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Association between platelet to lymphocyte ratio and febrile urinary tract infection after double-J stent removal in children underwent laparoscopic pyeloplasty

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Abstract

Objective To evaluate the association between the inflammatory biomarkers and the prevalence of febrile urinary tract infection (fUTI) after double-J (DJ) stent removal in pediatrics following laparoscopic pyeloplasty (LP).

Methods A retrospective study was conducted in pediatrics underwent DJ stent removal following LP owing to primary ureteropelvic junction obstruction (UPJO) between September 2021 and November 2024. Baseline characteristics, preoperative data and the incidence of fUTI were documented. The inflammatory index including neutrophil to lymphocyte ratio (NLR), platelet to lymphocyte ratio (PLR) and systemic immune-inflammation index (SII) were calculated. The results of cultured pathogens were also identified. The univariate and multivariate logistic analysis were conducted to determine the potential risk factors of fUTI after DJ stent removal. The predictive value of potential risk factors were determined by receiver operating characteristic curve (ROC).

Results Overall, 295 patients were included in the study. fUTI occurred in 22 patients (7.5%) after DJ stent removal. Patients in the fUTI group were younger ($P=0.008$) and had lower body weight ($P=0.003$) compared to non-fUTI group. Additionally, the fUTI group showed higher levels of platelets and neutrophils, associated with lower levels of lymphocytes. The most commonly identified pathogens were *Enterococcus* and *Escherichia coli* in fUTI patients. Multivariate logistic analysis revealed that age (OR = 0.978, 95% CI: 0.956–0.999, $P=0.047$), toilet training status (OR = 0.297, 95% CI: 0.109–0.807, $P=0.017$) and higher levels of PLR (OR = 1.101, 95% CI: 1.005–1.022, $P=0.002$) were predictive factors for fUTI after DJ stent removal. PLR had a high predictive value with an AUC of 0.827 with the sensitivity of 90.91% and the specificity of 69.23%.

Conclusion PLR is a promising predictor for diagnosing fUTI after DJ stent removal. Patients with higher levels of PLR before DJ stent removal should be closely monitored. Further well-designed and prospective cohorts are required in future to explore the cause-and-effect relationship between PLR and fUTI after DJ removal.

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Keywords Platelet to lymphocyte ratio, Febrile urinary tract infection, DJ stent removal, Laparoscopic pyeloplasty, Predictive factor

Introduction

Ureteropelvic junction obstruction (UPJO) is the most common cause of hydronephrosis among pediatrics, with the reported incidence of 1/1500 [1]. Since it was introduced, Anderson-Hynes dismembered pyeloplasty has been recommended as the standard surgical treatment for UPJO [2]. Recently, laparoscopic pyeloplasty (LP) have gained much popularity among surgeons with the reported success rates and complication rates were similar between open surgery and LP [3]. Moreover, compared to open surgery, LP as a minimally invasive surgery showed potential benefits of decreasing postoperative pain, shortening length of hospital stay and achieving favorable cosmetic outcomes [4, 5, 6]. Thus, LP has been widely accepted as the preferred surgical methods for treating UPJO in recent years.

While there remains some controversy about the best drainage methods in LP, a double J (DJ) stent is commonly inserted during surgery [7]. The DJ stent has been confirmed to play important roles in supporting the anastomotic site and draining the urine, reducing the incidence of urine leakage and restenosis [8]. However, previous studies also pointed that many postoperative complications were related to DJ stents, such as stent displacement, flank pain and febrile urinary tract infection (fUTI) [9]. Moreover, recent studies indicated that postoperative fUTI after DJ stent removal is an independent risk factor of restenosis [10, 11]. Thus, it is important to identify predictors of postoperative fUTI after LP.

Limited studies focused on the immune cells and inflammatory response on the occurrence of fUTI. A study has revealed that the pyroptosis of uroepithelial cells increased the susceptibility to infection [12]. The levels of many immune cells changed immediately during the acute inflammatory phase, such as C-reactive protein, neutrophils, lymphocytes, monocytes and platelets. Additionally, our previous studies have demonstrated the critical roles of platelets and platelet-derived extracellular vesicles in the progression of urosepsis [13, 14]. Recently, many inflammatory-related index are proposed as biomarkers in various diseases, including the systemic immune-inflammation index (SII), neutrophil to lymphocyte ratio (NLR), and platelet to lymphocyte ratio (PLR) [15, 16, 17]. Considering the growing evidence of the relationship between fUTI and inflammatory response, we explored whether the levels of serum inflammatory indicators mentioned above are associated with the incidence of fUTI after DJ stent removal.

Here, a retrospective study was conducted to evaluate the incidence of fUTI after DJ stent removal in pediatrics underwent LP due to primary UPJO. Moreover, the results of microbiology of fUTI were recorded and the potential risk factors of fUTI were investigated in the study.

