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Impact of intraoperative furosemide and dexamethasone on complications following mini-percutaneous nephrolithotripsy: a retrospective propensity score-matched cohort study

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Abstract

Objective To evaluate the impact of intraoperative use of furosemide (FUR) in combination with dexamethasone (DEX) on postoperative complications following mini-percutaneous nephrolithotripsy (mini-PCNL).

Patients and methods The study was a retrospective cohort analysis of adult patients with kidney calculi treated with mini-PCNL. Exposure was the intravenous administration of FUR and DEX during mini-PCNL. The primary outcome was postoperative fever (≥ 38°C), whereas the secondary outcomes were other complications. Propensity score matching (PSM) was performed at a 1:1 ratio. Subgroup analyses and interaction tests were used to examine differences among different demographic groups.

Results The pre-matched and propensity score-matched cohorts included 237 and 166 patients, respectively. In the PSM cohort, postoperative fever (≥ 38°C) occurred in 8.4% (7/83) of the FUR + DEX group and 20.5% (17/83) of the control group. The combined use of FUR and DEX was associated with a lower postoperative fever ($P = 0.027$). There was no statistically significant difference between the FUR + DEX group and the control group for other complications, including SIRS, urosepsis, and pain-requiring opioids. SIRS occurred in 4.8% (4/83) of the FUR + DEX group versus 8.4% (7/83) in the control group, while urosepsis rates were 2.4% (2/83) versus 3.6% (3/83), respectively. Subgroup analysis showed a significant reduction in postoperative fever in patients with an operation time of ≥ 2 h in the FUR + DEX group, as indicated by the interaction test ($P = 0.05$).

Conclusion The intravenous combined use of FUR and DEX in mini-PCNL reduces postoperative fever (≥ 38°C), particularly benefiting patients with an operative time of ≥ 2 h.

Keywords Kidney calculi, Percutaneous nephrolithotripsy, Furosemide, Dexamethasone, Complications

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Introduction

Kidney calculi are a common urinary system disorder with an increasing incidence rate. The prevalence of kidney calculi in Chinese adults is 6.4% [1], while in the United States it is 10.1% [2]. Kidney calculi have a high risk of recurrence, with a recurrence rate of 50% within 10 years [3]. Percutaneous nephrolithotripsy (PCNL) is the first-line treatment for large and complex kidney calculi. However, some complications may occur following PCNL, including fever, bleeding, systemic inflammatory response syndrome (SIRS), urosepsis, irrigation fluid absorption, renal injury, stone retention, injury to adjacent organs, and rarely death [4, 5]. Compared to standard PCNL, mini-PCNL reduces intraoperative bleeding and trauma; however, it may also increase the risk of postoperative infections due to its smaller working channel, which can elevate renal pelvis pressure [6]. This heightened pressure may result in pyelovenous backflow, allowing urine containing bacteria or endotoxins to flow retrograde from the renal collecting system into the bloodstream [7].

Furosemide (FUR) and dexamethasone (DEX) are frequently used in procedures to reduce perioperative complications [8–11]. FUR, a loop diuretic that inhibits the Na^+-K^+– $2Cl^-$ cotransporter, primarily aids in volume control by increasing urine production during surgery. DEX, a synthetic corticosteroid, is used to prevent surgical nausea and vomiting, reduce inflammatory reactions, control postoperative pain and quicken recovery [12, 13]. A recent study showed that using FUR in PCNL may reduce bacterial and endotoxin uptake, and combining DEX and FUR may reduce postoperative inflammatory response and shorten postoperative hospital stay [14]. Nevertheless, there is a lack of high-quality studies in the English literature assessing the efficacy and safety of intravenous FUR and/or DEX during PCNL to prevent surgical complications. Therefore, further research on the association between intraoperative combined furosemide and dexamethasone administration and postoperative complications is needed to explore novel strategies to reduce postoperative complications of PCNL.

