

Effectiveness of Intrapelvic Dioxidine Administration in Preventing Recurrence of Infection-Related Urolithiasis After Percutaneous Nephrolithotripsy

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Abstract: Background. Infection-related urolithiasis is associated with high recurrence rates due to persistent bacterial colonization and biofilm formation, which limit the effectiveness of standard systemic antimicrobial therapy. Additional local preventive strategies are required to improve postoperative outcomes. Objective. To evaluate the effectiveness of intrapelvic administration of dioxidine in reducing recurrence rates and improving microbiological eradication in patients with infection-related urolithiasis after percutaneous nephrolithotripsy (PCNL). Materials and Methods. A total of 268 patients with infection-related urolithiasis who underwent PCNL were included in this study. Patients were divided into two groups: a control group (n = 130) receiving standard prophylaxis and a main group (n = 138) receiving additional intrapelvic dioxidine instillation via a nephrostomy drain in the early postoperative period. Patients were followed for 24 months. Primary endpoints included recurrence rate and recurrence-free survival; secondary endpoints included microbiological eradication, bacteriuria, and antibiotic resistance. Statistical analysis was performed using appropriate comparative methods. Results. During the 24-month follow-up, recurrence was observed in 26.2% of patients in the control group and 11.6% in the main group ($p = 0.002$). The odds ratio for recurrence was 2.72 (95% CI: 1.45–5.10). The number needed to treat was 7. Microbiological eradication was achieved in 44.6% of control patients and 63.8% of main group patients ($p = 0.002$), with an odds ratio of 2.18 (95% CI: 1.33–3.57). The effect was sustained and associated with suppression of persistent infection. Conclusion. Intrapelvic administration of dioxidine significantly reduces recurrence of infection-related urolithiasis and improves microbiological outcomes, representing an effective adjunct to standard postoperative prophylaxis.

Keywords: Infection-related urolithiasis; percutaneous nephrolithotripsy; intrapelvic instillation; dioxidine; stone recurrence.

Introduction: Urolithiasis remains a common and clinically significant condition in modern urology, with a tendency toward recurrence and associated morbidity. Among its various forms, infection-related stones, particularly struvite calculi, represent a distinct subgroup characterized by rapid growth, high recurrence rates, and a strong association with urinary tract infections caused by urease-producing microorganisms [1,2]. The pathogenesis of infection stones is closely linked to persistent bacterial colonization, leading to urine alkalinization and precipitation of magnesium ammonium phosphate crystals. In addition, the formation of bacterial biofilms on the surface of stones and within the pelvicalyceal system contributes to chronic infection and reduces the effectiveness of systemic antibiotic therapy [3,4,5]. These mechanisms significantly complicate both treatment and prevention strategies.

Percutaneous nephrolithotripsy (PCNL) is considered the standard surgical approach for the management of large and complex renal stones, including infection-related calculi. However, despite advances in surgical techniques and perioperative care, postoperative infectious complications and stone recurrence remain important clinical challenges. According to current literature, residual fragments and persistent bacteriuria are key predictors of recurrence, even after apparently successful stone removal [6,7]. Standard prophylactic measures typically include systemic antibiotic therapy guided by microbiological findings and long-term metaphylaxis. Nevertheless, these approaches may be insufficient due to limited antibiotic penetration into biofilms and the increasing prevalence of antimicrobial resistance. Therefore, the development of additional local antimicrobial strategies aimed at directly targeting the site of infection is of considerable clinical interest [2,8,9].

In this context, intrapelvic administration of antimicrobial agents via a nephrostomy drain represents a promising approach, allowing high local drug concentrations and prolonged exposure within the collecting system. However, evidence regarding its clinical efficacy in preventing recurrence of infection-related stones remains limited.

The aim of the present study was to evaluate the effectiveness of local antimicrobial prophylaxis using intrapelvic dioxidine administration in reducing recurrence rates and improving microbiological outcomes in patients with infection-related urolithiasis after PCNL.

METHODS

The clinical phase of the study was conducted in the

Department of Urology at the Nasaf Medical Center (Karshi, Uzbekistan) and included 268 patients (active and former military personnel) diagnosed with infection-related urolithiasis who underwent percutaneous nephrolithotripsy (PCNL). Patient screening was performed based on the following criteria: confirmed infectious origin of urinary calculi, positive bacteriological culture of urine and/or stone material, and established indications for PCNL. The age of the patients ranged from 18 to 79 years, with a mean age of 48.7 ± 12.4 years and a median age of 49 years.

Following screening, all 268 patients were enrolled in the study and allocated into parallel groups. The control group comprised 130 patients who received standard prophylaxis, including systemic antibiotic therapy guided by antibiotic susceptibility testing (antibiogram) and conventional metaphylaxis. The main group consisted of 138 patients who, in addition to standard therapy, received intrapelvic administration of dioxidine via an indwelling nephrostomy drain in the early postoperative period.

