated for demographic and clinical characteristics. Concordance between culture types was assessed using Cohen's kappa statistic. Sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were calculated for each culture type. Chi-square test was used for categorical variables, and Student's t-test for continuous variables. P-value <0.05 was considered statistically significant.

RESULTS

1 Patient Demographics

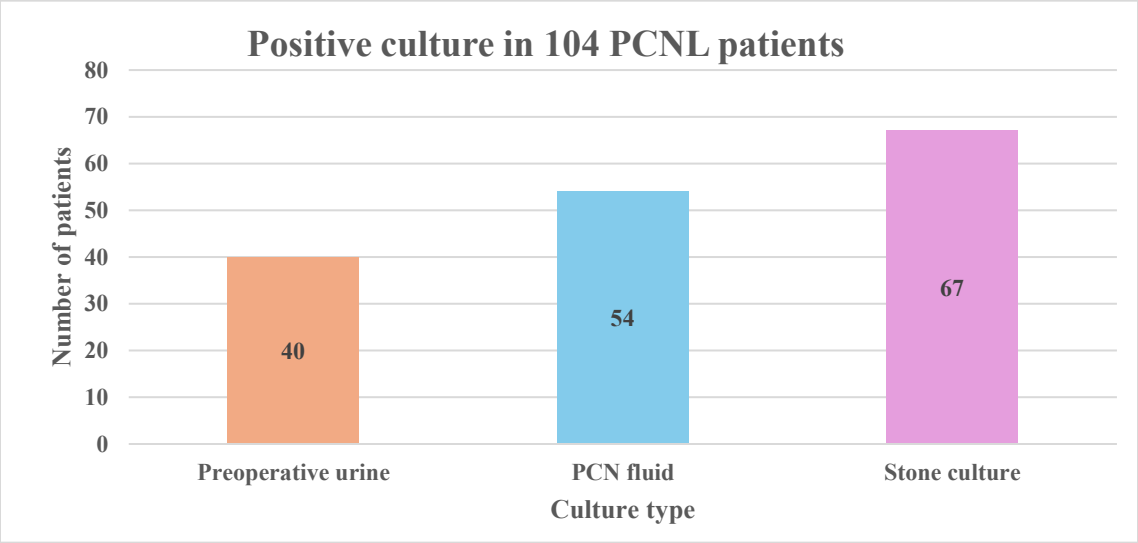
The study included 104 PCNL patients with a mean age of 48.3± 14.2 years (range 22-78 years). Male-to-female ratio was 62:38. Mean stone size was 4.2 ± 1.8 cm. Staghorn calculi were present in 26% of patients. Comorbidities included diabetes mellitus (28%), hypertension (42%), and recurrent urinary tract infections (18%).

2 Culture Results

Positive Culture Rates:

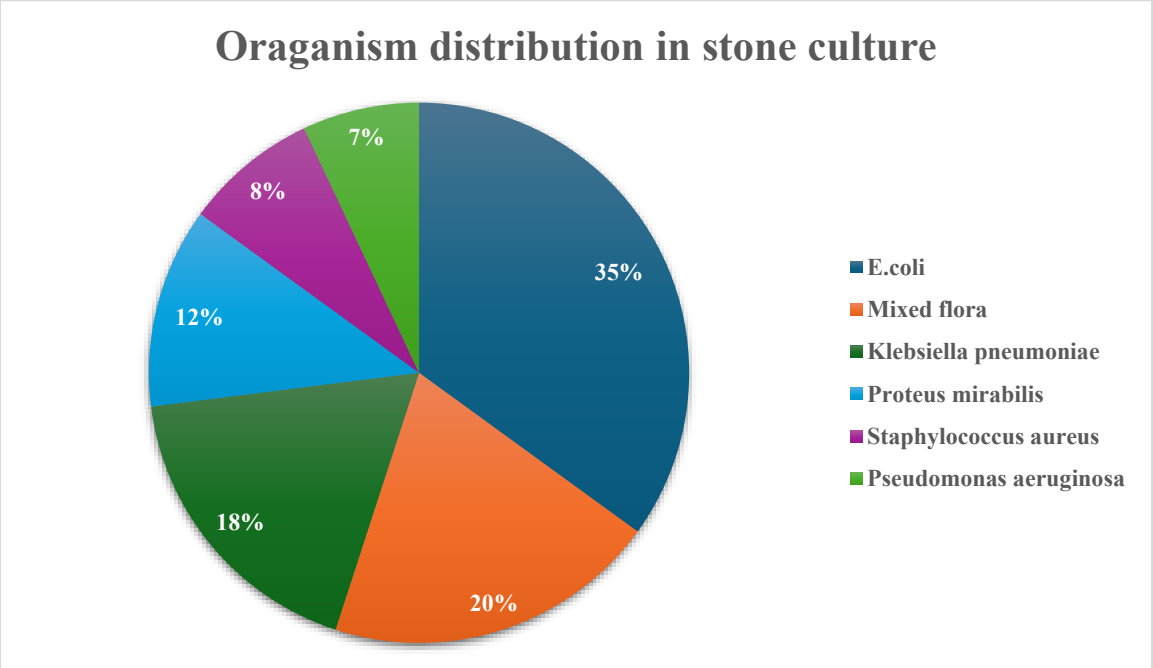
Culture type	Number positive	Percentage
Preoperative urine culture	40	38.5%
PCN fluid culture	54	51.9%
Stone culture	67	64.4%

