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Original Article

Effect of a urine culture stewardship initiative on urine culture utilization and catheter-associated urinary tract infections in intensive care units

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Abstract

Objective: Urine cultures have poor specificity for catheter-associated urinary tract infections (CAUTIs). We evaluated the effect of a urine-culture stewardship program on urine culture utilization and CAUTI in adult intensive care units (ICUs).

Design: A quasi-interventional study was performed from 2015 to 2017.

Setting and patients: The study cohort comprised 21,367 patients admitted to the ICU at a teaching hospital.

Intervention: The urine culture stewardship program included monthly 1-hour discussions with ICU house staff emphasizing avoidance of "pan-culture" for sepsis workup and obtaining urine culture only if a urinary source of sepsis is suspected. The urine culture utilization rate metric (UCUR; ie, no. urine cultueres/catheter days ×100) was utilized to measure the effect. Monthly UCUR, catheter utilization ratio (CUR), and CAUTI rate were reported on an interactive quality dashboard. To ensure safety, catheterized ICU patients (2015–2016) were evaluated for 30-day readmission for UTI. Time-series data and relationships were analyzed using Spearman correlation coefficients and regression analysis.

Results: Urine culture utilization decreased from 3,081 in 2015 to 2,158 in 2016 to 1,218 in 2017. CAUTIs decreased from 78 in 2015 to 60 in 2016 and 28 in 2017. Regression analysis over time showed significant decreases in UCUR (r, 0.917; $P < .0001$) and CAUTI rate (r, 0.657; $P < .0001$). The co-correlation between UCUR and CAUTI rate was (r, 0.625; $P < .0001$) compared to CUR and CAUTI rate (r, 0.523; $P = .004$). None of these patients was readmitted with a CAUTI.

Conclusions: Urine culture stewardship program was effective and safe in reducing UC overutilization and was correlated with a decrease in CAUTIs. Addition of urine-culture stewardship to standard best practices could reduce CAUTI in ICUs.

Catheter-associated urinary tract infection (CAUTI) is one of the most common healthcare associated infections (HAIs).[1] CAUTI is associated with higher morbidity, prolonged hospitalization and increased healthcare cost.[2] Most CAUTIs occur in intensive care units (ICUs), which partly reflects higher utilization of urinary catheters in the critical care setting.[3] Evidence-based, best-practice guidelines have focused on education, appropriate utilization, optimal insertion, and maintenance of urinary catheters to prevent CAUTIs.[4] Fever and bacteriuria are prevalent in catheterized ICU patients, and a positive urine culture often represents colonization.[5–7] Inappropriate urine culture testing in catheterized patients can lead to overutilization of laboratory resources, over diagnosis of CAUTI, antibiotic overuse, and antimicrobial resistance.[7]

Guidelines from the American College of Critical Care Medicine and the Infectious Diseases Society of America for evaluation of fever in the critically ill adults note that catheter-associated bacteriuria is rarely a cause of fever, unless the patient has urinary tract obstruction, recent urologic manipulation, or is granulocytopenic.[7] Furthermore, the guidelines recommend that urine culture be done only if clinical evaluation indicates the urinary tract as the source of fever.[7]

In 2013, a urinary-catheter best-practice bundle was implemented in our institution that emphasized appropriate use of urinary catheter and optimization of catheter-insertion and maintenance protocols. A study compared the impact of the

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bundle on CAUTI rates at our center and a comparable teaching hospital.[8] Despite a significant decrease in the catheter utilization ratio (CUR) from 0.67 to 0.64 at our center over a 2-year period, CAUTI rates remained unchanged in the range of 1.2–2.2 per 1,000 catheter days.[8] The lack of effect of the reduction of CUR on CAUTI rate was due to the high utilization of urine culture in catheterized ICU patients.[8] These data presented an opportunity to optimize urine-culture ordering practices in the ICU and led to the development of a urine-culture stewardship program. To evaluate the effect of the stewardship program, a new internal quality metric was incorporated: urine culture utilization rate (UCUR; ie, number of urine cultures/catheter days ×100).

In this report, we describe the implementation and impact of best-care practices for urinary catheter care combined with a urine-culture stewardship program on CAUTI rates in adult ICU patients.

Methods

The study was conducted in a Detroit teaching hospital with 156 adult ICU beds. An institutional CAUTI prevention team was created in 2013 that included physicians, nursing staff, and administration leadership personnel from critical care, general practice units and infection prevention and control. During the same year, this multidisciplinary team implemented a CAUTI prevention catheter care bundle in the ICUs (Appendix 1 online).

