RESEARCH PAPER

Risk Factors for Catheter-Associated Urinary Tract Infections (CA-UTI) in the Pediatric Intensive Care Unit

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Objective: To describe the occurrence, microbiology, and risk factors of catheter-associated urinary tract infections (CA-UTI) in critically ill children. **Methods:** We conducted a review of hospital records for CA-UTI in the pediatric intensive care unit (PICU) over a 7-year period (2014-2020). **Results:** 62 CA-UTI cases (48% boys, median (IQR) age 36 (12,96 month) were identified during the study period with occurrence rate of 7.2/1000 catheter-days. The most common organisms were *Escherichia coli* (32.4%) and *Enterococcus faecalis* (30.6%). Using a multivariate logistic regression analysis, the significant associated variables for CA-UTI were duration of catheter drainage (a OR (95% CI) 1.14, (1.03,1.27), *P*=-0.009), PICU stay (aOR (95% CI) 1.13 (1.05,1.21) (*P*<0.001), and hospital stay (aOR (95% CI): 1.03 (1.01,1.06), *P*=0.015). **Conclusion:** CA-UTI is not an uncommon nosocomial infection in PICU. The risk increases with increasing duration of catheter drainage, and hospital or PICU stay.

Keywords: *Causes, Organisms, Outcome, Urinary catheterization*.

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Catheter-associated urinary tract infections (CA-UTI) are one of the most common nosocomial infections, accounting for 30% of healthcare-associated infections [1]. The most important predictor for CA-UTI is the duration of catheterization [2]. The acquisition of CA-UTI is associated with a three-fold increase in mortality, and with longer duration of mechanical ventilation, hospital stay and healthcare charges [3,4].

Despite multiple studies in adult literature, little is known about CA-UTI in critically ill children, especially from India. Therefore, we conducted this study to describe the occurrence, microbiology, and risk factors of CA-UTI in critically ill children admitted to the pediatric intensive care unit (PICU).

METHODS

In this case-control study, we reviewed hospital records of all patients (1month to 18 years) with CA-UTI admitted at our 12-bedded tertiary care PICU between January 1, 2014, and December 31, 2020. Clearance of the study with waiver of informed consent was obtained from the institutional review board. Patients were identified from PICU clinical database, hospital infection committee register, and electronic hospital records entered to data abstraction forms. A CA-UTI was defined as per diagnostic criteria of the Centers for Disease Control and Prevention (CDC) and National Healthcare Safety Network (NHSN) [5]. The patients either had a urinary catheter placed for more than two consecutive days with fever (>38°C), and a quantitative culture with significant growth (≥10^5 colony forming units (CFU)/mL) of one or two micro-organisms present. Duplicate cultures and those with contaminants were eliminated from the analysis. A sample was considered contaminated if more than two types of micro-organisms were isolated [6]. Apart from demographic characteristics, details of causative pathogen, their susceptibility to commonly used antibiotics were collected from the microbiology laboratory reports. The CA-UTI rate per 1000 catheter-days was calculated by dividing the number of CA-UTI episodes by the number of catheter-days and multiplying the result by 1000.

To identify risk factors that may contribute to infection, CA-UTI patients were individually matched 1:2 by gender and age (±2 year) to those with a urinary catheter but did not experience CA-UTI (control group) within the study period. The PRISM-III score was used to match for severity of illness, and case matches were matched to within ± 10 points at admission [7].

Statistical analysis: All parameters were compared between CA-UTI and control groups by independent *t*-test/Mann-Whitney test in case of continuous variables, and chi-square/Fisher exact test in case of categorical variables. A univariate followed by multivariate logistic regression was conducted to estimate the effects of PICU stay, hospital stay and catheter days on CA-UTI adjusted for significant

factors across the groups. A *P* value <0.05 was considered as significant. The statistical software R version 4.0.3 (R Core Team, 2021) was used for data analysis.

RESULTS

Among 1488 catheterizations during the study period, 62 CA-UTI were identified after excluding five patients [duplicate cultures (*n*=3), asymptomatic colonizer (*n*=1) and contaminants (*n*=1)]. The overall CA-UTI occurrence rate was 7.2/1000 catheter-days [6.9 (2014 calendar year), 5.3 (2015 calendar year), 5.6 (2016 calendar year), 4.7 (2017 calendar year), 8.9 (2018 calendar year), 7.8 (2019 calendar year), and 4 (2020 calendar year)]. While two-third (73.3%) of CA-UTI cases had one indwelling urinary catheterization during their hospital stay, 26.7% had ≥2 indwelling urinary catheterizations.

