Original Article Risk factors for urological infection after laparoscopic ureterolithotomy

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Abstract: Objective: To investigate and analyze the risk factors of urological infection after laparoscopic ureterolithotomy. Methods: In this retrospective study, 312 patients who underwent laparoscopic ureterolithotomy were included. Among them, 164 patients developed urological infection post-surgery. Key risk factors for urological infection were identified using univariate and multivariate regression analyses. A clinical nomogram was constructed based on these factors, and its predictive accuracy was assessed using the concordance index (C-index) and calibration plot. Results: Univariate and multivariate regression analyses identified age >75 years old (95% CI 0.007-0.340; P=0.002), operation time ≥60 min (95% CI 4.506-90.528; P<0.001), postoperative catheter indwelling time >7 days (95% CI 2.315-6.060; P<0.001), diabetes mellitus (95% CI 4.051-24.682; P<0.001), and hospital stay >7 days (95% CI 1.600-37.144; P=0.011) as independent risk factors for urological infection after laparoscopic ureterolithotomy. Those factors were used to construct a predictive nomogram. The regression model was established as: logit (P) = -6.820 + 0.216 * age + 0.312 * operation time + 0.661 * postoperative indwelling catheter time + 0.433 * diabetes mellitus + 0.671 * hospital stay. The calibration curve demonstrated excellent accuracy of the nomogram model. Decision curve analysis indicated that the model is clinically applicable for threshold probabilities ranging from 20% to 75%. Conclusions: Age >75 years old, operation time ≥60 min, postoperative indwelling catheter time >7 days, diabetes mellitus, and hospital stay >7 days are independent risk factors for urological infection after laparoscopic ureterolithotomy. Effective monitoring, management, and predictive measures for high-risk patients should significantly reduce the incidence of urological infection.

Keywords: Risk factors, urological infection, after laparoscopic ureterolithotomy

Introduction

Urolithiasis is a common condition in urology, affecting approximately 10% of the global population at some time in their lives. Due to its high incidence and recurrence rates, it has become a major medical issue [1]. Urinary stones can be classified into four types: kidney stones, ureteral stones, bladder stones, and urethral stones. Among them, ureteral stones account for 33%-54% of urinary tract stones [2]. Four main surgical treatments are available for ureteral stones: extracorporeal shock wave lithotripsy (ESWL), transurethral ureteroscopic lithotripsy (URL), percutaneous nephrolithotomy (PCNL), and laparoscopic ureterolithotomy (LU). ESWL is the commonly preferred choice for upper ureteral stones due to its non-invasive nature and cost-effectiveness. However,

effectiveness is limited for larger or more complex stones [3]. LU offers advantages such as minimal invasiveness, a high stone removal rate, and fewer postoperative complications [4], and is increasingly recognized as a viable surgical option for treating upper ureteral stones.

Postoperative urological infection is a common complication following laparoscopic ureterolithotomy, with an incidence rate of approximately 7.8%-10% [5]. Research indicates that factors such as surgery duration, blood loss, stone size and location, intraoperative urine contamination, catheter use, and antibiotic resistance all contribute to the occurrence of urinary tract infections (UTIs) following laparoscopic ureterolithotomy [6, 7]. However, definitions and diagnostic criteria for UTI vary widely across studies. Some studies define UTI based on clinical

symptoms such as frequent urination, urgency, and fever, while others rely exclusively on laboratory tests (e.g., urine cultures) for confirmation. This lack of consistency makes it difficult to compare and synthesize results, potentially affecting the accuracy of conclusions [8, 9]. Additionally, many studies focus on single factors, neglecting the multifactorial mechanisms underlying UTIs [10]. Therefore, identifying the risk factors for urological infection after laparoscopic ureterolithotomy and taking timely intervention measures based on these factors are crucial to preventing complications and improving surgical outcomes.

This study aims to analyze the incidence and risk factors for urological infection in patients undergoing laparoscopic ureterolithotomy for ureteral stones and to propose preventive measures based on these risk factors, thereby reducing postoperative infection rates and improving surgical success.

Methods and materials

Study design and ethics

This study was a retrospective analysis conducted between January 2018 and December 2023 at Wujin Hospital Affiliated to Jiangsu University. It was reviewed and approved by the hospital Medical Ethics Committee.

Inclusion criteria

(1) Patients aged 18 years or older; (2) Diagnosis of unilateral ureteral calculi confirmed by B-ultrasound, CT, or KUB + IVU; (3) No renal stones; (4) Patients with negative urine cultures (including those with prior positive urine cultures which turned to negative after appropriate treatment, along with normal blood white cell count and C-reactive protein); (5) Complete medical records.