The bundle included education about appropriate indications for urinary catheter use, training and competencies regarding insertion, and maintenance of catheters. It also focused on a nurse-directed catheter removal daily review with bladder-scan–guided voiding protocol. Audits were performed on a weekly basis by infection control specialists and nursing staff in the ICUs. Audits in 2015 were performed manually, and starting in 2016, they were performed using an electronic online survey tool that facilitated real-time reporting on the quality dashboard.

In January 2015, these measures were complemented with the addition of several interventions: (1) Monthly educational presentations were given by the infection control medical director on prevention of HAIs in ICU patients with emphasis on CAUTI prevention strategies and urine-culture stewardship. The education, based on recommended guidance, emphasized avoidance of "pan-culture" for workup of fever and obtaining a urine culture only for suspected pyelonephritis or sepsis from unknown source (Appendix 2 online).[7] (2) Root-cause analysis (RCA) was performed by infection control within 72 hours of identification of CAUTI and feedback was provided to the ICU teams. (3) The new metric UCUR was implemented. (4) ICU unit-specific CAUTI rate, CUR, and UCUR were reported monthly on an online ICU quality dashboard.

During the observation period from January 1, 2015, to December 31, 2017, surveillance for CAUTI and CUR were performed according to the 2015 NHSN definition.[9] To evaluate the safety of the urine-culture stewardship program, an electronic report was generated for all ICU patients discharged with *International Classification of Diseases Ninth or Tenth* Revision (ICD-9/ICD-10) diagnosis codes for pyelonephritis. A similar report was generated for 30-day readmissions with ICD-9/ICD-10 diagnosis codes for pyelonephritis or urinary tract infection (UTI) (Appendix 3 online). These cases were reviewed to identify potential CAUTI that may not have been detected during ICU stay or during the immediate postdischarge period. Pyelonephritis was defined by suggestive signs, symptoms, imaging, or blood culture with urinary pathogens and no alternative infection. In readmitted patients, CAUTI was defined as a UTI that occurred within 2 calendar days of removal of urinary catheter.[10] Monthly unit-specific CAUTI rate, CUR, and UCUR were reported on the online interactive ICU quality dashboard (Appendix 4 and Fig. 1 online). Dashboard information was utilized during house staff education, collaborative rounds, and quality meetings.

Analyses were performed using SAS version 9.4 software (SAS Institute, Cary, NC). Time-series data were analyzed using the Kendall τ test for trend. The relationships between CAUTI rate, CUR, and UCUR were examined using the Spearman correlation test. Correlation coefficients (r) and P values were calculated for each relationship.

Results

In total, 21,367 patients were admitted to the ICUs during 2015–2017, representing a total of 137,336 ICU patient days. Total urinary catheter days were 29,978 in 2015, 29,365 in 2016, and 27,774 in 2017. Compliance with the catheter care bundle during the study period remained unchanged at >85%. The number of urine cultures declined from 3,081 in 2015 to 2,158 in 2016 and to 1,218 in 2017. In total, 166 CAUTIs were identified: 78 in 2015, 60 in 2016, and 28 in 2017. Table 1 shows the CAUTI rate, UCR, and UCUR for the study period. Figure 1 illustrates the trendline for average CAUTI rate, UCR, and UCUR for 2015–2017. Regression analysis over time showed statistically significant decreases in UCUR (r, 0.917; $P < .0001$) and CAUTI rate (r, 0.657; $p < .0001$) and modest decline in CUR (r, 0.532; $P < .0008$). The correlation between UCUR and CAUTI rate was (r, 0.625; $P < .0001$) compared to the correlation between CUR and CAUTI rate (r, 0.523; $P < .004$). The decrease in UCUR was comparable in the subset of medical ICU (MICU)-only and surgical ICU (SICU)-only units (Table 2).

Surveillance to evaluate safety of the stewardship program identified 21 ICU discharges with an ICD-9/ICD-10 discharge diagnosis that included pyelonephritis; however, 4 patients did not meet criteria for pyelonephritis. In the other 17 patients, pyelonephritis was diagnosed at time of ICU admission. A review of 30-day readmissions for 2015–2016 identified 8 previously catheterized ICU patients who were readmitted with a UTI. Of these patients, 2 had urine cultures during their index ICU stay. Of the remaining 6 patients with no prior urine cultures, the median time to readmission was 9 days (range, 2–22). None had a UTI within 2 calendar days of catheter removal.

