Preventing catheter-associated urinary tract infection in the zero-tolerance era

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Background: Catheter-associated urinary tract infection (CAUTI) is one of the most common health care–associated infections in the critical care setting.

Methods: A quasi-experimental study involving multiple interventions to reduce the incidence of CAUTI was conducted in a medical-surgical intensive care unit (ICU) and in 2 step-down units (SDUs). Between June 2005 and December 2007 (phase 1), we implemented some Centers for Disease Control and Prevention–recommended evidence-based practices. Between January 2008 and July 2010 (phase 2), we intervened to improve compliance with these practices at the same time that performance monitoring was being done at the bedside, and we implemented the Institute for Healthcare Improvement’s bladder bundle for all ICU and SDU patients requiring urinary catheters.

Results: There was a statistically significant reduction in the rate of CAUTI in the ICU, from 7.6 per 1,000 catheter-days (95% confidence interval [CI], 6.6-8.6) before the intervention to 5.0 per 1,000 catheter-days (95% CI, 4.2-5.8; P < .001) after the intervention. There also was a statistically significant reduction in the rate of CAUTI in the SDUs, from 15.3 per 1,000 catheter-days (95% CI, 13.9-16.6) before the intervention to 12.9 per 1,000 catheter-days (95% CI, 11.6-14.2) after the intervention (P = .014).

Conclusion: Our findings suggest that reducing CAUTI rates in the ICU setting is a complex process that involves multiple performance measures and interventions that can be applied to SDU settings as well.

Key Words: Health care-associated infection prevention; urinary catheter; intensive care; step-down unit.

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Urinary tract infections (UTIs) are commonly acquired in hospitals, with an estimated prevalence of 1%-10%, representing 30%-40% of all nosocomial infections. The most important risk factor for the development of nosocomial UTIs, especially in the intensive care setting, is the presence of a urinary catheter (UC). 

Guidelines from the Centers for Disease Control and Prevention and the Society for Healthcare Epidemiology of America-Infectious Diseases Society of America describe various interventions for preventing catheter-associated UTIs (CAUTIs) in intensive care units (ICUs). Each of these recommendations is categorized on the basis of existing scientific evidence, theoretical rationale, applicability, and potential economic impact.

As part of the 5 Million Lives campaign endorsed by leading US agencies and professional societies, The Institute for Healthcare Improvement (http://www.ihi.org/ihi) recommends that all intensive care units (ICUs) implement a bladder bundle aimed at reducing the incidence of CAUTI to zero. However, in ICUs, UCs might be needed for extended periods, and the duration of catheterization is the most important risk factor for the development of a CAUTI. In addition, ICU patients may be colonized with hospital-acquired organisms, and sometimes a UC must be inserted in urgent situations when optimal attention to aseptic technique might not be feasible. Recent data suggest that non-ICU medical wards have considerably lower device utilization rates than medical ICUs. Unfortunately, however, there are little data regarding the prevention of CAUTIs in step-down units (SDUs). The types of organisms that most commonly cause hospital-acquired UTI change over time, but gram-negative organisms—principally enteric gram-negative bacilli—are responsible for the great majority of CAUTI cases.

The purpose of this prospective, quality improvement study was to examine the effect of a series of interventions implemented in an ICU and 2 SDUs to reduce the incidence of CAUTIs and to analyze the
differences in CAUTI rates and causative microorganisms in the 2 study phases.

METHODS

Setting and study design

Thus quasi-experimental interrupted time series study was conducted in a 38-bed medical-surgical ICU and in two 20-bed SDUs with the same physical layout in a private tertiary care hospital in São Paulo, Brazil. The ICU has an open staffing model, and admits approximately 2,200 patients annually. All rooms in the ICU and the SDUs are single-bed rooms. The SDA patients are transferred from the medical-surgical ICU, from various wards, and from the Emergency Department. Because this study was considered a quality improvement project, it was not submitted to our Institutional Review Board.