Exclusion criteria

(1) Concomitant kidney-related diseases, such as renal tumors or tuberculosis; (2) History of abdominal surgery or surgery on the affected side of the ureter; (3) Presence of congenital kidney or ureteral malformations; (4) Severe heart or lung dysfunction, or severe liver and kidney damage that would preclude surgery; (5) Incomplete clinical data.

Diagnosis of urological infection

Within 30 days after laparoscopic ureterolithotomy, patients presenting with symptoms such as frequent urination, urgency, pain, and fever underwent routine urinalysis and midstream urine culture in a timely manner. The observation indicators include nitrite (NIT), leucocyte esterase (LEU), white blood cell (WBC), and urine culture of pathogenic bacteria. A diagnosis of urinary tract infection (UTI) was made if any of the following are positive: NIT, LEU, or WBC, and if the midstream urine culture is positive (Gram-positive bacteria $\geq 10^4$ CFU/ml or Gram-negative bacteria $\geq 10^5$ CFU/ml) [11].

Operation procedures

Under general anesthesia with tracheal intubation, the patient was positioned on the healthy side. A 1.0 cm incision was made 1.0 cm below the 12th rib along the posterior axillary line (point A). The subcutaneous muscle layer and lumbar dorsal fascia were bluntly separated using vascular forceps. The head was drawn towards the surgical site, and dissection proceeded along the anterior and lateral surfaces of the psoas major muscle. A self-made airbag was placed and inflated with 600-800 ml of air to expand the retroperitoneal space for approximately 5 minutes. A 10 mm curved trocar was inserted at the level of the iliac spine (point B); a second 10 mm and third 5 mm curved trocars were inserted at the anterior superior iliac spine along the anterior axillary line (point C), as shown in the surgical field. For cases with poor exposure, a fourth trocar may be inserted beneath the anterior rib arch (point D). Under microscopic observation, the peritoneal fold was carefully opened, and the perirenal fascia was incised. The perirenal fat was gently pushed along the surface of the psoas major muscle to expose the upper segment of the ureter. The stone was located, and the ureter was freed. A longitudinal incision was made along the entire length of the ureter, from the ureteral dilation above the stone to halfway along the surface of the stone. The stone was removed, and the integrity of the ureter was carefully checked to avoid residual stone fragments. A suction tube was used to explore and flush the proximal and distal ureters, ensuring patency. Guided by a guidewire, the distal end of a 5F double-J stent was inserted into the ure-

ter. Intermittent suturing of the ureteral incision was performed using 0/5 absorbable sutures, ensuring proper alignment of the ureteral mucosa. After removal of the stone, a fingertip was used for final cleaning, and a drainage tube was placed around the kidney. The drainage tube was removed after 4-5 days, and the double-J stent was typically removed 4-8 weeks later.

Data collection and measurement

Baseline clinical data were collected for all admitted patients, including demographic and clinical characteristics such as age, complications (history of hypertension, history of ureteral stones, number of stones, and diabetes), operation duration, postoperative catheter indwelling time, blood lipid markers (cholesterol, triglycerides, high-density lipoprotein cholesterol, and low-density lipoprotein cholesterol), and hospital stay.

Sample size calculation

The sample size for this study was determined through statistical power analysis. Based on prior research and clinical experience, we anticipated a medium effect size of 0.5 (Cohen's d), a significance level (α) of 0.05, and a statistical power (1- β) of 0.8. The power analysis indicated that a minimum of 130 participants per group was required to detect significant differences. To account for possible dropout and incomplete data, a total of 312 participants were included in the study (164 in the infected group and 148 in the non-infected group), which exceeds the required sample size of 260. This ensures adequate statistical power for the study's analyses and enhances the reliability of the results.

Statistical analysis

IBM SPSS 17.0 statistical software was used for statistical analysis. K-S (Kolmogorov Smirnov test) was used to test the normality of the collected data. Data with a normal distribution were expressed as mean ± standard deviation. One way ANOVA was used to compare multiple groups, with LSD (least significant difference) test used for pairwise comparisons. Data with a non-normal distribution were represented as median (P25, P75), and comparisons between groups were made using nonparametric tests, with the Kruskal-Wallis test used for pairwise

comparisons. Categorical variables were expressed as frequency (%), and the chi-square test was used for group comparisons. *P* values less than 0.05 were considered significant.

