The Impact of Catheter-Associated Urinary Tract Infection (CA-UTI) in Critically Ill Children in the Pediatric Intensive Care Unit

Ravi S. Samraj¹ Erika Stalets¹ John Butcher¹ Theresa Deck¹ James Frebis¹ Alma Helpling¹
Derek S. Wheeler¹

¹ Division of Critical Care Medicine and Pediatric Intensive Care Unit, Cincinnati Children's Hospital Medical Center, Cincinnati, Ohio, United States

Address for correspondence: Derek S. Wheeler, MD, MMM, Division of Critical Care Medicine and Pediatric Intensive Care Unit, Cincinnati Children's Hospital Medical Center, 3333 Burnet Avenue, Cincinnati, OH 45229-3039, United States (e-mail: derek.wheeler@cchmc.org).

J Pediatr Intensive Care 2016;5:7–11.

Abstract

Objective Catheter-associated urinary tract infections (CA-UTIs) comprise a significant proportion of hospital-acquired infections. However, the impact of CA-UTIs on important outcome measures, such as length of stay (LOS) and hospital charges, has not been examined in the pediatric intensive care unit (PICU) setting.

Design Single-center, retrospective, case-matched, cohort study and financial analysis.

Setting PICU in a tertiary-care children's medical center.

Patients A total of 41 critically ill children with CA-UTIs and 73 critically ill children without CA-UTI, matched for age, gender, severity of illness, and primary admission diagnosis.

Interventions None.

Measurements and Main Results We compared the length of hospital stay (LOS in PICU and in hospital), mortality, and hospital costs in critically ill children with CA-UTIs and their matched controls. Critically ill children experiencing CA-UTI had significantly longer PICU LOS, hospital LOS, duration of mechanical ventilation, and mortality compared with matched controls without CA-UTI. The longer LOS resulted in higher PICU and hospital charges in this group.

Conclusion Critically ill children with CA-UTI experience worse outcomes in the PICU compared with those without CA-UTI. Further studies on the impact of CA-UTI in the PICU are warranted.

Keywords

- catheter-associated urinary tract infections
- hospital-acquired infection
- increased health care costs
- patient safety
- quality improvement

Introduction

Health care–associated infections (HAIs) are a major threat to patient safety and quality of care. For example, 1.7 million HAIs in the United States in 2002 alone resulted in over 98,000 deaths.¹ Previous estimates suggest that there are nearly 2 million HAIs in the United States every year,^{2,3} costing the U.S. health care system between \$5 and \$10 billion annually.⁴ At least one-third of these infections are considered preventable.⁵

Nosocomial urinary tract infections (UTIs) are one of the most common HAIs reported in the United States and Canada, and are also among the most common HAIs reported in critically ill patients.^{6,7} Nosocomial UTIs have been associated with a threefold increase in mortality,⁸ as well as significantly increased length of hospital stay and cost.^{6,9,10} The vast majority of nosocomial UTIs are associated with the presence of a urinary catheter, that is, catheter-associated urinary tract infections (CA-UTIs).¹¹ A previous systematic

received
January 11, 2015
accepted after revision
July 12, 2015
published online
November 30, 2015

Copyright © 2016 by Georg Thieme
Verlag KG, Stuttgart · New York

DOI <http://dx.doi.org/10.1055/s-0035-1568148>.
ISSN 2146-4618.

review concluded that 79.3% of all nosocomial UTIs would be prevented if routine urinary catheterization was not performed.¹² By far, the strongest predictor for CA-UTI is the duration of urinary catheterization.¹³

The National Nosocomial Infection Surveillance System reported the overall prevalence of CA-UTI in pediatric intensive care units (PICUs) of 4.0 per 1,000 urinary catheter days.¹⁴ However, to our knowledge, there are no studies demonstrating the morbidity and financial impact of CA-UTI in critically ill children in the PICU setting. Since CA-UTI has been included as one of the hospital-acquired complications that will not be reimbursed by the Centers for Medicare and Medicaid Services, there has been renewed interest in studying the impact of CA-UTI.¹⁵ Additionally, CA-UTI is frequently included with other HAIs (e.g., central line-associated bloodstream infections, ventilator-associated pneumonia [VAP]) and hospital-acquired conditions (e.g., codes outside the ICU, serious safety events, wrong-site surgeries, etc.) that are frequently associated with significant mortality and morbidity in aggregate measures of preventable harm.^{16,17} Whether CA-UTI has the same impact as these other conditions has not been consistently shown. Accordingly, we conducted a retrospective, case-matched cohort study to determine whether CA-UTI was associated with increased PICU length of stay (LOS), hospital LOS, and increased health care charges in critically ill children.

