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Impact of a Daily PICU Rounding Checklist on Urinary Catheter Utilization and Infection

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ABSTRACT

Introduction: In critically ill children, inappropriate urinary catheter (UC) utilization is associated with increased morbidity, including catheter-associated urinary tract infections (CAUTIs). Checklists are effective for reducing medical errors, but there is little data on their impact on device utilization in pediatric critical care. In this study, we evaluated UC utilization trends and CAUTI rate after implementing a daily rounding checklist. **Methods:** A retrospective review of our checklist database from 2006 through 2016 was performed. The study setting was a 36-bed pediatric intensive care unit in a quaternary-care pediatric hospital. Interventions included the "Daily QI Checklist" in 2006, ongoing education regarding device necessity, and a CAUTI prevention bundle in 2013. UC utilization and duration were assessed via auto-correlated time series models and Cochran-Armitage tests for trend. Changes in CAUTI rate were assessed via Poisson regression. **Results:** UC utilization decreased from 30% of patient-days in 2006 to 18% in 2016 ($P < 0.0001$, Cochran-Armitage trend test), while duration of UC use (median, 2.0 days; interquartile range, 1–4) did not change over time ($P = 0.18$). CAUTI rate declined from 9.49/1,000 UC-days in 2009 to 1.04 in 2016 ($P = 0.0047$). **Conclusions:** Implementation of the checklist coincided with a sustained 40% reduction in UC utilization. The trend may be explained by a combination of more appropriate selection of patients for catheterization and improved timeliness of UC discontinuation. We also observed an 89% decline in CAUTI rate that occurred after stabilization of UC utilization. These findings underscore the potential impact of a checklist on incorporating best practices into daily care of critically ill children. *(Pediatr Qual Saf 2018;3;e078; doi: 10.1097/pq9.0000000000000078; Published online May 18, 2018.)*

INTRODUCTION

Infection of the urinary tract represents a major contributor to hospital-associated morbidity, comprising 32% of all health care–associated infections (HAIs) and 13% of deaths due to health care–associated infections.[1] The greatest risk factor for urinary tract infection in the hospital setting is the presence of a urinary catheter (UC),[2] with 70–80% of urinary tract infections attributable to indwelling UCs.[3] In turn, catheter-associated tract urinary infections (CAUTIs) markedly increase duration of hospitalization, cost, and mortality risk.[4,5] Despite their prevalence and impact, 65–70% of CAUTIs are preventable.[6] The Centers for Medicare and Medicaid Services does not reimburse hospitals for CAUTIs,[7] a significant position, given that CAUTIs cost inpatient hospital services approximately $400 million in 2002 according to a Centers for Disease Control (CDC) analysis.[8] As a result of the cost, morbidity, and potential for prevention of CAUTIs, there is significant financial and ethical impetus for health care institutions to reduce CAUTI rates.

A variety of methods of reducing CAUTIs have been reported and evaluated in the literature. A series of Cochrane reviews found that specialized drainage systems and antimicrobial catheter materials are not sufficient to significantly reduce CAUTI rates.[9,10] Indeed, the CDC recommends against using complex urinary drainage systems and only recommends using antimicrobial-impregnated catheters as a second-line measure after implementing other CAUTI reduction strategies.[11] The CDC also strongly recommends avoiding unnecessary UC placement and decreasing the duration that the UC is left in place. Unfortunately, unnecessary initiation of UCs is common, with as many as half of UCs being placed without an appropriate indication.[12] In addition, prolonged catheterization results in the formation of pathogenic biofilms on the catheter surface, which serve as a nidus for infection.[13,14] CAUTI rates rise linearly

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with increasing duration of catheterization.[15] Conversely, decreasing inappropriate UC placement and duration not only reduces CAUTIs, but also reduces other forms of morbidity associated with UC use including urethral stricture, mobility impairment, gross hematuria, and urine leakage.[16,17]

Like other medical errors, inappropriate or prolonged urinary catheterizations are avoidable events sensitive to quality improvement interventions. Checklists are an effective tool for safeguarding against preventable medical errors and for improving compliance with best practices in a variety of settings.[18,19] For example, a 2014 review by Simpson et al.[20] found that the use of bundled interventions including a checklist was associated with lower rates of central-line–related bloodstream infections in critically adults.[20] In another intensive care study, Berenholtz et al.[21] estimated that the use of a checklist prevented 43 catheter-related bloodstream infections, 8 deaths, and $1.95 million in additional costs per year.[21] Checklists have also been shown to reduce UC utilization and CAUTIs specifically. A study evaluating the effect of a UC indication checklist in an emergency department found that the introduction of the checklist coincided with a 75% reduction in the number of UCs placed over a 5-year period and a 22% decrease in inappropriate UC placement.[22] In an adult critical care setting, another study investigating the effect of a checklist on the use of indwelling UCs demonstrated a significant reduction in the duration of catheterization and occurrences of CAUTIs.[23] A similar study demonstrated that implementation of a daily rounding checklist in an adult intensive care unit reduced UC utilization by 15%.[24]

