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Pathogen distribution and risk factors for urinary tract infection in infants and young children with retained double-J catheters

Jianfeng Wang[1,2,*], Yu Cao[3,*], Li Zhang[1,2], Guoqing Liu[1,2] and Chunjing Li[1,2]

Abstract

Objectives: To investigate the pathogens and potential risk factors for urinary tract infection (UTI) in patients with retained double-J catheters (DJCs).

Methods: In total, 107 infants and young children with DJCs were included in this retrospective analysis. Patients were included in the infection group (n = 30) or non-infection group (n = 77), according to UTI presence or absence. The species and characteristics of pathogens were investigated, and the clinical features of the patients were recorded for further analysis.

Results: Gram-negative bacilli were the most common causative pathogens (69.2%), among which *Escherichia coli* was most frequent (38.5%). The second most common causative pathogens were Gram-positive cocci (28.2%), among which *Enterococcus faecalis* was most frequent (10.3%). UTIs among patients in this study were associated with the following factors: catheter retention (long-term) (odds ratio [OR] = 2.514, 95% confidence interval [CI] = 1.176–5.373), sex (male) (OR = 2.966, 95% CI = 1.032–8.529), DJC retention (long-term) (OR = 1.869, 95% CI = 1.194–2.926), and DJC number (unilateral) (OR = 0.309, 95% CI = 0.103–0.922).

Conclusions: Infants and young children with DJCs were likely to experience UTIs, mainly caused by Gram-negative bacilli. Long-term catheter retention or DJC retention, male sex, and bilateral DJC retention were risk factors for UTI.

[1]Affiliated Foshan Maternal and Child Healthcare Hospital, Southern Medical University, Foshan, China
[2]The Second School of Clinical Medicine, Southern Medical University, Guangzhou, China
[3]Ningxiang Hospital, Hunan University of Traditional Chinese Medicine, Ningxiang, China

*Jianfeng Wang and Yu Cao have contributed equally to this work.

Corresponding author:
Chunjing Li, Affiliated Foshan Maternal and Child Healthcare Hospital, Southern Medical University, 11th Renmin Xi Road, Foshan, Guangdong 528000, P.R. China.
Email: 164194249@qq.com

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Introduction

Urinary tract infection (UTI) is a common infectious disease in children.[1] Many factors may contribute to UTI onset, including congenital diseases (e.g., vesicoureteral reflux or repetitive ureter malformation)[2] and iatrogenic factors (e.g., catheterization).[3] Patients with indwelling double-J catheters (DJCs) are more likely to experience UTI, compared with patients who lack DJCs.[4,5] Compared with older children, symptoms of UTI in infants and young children under the age of 3 years considerably differ, but the diagnosis is dependent on urine culture.[6–8] However, little is known regarding the species of pathogens and other risk factors associated with UTI onset in infants and young children with DJCs. Thus, we performed this retrospective analysis to investigate potential risk factors for UTI in patients with DJCs.

Patients and methods

Participants and UTI assessment

The protocols were approved by the institutional review board of the Foshan Maternal and Child Health Hospital (approval no. FSFY-MEC-2019-012). Infants and young children with DJCs, who were treated in Foshan Maternal and Child Healthcare Hospital from January 2014 to January 2019, were included in this retrospective analysis. The parents of all patients in the study provided written or verbal informed consent to participate. All patients provided urine bacterial cultures after admission, prior to the administration of any antimicrobial agent; only patients with negative culture results were permitted to undergo DJC insertion into the ureter. All patients provided at least one urine bacterial culture before catheter removal; urine cultures were also performed for patients with suspected UTI (>10 white blood cells [WBC]/μL) during post-discharge follow-up. Bladder urine samples were collected simultaneously for bacterial culture during DJC removal. Urine samples (5.0 mL each) used for bacterial culture were obtained by bladder catheterization or using a plastic bag attached to cleaned genitalia. Patients were classified into infection and non-infection groups according to their culture results. UTI diagnostic criteria were based on European Association of Urology Guidelines on Paediatric Urology: UTI was defined as a bacterial colony count $>10^5$ colony-forming units/mL.[9] Pathogen identification was performed using the BD Phoenix-100 automatic microbial identification analyzer (BD, Franklin Lakes, NJ, USA).

