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Original Article

Uropathogens and clinical manifestations of pyuria-negative urinary tract infections in young infants: A single center cross-sectional study

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KEYWORDS
Urinary tract infections;
Pyuria;
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Abstract *Background:* Urine leukocyte count under microscopy is one of the most frequently used routine screening tests for urinary tract infection (UTI). Nevertheless, it is observed that pyuria is lacking in 10-25% of children with UTI. This study aims to determine the factors related to pyuria-negative UTI in young infants aged under four months old.
Method: This retrospective cross-sectional study was conducted on 157 patients aged under 4 months old with UTI. All subjects had paired urinalysis and urine culture, which were collected via transurethral catheterization. According to the results of their urinalysis, the patients were then classified as UTI cases with pyuria and UTI cases without pyuria. The clinical characteristics and outcomes of both groups were analyzed.
Result: Among the 157 UTI patients, the prevalence of pyuria-negative UTI was 44%. Significant risk factors associated with pyuria-negative UTI included non-*E.coli* pathogens, younger age, shorter duration of fever prior to hospital visit, lower white blood cell (WBC) count upon hospital visit, and absence of microscopic hematuria.
Conclusions: We found that non-*E.coli* uropathogens were the strongest factor related to pyuria-negative UTI. The absence of pyuria cannot exclude the diagnosis of UTI in young

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infants, and it's reasonable to perform both urinalysis and urine culture as a part of the assessment of febrile or ill-looking young infants.

Introduction

Urinary tract infection (UTI) accounts for approximately 10—20 percent of febrile neonates and young infants.[1—4] In this group of patients, UTI can also manifest with other nonspecific symptoms and signs aside from fever. These symptoms include vomiting, neonatal jaundice, poor feeding, irritability, and foul-smelling urine.[5—7] Delayed diagnosis and treatment of UTI may lead to serious sequelaes such as bacteremia and renal scarring.[2] Therefore, UTI must be considered when young infants are presented to a clinical setting with the aforementioned symptoms and signs. Urine leukocytes count under microscopy is one of the most frequently used routine screening tests for UTI. However, it has been observed that 10—25 percent of children with symptoms consistent with UTI lack pyuria on their initial urinalysis.[8—10] As a result, the diagnosis of UTI cannot be presumed until the urine culture reveals positive results. Thus, using urine white blood cell count as a screening method could make prompt diagnosis of UTI challenging in the first place and may lead to missing a certain proportion of UTI cases, especially in febrile infants without an identifiable source. UTI in young infants is associated with serious complications. Existing literature has reported that the rate of invasive bacterial infections secondary to febrile UTI is higher in young infants than in older children, and this rate has been observed to be inversely related to age.[11,12] However, despite the high prevalence of UTI and increased risk for morbidity and mortality from UTI and urosepsis among young infants, the existing literature focusing on this age group is limited.[13,14] Therefore, our aim is to determine the factors related to pyuria-negative UTI in this cross-sectional study of young infants aged under four months old.

Methods

Enrollment of patients

This retrospective cross-sectional study was approved by the Kaohsiung Veterans General Hospital (KSVGH) institutional review board (Approval No.: KSVGH22-CT10-08). Children admitted to the pediatric ward of KSVGH between January 2012 and June 2022, and in whom UTI was considered a possibility based on clinical grounds with paired urinalysis and urine culture, were screened. Patients with bagged urine culture, indwelling catheter usage, or an unknown urine collection method were excluded from the analysis. We included only young infants under 4 months of age. Patients with known congenital anomalies of the kidney and urinary tract (CAKUT) disease, immunocompromised status, recurrent UTI, or hospital-acquired UTI that occurred after 48 h of hospitalization were also excluded.