Results

Clinical characteristics

A total of 312 patients who underwent laparoscopic ureterolithotomy were included in this study. Among them, 164 patients developed postoperative urinary tract infection, serving as the UTI group; while the other 148 patients without postoperative UTI were classified as the non-UTI group. There were no significant differences in terms of age, body mass index (BMI), sex, history of ureteral stones, number of stones, education status, or ureteral stone locations between the two groups (all P>0.05) (Table 1).

Comparison of blood lipid indicators between two groups

The results showed that the levels of various lipid components were comparable between the two groups. Cholesterol, triglycerides, high-density lipoprotein cholesterol (HDL-C), and low-density lipoprotein cholesterol (LDL-C) values did not differ substantially between the groups, indicating that there was no remarkable variation in blood lipid profiles (all P>0.05) (Table 2).

Univariate analysis

As shown in **Table 3**, univariate analysis identified age, operation time, postoperative catheter indwelling time, diabetes mellitus, and hospital stay as factors associated with UTI risk after laparoscopic ureterolithotomy (all P<0.05).

Multivariate analysis

As shown in **Table 4**, multivariate analysis confirmed several independent risk factors for UTI after laparoscopic ureterolithotomy, including age >75 years old (95% CI 0.007-0.340; P=0.002), operation time ≥60 min (95% CI 4.506-90.528; P<0.001), postoperative catheter indwelling time >7 days (95% CI 2.315-6.060; P<0.001), diabetes mellitus (95% CI 4.051-24.682; P<0.001), and hospital stay >7 days (95% CI 1.600-37.144; P=0.011).

Table 1. Comparison of clinical characteristics between the UTI and non-UTI groups

	UTI group (n=164)	Non-UTI group (n=148)	t/χ²	Р
Age (years)	48.24±8.29	49.28±10.06	1.000	0.318
BMI	20.11±0.74	19.86±1.46	1.930	0.055
Sex			0.645	0.422
Male (n%)	89 (54.27%)	87 (58.78%)		
Female (n%)	75 (45.73%)	61 (41.22%)		
Education			3.169	0.674
Illiteracy	93 (56.70%)	81 (54.73%)		
Primary school	38 (23.17%)	37 (25.00%)		
Junior high school	13 (7.93%)	18 (12.16%)		
Highschool/Technical secondary school	7 (4.27%)	3 (2.03%)		
Junior college	6 (3.66%)	4 (2.70%)		
Bachelor's degree or above	7 (4.27%)	5 (3.38%)		
Ureteral stone locations			0.103	0.748
Upper ureter stones	89 (54.27%)	83 (56.08%)		
Mid-ureter stones	75 (45.73%)	65 (43.92%)		
History of ureteral stones	38 (23.17%)	37 (25.00%)	0.143	0.706
Number of stones	1.22±0.05	1.24±0.14	1.541	0.124

BMI: body mass index.

Table 2. Comparison of blood lipid indicators between the two groups

	UTI group (n=164)	Non-UTI group (n=148)	t	Р
СНО	3.99±1.07	4.03±0.46	0.386	0.700
TG	1.23±0.63	1.51±1.26	2.522	0.012
HDL	1.55±0.28	1.53±0.53	0.506	0.613
LDL	2.31±0.42	2.32±0.48	0.291	0.771

Note: CHO: cholesterol; TG: triglyceride; HDL: high-density lipoprotein; LDL: low-density lipoprotein.

Model establishment and validation

The risk factors for urological infection after laparoscopic ureterolithotomy were incorporated into a prediction model established using R software (R 3.6.3). The risk value for UTI was calculated based on the sum of the integral of each factor (**Figure 1**). The regression equation for the model was as follows: logit (P) = -6.820 + 0.216 * age + 0.312 * operation time + 0.661 * postoperative catheter indwelling time + 0.433 * diabetes mellitus + 0.671 * hospital stay.

The unadjusted concordance index (C-index) for the nomogram was 0.892 [95% CI 0.715-0.984]. The calibration plot of the nomogram is

shown in **Figure 2**. The AUC for the nomogram was 0.84 (**Figure 3**), indicating that the nomogram model demonstrated good discrimination and consistency in predicting the risk of UTI after laparoscopic ureterolithotomy. Decision curve analysis (DCA) demonstrated a higher net benefit compared to the "AII" and "None" strategies within the threshold probability range of approximately 0.2 to 0.75, indicating the clinical utility of the prediction model (**Figure 4**).