Materials and Methods

Setting

Cincinnati Children's Hospital Medical Center is a 598-bed academic, quaternary-care, freestanding children's hospital. It is the only pediatric hospital in the Greater Cincinnati area and serves as a primary referral center for an eight-county area in southwestern Ohio, northern Kentucky, and southeastern Indiana. Critically ill children are admitted to either the 24-bed cardiac intensive care unit (CICU) or the 35-bed PICU. The PICU admits over 2,200 children every year, including critically ill children following trauma, solid organ (kidney, liver, small bowel, multivisceral) transplant, cancer, and bone marrow transplant.

Study Design

We conducted a retrospective, case-matched, cohort study comparing the PICU and total hospital LOS and health care costs between critically ill children with CA-UTI and their matched controls without CA-UTI. The study was approved by our institutional review board, and the need for informed consent was waived in view of the retrospective nature of our study. We reviewed all cases of CA-UTI occurring in patients admitted to the PICU at our institution over a period of 5 years between January 1, 2006, and December 31, 2010. CA-UTI cases were identified using our hospital's Infection Control database and were cross-matched with our PICU clinical database. Patients admitted to the CICU were not included in this analysis.

Case Definition

CA-UTI was defined according to the definition issued by the Centers for Disease Control and Prevention (CDC) and National Healthcare Safety Network (NHSN).¹⁸ Accordingly, all the cases in our study were identified by the presence of indwelling urinary catheter for more than 24 hours at the time of infection, presence of fever, and a positive urine culture of $\geq 10^5$ colony-forming units (CFU)/mL with no more than two species of microorganisms. All our cases involved positive urine cultures, and we did not include any diagnosis of UTIs which were culture negative.

Criteria for Identifying Controls for CA-UTI Patients

We used the same methodology and similar matching criteria used in previous studies performed at our institution.^{19–21} We identified case-matched controls for our analysis based upon age, gender, severity of illness, duration of urinary catheterization (days), and primary diagnosis (underlying organ dysfunction). If a case had more than one CA-UTI during their hospitalization, they were matched based on their first CA-UTI episode only. Case-matched controls were identified as close in time as possible (i.e., during the same calendar year of admission to the PICU) to the CA-UTI patient, in terms of index admission. Wherever possible, we matched CA-UTI patients to at least two control patients. Age was matched to within ± 3 months, if possible. If this was not possible, we matched according to age group criteria (i.e., infant ≤ 12 months of age, child > 1 year and ≤ 8 years of age, preadolescent > 8 years and ≤ 12 years of age, and adolescent > 12 years of age). Duration of urinary catheterization was matched to within ± 2 days. Primary admission diagnostic category was based on organ dysfunction and was classified into six categories—postoperative, gastrointestinal, respiratory, neurologic, sepsis/shock, and miscellaneous medical. The Pediatric Risk of Mortality (PRISM)-III score was used to match for severity of illness.²² Case-matches were matched to within ± 10 points of the PRISM score. Matches of cases and controls were reviewed by two of the investigators (R. S. S. and D. S. W.) for appropriateness.

Data Collection

Patient data were collected from the PICU clinical database. Primary demographic data including age, gender, severity of illness, primary diagnosis, and duration of urinary catheterization before the CA-UTI were obtained. Data were also collected regarding hospital LOS, PICU LOS, duration of mechanical ventilation (i.e., ventilator days), and survival to PICU discharge (PICU mortality). Financial data for each case and control were obtained from the hospital accounting database. Charges were calculated for hospital LOS in FY 2006 dollars. The charges and LOS attributable to an occurrence of CA-UTI were calculated using the difference of median charge and LOS between CA-UTI patients and controls. The CA-UTI rate per 1,000 urinary catheter days was calculated by dividing the number of CA-UTIs by the number of catheter days and multiplying the result by 1,000. The urinary catheter utilization ratio was calculated by dividing the number of urinary catheter days by the number of patient days.