Patients and methods

Study design

A retrospective study was conducted in pediatrics who were diagnosed with primary UPJO and underwent LP between September 2021 and November 2024 at Children's Hospital of Nanjing Medical University. All surgery was conducted by three experienced surgeons with the same certification in laparoscopic surgery. The exclusion criteria included: patients with incomplete data or lost in follow-up; patients with kidney malformation, such as duplex kidney, solitary kidney, horseshoe or ectopic kidney; patients diagnosed with bilateral UPJO, and UPJO owing to crossing vascular or concomitant vesicoureteral reflux; patients with failure of DJ stent insert or convert to open surgery during LP. The baseline characteristics, preoperative data and postoperative outcomes were recorded. The study was conducted according to the Declaration of Helsinki and approved by the local institutional review board (No.202410041). Informed consent was waived owing to its retrospective nature.

Treatment

All patients included in the study underwent standard Anderson-Hynes pyeloplasty and DJ stent insertion under laparoscopy. The DJ stent was indwelled through the abdominal trocar in an antegrade way using hydrophilic guide wires during LP surgery. After discharge, the patients received oral cephalosporin (50 mg/kg.d) as prophylactic antibiotics for 1–2 weeks. Cystoscopic removal of the DJ stent was performed under general anesthesia at 4–6 weeks after surgery. The results of blood routine examination, biochemical examination and urine test were obtained before stent removal. The follow-up was performed at outpatient or with telephone interview at 3, 6, 12, 18 and 24 months after DJ stent removal.

Definitions and outcomes

The value of PLR, NLR and SII were calculated based on the serum blood cell counts.

As PLR was calculated as platelets count to lymphocytes count; NLR was calculated as neutrophils count to lymphocyte count and SII was calculated as platelets count × neutrophils count to lymphocytes count. Toilet training status was assessed at the time of stent placement and categorized as "trained" (child consistently uses

the toilet for urination) or "untrained" (requires diapers/pull-ups or has involuntary voiding). This was determined through parental report and clinical documents. Toilet training status was included as a binary variable in univariate and multivariate logistic regression models to evaluate its association with postoperative fUTI. The definition of fUTI was fever with temperature over 38 °C accompanied by urinary tract symptoms and positive urine culture. Plastic bag were used for urine sampling in infants. For females, wipe labia majora/minora with sterile saline-soaked gauze for three times and hold labia apart during bag application. For males, retract foreskin and clean glans with saline. Sterile, self-adhesive pediatric bag was used to collect urine samples and avoid anal contact to prevent fecal contamination. The urine culture was performed in the presence of fever (body temperature > 38℃) to confirm fUTI. The results were diagnosed positive when the bacterial count exceeds 10^5 colony-forming units per milliliter (CFU/ml) [18, 19]. The primary outcome in the study was the incidence of fUTI after DJ stent removal within 48 h. The secondary outcome was to explore the potential risk factors of fUTI. Furthermore, the results of microbiology of urine culture was also recorded.

Statistical analysis

Continuous variable were presented as mean ± standard deviation (SD) or median with interquartile range (IQR) according to their distribution, respectively. Accordingly, *t*-test or Mann-Whitney U test were conducted as appropriate. Categorical variables were expressed as frequency with percentage, and the comparison were performed by chi-squared or Fisher's exact tests. For investigating the potential risk factors of fUTI, the univariate and multivariate logistic analysis were conducted.

The predictive value of potential risk factors were determined by receiver operating characteristic curve (ROC) and the results were presented with the area under the curve (AUC). The best cutoff value was decided according to the sensitivity and specificity. The ROC curve was constructed based on MedCalc program (version 20.015). All statistical analysis performed in present study was conducted by software Stata (version 15.1), and p value < 0.05 was considered as statistically significant.

Results

Patient characteristics

Overall 295 patients were included in the study. The diagram is provided in Fig. 1. Based on the presence of fUTI after DJ stent removal, the entire population was divided into two groups: non-fUTI group ($n = 273$, 92.5%) and fUTI group ($n = 22$, 7.5%). The detailed baseline characteristics were represented in Table 1. For routine blood examination results, the levels of neutrophils (6.6 [5.1–8.6] vs. 4.2 [2.8–6.4], $P < 0.001$) and platelets (320.5 [269–458] vs. 287 [238–335], $P = 0.048$) were higher, and the levels of lymphocytes (1.94 [1.05–2.56] vs. 2.92 [2.23–4.23], $P < 0.001$) was lower in fUTI group compared to non-fUTI group. There was no statistically significant difference in other characteristics between two groups. The results of the variables were shown in Fig. 2.