Methods

Study population

A total of 237 patients with kidney calculi treated with mini-PCNL in the Department of Urology of the Lanzhou University Second Hospital between January 2022 and January 2024 were included. Patients either received both FUR and DEX during the surgery or did not receive either medication. Patients who fit any of the following criteria were excluded: (1) under the age of 18; (2) underwent other surgical treatments concurrently with mini-PCNL; (3) had congenital kidney anomalies such as horseshoe kidneys; (4) had malignant tumors; (5) had incomplete or inaccessible significant medical records; or (6) received only FUR or DEX. Following propensity score matching, 166 patients underwent statistical analysis. The Ethics Committee of Lanzhou University Second Hospital waived informed consent and approved the study.

Exposure and outcomes

The exposure involved the intravenous administration of FUR and DEX during mini-PCNL, typically administered around the midpoint of the procedure. These drugs were given as a single intravenous injection. The anesthesiologist and surgeon assessed the potential risk of postoperative complications based on the size of the stone and the duration of the surgery to determine the necessity and dosage of the medications. To ensure comparability between the FUR + DEX group and the control group, we utilized propensity score matching (PSM) to eliminate differences in risk factors such as stone size and operative time that could potentially affect postoperative complications. After PSM, in the FUR + DEX group, 29 patients (34.9%) received 5 mg of DEX and 10 mg of FUR, while 54 patients (65.1%) were administered 10 mg of DEX and 20 mg of FUR. The primary outcome included postoperative fever (≥ 38 °C). Secondary outcomes were SIRS, urosepsis, postoperative pain requiring opioids, blood transfusion, renal artery embolization, Clavien-Dindo score, and postoperative hospital stay.

Data collection

Preoperative, intraoperative, and postoperative clinical data were collected from the hospital information system of Lanzhou University Second Hospital. Preoperative data included imaging and laboratory results as well as baseline characteristics such as age, gender, and comorbidities. Urological CT scans and ultrasound imaging results were evaluated to determine the location, size, and presence of staghorn stones. Laboratory tests related to infection, including white blood cell count, urinalysis, and urine culture, were also collected. Intraoperative data included the surgical procedure and duration. Postoperative data mainly involved vital signs, nursing records, treatment records, postoperative laboratory and imaging results, and postoperative hospital stays. Postoperative complications such as fever, SIRS, urosepsis, blood transfusion, renal artery embolization, and pain requiring opioids were assessed. SIRS was defined by meeting any two of the following criteria: heart rate > 90/min; respiratory rate > 20/min or PaCO2 < 32 mmHg; temperature < 36 °C or > 38 °C; white blood cell count (WBC) > 12,000/

mm^3 or $< 4{,}000/mm^3$ [15]. The Clavien-Dindo classification system [16] was used to grade postoperative complications.

Intervention and surgical technique

All patients received prophylactic antibiotics 30 min before surgery, primarily quinolones or other antibiotics sensitive according to antibiogram findings. Patients with preoperative infections or positive urine cultures were treated with broad-spectrum or antibiotics based on sensitivity results for 3 to 7 days. Mini-PCNL was only performed after urine cultures were negative or when the infection was confirmed to be controlled based on a comprehensive assessment of indicators such as white blood cell count, urine leukocytes, procalcitonin (PCT), interleukin- 6 (IL- 6), and C-reactive protein (CRP) levels. For patients whose urine cultures remained non-sterile or whose laboratory indicators still suggested uncontrolled infection despite appropriate antibiotic treatment, percutaneous nephrostomy or ureteral stent placement was performed first, with mini-PCNL deferred until infection control was achieved.

All patients underwent mini-PCNL. The procedures were performed by four expert surgeons in the field of urolithiasis, each with over 10 years of experience. Under general anesthesia, the patients were initially positioned in the lithotomy position, and an open-ended 5 F ureteral catheter was inserted into the renal pelvis under direct vision. The patients were then repositioned to the prone position. In the absence of hydronephrosis, physiological saline was infused through the ureteral catheter to distend the renal pelvis system. Under continuous ultrasound guidance, an 18-gauge coaxial puncture needle was used to puncture the selected renal calyx papilla. If the irrigation fluid flowed freely from the needle hub after removing the stylet, the placement was considered successful. A 0.035"flexible-tip guidewire was inserted into the collecting system through the needle sheath. Sequential dilation was performed using fascial dilators, expanding to a size range of 14 - 20 F, depending on the case. A 12 F rigid nephroscope (KARL STORZ, Germany) was utilized via single-tract access. Stone fragmentation was achieved using Ho:YAG laser systems (Lumenis Pulse 120H/Lumenis MOSES 2.0 Laser, Israel; Raykeen SRM-H3B/Dahua DHL- 1-D, China) with energy settings of 0.8–2.0 J and a frequency of 15–35 Hz, delivered through 550-μm laser fibers. Automated saline irrigation was maintained at 200–400 mL/min to facilitate fragment clearance. Residual fragments resistant to irrigation were retrieved using stone-extraction baskets. In all cases, a 5 Fr ureteral stent and a nephrostomy tube were placed. Ureteral stents were routinely maintained for 2–4 weeks, while nephrostomy tubes were removed 1 day postoperatively unless extended retention was required due to severe hemorrhage or active infection.