Although the vast majority of studies on UC utilization have focused on adults, CAUTIs are also an important source of morbidity in hospitalized children. Indeed, CAUTI rates in both critical care and general inpatient settings are similar for adult and pediatric populations.[25] The few pediatric investigations that have been carried out are promising. A small study investigating the impact of a daily safety checklist in a pediatric intensive care unit (PICU) reported a significant reduction in UC-days over a 21-month period.[26] Additionally, 2 studies investigating the impact of comprehensive quality improvement programs reported drops in CAUTI rate from 23.3 to 5.8/1,000 and 5.41 to 2.49/1,000 catheter-days in pediatric critical care and hospital-wide settings, respectively.[27,28] The present study sought to add to this body of evidence by assessing trends in UC utilization and CAUTI rate after implementing a daily multi-professional verbalized checklist in a high-volume, quaternary-care PICU.

METHODS

Study Setting
The study was approved by the Institutional Review Board of Children's Healthcare of Atlanta (CHOA) and took place in the PICU of Children's Healthcare of Atlanta at Egleston, an academic, quaternary-care hospital. The PICU is a 36-bed combined medical/surgical (noncardiac) unit housed within the 272-bed pediatric hospital. It is equipped to care for children from 0 to 21 years of age with standard critical illnesses in addition to continuous renal replacement therapy, organ transplantation, and extracorporeal life support. Patients are rounded on each morning by a multidisciplinary team including a pediatric critical care medicine attending, fellow, resident, nurse, respiratory therapist, nutritionist, and pharmacist.

Intervention
A PICU Daily QI Checklist was developed in 2006 (Fig. 1). The checklist was developed internally via collaboration between physician and nursing leadership. It was initially on paper and subsequently was converted to a Microsoft Access database available to the attendings and fellows. It is completed during daily morning rounds by a physician member of the multidisciplinary team at the conclusion of bedside rounding, before moving to the next patient. For every patient in the PICU, the physician, usually a fellow, verbally reviews the checklist with each patient's nurse while the full team is still present. Responses to the checklist are based on the status of the patient at rounding time, not on what was planned for the day. For example, a sedation holiday was marked "yes" only if it was performed within the previous 24 hours; a device was marked present only if it was still in place at the time of rounding. The PICU Daily QI Checklist was implemented in January 2006. In August 2009, the PICU began tracking CAUTIs in a separate database. In January 2013, the critical care department joined the Solutions for Patient Safety. As part of this collaborative, efforts to cultivate a nurse-driven, "one is not zero" culture were implemented in addition to a formal urinary tract infection prevention bundle. Components of the bundle include aseptic insertion technique, avoiding unnecessary utilization, maintaining a closed drainage system, perineal hygiene, bag placement below level of bladder with unobstructed flow, removal when no longer needed, and catheter securement. As these changes were made, the tracking of device-days transformed into daily discussion of device necessity aimed to reduce device utilization where appropriate.

Study Design and Outcomes
A retrospective review of our checklist database from April 2006 through December 2016 was performed. PICU patients were selected if they had a UC at any point in their PICU stay. Device utilization ratio was calculated as UC-day per patient-day. Duration of catheterization was expressed as median UC-days per patient admission. To control for variability in admission time, duration was also assessed as the ratio of UC-days to length of stay (LOS). CAUTI rate was calculated as the number of infections per 1,000 catheter-days.