Statistical Analysis

All of the clinical data were collected and recorded into a password-protected Microsoft Excel 2010 database (Microsoft, Redmond, Washington, United States). Statistical analysis was performed using Stata/SE 11.2 (StataCorp LP, College Station, Texas, United States). Parametric continuous data were compared using the Student's *t*-test. Nonparametric continuous data were compared using the Wilcoxon signed-rank test. Categorical data were compared using the χ^2 or the Fisher exact test as appropriate. A *p*-value ≤ 0.05 was considered statistically significant for all comparisons.

Results

During the period of study (January 1, 2006, through December 31, 2010), there were 10,092 patients admitted to our PICU for a total of 43,624 ICU days. Of these patients, 5,751 patients had an indwelling urinary catheter at some point of time during their PICU stay, resulting in a urinary catheterization utilization ratio of 0.38. We identified 51 episodes of CA-UTI in 49 critically ill children during the study period (representing 0.5% of all admissions). There were 16,971 total urinary catheter days during the study period, resulting in a CA-UTI rate of 3.0 CA-UTI per 1,000 catheter days. One patient had three episodes of CA-UTI during the same hospital admission (one episode represented incomplete treatment), and only the first episode was included in the study. No controls could be identified for eight patients based on all of our five

matching criteria, and these patients were excluded from further analysis. We therefore collected and analyzed data from 41 patients with CA-UTI. We identified 73 matched controls without CA-UTI during the same study period. Two controls were identified for each of 32 CA-UTI patients, and one control was identified for each of 9 CA-UTI patients. There were no significant differences between the case and control patients with respect to age, gender, severity of illness, total urinary catheter days (before the infection), or primary admission diagnosis (►Table 1). We used the total number of urinary catheter days before infection in the CA-UTI group as a surrogate marker of exposure risk (i.e., greater number of urinary catheter days indicates a greater risk for CA-UTI). Importantly, the median total number of urinary catheter days in the CA-UTI group (which included the number of days both before and after the infection) was 9 (interquartile range: 5–16) days, suggesting that the urinary catheters were removed shortly after the infection was identified (*data not shown*).

Etiology of CA-UTI

All the patients with CA-UTI in our study had a microbiological diagnosis. Only one organism was isolated from urine culture in 46 patients, while the remaining 5 patients had two organisms isolated (note that all 51 CA-UTI episodes are included in these numbers). The sample was drawn from a urinary catheter, which was indwelling for at least 24 hours, in accordance with the CDC/NHSN diagnostic criteria. The most common pathogens responsible for CA-UTI in our study are listed in ►Table 2.

Table 1 Demographic characteristics and outcomes, CA-UTI versus control

	CA-UTI group (N = 41)	Control group (N = 73)	p-Value
Age (mo), median (IQR)	21 (7, 94)	22 (6, 106)	0.97
Gender (M:F)	12:29	24:49	0.69
PRISM score, median (IQR)	8 (3, 12)	7 (3, 12)	0.86
Risk of mortality (%), median (IQR)	2.8 (0.6, 8.4)	2.3 (0.8, 6.2)	0.77
Urinary catheterization days, median (IQR)	7.5 (4, 14)	8 (4, 13)	0.96
Primary diagnosis, n (%)			
Respiratory	12 (29)	31 (42)	0.66
Postoperative	9 (22)	16 (22)	
Neurologic	9 (22)	13 (18)	
Gastrointestinal	5 (12)	8 (11)	
Sepsis/shock	3 (7)	3 (4)	
Miscellaneous	3 (7)	2 (3)	
Deaths, n (%)	7 (17)	4 (5)	0.04
PICU LOS, median (IQR)	22 (12, 38)	13 (5, 21)	0.0001
Ventilator days, median (IQR)	18 (10, 29)	8 (3, 15)	<0.0001
Hospital LOS, median (IQR)	55 (28, 106)	26 (12, 57)	0.0006
Hospital charges, median (IQR)	\$201,237 (\$91,790, \$347,337)	\$104,504 (\$43,503, \$200,307)	0.003

Abbreviations: IQR, interquartile range; LOS, length of stay; PRISM, Pediatric Risk of Mortality.