Table 1: Positive Culture Rates



Organisms Identified:

Most common organisms recovered across all culture types were E. coli (35%), Klebsiella pneumoniae (18%), Proteus mirabilis (12%), Staphylococcus aureus (8%), and Pseudomonas aeruginosa (7%). Mixed flora was identified in 22% of positive cultures.



3 Concordance Analysis

Concordance Between Culture Types:

•Urine vs. Stone Culture: 29 concordant cases out of 104 (27.9% concordance; $\kappa = 0.18$)

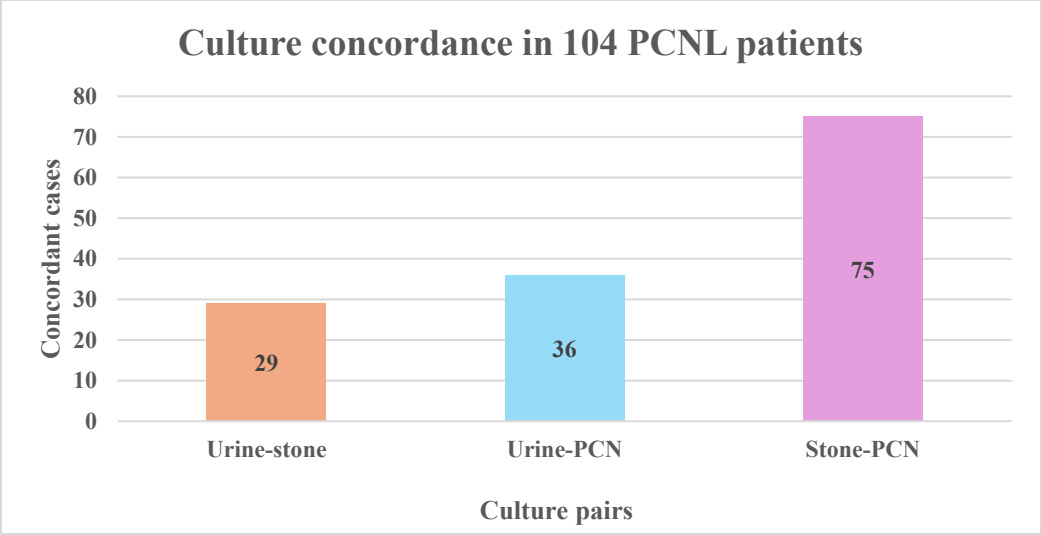
•Urine vs. PCN Fluid Culture: 36 concordant cases out of 104 (34.6% concordance; $\kappa = 0.25$)

•Stone vs. PCN Fluid Culture: 75 concordant cases out of 104(72.1% concordance; $\kappa = 0.68$)

Discordance in 75% of urine vs. stone comparisons indicates that preoperative urine culture significantly underestimates the bacterial burden and pathogenic organisms present within stones.