Discussion

Over a 3-year period, implementation of a urine-culture stewardship initiative in addition to an existing catheter-care bundle program was effective in reducing inappropriate urine-culture utilization and decreasing CAUTI rate in ICU patients. Multidisciplinary educational programs involving administration, staff, nurses, and infection prevention specialists have resulted in reduced HAI rates.[12–14] Adoption of the Michigan Health and Hospital Association (MHA) Keystone Center bladder bundle has improved appropriate use of urinary catheters.[15] Minimizing the use of urinary catheters has been the most effective intervention for CAUTI reduction.[16] Previous efforts at our institution directed at avoidance of catheter placement and prompt removal resulted in a low CUR but did not affect the CAUTI rate due to continued high urine-culture utilization.[9] Therefore, we complemented the bladder bundle with the introduction of a diagnostic stewardship

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Table 1. Urinary Catheter Utilization, Urine Culture Utilization and CAUTI Rates in All Intensive Care Units in 2015 - 2017

	2015 (by Quarter)				2016 (by Quarter)				2017 (by Quarter)			
Variable	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Catheter utilization ratio	0.53	0.57	0.53	0.57	0.57	0.57	0.53	0.50	0.50	0.46	0.50	0.50
Urine culture utilization rate	13.20	9.86	8.10	10.06	8.90	6.90	7.36	6.50	5.83	4.20	4.06	4.13
CAUTI rate	2.10	2.36	3.23	2.73	2.53	2.26	2.93	1.20	1.40	1.66	0.43	1.03

Note. CAUTI, catheter-associated urinary tract infection. Catheter utilization ratio = catheter days/patient days; urine culture utilization rate = no. of urine cultures/catheter days ×100; CAUTI rate = no. of CAUTI/catheter days ×1,000.

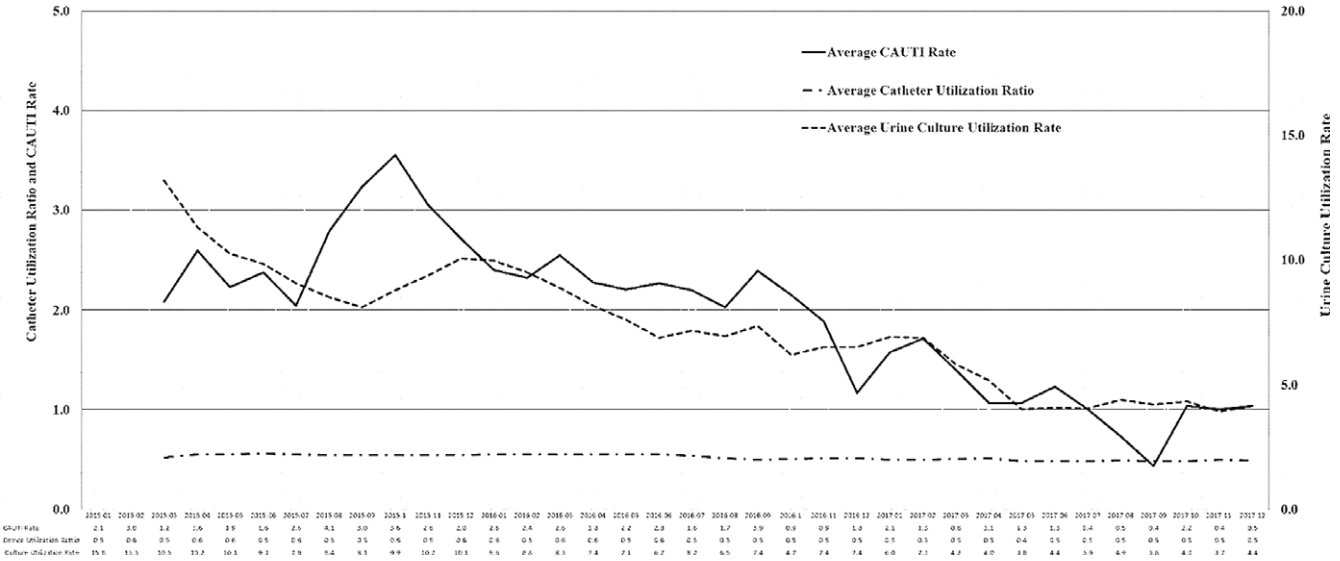

Fig. 1. Trends of catheter-associated urinary tract infection (CAUTI), catheter utilization ratio and urine culture utilization rate, 2015–2017. Note. CAUTI rate = number of CAUTI/catheter days ×1,000; catheter utilization ratio = catheter days/patient days; urine culture utilization rate = number of urine cultures/catheter days ×100.

educational initiative emphasizing appropriate ordering of urine culture in catheterized patients.