Study design and definitions

Children with at least one of the symptoms relevant to UTI and a positive urine culture were classified as having UTI. Symptoms relevant to UTI included fever, chillness, malodorous urine, darkened urine color, urethral discharge or gross hematuria, vomiting, decreased appetite, and decreased activity or irritability, which were based on caregivers' and medical staffs' statements, and medical records. Urethral discharge was further defined as abnormal purulent or mucoid or greenish secretions on the diaper or genital area.

A positive urine culture was defined as growth of $\geq$10,000 colony-forming units (CFUs)/mL of a single uropathogen or $\geq$50,000 CFU/mL of one uropathogen and $<$10,000 CFU/mL of a second pathogen. In our study, pathogenic urogenital organisms included *Escherichia coli*, *Enterococcus* spp., *Klebsiella* spp., *Pseudomonas aeruginosa*, *Proteus* spp., *Serratia marcescens*, *Enterobacter* spp., and *Streptococcus agalactiae*. No bacterial growth or a single uropathogen $<$10,000 CFU/mL were defined as a negative urine culture. Growth of a second uropathogen with $\geq$10,000 CFU/mL, growth of $>$2 organisms, or an organism other than the aforementioned uropathogens were considered contamination and were also excluded from this study. Test for antimicrobial susceptibility was performed with a Vitek 2 automated system (Vitek AMS; bioMerieux Vitek Systems, Hazelwood, MO, USA) with ID-GN and AST-N320 cards (Durham, NC, USA) applied to the selected bacterial colony. The breakpoints of antimicrobial agents for the duration of the study period were determined according to Clinical and Laboratory Standards Institute (CLSI) guidelines.

Urine white blood cells (WBCs) and red blood cells (RBCs) were counted per high-powered microscopic field (hpf). Pyuria and microscopic hematuria were defined as $>$5 WBCs/hpf and $>$5 RBCs/hpf on microscopic urinalysis, respectively.

Variables for comparison

We reviewed the electronic and paper medical records to gather demographic and clinical data including sex, age, body weight, body height, underlying diseases, symptoms, laboratory findings upon hospital visit, imaging findings, final diagnoses, and treatments.

Statistical analysis

All statistical analyses were conducted using STATA 17. Dichotomous variables were compared using the chi-square test or Fisher's exact test. Continuous variables were expressed as means ± standard deviation and were compared using an independent samples t-test or an analysis of variance. Univariate regression was performed, and variables with p-value < 0.1 were further assessed for their association with various factors using stepwise regression. A p-value less than 0.05 was considered statistically significant.

Results

From January 2012 to June 2022, a total of 11943 patients were admitted to the KSVGH pediatric ward with paired urinalysis and urine culture. Among them, 751 patients were aged below 4 months old and had catheter-collected urine specimens. Five hundred and ninety-four patients were excluded due to known CAKUT disease, recurrent UTI, hospital-acquired UTI, and negative urine culture. As a result, 157 patients were included for further analysis (see Fig. 1).

Clinical characteristics and outcomes of young infants with UTI presenting with or without pyuria

Table 1 describes the demographic features, clinical manifestations, and outcomes of the 157 patients. Overall, 66.2% were male, and the mean age was 42.9 ± 32.8 days old. Pyuria was present in 88 (56%) patients and was absent in 69 (44%). The mean age was 57.4 ± 29 days old in UTI cases with pyuria, and 24.4 ± 27.6 days old in UTI cases without pyuria (p-value < 0.001). Compared with UTI cases with pyuria, infants with pyuria-negative UTI tended to have a shorter fever duration prior to hospital visit and were less likely to have high fever above 39 °C and malodorous urine. Infants with pyuria-negative UTI also had significantly lower serum WBC count and CRP level upon hospital visit. As for the urinalysis, fewer infants with pyuria-negative UTI had positive leukocyte esterase, nitrite, and hematuria. Sex and other symptoms including chills, darkened urine color, urethral discharge or gross hematuria, vomiting, and decreased appetite were similar between the two groups. Infants with pyuria-negative UTI also experienced earlier defervescence than UTI cases with pyuria, but the mean duration of hospitalization showed no significant difference between the two groups. Among the 138 patients who had received kidney ultrasound, the percentage of abnormalities indicating renal parenchymal involvement didn't show significant difference between the two groups. Overall, nine patients developed bacteremia as a complication of UTI, but the rate was similar between the two groups.