Note: Urinary catheterization days before the infection (in the CA-UTI) group versus the total number of urinary catheterization days in the control group.

Table 2 Microorganisms causing CA-UTI in our cohort

Organism	n = 56 (%)
<i>Candida</i>	20 (36%)
<i>Escherichia coli</i>	11 (20%)
<i>Pseudomonas</i>	8 (14%)
<i>Enterococcus</i>	4 (7%)
<i>Proteus</i>	4 (7%)
<i>Enterobacter</i>	3 (5%)
<i>Klebsiella</i>	2 (4%)
Coagulase-negative <i>Staphylococcus</i>	1 (2%)
<i>Citrobacter</i>	1 (2%)
<i>Torulopsis glabrata</i>	1 (2%)
<i>Acinetobacter</i>	1 (2%)

Impact of CA-UTI

The mortality in the CA-UTI group was significantly higher (17%) compared with the control group (5%) ($p = 0.04$). In addition, PICU LOS, duration of mechanical ventilation, and hospital LOS were also significantly higher in the CA-UTI group. Finally, total hospital charges were also significantly greater in the CA-UTI group compared with the control group (►Table 1). CA-UTI therefore was associated with increased duration of mechanical ventilation (by ~10 days), increased PICU LOS (by ~9 days), increased hospital LOS (by ~29 days), and increased hospital charges (by approximately \$96,733).

Discussion

CA-UTIs are one of the most common HAIs reported in hospitalized patients. Traditionally, these infections have been considered relatively benign in terms of the level of harm experienced by an individual patient,²³ but our results suggest that CA-UTIs may have a greater impact, at least in critically ill children, than previously realized. In our cohort, the patients in the CA-UTI group had significantly longer duration of mechanical ventilation, mortality, PICU LOS, hospital LOS, and health care charges (as a surrogate measure for costs). Given the fact that the vast majority of CA-UTIs are largely preventable,¹² these results suggest that quality improvement efforts targeting CA-UTIs may improve outcomes and reduce costs of care in the PICU.

The presence of a urinary catheter and the length of time it is left in place are the two most important risk factors for CA-UTI. Unfortunately, enough attention is not paid to the necessity of inserting a urinary catheter or to remove it when it is no longer needed. Adverse effects associated with indwelling urinary catheters include increases in health care costs, LOS, morbidity, and mortality.^{4,8,9,13,24,25} A recent nationwide survey showed that more than half of hospitals did not have a system for monitoring urinary catheters. Three-fourths of the hospitals did not monitor the duration of urinary catheterization, and nearly one-third of the hospitals did not conduct any surveillance for UTIs.²⁶

Previous studies in the adult population have shown increased costs related to CA-UTI. Increased costs are a consequence of a longer stay in the hospital, increased medical care, associated therapy, and associated complications. While an episode of CA-UTI can cost an additional \$1,000 in care for each patient,^{27,28} if it is associated with bacteremia secondary to CA-UTI the estimated costs can be significantly higher. In our study, we did not measure hospital costs. The measurement of true costs is not feasible—therefore, we used hospital charges as a surrogate marker for hospital costs in our study. Regardless, the results of our study suggest that CA-UTI may be associated with higher hospital charges (and therefore likely hospital costs). Studies that have looked at financial impact have used the costs related to diagnosis and treatment of CA-UTI, not taking into account other costs related to increased hospital stay and associated costs. A single episode of CA-UTI in a relatively healthy patient would not be expected to increase the health care costs and hospital LOS to the degree observed in our study. However, the impact of CA-UTI in critically ill children, many of whom have some element of immune suppression or immune dysfunction, is likely even greater than what we observed in the current study if it is associated with bacteremia and other systemic complications.

The hospital charges we found in the current study were much higher than in our previously published VAP²⁰ and catheter-associated bloodstream infection studies.²¹ While we used similar methods to analyze charges, we would like to avoid comparisons between the three studies, as there were some minor differences in how we approached the economic analysis in each study. Regardless, the fact that charges were significantly higher in the CA-UTI group compared with the matched control group is noteworthy and provides justification for further study.