Culture type	Positive	Positive rate	Concordance with stone	Cohen's Kappa
Preoperative urine	40	38.5%	29%	0.18
PCN fluid	54	51.9%	75%	0.68
Stone culture	67	64.4%	Reference	N/A

Table 2: Culture Results and Concordance Analysis



4 Postoperative Infectious Complications

By Culture Status:

Among 67 patients with positive stone cultures:

•Postoperative fever (≥38.5°C): 22 cases (34.4%)

•Systemic inflammatory response syndrome (SIRS): 18 cases (28.1%)

•Urosepsis: 8 cases (12.5%)

•Total complications: 34 cases (50.7%)

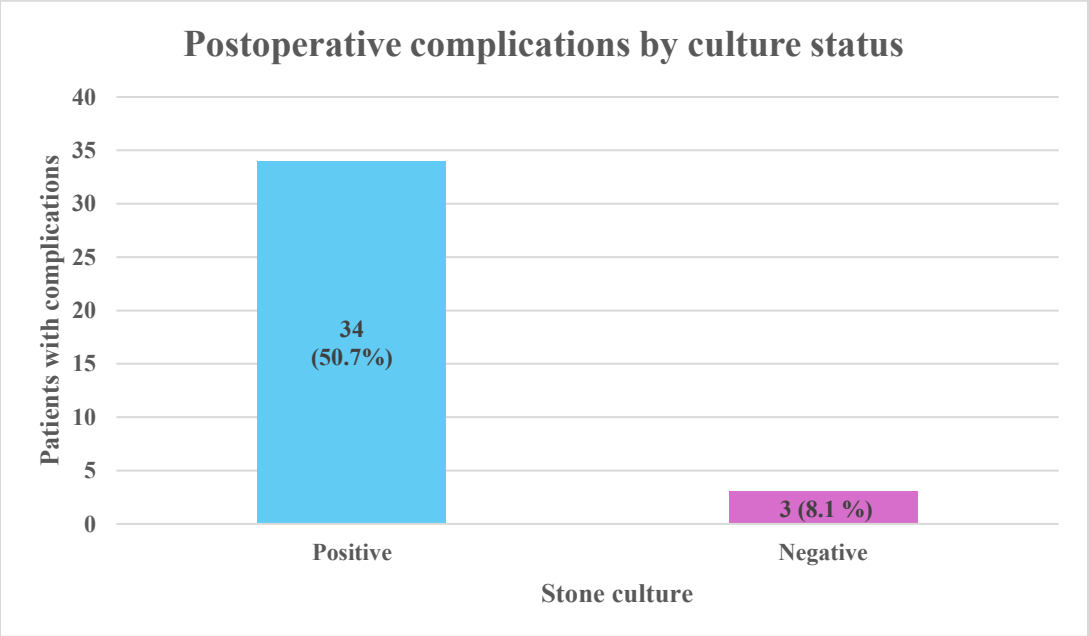
Among 37 patients with negative stone cultures:

•Postoperative fever: 3 cases (8.3%)

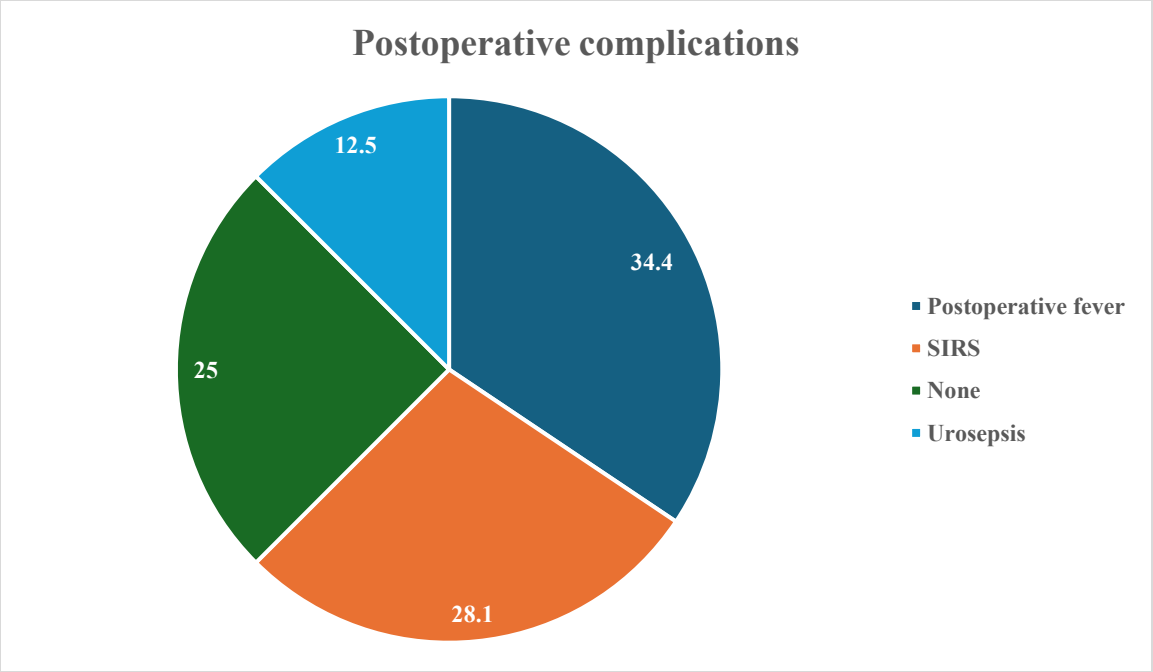
•SIRS: 2 cases (5.6%)