In the main group ($n=138$), a novel method of local antimicrobial prophylaxis was applied in the early postoperative period. This technique involved intrapelvic instillation of a dioxidine solution through the previously placed nephrostomy drain. After completion of PCNL and stabilization of the patient's condition—provided there were no signs of ongoing bleeding or significant hematuria—instillation of a 0.1% dioxidine solution (10–20 mL) was performed via the nephrostomy drain on postoperative days 1–2. The solution was administered slowly, without excessive pressure, until moderate resistance was felt. The drain was then clamped for 20–30 minutes to ensure adequate exposure of the drug within the renal pelvis. The procedure was carried out once daily for three consecutive days. Prior to each instillation, aspiration of the pelvic contents was performed with assessment of the effluent characteristics. All administrations were conducted under strict aseptic conditions.

In the early postoperative period, the following clinical parameters were evaluated: hyperthermia, leukocytosis, bacteriuria, and the incidence of infectious complications. Subsequently, patients were followed up dynamically for 24 months. Follow-up assessments were conducted at 1, 3, 6, 12, 18, and 24 months after surgery. Study endpoints were categorized as primary and secondary. Primary endpoints included the recurrence rate of infection-related stones and recurrence-free survival. Secondary endpoints comprised the incidence of bacteriuria $\geq 10^4$ CFU/mL, growth of residual stone fragments, changes in microbial flora, and the development of antibiotic

resistance. The final stage of the study involved statistical analysis of the obtained data, including evaluation of intergroup differences and identification of risk factors for recurrence.

Statistical processing of the results was performed using Statistica for Windows, version 6.1 (StatSoft Inc., USA).

RESULTS

During the two-year follow-up period, recurrence of infection-related stones was observed in 34 patients in the control group, corresponding to 26.2%, whereas in the main group, which received intrapelvic dioxidine administration, recurrence was detected in 16 patients (11.6%). The difference between the groups was

statistically significant ($p=0.002$). The odds ratio (OR) for recurrence in the control group compared with the main group was 2.72 (95% confidence interval [CI]: 1.45–5.10), indicating more than a twofold increased risk of recurrent stone formation in the absence of local antimicrobial prophylaxis. The absolute risk reduction (ARR) associated with dioxidine use was 14.6%, while the relative risk reduction (RRR) was 55.7%. The number needed to treat was calculated to be 7, indicating that intrapelvic prophylaxis in seven patients is required to prevent one recurrence of infection-related urolithiasis. This finding underscores the high clinical relevance and practical effectiveness of the proposed method (Fig. 1).

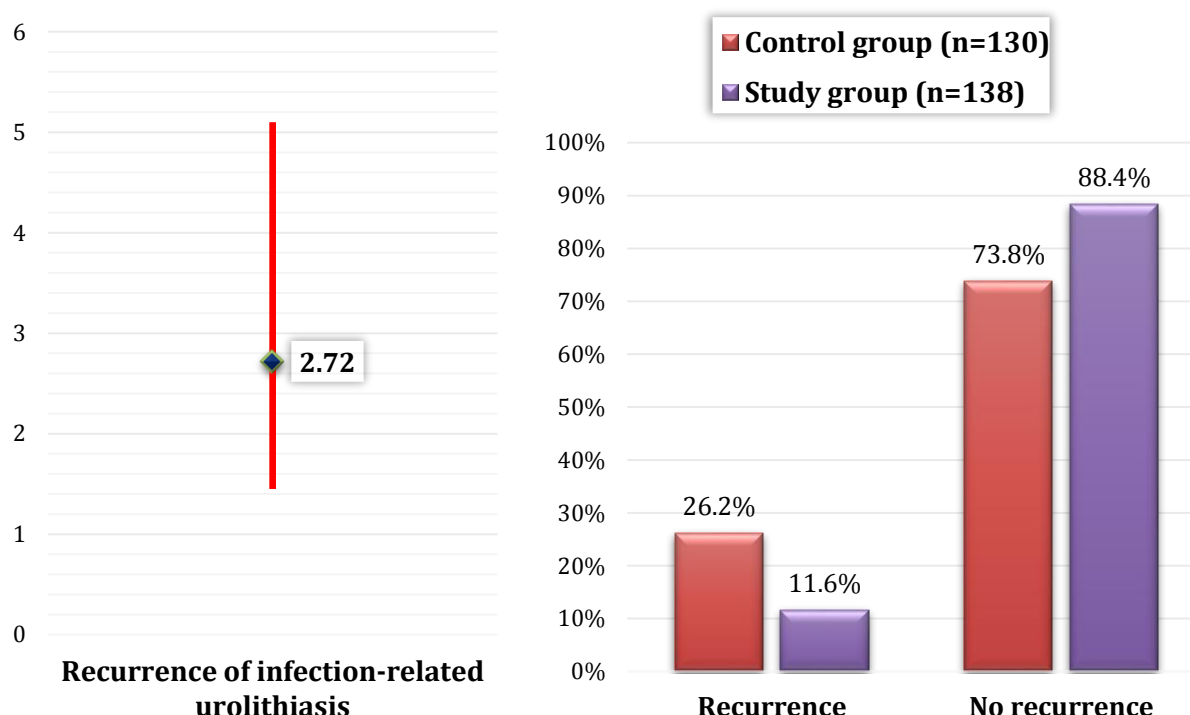


Figure 1. Odds ratio (OR; control group relative to the main group) for recurrence of infection-related stones in the early and intermediate postoperative periods.