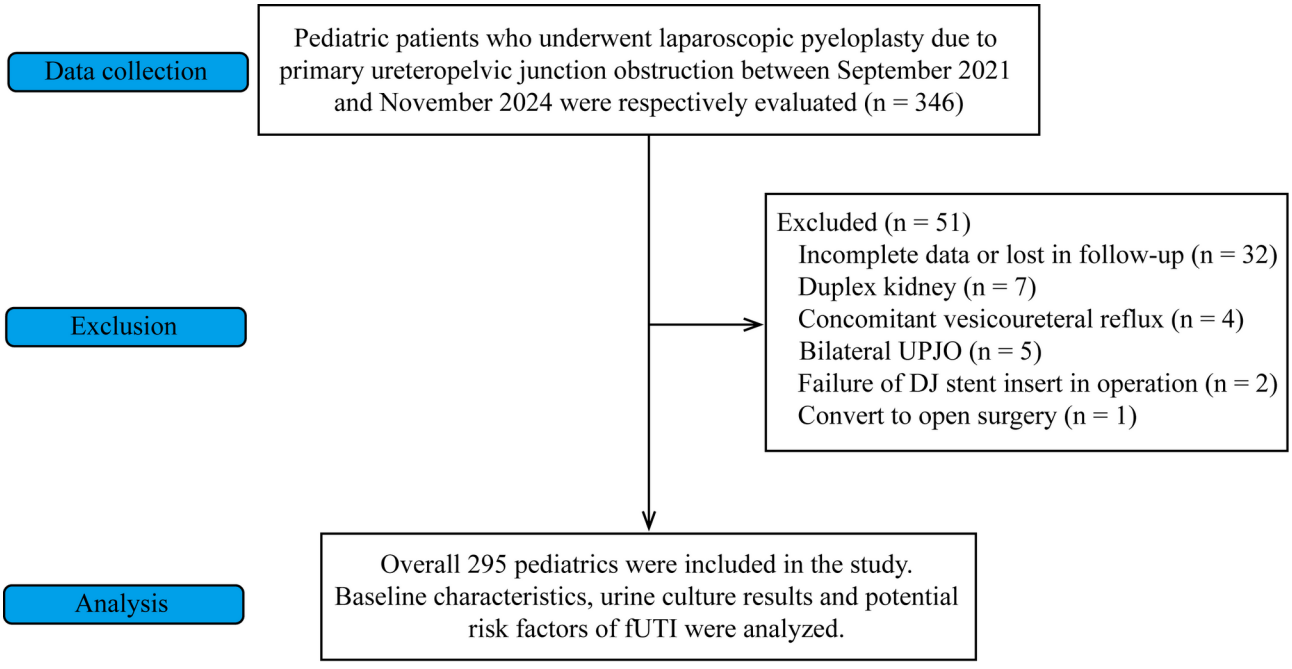

Fig. 1 The flow chart of the study

Table 1 Characteristics of included patients

Variable	Overall	Non-fUTI	fUTI	*P* value
	295	273 (92.5)	22 (7.5)	
Gender				0.988
Male	241 (81.7)	223 (81.7)	18 (81.8)	
Female	54 (18.3)	50 (18.3)	4 (18.2)	
Weight, kg	19 [9.5–31]	20 [10–31.5]	9.5 [6–23]	**0.008**
Age, months	61.9 [10.8–101.4]	64.8 [15.0–103.9]	14.3 [3.0–75.0]	**0.003**
Operation side				0.111
Left	239 (81.0)	224 (82.1)	15 (68.2)	
Right	56 (19.0)	49 (17.9)	7 (31.8)	
Symptom				**0.002**
Yes	135 (45.8)	132 (48.4)	3 (13.6)	
No	160 (54.2)	141 (51.6)	19 (86.4)	
History of pre-UTI				0.122
Yes	27 (9.2)	27 (9.9)	0 (0)	
No	268 (90.8)	246 (90.1)	22 (100)	
Toilet training status				**0.006**
Trained	210 (71.2)	200 (73.3)	10 (45.5)	
Untrained	85 (28.8)	73 (26.7)	12 (54.5)	
Duration of stent placement, days	30 [28.5–30.5]	29.5 [28.0–31.8]	30.5 [28.5–32.5]	0.395
DRF, %	44.0 [37.1–47.6]	43.9 [36.5–47.7]	42.4 [39.1–46.8]	0.959
Ultrasound Parameters				
Pre-APD, mm	30 [23–41]	30 [22–42]	33.5 [26–39]	0.472
Cortical thickness, mm	3 [2–3.5]	3 [2–3.5]	2.5 [2–3.5]	0.311
Operation time, min	100 [75–125]	100 [75–125]	100 [75–125]	0.963
Length of hospital stay, days	10 [7–13]	10 [7–13]	9.5 [8–15]	0.665
Blood examinations				
Lymphocytes, 10^9/L	2.83 [2.02–4.14]	2.92 [2.23–4.23]	1.94 [1.05–2.56]	**< 0.001**
Monocytes, 10^9/L	0.62 [0.47–0.82]	0.62 [0.47–0.81]	0.75 [0.48–0.89]	0.127
Neutrophils, 10^9/L	4.3 [2.9–6.5]	4.2 [2.8–6.4]	6.6 [5.1–8.6]	**< 0.001**
Platelets, 10^9/L	288 [240–343]	287 [238–335]	320.5 [269–458]	**0.048**
NLR	1.49 [0.86–2.98]	1.39 [0.78–2.60]	3.55 [3.23–4.09]	**< 0.001**
PLR	96.9 [68.8–144.7]	93.7 [68.0–135.5]	176.0 [142.9–245.2]	**< 0.001**
SII	402.8 [233.3–907.6]	368.3 [231.7–776.1]	1139.5 [843.7–1773.1]	**< 0.001**