Limitations of Our Study

Our study has inherent limitations, with the retrospective nature of our study being the most obvious. Our patient population is very heterogeneous and it is very difficult to match patients and controls precisely. However, we tried to match them as closely as possible with the data available in our PICU clinical database. While we matched for primary diagnosis, severity of illness, age, and gender, there are potentially other differences that we did not account for between the cases and controls. Alternatively, our matching criteria may have failed to discern subtle differences in the patient's severity of illness, which could have accounted for some of the differences in duration of mechanical ventilation, PICU and hospital LOS, and mortality. For example, other authors have utilized propensity scoring to match cases and controls.²⁹ We used an alternative strategy which has been used in the past.^{20,21} However, given the limitations of our study design, further studies are necessary. Regardless, we feel that the results of our study do at least justify a renewed focus on reduction of CA-UTI in the PICU, which was the primary reason for completing the study. CA-UTIs necessitate antimicrobial treatment, with all of the attendant risks of adverse drug events, increased selection pressure for

microbial resistance, etc. Given these potential risks, as well as the association between CA-UTI and longer LOS and costs, CA-UTIs may have a greater impact on quality of care than previously believed.^{26,30,31}

Conclusion

Our study provides data to suggest that CA-UTIs in critically ill children have a greater degree of importance than perhaps previously realized. In our study, children with CA-UTIs had significantly increased hospital costs and LOS as well PICU costs and LOS when compared with children without CA-UTI. This study provides at least some preliminary data about the potential for increased morbidity and health care costs related to CA-UTI in critically ill children. Further studies are certainly warranted. In the current era of rising medical costs, Medicaid changes pertaining to nonreimbursement of hospital-acquired infections and more importantly the potential for increased morbidity and potential patient harm, due diligence should be given to prevention of CA-UTI.

Conflicts of Interest

None.