Statistical analysis

All statistical analyses were performed using IBM SPSS Statistics, version 22.0 (IBM Corp., Armonk, NY, USA). Measurement data were expressed as the mean $\pm$ standard deviation; differences regarding rates or percentages were compared by the chi-squared test. A binary logistic regression model was constructed

to identify the associations of clinical features with UTI. Risk factors were expressed using adjusted odds ratios (ORs) and 95% confidence intervals (CIs). P values <0.05 were considered statistically significant.

Results

Patient and clinical characteristics

In total, 107 infants and young children (55 boys and 52 girls) with DJCs from Jan 2014 to Jan 2019 were retrospectively analyzed in Foshan Maternal and Child Healthcare Hospital in the study. The mean age was 12.4±8.4 months (range, 3–36 months). Thirty patients were diagnosed with UTI (infection group) and 77 patients were infection-free (non-infection group). Patient age, weight, and other characteristics did not significantly differ between the two groups (Table 1). Clinical features potentially associated with UTI were examined and are summarized in Table 2.

UTI in patients and species of pathogens

Urine culture results were positive for 30 patients (Table 3); 39 strains of pathogens were detected. Six patients developed fever and were hospitalized, but none progressed to sepsis. The remaining 24 patients received oral antibiotics in an outpatient clinic. The incidence of UTI was 28.04%. The culture results exhibited a single pathogen species in 21 urine samples and two pathogen species in eight samples. In addition, fungus was detected in one patient. Gram-negative bacteria (27 strains, 69.2%) were the major pathogens and *Escherichia coli* was the dominant bacteria, followed by *Klebsiella pneumoniae* and *Pseudomonas aeruginosa*. Gram-positive cocci were the second most common causative pathogens (11 strains, 28.2%), mainly including *Enterococcus faecalis*, followed by *Enterococcus faecium* and *Staphylococcus aureus*.

Risk factors for UTI

Binary logistic regression analysis showed that the occurrence of UTI in infants and young children with DJCs was significantly associated with the following factors: catheter retention time, sex, DJC retention time, and DJC number. Among these factors, long-term catheter retention (OR = 2.514, 95% CI = 1.176–5.373; P = 0.017), sex (male) (OR = 2.966, 95% CI = 1.032–8.529; P = 0.044), and long-term DJC retention (OR = 1.869, 95% CI = 1.194–2.926; P = 0.006) were identified as risk factors for UTI; while the DJC number (unilateral) (OR = 0.309, 95% CI = 0.103–0.922; P = 0.035) was protective against UTI (Table 4).

Discussion

Infants and children with DJCs usually exhibit unclear or nonspecific symptoms when UTI occurs (e.g., only abnormal

Table 1. Patient characteristics.

		J catheter indwelling (cases)				Disease classification (cases)						
Group	Patients (cases)	Unilateral	Bilateral	Weight (kg)	Age (months)	UPJO	UVJO	EU	VUR	CM	UUTC	Others
Infection	30	22	8	10.3 ± 2.5	13.5 ± 8.0	13	3	4	5	2	1	2
Non-infection	77	62	15	9.6 ± 2.5[a]	11.9 ± 8.6[b]	37	7	9	14	5	2	3

[a]P = 0.0995; [b]P = 0.191.

CM, congenital megaureter; EU: ectopic ureter; UPJO, ureteropelvic junction obstruction; UUTC, upper urinary tract calculi; VUR, vesicoureteric reflux.

Table 2. Clinical features potentially associated with urinary tract infection.