Overall, the most common uropathogen was *E. coli* (74.5%), followed by *Enterococcus* spp. (8.9%), *Klebsiella pneumoniae* (8.3%), and other bacteria (8.3%) including *Proteus* spp., *S. marcescens*, *Enterobacter* spp., and *S. agalactiae*. *E. coli* was more prevalent in UTI cases with pyuria (95.5% in pyuria group vs 47.8% in pyuria-negative group), whereas pathogens other than *E. coli* were more frequent in UTI cases without pyuria (4.5% in pyuria group vs 52.2% in pyuria-negative group, p-value < 0.001).

Factors associated with pyuria-negative UTI

Univariate and stepwise logistic regression revealed that non-*E. coli* infection was the factor most strongly associated with pyuria-negative UTI (adjusted odds ratios [aOR] 10.68 (2.84–40.09)). Younger age, shorter duration of fever prior to hospital visit, lower WBC count upon hospital visit, and absence of microscopic hematuria were also associated with pyuria-negative UTI (see Table 2).

Characteristics and outcomes of young infants with different uropathogens

We further divided the patients into four groups according to their uropathogens. Table 3 describes the characteristics of the four groups. The mean age of the patients infected with *E. coli* was 50.8 ± 32.6 days old, while the mean age of the patients infected with *Enterococcus* spp., *K. pneumoniae* and other pathogens were 23.4 ± 25.7 days old, 15.6 ± 15.5 days old, and 20.3 ± 17.2 days old, respectively (p-value < 0.001). There were significantly more patients infected with *E. coli* who had high fever above 39 °C, compared with patients infected with *Enterococcus* spp., *K. pneumoniae* and other pathogens. Other symptoms, including chillness, malodorous urine, urethral discharge or gross hematuria, darkened urine color, vomiting, and decreased appetite, showed no significant difference between the four groups. CRP levels upon hospital visit were significantly higher in patients infected with *E. coli*. Additionally, more patients infected with *E. coli* had pyuria and microscopic hematuria. Other laboratory examinations including WBC count, creatinine, urine specific gravity (SPG), urine pH, and urine nitrite showed no significant difference between the four groups.

The frequency of resistance to selected antibiotics was also shown in Table 3. Resistance to ampicillin/sulbactam in *E. coli* was significant (70% resistant isolates). Compared with ampicillin/sulbactam, cefazolin was more active against *E. coli* and *K. pneumoniae* (45.2% and 46.2% resistant isolates, respectively). On the contrary, only 21.4% of the *Enterococcus* spp. isolates were found to be resistant to ampicillin/sulbactam.

In children infected with *E. coli*, defervescence occurred significantly later than in children infected with *Enterococcus* spp., *K. pneumoniae* and other pathogens. There was no significant difference in the duration of hospital stay and occurrence of bacteremia between the four groups.

Discussion

In this retrospective cross-sectional study, we found that non-*E. coli* pathogens were the strongest risk factor related to the absence of pyuria. Compared to *E. coli*, the risk of pyuria-negative UTI was 10 times higher with non-*E. coli* uropathogens.