Statistical analysis

Statistical analyses were performed using IBM SPSS Statistics for Windows, version 27.0 (IBM Corp., Armonk, N.Y., USA). A p-value of < 0.05 was considered statistically significant. Normality was tested using the Shapiro–Wilk test. Categorical variables were expressed as numbers and percentages and compared using the chi-squared test, or Fisher's exact test. Continuous variables were reported as medians (interquartile range [IQR]) and compared using the Mann–Whitney U test. PSM was used to adjust for intergroup variables. A logistic regression model was used to calculate the propensity score for each patient receiving FUR and DEX treatment, adjusting for potential confounding variables. Variables in the propensity score model included the maximum stone diameter, presence of staghorn stones, and operation time ≥ 2 h. Matching was performed in a 1:1 ratio using a caliper value of 0.02 to optimize balance between the groups. The balance of variables between groups before and after matching was assessed by comparing statistical significance. Subgroup analyses in the matched cohort were based on age (< 60 vs. ≥ 60 years), gender, urine culture status (positive vs. negative), and operative time ($\geq$ 2 vs. < 2 h). For subgroup analysis, a logistic regression model was used to generate odds ratios (OR) and 95% confidence intervals (CI) for the primary outcome of postoperative fever ($\geq$ 38 °C) [17]. Interaction tests were performed between subgroups [18].

Results

A total of 237 patients were included in the cohort, with 98 (41.4%) receiving intravenous FUR and DEX in mini-PCNL, while 139 did not receive either drug. The matched cohort consisted of 166 patients, with 83 in each group. Table 1 shows the clinical characteristics before and after propensity score matching. Both the Charlson comorbidity index and Guy's stone score showed no statistically significant differences between groups either before or after matching. In the entire cohort, 15.3% (15/98) of the FUR + DEX group had staghorn stones, 73.4% (72/98) had operation time ≥ 2 h, and the median [IQR] maximum stone diameter was 22 [16, 27.75] mm. In contrast, 3.6% (5/139) of the control group had staghorn stones, 52.5% (73/139) had an operation time of ≥ 2 h, and the median [IQR] maximum stone diameter was 20 [15, 25] mm. Compared to the control group, the FUR + DEX group had a substantially greater proportion of staghorn stones ($P = 0.001$) and operation time of ≥ 2 h ($P = 0.001$), indicating more complicated stones and