Statistical Analysis
Descriptive statistics including proportions and medians [interquartile range (IQR)] were used to characterize

Fig. 1. PICU daily rounding checklist.

the study population. Median descriptive statistics were reported instead of means due to nonnormal distributions and large variances in estimates. Cochran-Armitage trend tests were used to assess changes in overall UC catheter utilization, measured as the proportions of device days per total patient days. Trends in UC duration (median device days per patient's admission and ratio of device days to total LOS per patient admission) were evaluated with auto-correlated time series models using monthly intervals. Similar methods were used to assess trends in checklist compliance. Compliance for the UC portion of the checklist was determined by dividing the number of patients for whom a response to the "Foley?" item (Fig. 1) was recorded by the total number of patients in the database. Compliance data for the CAUTI bundle was not available. In addition to Pediatric Risk of Mortality (PRISM) and Pediatric Index of Mortality 2 (PIM2) scores, which were only available for years 2011 to 2015, illness severity was approximated by percentage of ventilation days. Durbin-Watson statistics for autocorrelation were checked, and model residuals were assessed for normality. To examine overall CAUTI rate differences across years, rates were modeled using a Poisson model with year as a categorical predictor. Rate differences between different years were assessed by looking at differences in least-squares mean rates. A statistical process control chart (u-chart) created with QI Macros was also plotted to examine variation in the monthly CAUTI rate following implementation of the bundle. Standard definitions for determining centerline shifts and upper and lower control limits were used. All statistical testing was

conducted using SAS 9.4 (Cary, N.C.). Significance was assessed at the 0.05 level.

RESULTS

UC data from 22,644 admissions (16,316 unique patients) with 94,398 patient-days from April 2006 to December 2016 were included in the analyses. UC utilization decreased from 30% (1,379 device days per 4,640 patient days) in 2006 to 18% (1,900 device days per 10,762 patient days) in 2016 (Table 1; Fig. 2). This statistically significant decline (Cochran-Armitage Trend Test: Z = -24.36, $P < 0.0001$) was sustained throughout the study period. Key interventions are annotated in Figure 2. Among 5,906 admissions who had a UC at any point during their PICU course, median (25th to 75th) UC days was 2.0 (1–4) and the average %UC-days/LOS was 60.5%. Duration of catheterization (Table 1) for admissions with a UC, expressed as median UC-days per admission or as the average % UC-days/LOS per admission, did not change over time (autoregressive models: β-estimate for month = 0.0001, $P = 0.18$; $\beta = 0.001$, $P = 0.07$, respectively). There were a total of 38,719 ventilation days, with 41% of patient days ventilated on average per total annual patient days; this did not change over time. Checklist compliance remained above 98% for the entire study period and did not change over time (Table 1). From 2011 to 2015, PIM2 scores (median, 0.98% in 2011 Q1 and 0.78% in 2015 Q4, $P = 0.07$) decreased slightly, although not significantly, whereas PRISM scores did not significantly change (0.41% in

Table 1. Summary of Patient UC Utilization and Duration Over Time

Variable	Overall	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	P*
All patients													
Admissions (#)	22,644	1,098	1,554	1,655	1,985	1,941	2,089	2,232	2,262	2,428	2,540	2,860	
Total patient days	94,398	4,640	6,982	7,999	8,456	8,411	8,585	9,421	9,182	9,592	10,368	10,762	< 0.0001
Percent UC days (% of total)	21	30	29	25	23	19	18	20	21	19	18	18	< 0.0001
Ventilated days (% of total)	41	41	44	46	39	40	38	40	43	42	43	36	0.44
Checklist compliance (%)	99.0	98.6	98.3	99.0	98.8	99.2	99.6	99.6	99.7	98.4	99.1	99.1	0.25
Median (IQR) LOS (d)	2 (1–4)	2 (1–5)	3 (1–5)	3 (1–5)	2 (1–5)	2 (1–5)	2 (1–4)	2 (1–4)	2 (1–4)	2 (1–4)	2 (1–4)	2 (1–4)	
Patients with UC													
Admissions (#)	5,906	409	600	562	543	511	530	560	587	525	534	545	
Median (IQR) UC Days†	2 (1–4)	2 (1–4)	2 (1–4)	2 (1–4)	2 (1–4)	2 (1–3)	2 (1–4)	2 (1–4)	2 (1–4)	2 (1–4)	2 (1–4)	2 (1–4)	0.18
Median (IQR) LOS (d) †	4 (2–9)	4 (2–8)	5 (2–9)	5 (2–11)	4 (2–9)	4 (2–9)	4 (2–8)	4 (2–9)	4 (2–9)	4 (2–9)	4 (2–9)	5 (2–10)	0.16
Total UC days per LOS (mean %)†	60.5	61	58	57	61	58	62	63	62	63	62	59	0.07

*P where applicable: Cochran-Armitage trend test or P from β-time in auto-correlated regression models (month interval for time series analysis).

†Per patient admission; results aggregated by year in table (monthly intervals used in time series models for more granular analyses, for example, 11 years versus 129 months).