Postoperative outcomes

The incidence of fUTI in pediatrics underwent DJ stent removal following LP was 7.5%. Twenty-two patients diagnosed with fUTI and all had positive urine culture results. The microbiology results were shown in Fig. 3. The most commonly identified pathogens among patients in the study were *Enterococcus* ($n = 11$, 50%), followed by *Escherichia coli* ($n = 6$, 27.3%), *Pseudomonas aeruginosa* ($n = 3$, 13.7%), *Klebsiella pneumoniae* ($n = 1$, 4.5%) and *Candida* ($n = 1$, 4.5%). All patients diagnosed with fUTI received treatment with antibiotics. Before discharge, the patients' temperature returned to normal with the symptoms of upper urinary tract disappeared, and the results of urine test and urine culture were negative.

Risk factors of fUTI

To explore the potential risk factors of fUTI after DJ stent removal in pediatrics underwent LP, the univariate and multivariate logistic regression analysis were conducted. All variables included in the study were screened to identify the relationship between fUTI. The univariate analysis indicated that age (OR = 0.985, 95% CI: 0.974–0.996, $P = 0.006$), weight (OR = 0.957, 95% CI: 0.919–0.996, $P = 0.032$), toilet training status (OR = 0.304, 95% CI: 0.126–0.734, $P = 0.008$), symptom (OR = 0.169, 95% CI: 0.048–0.583, $P = 0.005$), NLR (OR = 1.374, 95% CI: 1.161–1.626, $P < 0.001$), PLR (OR = 1.016, 95% CI: 1.010–1.022, $P < 0.001$) and SII (OR = 1.001, 95% CI: 1.000-1.002, $P < 0.001$) were potential risk factors of fUTI after DJ stent removal.

Then, these identified variables were further sent to multivariate logistic regression analysis. The results