Our finding of varied pyuria rates among different uropathogens is consistent with existing literature. In the study

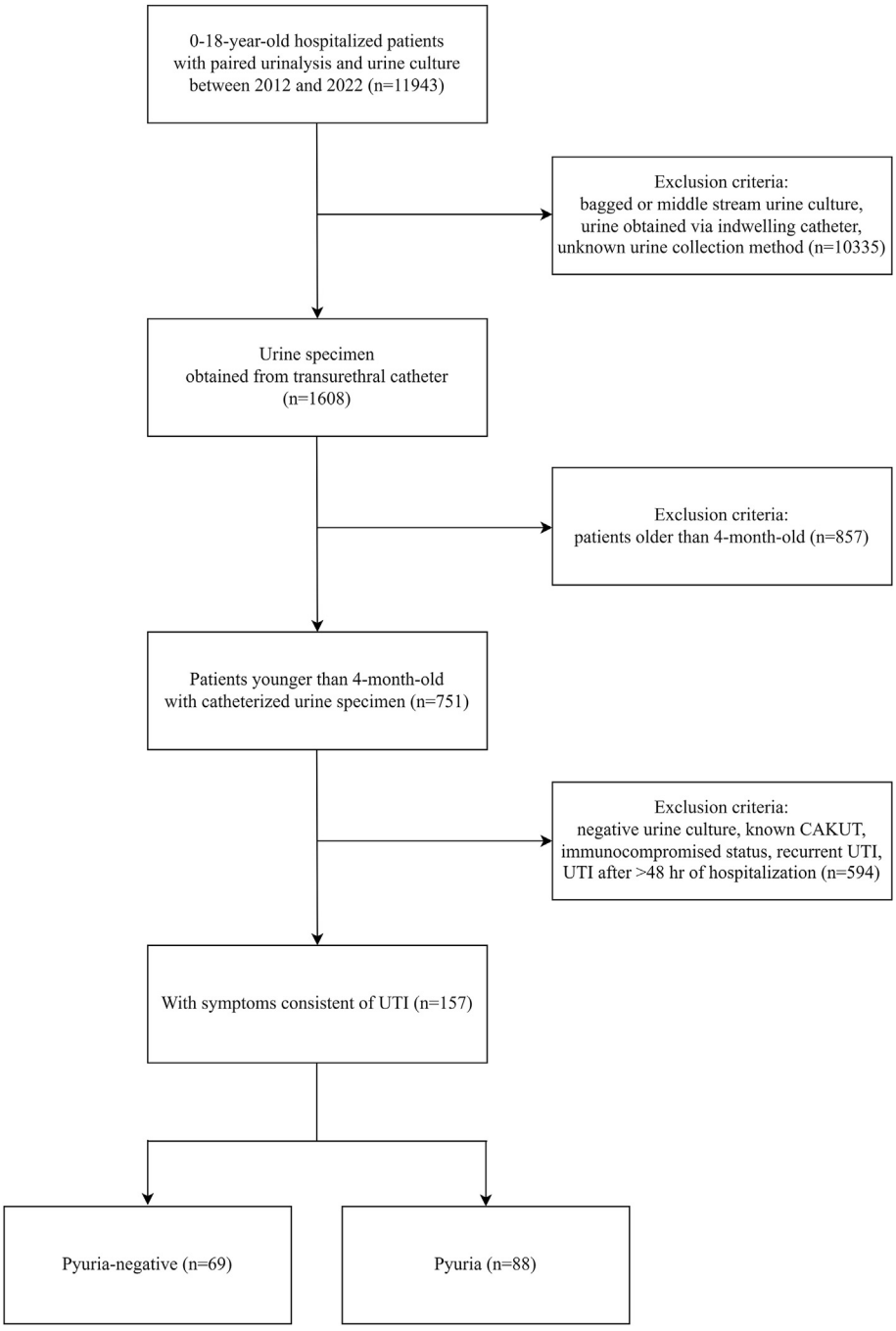

Figure 1. Flowchart of patient selection process. CAKUT: congenital anomalies of the kidney and urinary tract, UTI: urinary tract infection.