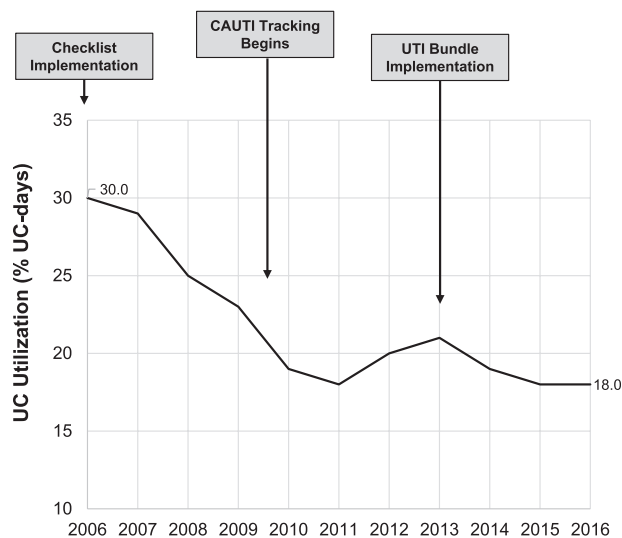Note: UC, urinary catheter; IQR, interquartile range; LOS, length of stay; d, days.

Fig. 2. UC utilization and interventions over time. Cochran-Armitage Trend Test: Z = -24.36, P < 0.0001.

2011 Q1 to 0.45% 2015 Q4; P = 0.78). CAUTI rate per 1,000 UC-days declined significantly from 9.49/1,000 UC days in 2009 to 1.04 in 2016 (P = 0.0047). Using August 2009 through December 2013 as the baseline period, there was a significant decrease in the monthly CAUTI rate in January 2015, 2 years after CAUTI bundle implementation (5.05/1,000 UC-days before January 2015 to 1.05/1,000 UC-days, Fig. 3).

DISCUSSION

Prolonged and/or unnecessary use of UCs represents a major source of morbidity in hospitalized patients, including in critically ill children.[29] Daily rounding checklists are simple and effective tools for reducing medical errors and improving patient outcomes. Several studies have demonstrated the utility of checklists in the reduction of UC utilization in adult populations. However, there is a relative paucity of data in pediatric patients, especially in

the intensive care setting. In the present study, we evaluated changes in UC utilization and CAUTI rate following the implementation of a PICU Daily QI Checklist (Fig. 1).

We observed a 40% reduction in UC utilization within the first 5 years following introduction of the checklist. This reduction was sustained for the remainder of the study, suggestive of more appropriate patient selection and timely removal. Over the same period, PICU volume significantly increased yet PRISM scores, PIM2 scores, and utilization rates for mechanical ventilation did not change (Table 1), effectively ruling out changes in illness severity as a driver of the decline in utilization. In addition, the introduction of safety culture-change efforts and the CAUTI prevention bundle in 2013 occurred after UC utilization had stabilized, making them unlikely contributors to utilization reduction. Interestingly, median duration of catheterization remained unchanged over time. Of the admissions with a UC, the percentage with short (younger than 2 days) and long (older than 5 days) catheterizations also did not change over time (P-trend = 0.28, P-trend = 0.55, respectively), indicating that the distribution of durations also remain unchanged. One explanation for this finding is that with daily directed attentiveness to UC necessity, unwarranted device initiation has been minimized for children admitted to the PICU. Understandably, there is a population of critically ill children for whom UC is necessary to aid in management and that is reflected in the finding that patients who did have an UC while in the PICU also had a longer median LOS (Table 1).