Table 1 Clinical characteristics before and after propensity score matching

Variables	Before propensity score matching			After propensity score matching		
	FUR + DEX ($n = 98$)	Control($n = 139$)	*P* value	FUR + DEX ($n = 83$)	Control ($n = 83$)	*P* value
Age (years)	49 [35–57]	50 [43–56]	0.171	48[34–57]	50 [44–57]	0.099
Gender (Female)	22 (22.4%)	40 (28.7%)	0.275	18 (21.6%)	23 (27.7%)	0.368
BMI (kg/m^2)	24.22 [21.34–26.87]	24.68 [21.38–26.82]	0.406	24.21 [21.25–26.76]	24.69 [22.06–26.44]	0.420
Hypertension	19 (19.39%)	31 (22.30%)	0.588	17 (20.4%)	17 (20.4%)	1.000
Diabetes	9 (9.1%)	13 (9.3%)	0.965	7 (8.43%)	8 (9.64%)	0.787
Charlson Comorbidity Index			0.413			0.327
0	77 (78.6%)	115 (82.7%)		64 (77.1%)	69 (83.1%)	
1	18 (18.4%)	21 (15.1%)		16 (19.3%)	12 (14.5%)	
≥ 2	3 (3.1%)	3 (2.2%)		3 (3.6%)	2 (2.4%)	
Stone location (right)	38 (38.7%)	57 (41%)	0.730	34 (40.9%)	30 (36.1%)	0.524
History of stones	44 (44.90%)	68 (48.92%)	0.541	52 (62.6%)	54 (65.0%)	0.747
Maximum diameter of stone (mm)	22 [16–27.75]	20 [15–25]	0.071	22 [16–24]	20 [17–23]	0.307
Staghorn stone	15 (15.3%)	5 (3.6%)	**0.001**	4 (4.8%)	4 (4.8%)	1.000
Guy's stone score			0.571			0.206
Grade I	17 (17.3%)	22 (15.8%)		17 (20.5%)	13 (15.7%)	
Grade II	43 (43.9%)	64 (46.0%)		41 (49.4%)	37 (44.6%)	
Grade III	23 (23.5%)	48 (34.5%)		21 (25.3%)	29 (34.9%)	
Grade IV	15 (15.3%)	5 (3.6%)		4 (4.8%)	4 (4.8%)	
Urine culture	23 (23.4%)	33 (23.7%)	0.961	21 (25.3%)	22 (26.5%)	0.859
Urinary white cell count (/uL)	50 [12–169.25]	34 [10–120]	0.101	42 [9.75–151.25]	33 [10–112]	0.412
WBC count (× 10^9/L)	6.4 [5.5–7.57]	6.32 [5.23–7.32]	0.321	6.4 [5.5–7.57]	6.32 [5.23–7.32]	0.846
Haemoglobin (g/L)	148.5 [133.75–159.25]	153 [138–161]	0.201	148 [134–159.25]	155 [139–161]	0.211
Urea nitrogen (mmol/L)	5.55 [4.6–6.8]	5.3 [4.45–6.55]	0.193	5.6 [4.7–5.85]	5.5 [4.6–6.5]	0.814
Serum creatinine (μmol/L)	71.1 [61.9–79.93]	70.2 [60.1–79]	0.758	71.3 [61.75–79.93]	70.6 [61.3–80.4]	0.930
Operation time ≥ 2 h	72 (73.4%)	73 (52.5%)	**0.001**	59 (71.0%)	62 (74.6%)	0.600

Data are presented as median [IQR] or n (%)

FUR furosemide, *DEX* dexamethasone, *BMI* body mass index, *IQR* interquartile range, *WBC* white blood cell

more difficult surgeries. Matching improved the balance of variables, and the differences between groups were no longer statistically significant.

Table 2 describes the postoperative outcomes and complications in the matched cohort. Figure 1 displays the maximum postoperative temperatures of matched

Table 2 Outcomes and complications after propensity score matching

Variables	FUR + DEX ($n = 83$)	Control ($n = 83$)	*P* value
Post-operative complication	30 (36.1%)	37 (44.5%)	0.268
Clavien-Dindo score ≥ 3	3 (3.6%)	4 (4.8%)	1.000
Clavien-Dindo score < 3	27 (32.5%)	33 (39.8%)	0.332
T ≥ 38 °C	7 (8.4%)	17 (20.5%)	**0.027**
SIRS	4 (4.8%)	7 (8.4%)	0.349
Urosepsis	2 (2.4%)	3 (3.6%)	1.000
Pain requiring opioids	22 (26.5%)	24 (28.9%)	0.729
Blood transfusion	1 (1.2%)	1 (1.2%)	1.000
Renal arterial embolization	1 (1.2%)	1 (1.2%)	1.000
Postoperative hospital stays (days)	6 [5–7]	6 [4–6.25]	0.251

Data are presented as median [IQR] or n (%)

FUR furosemide, *DEX* dexamethasone, *SIRS* systemic inflammatory response syndrome