The median (IQR) age of the study population was 36 (12, 96) month and 48% were males. Sixty-two patients with CA-UTI were then matched to 120 control patients. Demographic profile of the cases and controls are described in **Table I**. The potential risk factors like neurogenic bladder and surgical procedure did not have an influence on acquiring CA-UTI, except for patients with congenital anomalies of genitourinary tract (14.5% vs 3%, *P*=0.004). The mean (SD) length of PICU stay [7.2 (2.2) vs 4.8 (2) days; *P*<0.001] and hospital stay [15.3 (2.3) vs 10.6 (2.2) days; *P*=0.012] among children with CA-UTI was longer than control group. CA-UTI patients were more likely to have catheters in place for a longer period compared to control group [mean (SD) 5 (4.29) vs 3.3 (2.8) days; *P*= 0.01].

Both in univariate analyses and multivariate analyses, none of the potential risk factors that could increase the risk of UTI influence CA-UTI rates compared to control patients. Using a multivariate logistic regression analysis, the three variables associated with acquiring CA-UTI were duration of catheter drainage [aOR (95% CI) 1.14 (1.03,1.27); *P*=0.001], PICU stay [aOR (95% CI) 1.13 (1.05,1.21); *P*=0.001], and hospital stay [aOR (95% CI) 1.03 (1.01,1.06); *P*=0.015] (**Table II**). The odds of CA-UTI occurrence increased by 14% for each additional day the catheter remained in situ.

Table I Baseline Characteristics of Children in the Pediatric Intensive Care Unit Enrolled in the Study

Characteristic	*CA-UTI (n=62)*	*Non-CA-UTI (n=120)*
Age[a]	36 (12,96)	42 (14,84)
Male	30 (48.4)	58 (49)
PRISM III[b]	7.2 (5.5)	7 (4.2)
Potential risk factors		
CAKUT [c]	9 (14.5)	3(2.5%)
History of neurogenic bladder	3 (6.2)	2(1.7)
Surgical procedures	6 (9.8)	9(7.6)
Hemoglobin (g/dL)[b]	9.7 (2.47)	10.1 (1.43)
Total WBC ($\times10^9$/L)[a]	13.59 (6.7,18.56)	15.74 (8.76,18.7)
Platelets[a] ($\times10^9$/L)	220 (94,3.13)	272 (1.0,4.03)
Catheter days [b,c]	5 (4.29)	3.3 (2.8)
PICU length of stay (d)[b,d]	7.2 (2.2)	4.8 (2)
Hospital length of stay (d) [b,c]	15.3 (2.3)	10.6 (2.2)
Mortality	11 (17.7)	10 (8.3)

Data presented as no. (%), [a]median (IQR) or [b]mean (SD). [c]P<0.05; [d]P=0.001. CA-UTI: catheter associate urinary tract infection, CAKUT: congenital anomalies of the urinary tract; PICU: pediatric intensive care unit; PRISM: pediatric risk of mortality; WBC: white blood count.

The most common isolated organisms were *Escherichia coli* (32.4%), *Enterococcus faecalis* (30.6%), *Klebsiella pneumoniae* (9.6%), candida non-albicans (13%), *Candida albicans* (3.2%), and pseudomonas (4.8%) (**Fig.1**). Gram-negative infections were multidrug-resistant with limited sensitivity to piperacillin-tazobactam (40%) and meropenem (60%), and maximum sensitivity to aminoglycosides (70%) and colistin (90%) (**Web Fig 1a** and **1b**).

DISCUSSION

In this study conducted in critically ill children, the occurrence rate of CA-UTI was 7.2/1000 catheter days, slightly higher than other studies [8,9]. The occurrence of CA-UTI varied from 4 to 8.9/1000 catheter days from 2014-2019, dropping again to 4/1000 catheter days in 2020. The

Table II Risk Factors for Catheter-Associated Urinary Tract Infection

Variable	*OR (95% CI)*	*P value*	*aOR (95% CI)*	*P value*
CAKUT	6.2 (1.53, 25.14)	0.004	0.66 (0.08,5.23)	0.696
Catheter days	1.13 (1.02,1.26)	0.013	1.14 (1.03,1.27)	0.009
PICU stay[a]	1.1 (1.04,1.17)	<0.001	1.13 (1.05,1.21)	<0.001
Hospital stay[a]	1.03 (1.01,1.06)	0.016	1.03 (1.01,1.06)	0.015

CAKUT: congenital anomalies of kidney and urinary tract; PICU: pediatric intensive care unit. [a]Length of stay.

WHAT THIS STUDY ADDS?

- Longer duration of catheter drainage, longer pediatric intensive care unit (PICU) stay, and longer hospital stay were the three major risk factors for catheter-associated urinary tract infections in children admitted to a tertiary level PICU.