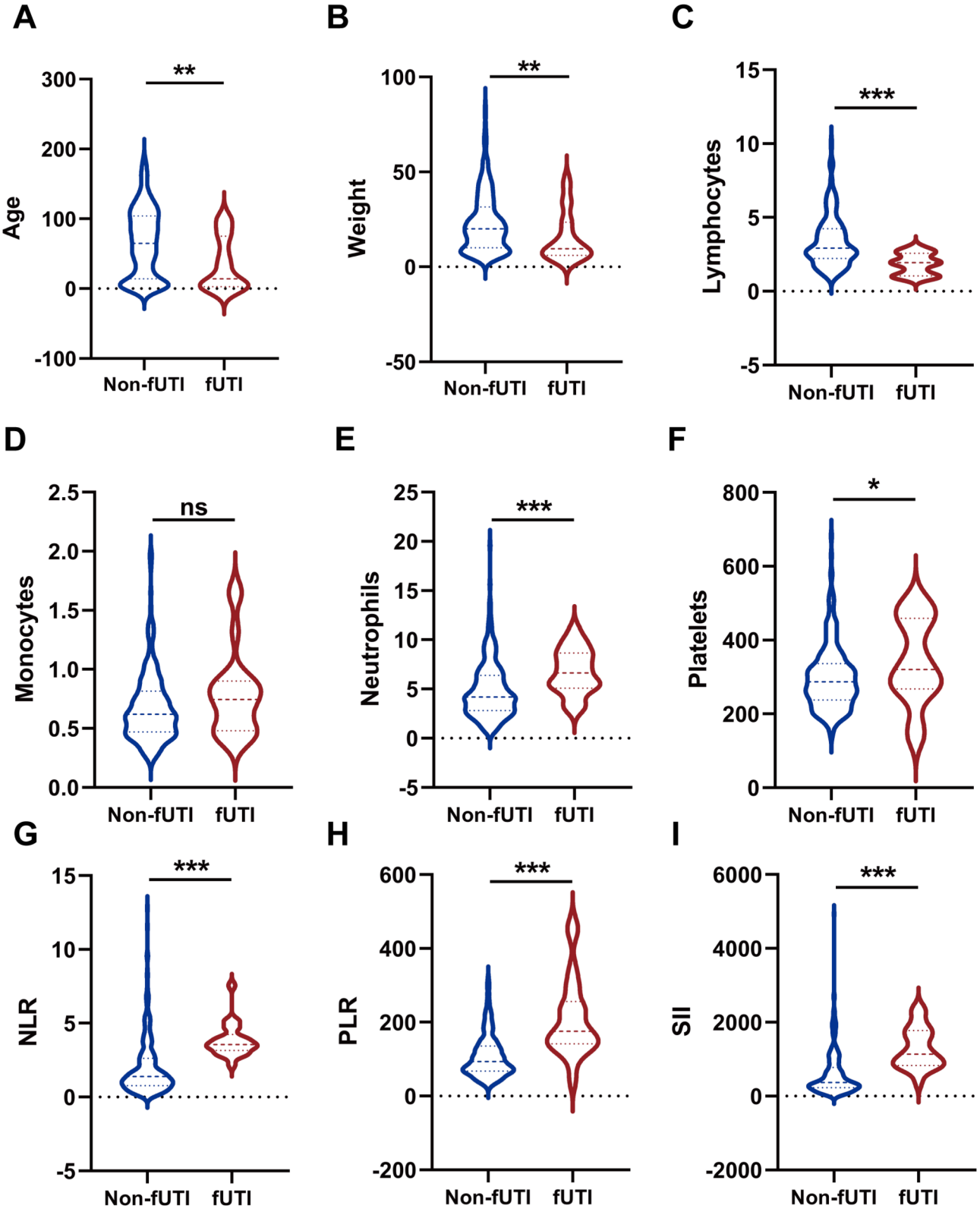

Fig. 2 The values of (**A**) age; (**B**) weight; (**C**) lymphocytes; (**D**) monocytes; (**E**) neutrophils; (**F**) platelets; (**G**) NLR; (**H**) PLR; (**I**) SII between two groups