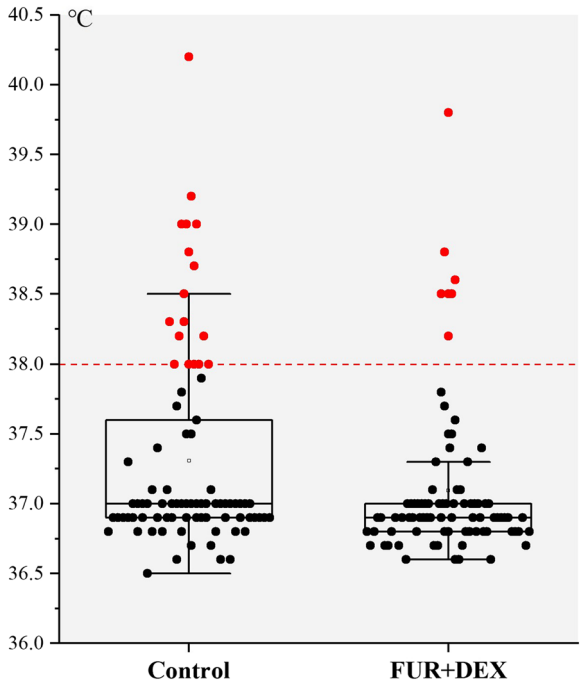

Fig. 1 The maximum postoperative temperatures of matched patients

patients. In the matched cohort, 8.4% (7/83) of the FUR + DEX group experienced postoperative fever ≥ 38 °C compared to 20.5% (17/83) of the control group. The incidence of postoperative fever was significantly higher in the control group ($P = 0.027$), suggesting that intravenous FUR and DEX in mini-PCNL may reduce postoperative fever. In the FUR + DEX group, 36.1% (30/83) experienced any postoperative complications. Among them, 3.6% (3/83) had Clavien-Dindo scores ≥ 3 and 32.5% (27/83) had Clavien-Dindo scores < 3. In the control group, 44.5% (37/83) suffered postoperative complications, with 4.8% (4/83) having Clavien-Dindo scores ≥ 3 and 39.8% (33/83) having Clavien-Dindo scores < 3. Although the complication rate was lower in the FUR + DEX group, the difference between the groups was not statistically significant. In addition, there was no statistical difference between the FUR + DEX group and the control group for other complications except fever. For infection-related complications, the rates of SIRS and urosepsis in the FUR + DEX group were 4.8% (4/83) and 2.4% (2/83), respectively, compared to 8.4% (7/83) and 3.6% (3/83) in the control group. For pain requiring opioids, the rates were 26.5% (22/83) and 28.9% (24/83) for the FUR + DEX and control groups, respectively. One patient in each group required a blood transfusion and one patient required renal artery embolization. The median [IQR] postoperative hospital stay was 6 [5, 7] days for the FUR + DEX group and 6 [4,6.25] days for the control group, with no significant difference between groups.

Subgroup analysis of the primary outcome (fever ≥ 38 °C) is shown in Table 3. There was a statistical difference in postoperative fever between the FUR + DEX and control groups in the subgroup with operation time ≥ 2 h, but not in the subgroup with operation time < 2 h. The interaction test for operation time was statistically significant, but the p-value was only 0.05. This suggests that

Table 3 Subgroup analysis of patients with postoperative fever ≥ 38 °C

Subgroups	FUR + DEX	Control	OR (95% CI)	*P* value	*P* value of the interaction
	T ≥ 38 °C/Total	T ≥ 38 °C/Total			
All patients	7/83 (8.4%)	17/83 (20.5%)	0.358 (0.140–0.915)	**0.027**	
Age					0.433
< 60 yr	5/68 (7.34%)	14/66 (21.2%)	0.295 (0.100–0.873)	**0.027**	
≥ 60 yr	2/15 (13.3%)	3/17 (17.6%)	0.269 (0.103–5.006)	0.738	
Sex					0.320
Female	4/18 (22.2%)	7/23 (30.4%)	0.653 (0.157–2.709)	0.557	
Male	3/65 (4.6%)	10/60 (16.7%)	0.242 (0.063–0.927)	**0.038**	
Urine culture					0.064
Positive	6/21 (28.6%)	7/22 (31.8%)	0.857 (0.233–3.159)	0.817	
Negative	1/62 (1.6%)	10/61 (16.4%)	0.084 (0.010–0.675)	**0.020**	
Operation time					**0.050**
≥ 2 h	4/59 (6.8%)	16/62 (25.8%)	0.209 (0.065–0.669)	**0.008**	
< 2 h	3/24 (12.5%)	1/21 (4.8%)	2.857 (0.274–29.796)	0.380	