Discussion

Our study identified age >75 years, operation time ≥60 min, postoperative catheter indwelling time >7 days, diabetes mellitus, and hospital stay >7 days as the independent risk factors for UTI after laparoscopic ureterolithotomy. Furthermore, we constructed a predictive nomogram model to estimate the risk of UTI following laparoscopic ureterolithotomy. Calibration plot revealed that this nomogram model had good accuracy and clinical applicability, with a high C-index and AUC for the nomogram. The DCA demonstrated clinical usefulness of this nomogram for predicting the risk of urological infection after laparoscopic ureterolithotomy. In addition, this model would enable early recognition of a high-risk population.

Table 3. Univariate analysis of risk factors for postoperative urological infection

	UTI group (n=164)	Non-UTI group (n=148)	t/χ²	Р
Sex			0.645	0.422
Male (n%)	89 (54.27%)	87 (58.78%)		
Female (n%)	75 (45.73%)	61 (41.22%)		
Age (years)			33.645	0.000
18-45	7 (4.27%)	6 (4.45%)		
46-60	11 (6.71%)	41 (27.70%)		
61-75	70 (42.68%)	68 (45.95%)		
>75	76 (46.34%)	33 (22.30%)		
BMI (kg/m²)			0.326	0.849
18.5-23.9	125 (76.22%)	116 (78.38%)		
<18.5	33 (20.12%)	28 (18.92%)		
≥24	6 (3.66%)	4 (2.70%)		
Operation time (min)			45.812	0.000
40-60	74 (45.12%)	111 (75.00%)		
<40	47 (28.66%)	35 (23.65%)		
≥60	43 (26.22%)	2 (1.35%)		
Hypertension			0.021	0.884
No	74 (45.12%)	68 (45.95%)		
Yes	90 (54.88%)	80 (54.05%)		
Postoperative catheter indwelling time (days)			31.708	0.000
<3	2 (1.22%)	5 (3.38%)		
3-7	66 (40.24%)	103 (69.59%)		
>7	96 (58.54%)	40 (27.03%)		
Diameter of the calculi (mm)			0.840	0.657
<10	74 (45.12%)	60 (40.54%)		
10-15	87 (53.05%)	84 (56.76%)		
>15	3 (1.83%)	4 (2.70%)		
Diabetes mellitus			42.396	0.000
No	77 (46.95%)	122 (82.43%)		
Yes	87 (53.05%)	26 (17.57%)		
Hospital stay (days)			23.579	0.000
≤7	13 (7.93%)	43 (29.05%)		
>7	151 (92.07%)	105 (60.95%)		

BMI: body mass index.

Our study identified age over 75 years as an independent risk factor for UTI after laparoscopic ureterolithotomy, consistent with previous findings [12]. This association can be attributed to several mechanisms. First, agerelated immune decline plays a critical role, as the aging immune system exhibits reduced cellular function and impaired responses to infections, particularly in postoperative settings [13]. This weakened immune response heightens susceptibility to UTIs in elderly patients. Second, older adults are more likely to have

chronic comorbidities, such as diabetes and cardiovascular diseases, which impair immune function, disrupt microcirculation, and contribute to urinary retention, further elevating infection risk [14]. Additionally, structural and functional deterioration of the urinary system, including poor bladder emptying and conditions like benign prostatic hyperplasia, creates a favorable environment for bacterial growth [15]. Finally, elderly patients often experience slower postoperative recovery, characterized by prolonged surgical stress responses,

Table 4. Multivariate regression analysis of independent risk factors for postoperative urological infection

Factor		β	SE	Wals	Р	OR	95% CI	
Age (years)							<u> </u>	
18-45		-	-	17.025	0.001	1		
46-60		4.996	1.220	16.784	0.000	0.007	0.001-0.07	4
61-75		1.190	0.620	3.689	0.055	0.304	0.090-1.02	5
>75		3.023	0.992	9.286	0.002	0.049	0.007-0.34	0
Operation time (min)								
40-60		-	-	16.236	0.000	1		
<40		3.565	0.985	13.107	0.000	35.345	5.130-24.52	29
≥60		3.006	0.765	15.420	0.000	20.197	4.506-90.52	
Postoperative catheter	indwelling time (days)							
<3		-	-	30.374	0.000	1		
3-7		1.792	0.858	4.365	0.037	6.000	1.117-32.21	L9
>7		1.321	0.246	28.930	0.000	3.745	2.315-6.06	
Diabetes mellitus								
No		-	-	0.334	0.663	1		
Yes		2.303	0.461	24.950	0.000	10.000	4.051-24.68	32
Hospital stay (day)								
≤7		-	-	0.197	0.078	1		
>7		2.042	0.802	6.480	0.011	7.708	1.600-37.14	14
Points	0 10 20	30	40	50 6	50 70	80	90 1	100
Age					18-45		>	>75
	46-60				61-75			
DM	No		Had 					
	<3							
PICT	3-7	>7						
ОТ	<40							
	40-60	=60						
HS	-7					>	7	
	=7							
Total Points	0 20 40	60 80	100 12	20 140	160 180	200	220 240 2	¬ 260