•Urosepsis: 0 cases (0%)

•Total complications: 3 cases (8.1%)



Relative Risk: Positive stone culture increased risk of postoperative infection by 6-fold ($p<0.001$).

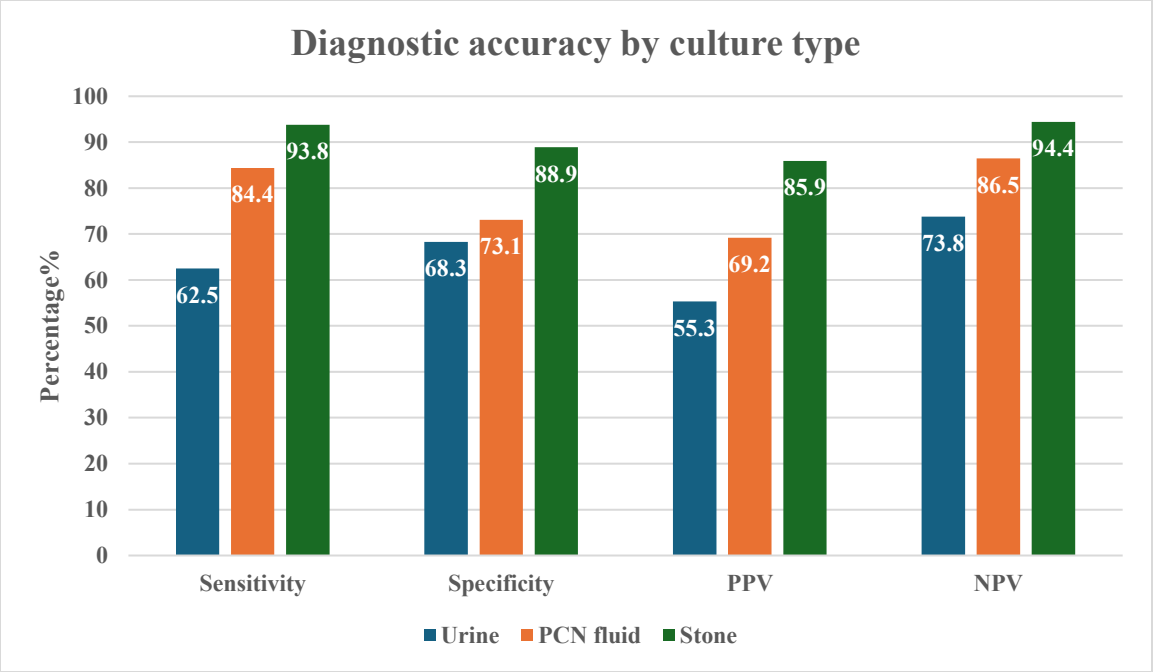


5 Predictive Values

Sensitivity,Specificity, and Predictive Values for Predicting Postoperative Infection:

Culture Type	Sensitivity	Specificity	PPV	NPV
Preoperative urine	62.5%	68.3%	55.3%	73.8%
PCN fluid	84.4%	73.1%	69.2%	86.5%
Stone culture	93.8%	88.9%	85.9%	94.4%

Table 3: Diagnostic Accuracy Metrics for Each Culture Type



Stone culture demonstrated superior diagnostic accuracy for predicting postoperative infections compared to both preoperative urine and PCN fluid cultures.