The primary criterion of microbiological efficacy was the rate of complete eradication of microflora, defined

as the absence of growth of clinically significant microorganisms ($\geq 10^4$ CFU/mL) in two consecutive follow-up bacteriological cultures (Table 2).

Table 2.

Rate of Microflora Eradication During 6 Months of Follow-up.

Parameter	Control group (n=130)	Main group (n=138)	OR	95% CI	p
Microflora eradication	58 (44.6%)	88 (63.8%)	2.18	1.33–3.57	0.002
Microflora persistence	72 (55.4%)	50 (36.2%)			

Note: Eradication was defined as the absence of growth of clinically significant microflora ($\geq 10^4$ CFU/mL) in two consecutive follow-up cultures.

The odds ratio (OR) was calculated for the main group relative to the control group. Group comparisons were performed using the Pearson χ^2 test. Differences were considered statistically significant at $p < 0.05$.

During the six-month follow-up period, eradication was achieved in 44.6% of patients in the control group and in 63.8% of patients in the main group. The difference was statistically significant ($p=0.002$). The odds ratio

(OR) for achieving microbiological eradication in the main group compared with the control group was 2.18 (95% confidence interval [CI]: 1.33–3.57), indicating more than a twofold increase in the likelihood of eliminating persistent infection with the use of intrapelvic dioxidine administration. Importantly, the observed effect was sustained and not limited to a transient reduction in colony-forming unit (CFU) counts, but was accompanied by a stable absence of uropathogen growth in subsequent follow-up cultures. This finding suggests suppression of microbial persistence, likely associated with biofilm formation on the mucosal surface of the pelvicalyceal system and on residual stone microfragments.

DISCUSSION

The results of the present study demonstrate that intrapelvic administration of dioxidine in the early postoperative period after PCNL is associated with a significant reduction in recurrence of infection-related stones and improved microbiological outcomes. Over a 24-month follow-up period, the recurrence rate in the main group was significantly lower compared to the control group. The calculated odds ratio indicates that the absence of local antimicrobial prophylaxis more than doubles the risk of recurrent stone formation. In addition, the number needed to treat suggests a clinically meaningful benefit and supports the practical applicability of the proposed method.

The observed reduction in recurrence may be explained by the direct effect of dioxidine on residual microbial contamination within the pelvicalyceal system. Unlike systemic antibiotics, local administration allows higher concentrations of the antimicrobial agent at the site of infection, potentially overcoming the limitations associated with poor tissue penetration and biofilm resistance. This is particularly relevant in infection-related urolithiasis, where bacterial biofilms play a key role in disease persistence and recurrence.

The microbiological findings further support this mechanism. The rate of complete eradication of clinically significant microflora was significantly higher in the main group. Importantly, this effect was sustained over time and was not limited to a temporary reduction in bacterial load, indicating effective suppression of persistent infection. Such results suggest that intrapelvic dioxidine may disrupt biofilm-associated microbial communities and prevent recolonization. These findings are consistent with existing concepts regarding the importance of infection control in preventing stone recurrence. Previous studies have identified persistent bacteriuria and residual fragments as major risk factors for recurrence.

Therefore, strategies aimed at eliminating infection at the local level may provide additional benefit when combined with standard systemic therapy.

At the same time, several limitations of the study should be acknowledged. The study was conducted at a single center and included a specific patient population, which may limit generalizability. In addition, although the follow-up period of 24 months is sufficient to assess early and intermediate outcomes, longer observation may be required to evaluate long-term recurrence patterns. Further multicenter randomized studies are needed to confirm these findings and to compare different local antimicrobial agents and administration protocols. Despite these limitations, the results indicate that the proposed method is safe, feasible, and clinically effective. The use of intrapelvic antimicrobial prophylaxis may represent a valuable adjunct to standard postoperative management in patients with infection-related urolithiasis.

CONCLUSION

Intrapelvic administration of dioxidine in the early postoperative period after percutaneous nephrolithotripsy significantly reduces the risk of recurrence of infection-related urolithiasis and improves microbiological eradication rates, demonstrating its clinical effectiveness as a promising adjunct to standard prophylactic strategies.

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