by Shaikh et al., which enrolled patients under 18 years old with UTI, pyuria was absent in 13% of patients. They found that certain uropathogens such as *Enterococcus* spp., *Klebsiella* spp., and *P. aeruginosa* were significantly less likely to exhibit pyuria than children with *E. coli*.[8] Another study by Ünsal et al., which also included patients under 18 years old with UTI, noted that 25% of patients didn't have pyuria in their urinalysis, and that the absence of pyuria was more common in patients with *Enterococcus* spp. and *Klebsiella* spp. infection.[9] Recently, Nadeem et al. further investigated UTI patients younger than 24 months old and also had similar results: pyuria was absent in 11.8% of the patients, and children with non-*E. coli* species were less likely to exhibit microscopic pyuria than children with *E. coli*, with a more pronounced effect on *Enterococcus* spp. and *Klebsiella* spp.[10]

Previous studies have mentioned that the difference in the levels of pyuria may arise from variations in host defense mechanisms and the host's immune response to different uropathogens.[8,9,15] In our study, we observed a

Table 1 Demographic characteristics, clinical manifestations, and outcomes in UTI cases with and without pyuria in infants younger than 4-month-old.

Variables	Total	With pyuria	Without pyuria	p-value
	n = 157 (%)	n = 88 (%)	n = 69 (%)	
Male	104 (66.2)	63 (71.6)	41 (59.4)	0.11
Age (day)	42.9 ± 32.8	57.4 ± 29	24.4 ± 27.6	<0.001
Body weight (kg)	4.3 ± 1.4	4.9 ± 1.2	3.6 ± 1.2	<0.001
Fever ≥39 °C	55 (35)	44 (50)	11 (15.9)	<0.001
Duration of fever prior to hospital visit (day)	0.9 ± 0.8	1.2 ± 0.9	0.5 ± 0.5	<0.001
Chillness	5 (3.2)	4 (4.6)	1 (1.5)	0.27
Malodorous urine	11 (7)	11 (12.5)	0 (0)	0.002
Darkened urine color	23 (14.7)	12 (13.6)	11 (15.9)	0.69
Urethral discharge or gross hematuria	8 (5.1)	7 (8)	1 (1.5)	0.07
Vomiting	14 (8.9)	8 (9.1)	6 (8.7)	0.93
Decreased appetite	75 (47.8)	47 (53.4)	28 (40.6)	0.11
WBC (1000/uL)	12.9 ± 4.8	14.1 ± 4.9	11.3 ± 4.3	<0.001
Neutrophil (%)	45.7 ± 15.3	47.6 ± 14.1	43.3 ± 16.6	0.09
Platelet (1000/uL)	412.9 ± 150.8	445.2 ± 143	371.7 ± 151.5	0.002
CRP (mg/dL)	3.1 ± 4.3	4.7 ± 4.6	1.2 ± 2.7	<0.001
Creatinine (mg/dL)	0.43 ± 0.3	0.37 ± 0.1	0.51 ± 0.4	0.005
Urine SPG	1.007 ± 0.00043	1.007 ± 0.00077	1.007 ± 0.00049	0.594
Urine pH	6.4 ± 0.7	6.3 ± 0.7	6.5 ± 0.7	0.04
Urine LEU	79(50.3)	66(75.9)	13(18.6)	<0.001
Urine nitrite	17 (10.8)	14 (15.9)	3 (4.4)	0.02
Microscopic hematuria	74 (47.1)	60 (68.2)	14 (20.3)	<0.001
Fever duration after antibiotics (day)	0.9 ± 0.8	1.2 ± 0.8	0.6 ± 0.7	<0.001
Duration of hospitalization (days)	9.3 ± 4.9	8.9 ± 3.6	9.8 ± 6.2	0.25
Isolated uropathogen				<0.001
E. coli	117 (74.5)	84 (95.5)	33 (47.8)	
Enterococcus spp.	14 (8.9)	1 (1.1)	13 (18.8)	
K. pneumoniae	13 (8.3)	1 (1.1)	12 (17.4)	
Other	13 (8.9)	2 (2.3)	11 (16)	
Bacteremia	9 (5.7)	6 (6.8)	3 (4.4)	0.12
Positive kidney ultrasound/total exams	45/137 (32.9)	33/87 (37.9)	12/50(24.0)	0.095