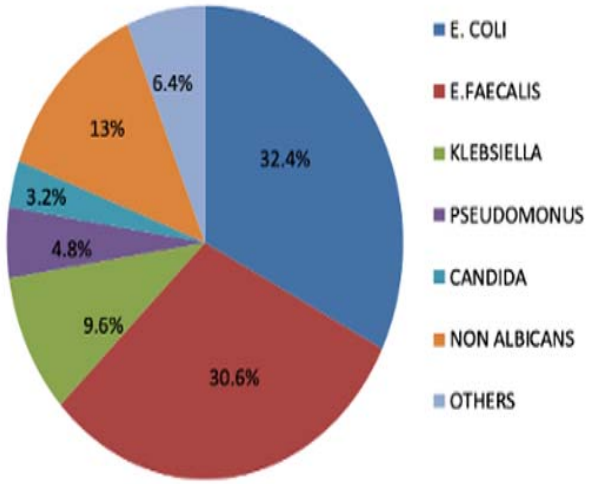

Fig. 1 Various pathogens isolated causing CA-UTI among children in the pediatric intensive care unit (*n*=62).

lower rate of CA-UTI in the last year of the study is likely due to the introduction of quality-improvement initiative to reduce hospital-acquired infections in that year.

Previous studies have also reported male preponderance in their cohort [10,11]. However, Goudie, et al. [12] published a study with a similar demographic profile as our group with females experiencing CA-UTI and a high incidence among children between 1- 4 years of age. Similar to our results, other authors have also shown strains of MDR Gram negative bacteria causing CAUTI [13,].

Factors associated with CA-UTI, identified in our study, have also been previously reported [12,14]. The duration of catheterization appeared to be contributing additively to the odds of the occurrence of CA-UTI, with an 14% increase in odds for each consecutive day that the catheter was left in place. The data is consistent with the adult study by Lo, et al. [2], which showed a 3-7% risk of bacteriuria for every additional day the catheter is left in place [2]. The relationship between length of stay and duration of catheterization with risk for CA-UTI has also been described in previous adult study [15].

Our study has inherent limitation of case-control design. Due to this limitation, we were unable to evaluate for potential confounding risk factors for CA-UTI, including antibiotic exposure, prior hospitalizations, and urinary tract infections, especially if patients sought their care at other institutions. Although these patients were found to have longer PICU stay and hospital stay, with presumed CA-UTI, it was difficult to determine whether these effects were due to the primary disease or the UTI.

CA-UTI is not an uncommon hospital acquired infection with common pathogens being *E. coli* and *E. faecalis.* The three most common risk factors for acquiring CA-UTI were duration of catheter drainage, length of PICU stay and hospital stay. Further research is needed to elucidate the factors associated with CAUTIs among critically ill children.

Ethics clearance: IEC, St John's Medical College; No. 94/2019 dated March 14, 2019.
Note: Additional material related to the study is available with the online version at *www.indianpediatrics.net*
Contributors: LAV: contributed to data collection, analysis of the data and writing of the manuscript. MP: contributed to study design, analysis of data and writing of the manuscript; SV: contributed to critical review of the manuscript; and SG: contributed to statistical analysis and review of the manuscript. All authors approved the final version of manuscript and are accountable for all aspects related to the study.
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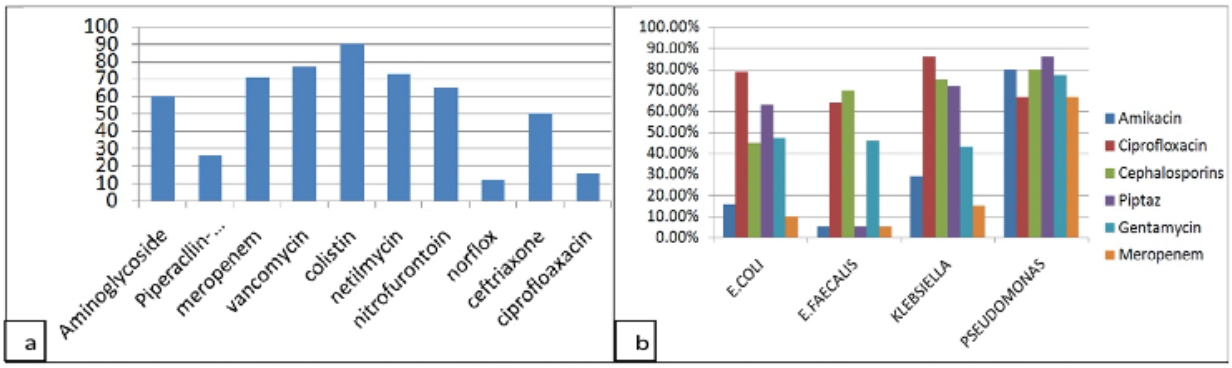

Web Fig. 1 *a)* Antibiotic sensitivity and *b)* resistance pattern among different microbes isolated from children with catheter-associated urinary tract infections in the pediatric intensive care unit.