Figure 1. Nomogram for predicting urological infection after laparoscopic ureterolithotomy. DM: Diabetes mellitus; PICT: Postoperative indwelling catheter time; OT: Operation time; HS: Hospital stay.

0.2

0.3

0.1

Risk of urological infection

0.4 0.5 0.6 0.7

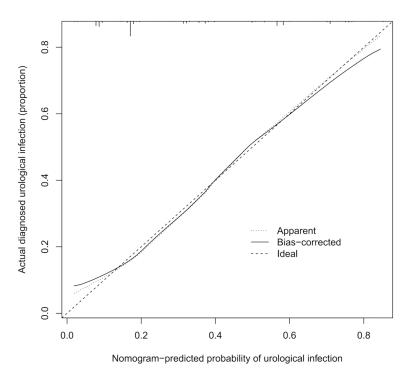


Figure 2. Calibration curves for the nomogram model in predicting UTI risk after laparoscopic ureterolithotomy.

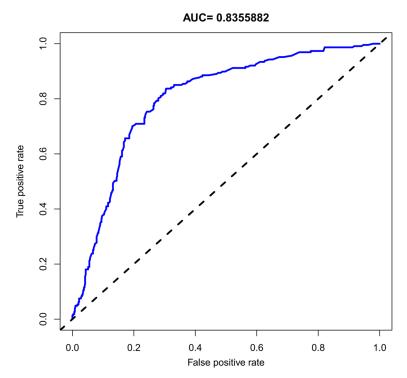


Figure 3. ROC curves for the nomogram in predicting the UTI risk after laparoscopic ureterolithotomy.

delayed wound healing, and extended hospitalization. These factors, combined with frequent use of indwelling catheters and antibiotics, significantly increase the likelihood of UTIs in this population [16]. Thus, age over 75 years predisposes patients to postoperative UTIs through a combination of immune decline, comorbidities, urinary system dysfunction, and delayed recovery. These findings highlight the need for targeted perioperative strategies to mitigate infection risk in elderly patients undergoing laparoscopic ureterolithotomy.

Prolonged surgical duration (≥60 minutes) was also identified as an independent risk factor for postoperative UTI in our study. Longer surgeries are associated with extended exposure to surgical stress and anesthesia, leading to greater tissue damage, heightened systemic inflammatory responses, and suppressed immune function, all of which increase susceptibility to infections [17]. Additionally, frequent urinary tract manipulations during prolonged surgeries facilitate bacterial invasion, further elevating the risk of UTIs [18]. Prolonged surgery can also disrupt homeostasis. causing fluctuations in body temperature and electrolyte imbalances that impair immune response and wound healing. To address this risk, strategies such as optimizing surgical techniques, minimizing urinary tract manipulations, and avoiding unnecessary procedural steps are essential [19]. Furthermore,

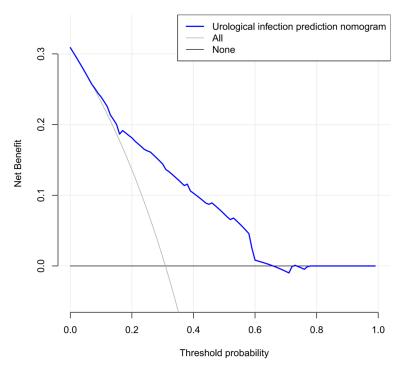


Figure 4. Decision curve analysis for the nomogram.

implementing early postoperative monitoring, regulating antibiotic use, and enhancing patients' immune status may effectively reduce the infection risk associated with prolonged surgeries [20]. Reducing surgical duration and limiting unnecessary urinary tract manipulations during laparoscopic ureterolithotomy should be prioritized to minimize postoperative UTI risk.