UTI: urinary tract infection, WBC: white blood cell, CRP: C-reactive protein, SPG, specific gravity, LEU, leukocyte esterase, *E. coli*: *Escherichia coli*, *K. pneumoniae*: *Klebsiella pneumoniae*.

lower occurrence of high fever, earlier defervescence, and reduced levels of CRP in the non-*E. coli* group when compared to the *E. coli* group, indicating that non-*E. coli* pathogens may not elicit a host inflammatory response as robust as *E. coli* does. A similar finding with a lower CRP level in patients with pyuria-negative UTI was also found in a Japanese study.[16]

We also found that pyuria-negative UTI was more prevalent in patients with a younger age. Prior studies have shown that compared with older age groups, in which *E. coli* is the predominant pathogen in up to 80% of UTIs, non-*E. coli* pathogens, especially *K. pneumoniae* or *Enterococcus* spp., account for approximately 50% of neonatal UTIs.[17–19] The higher prevalence of non-*E. coli* pathogens in this age group seems to be concordant with the higher proportion of pyuria-negative UTI. Another explanation is that young infants, especially neonates, possess an incompletely developed immunity and their inflammatory responses are suboptimal.[5] Hence, pyuria may be lacking in this group. Prior studies also showed that high fever was absent in nearly two-thirds of febrile neonates with UTI, and that high fever and pyuria are unreliable criteria for screening for UTIs in young infants.[2,20]

Although we didn't compare the bacterial count in the urine culture in this study, research by Kanellopoulos et al. provided an interesting speculation.[21] They found that the number of urine leukocytes was significantly greater in urine samples with a high bacterial count ($\geqq 10^5$ CFU/ml) than in those with a low bacterial count ($\leqq 5 \times 10^4$ CFU/ml), and that low bacterial count UTIs were often due to gram-negative bacteria other than *E. coli* and usually affected infants and young children. Unlike *E. coli*, whose cell receptors are distributed throughout the urinary tract and are present from birth, receptors for non-*E. coli* pathogens in uroepithelial cells are not fully expressed in young children. Consequently, the adherence of bacteria other than *E. coli* is defective. This might be the possible mechanism for a low bacterial count and therefore inadequate inflammatory response, including a lower proportion of pyuria.

Table 2 Clinical variables related to UTI cases without pyuria in young infants.

	Univariate	p-value	Stepwise	p-value
	OR (95% CI)		aOR (95% CI)	
Uropathogen				
E. coli	Reference			
Non- *E. coli*	22.90 (7.56–69.42)	<0.001	10.68 (2.84–40.09)	<0.001
Gender, male	1.72 (0.88–3.35)	0.11		
Age (day)	0.96 (0.95–0.97)	<0.001	0.98 (0.96–0.99)	0.003
Body weight (kg)	0.42 (0.31–0.58)	<0.001		
Fever ≥39 °C	0.19 (0.09–0.41)	<0.001		
Duration of fever prior to hospital visit (day)	0.16 (0.08–0.33)	<0.001	0.34 (0.14–0.84)	0.020
Chillness	0.31 (0.03–2.83)	0.30		
Darkened urine color	1.2 (0.50–2.92)	0.69		
Discharge or gross hematuria	0.17 (0.02–1.42)	0.10		
Vomiting	0.95 (0.31–2.89)	0.93		
Decreased appetite	0.60 (0.31–1.12)	0.11		
WBC (1000/uL)	0.87 (0.81–0.94)	<0.001	0.9 (0.81–0.99)	0.045
Neutrophil (%)	0.98 (0.96–1)	0.09		
Platelet (1000/uL)	0.99 (0.994–0.998)	0.003		
CRP (mg/dL)	0.66 (0.55–0.80)	<0.001		
Urine pH	1.63 (1.01–2.63)	0.045		
Urine nitrite	0.24 (0.07–0.87)	0.030		
Microscopic hematuria	0.12 (0.05–0.25)	<0.001	0.18 (0.07–0.48)	0.001

OR: odds ratio, aOR: adjusted odds ratio.