FUR furosemide, *DEX* dexamethasone, *OR* odds ratio, *CI* confidence interval

the impact of intravenous FUR + DEX in mini-PCNL on postoperative fever may depend on operation time. There were no significant differences in postoperative fever between the FUR + DEX and control groups in patients aged ≥60 years, females, or those with positive urine cultures. However, the interaction tests for age, gender, and urine culture were not statistically significant, implying that the impact of intravenous FUR + DEX in mini-PCNL on postoperative fever may not differ across these characteristics. Further research with larger sample numbers is required to reach more robust conclusions.

Discussion

Fever is one of the major complications after PCNL. A recent meta-analysis reported that postoperative fever and sepsis occur in 9.5% and 4.5% of PCNL patients, respectively [19]. In individuals with urolithiasis, bacteria are often found within the stones as well as in the urine, and colonized bacteria and endotoxins are released during stone fragmentation [20, 21]. Additionally, the use of large volumes of irrigation fluid in PCNL to maintain a clear field can cause increased intrarenal pressure, pyelovenous reflux, and varying degrees of fluid absorption, resulting in bacteria and endotoxins entering the circulation through damaged renal mucosa, ultimately leading to postoperative fever and infection [5, 22, 23]. However, antibiotic prophylaxis cannot completely eliminate the risk of infection associated with PCNL. Despite antibiotic prophylaxis, postoperative fever still occurs in 8.8% of patients with sterile preoperative urine cultures and 18.2% of patients with positive preoperative urine cultures [24]. Additional preventive measures to further reduce the incidence of fever and other infectious complications should be considered.

Our findings suggest that intravenous FUR and DEX during mini-PCNL can reduce postoperative fever (≥ 38 °C), although the exact mechanism remains unclear. As a glucocorticoid, DEX usually has immunosuppressive and anti-inflammatory effects, which may account for its function in lowering postoperative fever [25, 26]. DEX has a plasma half-life of 100 to 300 min and a biological half-life of 36 to 72 h [13]. DEX affects the body in a multitude of ways. It works by decreasing capillary membrane permeability, enhancing lysosomal membrane stability, increasing serum prostaglandin levels, and inhibiting several cytokines (interleukin- 1, interleukin-12, interleukin- 18, tumor necrosis factor, gamma interferon, and granulocyte–macrophage colony-stimulating factor) [27–32].

It is unclear whether FUR is also involved in reducing postoperative fever. As a loop diuretic, FUR does not directly inhibit inflammatory responses or fever. However, some researchers suggest that its diuretic effect can reduce the absorption of endotoxins and bacteria in PCNL, and the perioperative combined use of DEX and FUR can alleviate postoperative inflammatory responses and shorten postoperative hospital stays [14]. Moreover, FUR affects the glomerular filtration rate, the renin-angiotensin system, and the renal sympathetic nervous system, but the mechanisms involved are not fully understood [33]. Holstein-Rathlou and Leyssac found that administering furosemide intraluminally caused an acute increase in tubular pressure of approximately 5–7 mmHg, which is relevant to an estimated net ultrafiltration pressure of 20–25 mmHg [34]. Oppermann et al. reported a very strong increase in free flow proximal tubular pressure upon systemic administration of FUR, which was attenuated by decapsulation [35]. However, relevant mechanistic studies are lacking regarding whether FUR-induced diuresis, increased tubular pressure, or changes in glomerular filtration rate and renal blood flow can inhibit bacterial and endotoxin absorption in PCNL.