Clinical features	Infection group (cases)	Non-infection group (cases)
Surgery time		
<1 hour	8	16
≥1 hour and <2 hours	7	30
≥2 hours and <3 hours	8	21
≥3 hours and <4 hours	7	10
Catheter indwelling time		
<3 days	4	24
≥3 days and <7 days	15	42
≥7 days	11	11
Hematuria		
Yes	22	64
No	8	13
Sex		
Male	21	34
Female	9	43
Oral antibiotics after discharge		
Never	19	38
Intermittent	8	30
Continuous	3	9
DJC indwelling time		
≥4 weeks and <5 weeks	3	24
≥5 weeks and <6 weeks	11	30
≥6 weeks and <7 weeks	8	16
≥7 weeks and <8 weeks	5	4
≥8 weeks	3	3
DJC number		
Unilateral	18	62
Bilateral	12	15

DJC, double-J catheter.

Table 3. Species of pathogens identified in 30 patients with urinary tract infection.

	Gram-negative bacteria (cases, %)				Gram-positive bacteria (cases, %)				
Pathogens	*E. coli*	KPC	PAE	Others	*E. faecalis*	*E. faecium*	*S. aureus*	Others	Fungus (cases,%)
Strains (%)	15(38.5)	5(12.8)	4(10.3)	3(7.7)	4(10.3)	2(5.1)	2(5.1)	3(7.7)	1(2.6)

E. coli, *Escherichia coli*; *E. faecalis*, *Enterococcus faecalis*; *E. faecium*, *Enterococcus faecium*; KPC, Klebsiella pneumoniae; PAE, Pseudomonas aeruginosa; *S. aureus*: *Staphylococcus aureus*.

WBC count in urine), although some patients may exhibit bacteremia.[10] For children with UTI, the WBC count in urine would be affected by DJC placement, and therefore it is inappropriate for use as a UTI diagnostic criterion.[11] Accordingly, diagnosis continues to rely on bacterial culture of urine samples.[6,9] In the present

Table 4. Logistic regression analysis of urinary tract infection in infants and young children with indwelling DJCs.

Factors	OR	95% CI	P
Surgery time			
Short versus long (each additional hour)	1.142	0.682–1.911	0.615
Catheter retention time			
Short versus long (each additional week)	2.514	1.176–5.373	0.017
Hematuria			
Yes versus no (follow-up period)	0.691	0.198–2.413	0.562
Sex			
Female versus male	2.966	1.032–8.529	0.044
Oral antibiotics after discharge			
Never versus occasional/continuous	0.695	0.331–1.460	0.337
DJC retention time			
Short versus long (each additional week)	1.869	1.194–2.926	0.006
DJC number			
Bilateral versus unilateral	0.309	0.103–0.922	0.035
Age	0.459	0.962–1.089	0.459

DJC, double-J catheter.

study, bacterial cultures were performed for all patients during hospitalization and for some patients during follow-up. Bladder urine samples for bacterial culture were also collected during DJC withdrawal. Repeated culture might avoid missed diagnosis but can also greatly improve the rate of pathogen detection; this may explain the high incidence of UTI found in our study. The main pathogens identified were Gram-negative bacilli, including *E. coli*, *K. pneumoniae*, and *P. aeruginosa*; these results were consistent with prior findings that *E. coli* is the most common causative bacteria for UTI in infants and young children.[8] Furthermore, *K. pneumoniae* is a species of opportunistic bacteria distributed in the perineum, which may easily colonize the urinary tract.[12] *P. aeruginosa* also colonizes the vulva surface and could easy enter the urinary tract.[13] Notably, Gram-positive cocci were detected in some urine samples, mainly including *E. faecalis*, *S. aureus,* and *E. faecium*. *E. faecalis* establishes a symbiotic relationship with *E. coli* and is reportedly a common pathogen in the urinary tract.[14] *S. aureus*, which adheres to the skin surface, can be introduced into the urinary tract during catheter placement.[15] *E. faecium* is likely to colonize the urinary tract because of its specialized fimbriae.[16] A strain of *Candida albicans* was also detected in a urine sample, and the presence of fungus could likely be attributed to dysbiosis caused by the long-term application of antibiotics;[17] this treatment history was confirmed by reviewing the patient's medical records.