References

- Klevens RM, Edwards JR, Richards CL Jr, et al. Estimating health care-associated infections and deaths in U.S. hospitals, 2002. *Public Health Rep* 2007;122(2):160–166
- Kung HC, Hoyert DL, Xu J, Murphy SL. Deaths: final data for 2005. *Natl Vital Stat Rep* 2008;56(10):1–120
- Peleg AY, Hooper DC. Hospital-acquired infections due to gram-negative bacteria. *N Engl J Med* 2010;362(19):1804–1813
- Stone PW, Hedblom EC, Murphy DM, Miller SB. The economic impact of infection control: making the business case for increased infection control resources. *Am J Infect Control* 2005;33(9):542–547
- Yokoe DS, Mermel LA, Anderson DJ, et al. A compendium of strategies to prevent healthcare-associated infections in acute care hospitals. *Infect Control Hosp Epidemiol* 2008;29(Suppl 1):S12–S21
- Chenoweth CE, Saint S. Urinary tract infections. *Infect Dis Clin North Am* 2011;25(1):103–115
- Patrick SW, Kawai AT, Kleinman K, et al. Health care-associated infections among critically ill children in the US, 2007–2012. *Pediatrics* 2014;134(4):705–712
- Platt R, Polk BF, Murdock B, Rosner B. Mortality associated with nosocomial urinary-tract infection. *N Engl J Med* 1982;307(11):637–642
- Givens CD, Wenzel RP. Catheter-associated urinary tract infections in surgical patients: a controlled study on the excess morbidity and costs. *J Urol* 1980;124(5):646–648
- Laupland KB, Bagshaw SM, Gregson DB, Kirkpatrick AW, Ross T, Church DL. Intensive care unit-acquired urinary tract infections in a regional critical care system. *Crit Care* 2005;9(2):R60–R65
- Laupland KB, Zygun DA, Davies HD, Church DL, Louie TJ, Doig CJ. Incidence and risk factors for acquiring nosocomial urinary tract infection in the critically ill. *J Crit Care* 2002;17(1):50–57
- King C, Garcia Alvarez L, Holmes A, Moore L, Galletly T, Aylin P. Risk factors for healthcare-associated urinary tract infection and their applications in surveillance using hospital administrative data: a systematic review. *J Hosp Infect* 2012;82(4):219–226
- Plowman R, Graves N, Esquivel J, Roberts JA. An economic model to assess the cost and benefits of the routine use of silver alloy coated urinary catheters to reduce the risk of urinary tract infections in catheterized patients. *J Hosp Infect* 2001;48(1):33–42
- National Nosocomial Infections Surveillance System. National Nosocomial Infections Surveillance (NNIS) System Report, data summary from January 1992 through June 2004, issued October 2004. *Am J Infect Control* 2004;32(8):470–485
- Saint S, Meddings JA, Calfee D, Kowalski CP, Krein SL. Catheter-associated urinary tract infection and the Medicare rule changes. *Ann Intern Med* 2009;150(12):877–884
- Brilli RJ, McClead RE Jr, Davis T, Stoverock L, Rayburn A, Berry JC. The Preventable Harm Index: an effective motivator to facilitate the drive to zero. *J Pediatr* 2010;157(4):681–683
- Crandall WV, Davis JT, McClead R, Brilli RJ. Is preventable harm the right patient safety metric? *Pediatr Clin North Am* 2012;59(6):1279–1292
- Centers for Disease Control and Prevention. Catheter-Associated Urinary Tract Infection (CAUTI) Event. Atlanta, GA: Centers for Disease Control and Prevention; 2013 [cited June 1, 2012]. Available at: <http://www.cdc.gov/nhsn/PDFs/pscManual/7pscCAUTI-current.pdf>
- Sparling KW, Ryckman FC, Schoettker PJ, et al. Financial impact of failing to prevent surgical site infections. *Qual Manag Health Care* 2007;16(3):219–225
- Brilli RJ, Sparling KW, Lake MR, et al. The business case for preventing ventilator-associated pneumonia in pediatric intensive care unit patients. *Jt Comm J Qual Patient Saf* 2008;34(11):629–638
- Nowak JE, Brilli RJ, Lake MR, et al. Reducing catheter-associated bloodstream infections in the pediatric intensive care unit: business case for quality improvement. *Pediatr Crit Care Med* 2010;11(5):579–587
- Pollack MM, Patel KM, Ruttimann UE. PRISM III: an updated Pediatric Risk of Mortality score. *Crit Care Med* 1996;24(5):743–752
- Langley JM, Hanakowski M, Leblanc JC. Unique epidemiology of nosocomial urinary tract infection in children. *Am J Infect Control* 2001;29(2):94–98
- Lo E, Nicolle L, Classen D, et al. Strategies to prevent catheter-associated urinary tract infections in acute care hospitals. *Infect Control Hosp Epidemiol* 2008;29(Suppl 1):S41–S50
- Brindha SM, Jayashree M, Singhi S, Taneja N. Study of nosocomial urinary tract infections in a pediatric intensive care unit. *J Trop Pediatr* 2011;57(5):357–362
- Saint S, Kowalski CP, Kaufman SR, et al. Preventing hospital-acquired urinary tract infection in the United States: a national study. *Clin Infect Dis* 2008;46(2):243–250
- Institute for Improvement. Reducing Catheter-Associated Urinary Tract Infections. Boston, MA: Institute for Healthcare Improvement; 2009 [cited January 1, 2010]. Available at: <http://www.ihl.org/IHI/Programs/ImprovementMap/PreventCatheterAssociatedUrinaryTractInfections.html>
- Centers for Disease Control and Prevention. The Direct Medical Costs of Healthcare-Associated Infections in US Hospitals and the Benefits of Prevention. Atlanta, GA: Centers for Disease Control and Prevention; 2009 [cited May 1, 2013]. Available at: http://www.cdc.gov/ncidod/dhqp/pdf/Scott_Cost.Published March 2009
- Goudie A, Dynan L, Brady PW, Rettiganti M. Attributable cost and length of stay for central line-associated bloodstream infections. *Pediatrics* 2014;133(6):e1525–e1532
- Harrod M, Kowalski CP, Saint S, Forman J, Krein SL. Variations in risk perceptions: a qualitative study of why unnecessary urinary catheter use continues to be problematic. *BMC Health Serv Res* 2013;13:151
- Krein SL, Kowalski CP, Harrod M, Forman J, Saint S. Barriers to reducing urinary catheter use: a qualitative assessment of a statewide initiative. *JAMA Intern Med* 2013;173(10):881–886