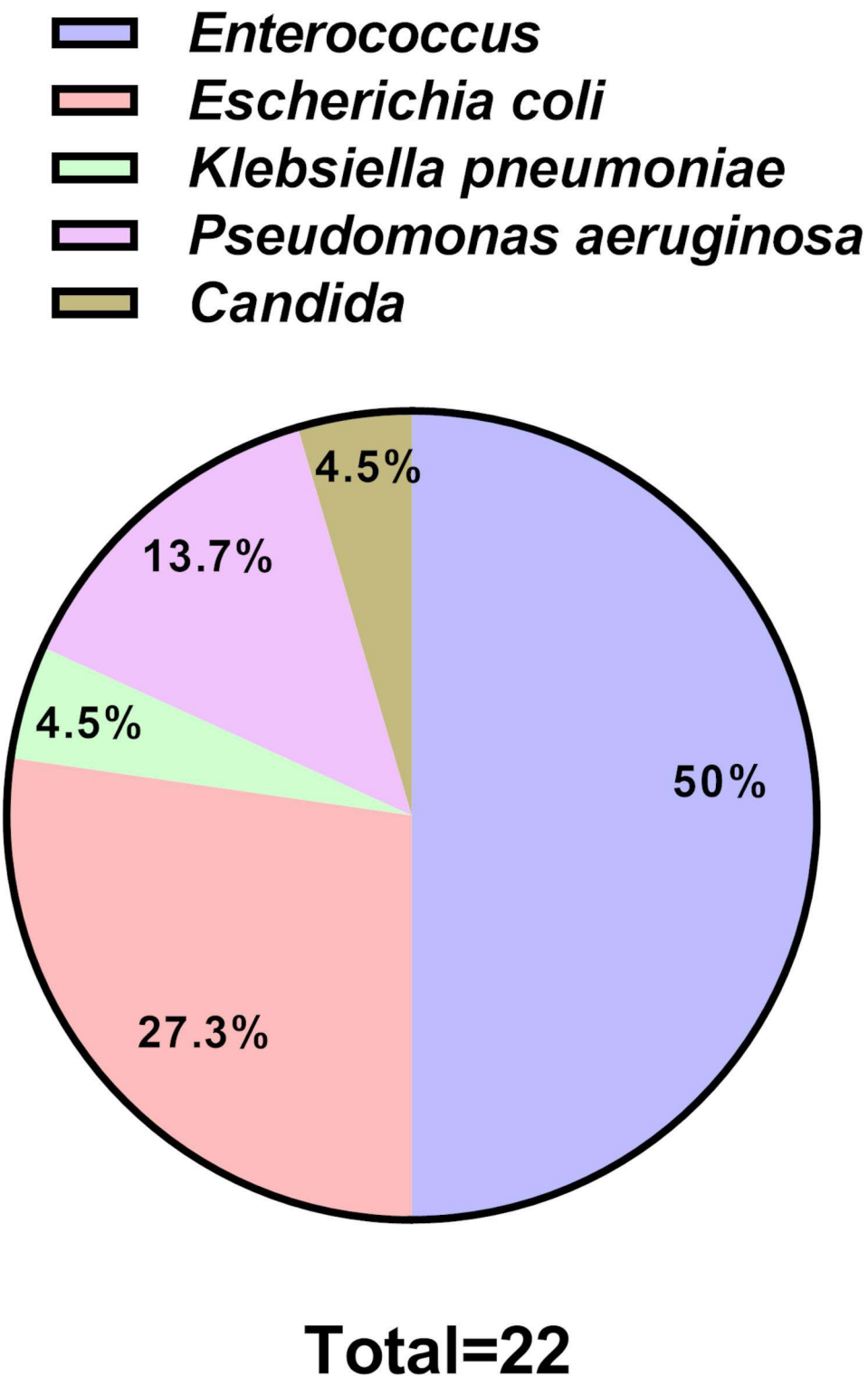

Fig. 3 The identified pathogens among patients diagnosed with fUTI

demonstrated that age (OR = 0.978, 95% CI: 0.956–0.999, $P = 0.047$), toilet training status (OR = 0.297, 95% CI: 0.109–0.807, $P = 0.017$) and PLR (OR = 1.101, 95% CI: 1.005–1.022, $P = 0.002$) were predictive factors of fUTI after DJ stent removal. The results of univariate and multivariate logistic regression analysis was listed in Table 2. To further evaluate the predictive value of PLR in fUTI after DJ stent removal, the ROC was constructed (Fig. 4).

Table 2 Univariate and multivariate logistic regression analysis of fUTI after DJ stent removal

Variable	Univariate analysis			Multivariate analysis		
	OR	95% CI	*P* value	OR	95% CI	*P* value
Gender						
Boys		Reference				
Girls	0.991	0.321–3.056	0.988			
Operation side						
Left		Reference				
Right	2.133	0.826–5.510	0.118			
Weight	0.957	0.919–0.996	0.032	1.023	0.971–1.078	0.395
Age	0.985	0.974–0.996	0.006	0.978	0.956–0.999	**0.047**
DRF	1.028	0.974–1.085	0.322			
Pre-APD	1.003	0.976–1.030	0.825			
Pre-CT	0.775	0.498–1.208	0.260			
Symptom						
No		Reference				
Yes	0.169	0.048–0.583	0.005	0.277	0.057–1.339	0.110
Toilet training						
Untrained		Reference				
Trained	0.304	0.126–0.734	0.008	0.297	0.109–0.807	**0.017**
History of UTI						
No		Reference				
Yes	1.000	-	-			
Operation time	1.001	0.991–1.011	0.826			
LOS	1.059	0.968–1.158	0.213			
NLR	1.374	1.161–1.626	< 0.001	1.408	0.868–2.282	0.165
PLR	1.016	1.010–1.022	< 0.001	1.101	1.005–1.022	**0.002**
SII	1.001	1.000–1.002	< 0.001	1.000	0.998–1.001	0.667

The results showed that PLR had a high predictive potential in fUTI after DJ stent removal, with an AUC of 0.827. The best cutoff value of PLR was 124.2, with the sensitivity of 90.91% and the specificity of 69.23%.

Discussion

As a minimally invasive treatment for UPJO, LP has achieved great popularity among surgeons. Many studies have reported that compared to open surgery, LP showed similar success and complication rates, shorter length of hospital stay and better cosmetic results [2, 3, 5]. Previous studies have reported various complications after LP, such as hematuria, flank pain and fUTI [10]. Accordingly, fUTI is one of the most common complications following LP. While the benefits of DJ stent in LP treating UPJO have been proved, it still brings some issues. As a foreign tube inserted in the body, it inevitably increased the bacterial colonization and added the risk of infection. The existing evidence indicated that the occurrence of fUTI after DJ stent removal is associated with the incidence of restenosis [11, 19]. Thus, it is of great clinical significance to explore the potential risk factors of fUTI in DJ stent removal after LP.

In present study, we explored the incidence of fUTI in pediatrics who underwent DJ stent removal after LP. Moreover, we also investigated the potential risk factors of fUTI following DJ stent removal. Overall, 295 patients were included in this retrospective study. Compared to non-fUTI group, patients in fUTI group was younger and with lower weight. In terms of preoperative blood examination, the levels of neutrophils and platelets were higher and the levels of lymphocytes were lower in fUTI group compared to non-fUTI group. Additionally, more patients with typical symptoms were in non-fUTI group. There was no significant difference between non-fUTI group and fUTI group about other variables.