Additionally, our study identified postoperative indwelling catheterization exceeding 7 days as a significant risk factor for UTIs, consistent with previous findings [21]. Prolonged catheterization provides a direct pathway for bacterial invasion, allowing bacteria to enter and proliferate in the bladder, particularly when catheters are not properly disinfected or replaced in a timely manner [22]. Additionally, long-term catheterization can lead to urine retention, increased bacterial load, and mechanical irritation of the urinary tract, further promoting local inflammation and susceptibility to infection [23]. To mitigate this risk, minimizing catheterization duration and evaluating the possibility of early removal post-surgery are essential. Standardized management of postoperative antibiotics and infection prevention protocols should also be prioritized. Future studies should

explore the optimal duration of catheterization to balance infection prevention with postoperative recovery, providing more precise guidance for clinical practice.

Diabetes mellitus is another independent risk factor for postoperative UTIs identified in our study, consistent with previous findings [24]. Diabetic patients often exhibit impaired immune function due to chronic hyperglycemia, which weakens immune cell activity, reduces infection defense, and suppresses inflammatory responses [25, 26]. Hyperglycemia further provides an ideal environment for bacterial growth, particularly for pathogens like Escherichia coli, thereby increasing the risk of UTIs. Urinary dysfunc-

tion commonly observed in diabetic patients, including diabetic cystopathy and incomplete bladder emptying, exacerbates the risk by creating conditions favorable for bacterial colonization and proliferation [27]. To address these challenges, strict blood glucose control, optimized anti-infection strategies, and early interventions should be prioritized in diabetic patients. Future research should focus on strategies to regulate immune function and improve urinary tract conditions during the perioperative period, providing a more comprehensive approachtoreducingUTlincidenceindiabeticpopulations.

A hospital stay longer than 7 days was identified as a significant risk factor for UTI. Prolonged hospitalization often reflects a slower postoperative recovery, during which immune suppression caused by stress and prolonged antibiotic use reduces the body's ability to combat infections [28]. Extended hospital stays also increase exposure to hospital-acquired pathogens, particularly multidrug-resistant organisms, and elevate the risk of bacterial invasion through medical interventions such as indwelling catheters and intravenous infusions [29]. Additionally, reduced mobility and poor urine drainage during extended hospital stays create

favorable conditions for bacterial proliferation, further contributing to UTI risk. To mitigate this, strategies such as promoting early recovery, minimizing unnecessary hospital stays, and strengthening infection control measures during hospitalization are essential. Future research should explore the relationship between hospital stay duration and postoperative infections and identify effective approaches to optimize hospital and postoperative care to reduce infection risk.

The findings of this study suggest that lipid metabolism is not a major contributing factor to UTI risk following laparoscopic ureterolithotomy. Previous studies have highlighted the potential role of lipid metabolism in systemic inflammation and immune modulation, which might influence the susceptibility to infections [30]. However, this study found no significant variation in lipid profiles between the infected and non-infected groups, indicating that lipid components were unlikely be independent risk factors for postoperative urological infections. This finding aligns with the notion that other factors, such as surgical technique, stone characteristics, or individual patient comorbidities, may play a more prominent role in determining infection risk [31, 32]. Future studies may explore whether specific patient subgroups, such as those with metabolic syndrome or severe dyslipidemia, exhibit different risks of postoperative infections. Additionally, investigating the interplay between lipid metabolism, systemic inflammation, and immune response in the context of urological infections may provide further insight into the underlying mechanisms.

This study has several limitations. First, as a retrospective study, it relied on previously collected data, which may be subject to incomplete or inaccurate records, leading to potential biases in the analysis. Second, the study only included patients from a single center, which may limit the applicability of the findings to other populations or healthcare settings with different patient characteristics or clinical practices. Additionally, while the study identified several risk factors, it did not account for potential confounding variables, such as comorbid conditions, medication use, or postoperative care protocols, which may also influence the incidence of urinary tract infections. Finally, the

study lacked a prospective validation cohort, which would be valuable in confirming the robustness and reproducibility of the identified risk factors. Future studies should aim to address these limitations by including larger, multicenter populations and prospective designs.

Conclusion

Age >75 years old, operation time ≥60 min, postoperative catheter indwelling time >7 days, diabetes mellitus, and hospital stay >7 days are independent risk factors for urological infection after laparoscopic ureterolithotomy. The constructed predictive nomogram model based on these factors demonstrates good accuracy and clinical applicability for assessing the risk of urological infection after laparoscopic ureterolithotomy.

Disclosure of conflict of interest

None.

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