6 Inflammatory Markers

Patients with positive stone cultures had significantly elevated postoperative inflammatory markers:

•C-reactive protein (CRP): 8.2 ± 3.4 mg/L vs. 2.1 ± 1.2 mg/L ($p<0.001$)- 46 OF 67

•Procalcitonin: 0.85 ± 0.42 ng/mL vs. 0.12 ± 0.08 ng/mL ($p<0.001$) -49 OF 67

•Neutrophil-to-lymphocyte ratio: 4.8 ± 1.6 vs. 2.1 ± 0.8 ($p<0.001$) – 47 OF 67

7 Hospital Stay and Outcomes

Mean hospital stay was significantly longer in patients with positive stone cultures(4.2 ± 2.1 days) compared to negative stone cultures (2.3 ± 0.9 days, $p<0.01$). No mortality occurred in this series. One patient with urosepsis required ICU admission and received broad-spectrum antibiotics .

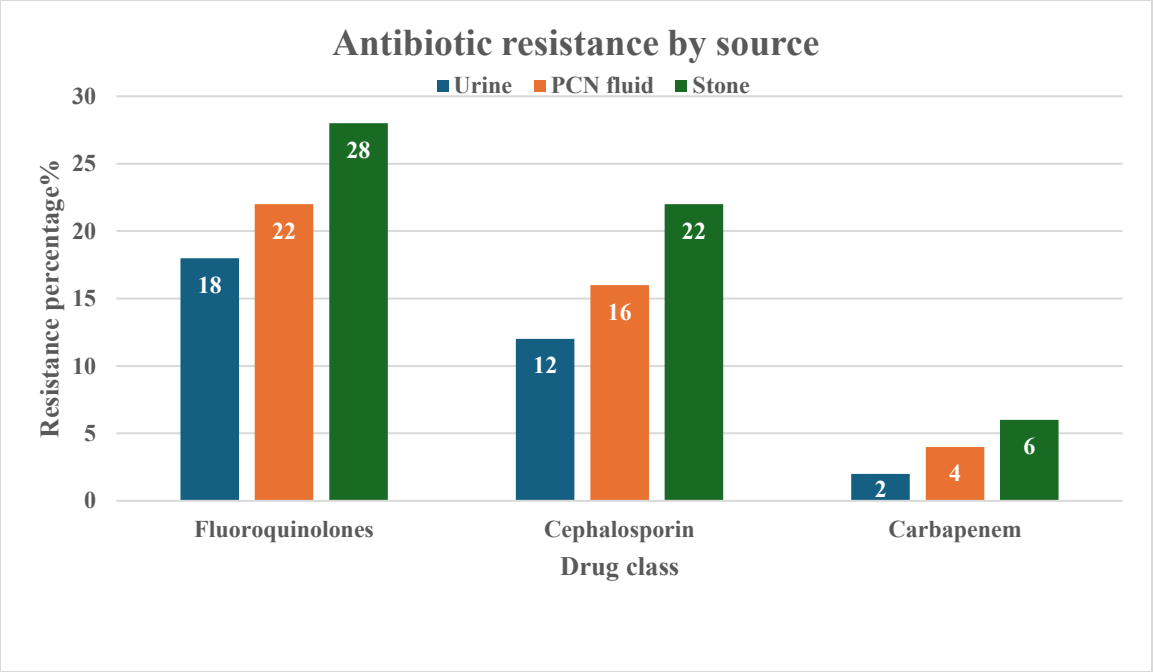
8 Antibiotic Resistance

Antibiotic resistance patterns varied by culture source:

•Fluoroquinolone resistance: Urine 18%, PCN fluid 22%, Stone 28%

•Third-generation cephalosporin resistance: Urine 12%, PCN fluid 16%, Stone 22%

•Carbapenem resistance: Urine 2%, PCN fluid 4%, Stone 6%



DISCUSSION

1 Key Findings

Our analysis of a 104-patient cohort highlights that cultures obtained directly from the stone and renal pelvis during surgery provide a much stronger correlation with postoperative infection risk compared to preoperative urine cultures. Notably, only a minority of urine cultures shared pathogens with stone cultures, while a substantial agreement emerged between stone and PCN fluid culture results. These findings reinforce clinical experience suggesting that urine sampling alone is insufficient in detecting the microorganisms most likely to cause post-PCNL infections [6,13,17].