In consistent with previous studies, the incidence of fUTI after DJ stent removal was 7.5% (22/295) in present study. Liu et al. [19] conducted a retrospective study, which included 503 patients and the fUTI occurred in 5.57% of the cohort. Chan et al. [20] retrospectively reviewed 152 patients and reported that eight patients (5.2%) developed UTI after RALP. Chu et al. [21] observed the incidence of UTI was 11% among pediatrics underwent RALP. However, Braga et al. [22] reported a relative lower postoperative UTI rate (2%) in open surgery series. Indeed, considering the history of preoperative UTI, accompanied vesicoureteral reflux, the status of circumcision, bladder-bowel dysfunction and the utilization of prophylactic antibiotics, the rates of fUTI after DJ stent removal varied among studies. More well-designed

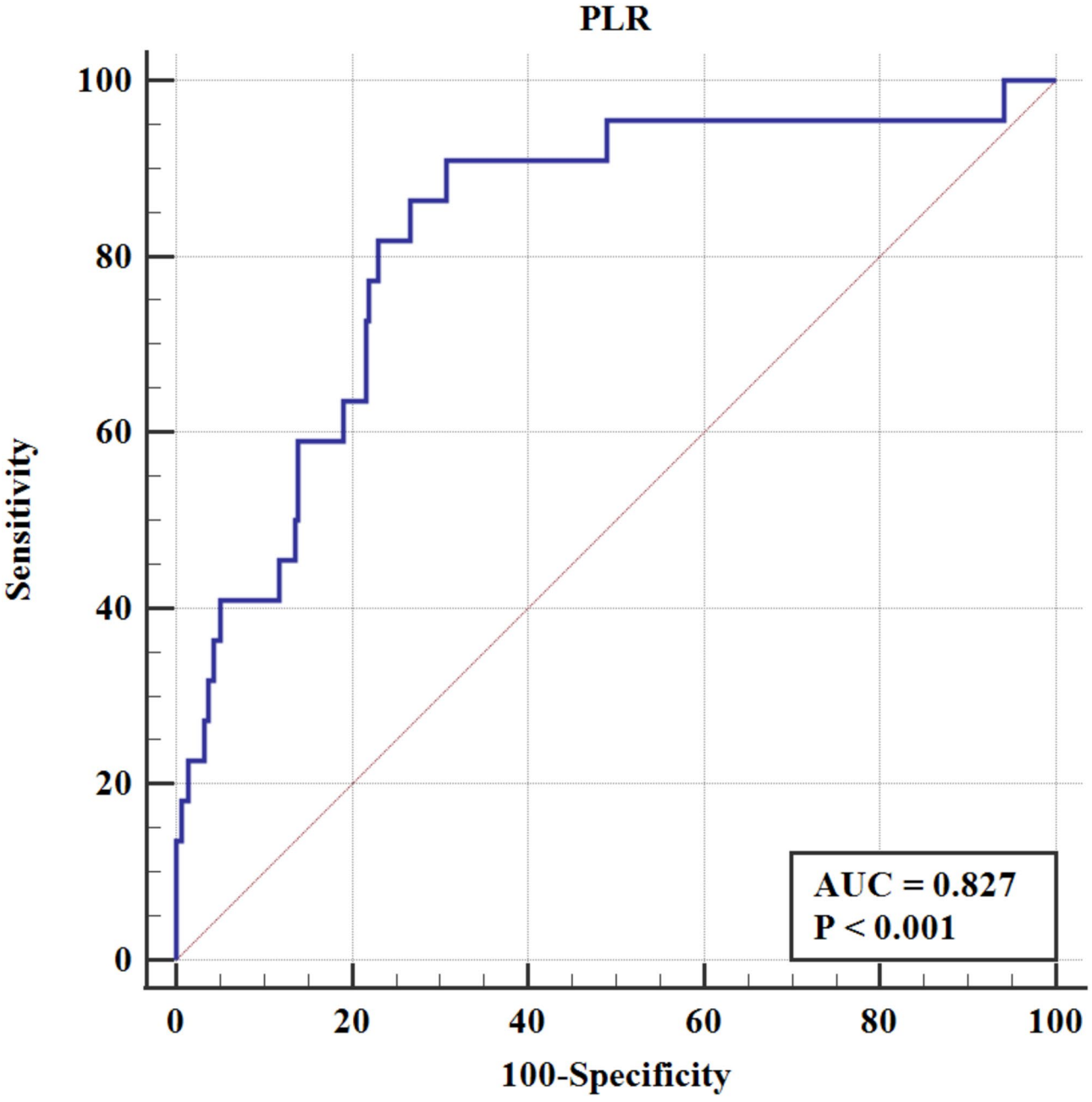

Fig. 4 The ROC of PLR in predicting fUTI after DJ stent removal

prospective cohorts are required to further investigate the incidence of fUTI after DJ stent removal.