Accordingly, above findings suggest that a urine culture is a necessary part of the evaluation of febrile or ill-looking young infants, regardless of the urinalysis findings.[17,20]

A shorter fever duration was noted to be associated with pyuria-negative UTI in the present study. This observation was supported by a prior similar study conducted in Korea.[22] It was hypothesized that in patients who presented a shorter duration of fever, pyuria may be absent because urinary inflammation has not yet developed.[16,22] In Taiwan, the availability of medical services is generally sufficient, and patients often seek medical attention at hospitals within 24 hours of fever onset, particularly among young infants. Therefore, the initially collected urine sample may reveal normal findings.

Compared with the aforementioned literature, in which the prevalence of pyuria-negative UTI in children varied from 10% to 25%,[8–10] our study identified pyuria negativity in approximately 44% of young infants with UTI. This higher prevalence of the absence of pyuria may be explained by the age of the patients enrolled in our study. Uropathogens other than *E. coli* were more prevalent in neonates and young infants, as mentioned before.[9,17,20,23] Moreover, in infants who have not yet undergone toilet training, urine is not retained in the bladder for a sufficient duration for pyuria to be detected during urinalysis.[24]

In young infants, prompt antibiotic therapy is indicated for suspected UTI based on clinical findings and/or abnormal urinalysis while awaiting the culture results, and the empirical antibiotic selected should offer sufficient coverage against Gram-negative rods, particularly *E. coli*, as well as Gram-positive cocci.[5] Empirical treatment strategies should also consider local resistance patterns, which can vary between countries and hospitals.[17,25] Antibiotic resistance has been on the rise in recent years due to the emergence of extended-spectrum beta-lactamase-producing organisms.[5,25] As demonstrated in our study, the frequency of resistance to ampicillin/sulbactam (65.0%) was higher than the other antibiotics. In contrary, the combination of ampicillin or cefazolin and gentamicin could afford satisfactory coverage for the most common uropathogens including *E. coli*, *Enterococcus* spp. and *K. pneumoniae* (32.5% isolated bacteria resistant to both ampicillin/sulbactam and gentamicin, and 31.8% to both cefazolin and gentamicin). Hence, these combinations might be more suitable alternatives in empirical treatment for UTI.

The present study had some limitations. First, because bag-collected urine is susceptible to contamination by periurethral flora, with a high contamination risk of 50–60%[5,17,25], patients with bag-collected urine specimens were excluded from the study. The case number was therefore small due to many patients' urine specimens were collected using a bag. Second, not every patient had undergone image examination for the evaluation of acute pyelonephritis, and the data on ultrasound and renal scan findings were limited. Finally, though our study didn't identify specific symptoms or cut-off points of inflammatory marker values that indicate pyuria-negative UTI, we

Table 3 Characteristics, clinical manifestations, **and outcomes** in UTI cases with different uropathogens in infants younger than 4-month-old.