We conducted a subgroup analysis to examine the differences in the contribution of intraoperative FUR + DEX use in reducing postoperative fever after mini-PCNL in different demographic groups. The interaction analysis indicated that the duration of surgery may influence the efficacy of FUR + DEX in reducing fever, while there were no significant interactions between age, sex, and urine culture with respect to efficacy. The use of FUR + DEX significantly reduced postoperative fever in patients with surgical durations of 2 h or more, while it did not have a significant effect in those with surgical durations of less than 2 h. Prolonged PCNL surgery duration (more than 60 min [36], 90 min [37], or 100 min [38]) is associated with an increased risk of postoperative fever. Therefore, intravenous FUR + DEX in mini-PCNL may be more appropriate for patients with longer operative times, which is consistent with empirical clinical practice. It should be noted that the p-value for the interaction test regarding operation time was only 0.05, indicating limited statistical significance and necessitating cautious interpretation. The borderline nature of the p-value can be attributed to the small sample size used in the study. The interaction tests for age, sex, and urine culture subgroups were not statistically significant ($P > 0.05$), indicating that there is insufficient evidence to suggest that these variables influence the effect of intravenous FUR + DEX on postoperative fever during mini-PCNL. However, a lack of statistical significance in the interaction does not necessarily imply that the interaction is absent; it may be due to factors such as insufficient sample size. For example, the P value for the interaction test in the urine culture subgroup was close to 0.05, suggesting that a larger sample size and improved study design might yield a statistically significant result.

Other complications did not differ significantly between groups except for fever. Qi et al. found that intravenous FUR + DEX in PCNL reduced the incidence of postoperative urosepsis and decreased serum IL- 6 and PCT levels in patients with postoperative urosepsis [14]. In this study, although the incidence of postoperative SIRS and urosepsis was lower in the FUR + DEX group, the difference between the groups was not statistically significant, likely due to the small sample size. The use of DEX in some surgeries can reduce postoperative pain. DEX doses greater than 0.1 mg/kg are effective adjuvants in multimodal strategies to reduce postoperative pain and opioid consumption, but low-dose DEX does not reduce opioid consumption [39]. We found that intravenous 5–10 mg DEX in mini-PCNL did not reduce postoperative opioid consumption. Furthermore, intravenous FUR + DEX administered during surgery had no effect on postoperative blood transfusion or renal artery embolization treatment. Unexpectedly, despite more complications, the IQR of postoperative hospital stay was smaller in the FUR + DEX group than in the control group, although there were no statistical differences in both complication rates and postoperative hospital stay. This may be because normal discharge was restricted for some patients due to pandemic prevention measures during the COVID- 19 pandemic.

Significantly, the dosage and timing of intravenous FUR + DEX varied in mini-PCNL, contributing to increased heterogeneity in the study results. In addition, future research should explore the efficacy of monotherapy compared to combination therapy, while elucidating the specific mechanisms of action of each drug. Expanding the sample size in subsequent studies will enhance statistical power. Furthermore, additional research is warranted to identify which patient populations derive the greatest benefit from specific dosages of FUR + DEX administered at particular time points during mini-PCNL. These findings will offer valuable clinical insights for the rational, standardized, and safe utilization of FUR and DEX in the context of mini-PCNL.

Conclusion

In conclusion, the intravenous combined use of FUR and DEX in mini-PCNL reduces postoperative fever (≥ 38 °C), particularly benefiting patients with an operative time of ≥ 2 h. However, this combination does not diminish postoperative pain requiring opioids. Larger-scale studies are needed to determine whether it reduces postoperative SIRS and urosepsis.

Abbreviations

BMI	Body Mass Index
CI	Confidence Interval
CRP	C-Reactive Protein
DEX	Dexamethasone
FUR	Furosemide
IQR	Interquartile Range
IL- 6	Interleukin-6
OR	Odds Ratio
PCNL	Percutaneous Nephrolithotripsy
PCT	Procalcitonin
PSM	Propensity Score Matching
SIRS	Systemic Inflammatory Response Syndrome
WBC	White Blood Cell

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Clinical trial number

Not applicable.

Authors' contributions

G.W. and Q.Z. contributed to the conception of the study, performed the data analyses, and wrote the main manuscript text. W.M., E.Y. and S.J. contributed to data collection and data management. L.Z., Q.J. and Q.H. participated in the study design and provided advice on data analysis. X.L. and Z.W. revised the manuscript. All of the authors read and approved the final manuscript.

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Data availability

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

This research involving human data have been performed in accordance with the Declaration of Helsinki and have been approved by an appropriate ethics committee. The name of the ethics committee: Medical Ethics Committee of the Second Hospital of Lanzhou University. The reference number: 2024 A- 707.

Consent for publication

All authors have reviewed and approved the manuscript for publication.

Competing interests

The authors declare no competing interests.

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