In the study, the most commonly cultured pathogens after DJ stent removal were *Enterococcus* (50.0%), followed by *Escherichia coli* (27.3%), and *Pseudomonas aeruginosa* (13.7%). The results were similar, as Ben-Meir et al. [22] and Braga et al. [23] reported that *Enterococcus* and *Pseudomonas aeruginosa* were the main cultured pathogens, respectively. Additionally, our previous study revealed that in adults who underwent radical cystectomy and urinary diversion, the predominantly pathogens were Gram-positive *Enterococcus* [24]. For complicated UTI, the determination of pathogenic bacteria had great clinical significance for guiding antibiotics utilization. Despite the high positive rate in stent culture, studies implied that there was no link between stent culture results and the incidence of UTI. Marshal et al. [25] conducted a systematic review and meta-analysis and concluded that patients could benefit from antibiotics at the time of catheter withdraw and stent removal. Currently, according to the the American Urological Association (AUA) guidelines, prophylactic antibiotics were

recommended in patients underwent DJ stent removal, especially those with potential risk factors.

While fUTI after DJ stent removal is not uncommon in clinics, it is generally believed that many children were painful after DJ stent removal and avoided voiding, which caused urine stagnancy. Additionally, others thought that the procedure of DJ stent removal caused the transient anastomotic tissue edema, leading to the incidence of fUTI. In this study, we found that compared to non-fUTI group, fUTI group was younger and the body weight was lower. Moreover, multivariate analysis indicated that young age and PLR were independent risk factors of fUTI after DJ stent removal. In terms of risk factors of fUTI, Chan et al. [20] reported that the uncircumcised status and preoperative prophylactic antibiotics were risk factors of fUTI. While the status of circumcise was not recorded in the study, we actually observed that most fUTI series happened in children under 7 years old. The increased UTI risk in non-toilet-trained children likely reflects immature bladder function, including incomplete voiding, higher post-void residuals, and possible vesicoureteral reflux exacerbated by the stent, which could promote bacterial colonization and urinary stasis [26]. For untrained children, intensified surveillance may mitigate UTI risk and toilet training status should be considered in postoperative counseling and risk stratification.

During the process of inflammation, platelets could secrete inflammatory cytokines and promote the development of inflammation [27]. As a combined index of platelets and lymphocytes, the change of PLR value indicated the increase of platelets associated with the decrease of lymphocytes, which could better reflect the inflammatory responses. Considering that blood routine examination is economical, easy to access and contains a large amount of valuable information, it is recommended to utilize promotion in fUTI diagnosis after DJ stent removal.

There are still some limitations in the study. First, it is limited by its retrospective design, considering that only patients with unilateral primary UPJO without vesicoureteral reflux were included in the study, which inevitably leads to selection bias. Moreover, additional risk factors such as circumcision status and bladder-bowel dysfunction deserve further investigation. Thus, more multicenter, prospective studies with larger sample sizes are needed to confirm the findings and improve generalizability. Second, while the study reported the incidence of fUTI, the association between fUTI and long-term kidney function deserves further exploration. Finally, although we concluded that age and PLR were independent risk factors of fUTI, we could not provide the direct link between them. We believe that the conclusion needs to be further confirmed in a large sample study.

Conclusion

Overall, the incidence of fUTI in pediatrics underwent DJ stent removal following LP was 7.5%. The most commonly identified pathogens after DJ stent removal were *Enterococcus.* Our result demonstrated that age, toilet training status and levels of PLR were associated with fUTI after DJ stent removal. Patients with higher levels of PLR before DJ stent removal should be closely monitored.

Abbreviations

fUTI	Febrile urinary tract infection
LP	Laparoscopic pyeloplasty
UPJO	Ureteropelvic junction obstruction
PLR	Platelet to lymphocyte ratio
DJ stent	Double-J stent
IQR	Inter-quartile range
ROC	Receiver operating characteristic curve

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12894-025-01808-5.

Supplementary Material 1

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Author contributions

XL and QC designed the study. LXW, HBZ and LQH collected the data and participated in the operation. XL and JCZ conducted the statistical analysis. XL and QC draft the manuscript and YFG approved the submitted version.

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None.

Data availability

The raw data supporting the conclusions of this article will be made available by the corresponding authors on reasonable requirement.

Declarations

Ethics approval and consent to participate

The study protocol has been approved by the Research Ethics Board of Children's Hospital of Nanjing Medical University (No.202410041) and it conforms to the provisions of the Declaration of Helsinki. Informed consent to participate was obtained from the participants in the study.

Consent for publication

Consents for publication were obtained from the participants in the study.

Competing interests

The authors declare no competing interests.

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