Variables	*E. coli*	*Enterococcus* spp.	*K. pneumoniae*	Other pathogens	p-value
	n = 117 (%)	n = 14 (%)	n = 13 (%)	n = 13 (%)	
Male	74 (63.3)	12 (85.7)	10 (76.9)	18 (61.5)	0.30
Age (day)	50.8 ± 32.6	23.4 ± 25.7	15.6 ± 15.5	20.3 ± 17.2	<0.001
Fever ≥39 °C	51 (43.6)	0	1 (7.7)	3 (23.1)	0.001
Duration of fever prior to hospital visit (day)	1.1 ± 0.8	0.3 ± 0.5	0.4 ± 0.4	0.6 ± 0.5	<0.001
Chillness	4 (3.4)	1 (7.1)	0	0	0.66
Malodorous urine	11 (9.4)	0)	0	0	0.26
Darkened urine color	18 (15.4)	3 (21.4)	1 (7.7)	1 (7.7)	0.67
Urethral discharge or gross hematuria	8 (6.8)	0	0	0	0.41
Vomiting	11 (9.4)	3 (21.4)	0	0	0.15
Decreased appetite	59 (50.4)	7 (50)	5 (38.5)	4 (30.8)	0.51
WBC (1000/uL)	13.4 ± 5	11.3 ± 3.2	11.5 ± 4.1	11.5 ± 5.3	0.19
Neutrophil (%)	47 ± 15	37.9 ± 11.4	40.9 ± 16.8	47.8 ± 18.4	0.11
CRP (mg/dL)	4 ± 4.6	0.4 ± 0.3	0.7 ± 1	1.2 ± 1.7	<0.001
Creatinine (mg/dL)	0.45 ± 0.15	0.51 ± 0.16	0.51 ± 0.16	0.4 ± 0.07	0.82
Urine nitrite	17 (14.5)	0	0	0	0.09
Pyuria	84 (71.8)	1 (7.1)	1 (7.7)	2 (15.4)	<0.001
Microscopic hematuria	65 (55.6)	4 (28.6)	3 (23.1)	2 (15.4)	0.004
Fever duration after antibiotics (day)	1.1 ± 0.8	0.3 ± 0.6	0.2 ± 0.4	0.7 ± 0.8	<0.001
Duration of hospitalization (days)	9.1 ± 4.7	9.8 ± 5.7	9 ± 2.3	10.8 ± 7.5	0.685
Resistance					
To Amp/Sul	82 (70.0)	3 (21.4)	7 (53.8)	10 (76.9)	<0.001
To Cefazolin	53 (45.2)	NP	6 (46.1)	10 (76.0)	<0.001
To Gentamicin	49 (41.9)	10 (71.4)	6 (46.1)	3 (23.1)	0.010
Positive blood culture	9(7.7)	0	0	0	0.412
Positive kidney ultrasound/total exams	39/110 (35.5)	3/8 (37.5)	1/9(11.1)	2/10(20)	0.377

E. coli, Escherichia coli, K. pneumoniae: Klebsiella pneumoniae, Amp/Sul, ampicillin/sulbactam, NP, not performed.

hope that more studies on a larger group of patients may confirm these findings, and studies focused on neonates are also anticipated.

Conclusion

In summary, we attempted to determine the prevalence of pyuria-negative UTI in young infants and evaluate the associated factors. Consistent with existing literature, we found that non-*E. coli* uropathogens are the strongest factors related to pyuria-negative UTI. Compared with the previously cited studies, pyuria-negative UTI was more prevalent among young infants in our study. The results of our study seem to be useful since UTI is common among young infants and could lead to severe complications if the diagnosis is missed and the treatment is delayed. Clinicians should keep in mind that the absence of pyuria cannot exclude the diagnosis of UTI, and it's reasonable to perform both urinalysis and urine culture, preferably collected through transurethral catheterization, as part of the assessment of febrile or ill-looking young infants.

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Credit authorship contribution statement

Li-Sang Hsu: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Resources, Writing — original draft. **Ing Chen:** Data curation, Formal analysis, Methodology. **Cai-Sin Yao:** Data curation, Formal analysis, Investigation, Methodology, Software, Visualization. **Yu-Shan Huang:** Conceptualization, Data curation, Investigation, Methodology. **Jenn-Tzong Chang:** Supervision, Writing — review & editing. **Hsiao-Ping Wang:** Supervision, Visualization, Writing —

review & editing. **Nai-Wen Fang:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Supervision, Writing — review & editing.

Declaration of competing interest

The authors declare that they have no potential conflicts of interest.

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