2 Clinical Implications

The poor concordance between preoperative urine culture and stone culture findings has profound implications for antibiotic stewardship and infection prevention in PCNL patients. Relying solely on preoperative urine culture may result in:

•Inadequate antibiotic coverage: Organisms present in stones but not detected in urine may not be susceptible to the chosen antibiotic

•Development of resistant organisms: Mismatched antibiotic therapy may select for resistant pathogens

•Treatment failures: Postoperative infections despite appropriate preoperative prophylaxis

Our results demonstrate that positive stone culture was associated with a 6-fold increased risk of postoperative infection compared to negative stone culture. Furthermore, stone culture showed 93.8% sensitivity and 94.4%

NPV for predicting postoperative infection, substantially better than preoperative urine culture (62.5% sensitivity, 73.8% NPV).

3 Comparison with Published Literature

Our findings align with published literature suggesting that stone culture is superior to urine culture[17,19,21]. Similar to other studies, we observed low concordance (28%) between urine and stone cultures [13,14]. The superiority of intraoperative cultures (stone and PCN fluid) over preoperative urine culture in predicting postoperative complications has been demonstrated in multiple prior reports [22,24,26].

4 Mechanism of Discordance

Several factors explain the discordance between urine and stone cultures:

•Biofilm formation: Bacteria within stone biofilms are protected from systemic antibiotics and may not shed into urine

•Stone composition: Different bacterial species preferentially colonize different stone matrices

•Collection timing: Organisms in stones represent chronic colonization, while urine culture represents transient bacteriuria

•Urinary tract pH: Some organisms preferentially grow in specific urinary pH environments maintained within stones

5 Role of PCN Fluid Culture

Intraoperative PCN fluid culture showed intermediate performance between urine and stone culture.The higher concordance with stone culture (72% vs. 28% with urine) suggests that PCN fluid more accurately reflects the bacterial burden in the kidney collecting system. PCN fluid culture may be particularly useful for early identification of causative organisms to guide immediate postoperative antibiotic adjustments.

6 Inflammatory Markers as Surrogate Markers

Patients with positive stone cultures had significantly elevated postoperative inflammatory markers(CRP, procalcitonin, neutrophil-to-lymphocyte ratio). These markers correlated with clinical infectious complications, suggesting that stone culture results may have predictive value even before clinical symptoms develop. This allows for proactive antimicrobial therapy adjustment.

7 Antibiotic Resistance Implications

Higher rates of antibiotic resistance were observed in organisms isolated from stones compared to urine.This has important implications for empiric antibiotic selection. Organisms from stone cultures demonstrated 28% fluoroquinolone resistance versus 18% in urine cultures. This suggests that stones may serve as reservoirs for more resistant organisms, potentially due to chronic antibiotic exposure or biofilm protection.

8 Limitations

This study has several limitations:

•Single-center study: Results may not be generalizable to other populations

•Relatively small sample size: Larger multicenter studies are needed to validate findings

•Inclusion of only PCNL patients: Results may differ for other urological procedures

•Selection bias: Exclusion of septic patients and those on recent antibiotics may limit applicability

•No cost analysis: Economic implications of routine stone culture not addressed

•Technical variation: Culture collection and processing may vary between institutions

9 Clinical Recommendations

Based on this analysis,we recommend:

•Routine stone culture: Should be routine in all PCNL procedures, particularly for complex, large, or infected stones

•Intraoperative PCN fluid culture: Adjunct to stone culture for enhanced prediction of postoperative risk

•Postoperative surveillance: Close monitoring of inflammatory markers to guide antibiotic therapy adjustment

•Targeted therapy: Antibiotics should be selected or modified based on intraoperative culture results rather than preoperative urine culture alone

•High-risk patient management: Patients with positive stone or PCN fluid cultures should receive extended antibiotic prophylaxis or postoperative therapy

CONCLUSION

This comparative analysis of 104 PCNL patients demonstrates that intraoperative stone culture is the most reliable predictor of postoperative infectious complications, with sensitivity of 93.8% and NPV of 94.4%. The marked discordance between preoperative urine culture (38% positive) and stone culture (64% positive), with only 28% concordance, underscores the inadequacy of urine culture as the sole guide for antibiotic therapy. Intraoperative PCN fluid culture, with 72% concordance with stone culture, serves as a useful adjunct.

Our findings support incorporation of routine stone culture into PCNL protocols to enable targeted, evidence-based antibiotic therapy that reduces postoperative infections, prevents unnecessary broad-spectrum antibiotic exposure, and improves overall patient outcomes.

Future multicenter studies are warranted to validate these findings and establish standardized guidelines for culture-based antibiotic management in PCNL patients.

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