When a catheter is inserted into the urinary tract, bacteria in the urine might adhere to the catheter wall and generate bacterial biofilms on the catheter surface. Microscopic analysis of bacterial biofilms reveals a honeycomb structure, which is difficult for antibiotics to infiltrate; the corresponding repeated antibiotic application may lead to multidrug resistance.[18] A relationship between DJC and UTI was previously reported, whereby the retention time was positively correlated with the UTI incidence.[19–21] Because DJC placement can attenuate ureteral peristalsis and cause

bladder–ureter regurgitation,[22,23] the risk of UTI is substantially increased when DJCs are placed in bilateral ureters. Our study indicated that long-term retention and indwelling of DJCs in bilateral ureters constituted risk factors for UTI. The results emphasize the need for rapid removal of DJCs, especially for patients with bilateral DJCs, to reduce the risk of UTI. Generally, bacteria distributed on the body surface do not migrate into the bladder because of the urinary tract defense mechanism, but catheter retention may disrupt this balance. Longer catheter retention is reportedly associated with a higher incidence of UTI.[24,25] In the present study, some children retained catheters for durations of longer than 1 week because they did not return to the hospital for timely catheter withdrawal after discharge. Considering the risk caused by long-term catheter retention, the catheters should be withdrawn before patient discharge when possible.

Compared with female infants and young children, male infants and young children are more likely to experience UTI due to congenital phimosis.[26] Few male infants undergo circumcision in China, although some eventually undergo this surgery in adulthood.[27] Phimosis is regarded as a risk factor for UTI.[28,29] Bacteria could colonize the prepuce cavity and cause retrograde infection.[30]

Previous studies revealed that surgery time was correlated with postoperative UTI incidence,[31,32] but our results indicated no correlation between operation time and UTI incidence. This difference could be related to multiple contributing factors. First, most operations in this study were performed by laparoscopy and involved minimal organ-related damage. Second, the included infants and young children were energetic and active; continuous physical activity after surgery reportedly helps to reduce the risk of UTI.[33] Finally, the number of urine samples from patients included in this retrospective analysis may have been insufficient.

For parents of patients with DJCs, any change in urine color after discharge could serve as a reminder to return to the hospital. Approximately 30% of cases of idiopathic hematuria are reportedly associated with UTI.[34] However, for children with DJCs, hematuria is a common complication that is unrelated to UTI.[35,36]

A previous study showed that children younger than 2 years of age were more likely to experience UTI.[37] However, our study did not find that age was a risk factor for infection. Notably, most children in this study were younger than 2 years of age (median age, 10 months); thus, differences may have been difficult to discern. To prevent UTI after discharge, some community or family physicians may prescribe antibiotics continuously or intermittently for patients with DJCs; as we noted above, bacteria in biofilm communities are difficult to kill, and oral antibiotics are reportedly ineffective for preventing catheter-related infections.[31,38] These findings were confirmed in the present study.

There were some limitations in this study. First, patients in this study only underwent urine bacterial culture analyses, rather than DJC bacterial culture analyses. It remains controversial whether simultaneous DJC cultures are necessary. Some studies have suggested that the results of DJC cultures are consistent with the results of urine culture because bacteria that colonize DJCs can be released into urine;[39,40] conversely, some studies have shown that the detection rate was much higher for DJC culture than for bladder urine culture, and the detected pathogens may differ between culture methods.[3,41] In this study, patients did not undergo both culture analyses simultaneously; thus, we could not draw a definitive conclusion regarding this point. Second, because of the limited number of cases included in this study, it

was difficult to clearly summarize any drug sensitivity characteristics.

In conclusion, infants and young children with DJCs were more likely to experience UTI, and Gram-negative bacilli were the most common causative pathogens. Rapid catheter or DJC withdrawal, especially for boys or patients with double DJCs, could aid in preventing UTI.

Declaration of conflicting interest

The authors declare that there is no conflict of interest.

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ORCID iD

Chunjing Li https://orcid.org/0000-0002-4212-2386

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