Urine cultures are easy to obtain and are often overutilized in the critical care setting for evaluation of sepsis, despite the lack of specificity to distinguish infection from asymptomatic carriage in catheterized patients.[16] Acknowledging this limitation and incorporating the guidance for evaluation of fevers in ICU patients were key elements used in developing education around "mindful culturing" of the ICU patient with sepsis.[7] Several factors contributed to the success of the program. The education focused on the house staff in the ICU, the primary drivers of UC orders. The implementation and reporting of an internal quality metric UCUR that complemented the traditional CAUTI metrics helped validate the positive effect of the stewardship program. CAUTI surveillance data and urine-culture utilization metrics were incorporated into a user-friendly, online, interactive, quality dashboard that was able to analyze information to the unit level information. This system provided a visual means to monitor the progress and effect of the stewardship program. The dashboard was accessible to all users of the EMR and served as a useful tool to promote CAUTI prevention measures during collaborative rounds and quality huddles. The utilization of informatics and electronic surveillance systems has been increasing in CAUTI prevention strategies and has positively influenced affected CAUTI rates while limiting the use of resources.[17] The provision in the EMR of a nurse-driven catheter removal protocol has also reduced CAUTI rates.[17]

Prior studies have evaluated measures to decrease overutilization of urine culture in catheterized patients. A study using EMR-anchored embedded education on appropriate indications for ordering urine culture was effective in reducing urine cultures ordered in catheterized patients.[18] Our findings are similar to those of Mullin et al,[19] who assessed the impact of implementing a best-practices bundle for urinary catheters together with a consensus-driven approach adopted by all ICU disciplines when evaluating fever in the ICU patient. The study demonstrated a decrease in CAUTI rates from 3.0 per 1,000 catheter days in 2013 to 1.9 in 2014 and paralleled a decrease in the number of urine cultures performed. Although our study supports the reported findings of the impact of diagnostic stewardship on CAUTI, it differed in a few ways. It was conducted after the implementation of the 2015 NHSN CAUTI criteria and only in adult ICUs. Our initiative focused on the education of frontline trainees about mindful ordering of urine culture combined with prompt feedback through the RCA process and dashboard reporting. We used UCUR as a novel metric and correlation analysis to assess the effect of the stewardship initiative. Safety of the stewardship program was evaluated through assessment of reported pyelonephritis in ICU patients and review of 30-day readmissions for UTI. No cases of unrecognized pyelonephritis or CAUTI were identified. Both studies support the recent CDC guidance of an evidence-based, tiered strategy to CAUTI prevention that focuses on placement for appropriate indications, use of alternatives to urinary catheters, proper

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Table 2. Urinary Catheter Utilization, Urine Culture Utilization and CAUTI Rates in Primary Surgical and Medical Intensive Care Units in 2015–2017

	MICU			SICU		
Variable	2015	2016	2017	2015	2016	2017
No. of CAUTIs	60	38	21	18	22	7
CAUTI rate	3.41	2.25	1.36	1.45	1.75	0.56
Catheter utilization ratio	0.67	0.63	0.57	0.65	0.66	0.64
Urine culture utilization rate	11.47	8.45	5.44	8.64	5.75	3.11

Note. MICU, medical intensive care unit; SICU, surgical intensive care unit; CAUTI, catheter-associated urinary tract infection. CAUTI rate = no. of CAUTI/catheter days ×1,000; catheter utilization ratio = catheter days/patient days; urine culture utilization rate = no. of urine cultures/catheter days ×100.

insertion and maintenance, prompt removal as well as urine culture stewardship to prevent CAUTI.[20]

Our study has limitations, including the implementation in adult-only ICUs at a large tertiary-care teaching hospital; hence, the results may not be generalizable. However, the use of UCUR as a metric and application of informatics to extract data from the EHR to monitor and display surveillance data may be easily applicable to other settings. There was a gradual rather than abrupt decline in UCUR and CAUTI rate over the 3 years. This gradual decrease was likely due to the emphasis on education to guide clinical decision making for ordering urine culture rather than implementation of a criteria-based mandate.

In summary, a urine-culture stewardship initiative was safe and effective in reducing unnecessary urine cultures in catheterized patients and was correlated with a decrease in CAUTIs. Urine-culture stewardship programs in combination with standard best practices could significantly influence CAUTI rates in ICUs.

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