We also examined whether the decline in UC utilization was related to changes in CAUTI rate, which is associated with prolonged hospitalization, increased cost, and increased mortality in critically ill children.[4,30] From 2009, when data became available, to 2016, there was an 89% decline CAUTI rate. This decline occurred after the UC utilization rate had reached its nadir, suggesting that the low utilization rate may haven a precondition for the reduction in CAUTI rate but was not the main driver. Instead, as illustrated in Figure 3, there was a shift in the
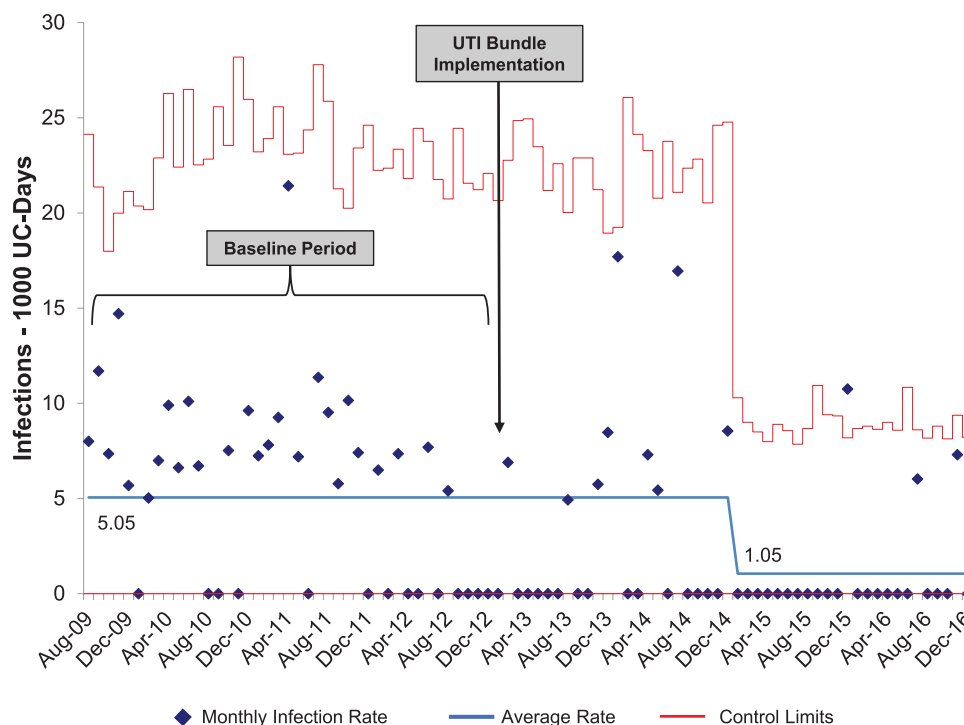
Fig. 3. Control chart of CAUTIs over time. After the baseline period of August 2009 through December 2012, a change in mean CAUTI rate (centerline shift) occurred in January 2015 according to standard statistical process control rules.

mean CAUTI rate following CAUTI bundle implementation, implying that the bundle was a driving factor. The long latency between bundle implementation and change in the centerline suggests that other UC management practices initiated over this time period, such as disinfecting port protectors and establishing that urine cultures would be performed only if the urinalysis is consistent with infection, also contributed to the reduction in CAUTI rate.

A major strength of this study is that the longitudinal nature of our database allowed us to analyze a large dataset: 94,398 patient-days among 22,644 admissions. By comparison, a previous study assessing the effect of a checklist on device utilization in a PICU included only 4,001 patient-days among 660 admissions.[26] Observations in our PICU are consistent with the previous study's finding that UC utilization declined by 26% following the introduction of the checklist. Additionally, we have shown that this decrease has been sustained during the observed study period.

Our checklist has a number of features that may have contributed to its success. First, it was developed specifically for our practice setting, taking into account the needs of our PICU. Second, the checklist was integrated into morning rounds, rather than requiring a separate encounter. Consequently, it did not appreciably increase provider workload or require a data collector. Third, we used the checklist to spark a discussion regarding whether a UC was still appropriate for the patient, whether the catheter could be removed and, if not that day, what milestones should be achieved to reconsider removal. This experience is corroborated by prior investigations documenting

improvement in attention to patient safety following quality improvement checklist implementation.[31] Finally, we employed computerized physician prompting, a technique shown to both increase checklist compliance and decrease patient morbidity.[32]

Limitations of this study include the lack of a preintervention period before checklist implementation, which makes it impossible to attribute a causal relationship between the checklist and UC utilization. It is plausible that the reduction in catheter use is a consequence of larger trend in the intensive care unit. Additionally, CAUTI data were not available until 2009, so we were unable to assess the association between the initial decline in UC utilization and CAUTI rate. Finally, the study was conducted at a large, academic, quaternary care center and therefore may not be generalizable to all intensive care settings.

In conclusion, implementation and daily use of a PICU rounding checklist coincided with a significant reduction in UC utilization. This reduction, along with other quality improvement interventions including an infection prevention bundle, was followed by a significant decline in CAUTI rate. Taken together, these findings highlight the potential value of checklists in the incorporation of best practices into daily care of critically ill children and underscore the need for further evaluation of checklists in this vulnerable population.

DISCLOSURE

The authors have no financial interest to declare in relation to the content of this article.

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