The study was carried out in 2 phases. In phase 1 (June 2005 to December 2007), ICU nurses or and physicians (primarily urologists) inserted UCs using aseptic technique with a 2% chlorhexidine preparation for skin antisepsis. Catheter insertion and maintenance were in accordance with CDC guidelines. UCs were not routinely replaced. The decision to remove a UC was made solely by the patient’s physician, with catheters kept in place until it is no longer needed or until an adverse event necessitates its removal. Each year, in a convenience sample of patients, UC insertion was directly observed by assigned nurses, who provided feedback on compliance with appropriate practices to the ICU team via e-mail.

In phase 2 (January 2008 to July 2010), after the hospital’s chief executive officer articulated a policy of zero tolerance for CAUTIs, we continued the processes begun in phase 1, but audited these process measures once monthly at random intervals in a small sample of patients undergoing UC insertion. In January 2008, we implemented the bladder bundle. The bundle components included the creation of a UC insertion cart; hand hygiene; chlorhexidine skin and meatal antisepsis; sterile field and sterile gloves; only one attempt at insertion allowed for each catheter (ie, a new catheter used for each attempt); adequate UC balloon inflation; and daily review of the need for a UC with prompt removal if no longer needed. The bundle was used for all ICU and SDU patients requiring a UC. Nurses intervened in this process at the same time that performance monitoring was occurring at the bedside if noncompliance with an element of the bundle (eg, hand hygiène was not performed) was detected during UC insertion.

Before the start of phase 2, we delivered a brief presentation to the ICU staff on CAUTI prevention, reviewed the study protocol, and encouraged participation in our “UC Bundle—Getting to Zero” program. During phase 2, each month we provided feedback on compliance with the bundle components via e-mail to the ICU and SDU teams (doctors and nurses). We also placed posters in the ICU and SDUs with bar graphs displaying compliance with process of care measures as well as the CAUTI rate, determined by surveillance conducted by the infection control and hospital epidemiology program. We created an ICU nurses’ group to remove unnecessary UCs daily. Once a day, an ICU nurse (not on clinical duty) checked all of the ICU patients with UCs and asked the ICU doctor on duty if the UC was necessary. Placement of a UC was considered appropriate when the indication was for close monitoring of urine output in an incontinent patient or in a critically ill patient requiring intensive monitoring during vasopressor infusion. The same strategy was followed in the SDUs, but with each bedside nurse questioning the SDU doctors on duty about the need for a UC in each patient. Unfortunately, these data are available for the SDUs only for May-July 2010.

We did not use impregnated UCs in the ICU and SDU patients. Compliance with all process measures during UC insertion was evaluated for all UCs placed in the ICU and SDUs. Bladder ultrasonography was used sporadically to aid the decision of whether or not to place a UC, and we plan to train all ICU doctors and nurses in the use of bladder ultrasonography to avoid indwelling catheterization. Since October 2009, all ICU and SDU patients with an indwelling device (eg, central venous catheter, UC) receive a daily chlorhexidine bath.

Definitions

CAUTI surveillance was performed by trained infection control practitioners using the CDC’s definition of laboratory-confirmed UTI for the 2 phases of the study. A CAUTI was attributed to a specific unit if it was detected at least 48 hours after admission or less than 48 hours after discharge from the unit. The device utilization ratio was defined as the number of UC-days divided by the number of patient-days.

Microbiological methods

All isolates were identified by manual or automated methods and confirmed using the Vitek 2 system (bio-Merieux Vitek, Hazelwood, MO).

Statistical analysis

A generalized linear model was used to model Poisson distribution count data using the number of CAUTI cases as the dependent variable and the preintervention and postintervention periods as the independent variable. All tests of statistical significance were 2-sided, with the significance level set at $P = .05$. All
data analyses were performed using SPSS for Windows 17.0 (SPSS Inc, Chicago, IL).

RESULTS

Study sample, compliance, and incidence density of CAUTI in each study phase

In ICU phase 1, there were 24,820 patient-days and 15,500 UC-days, for a UC utilization ratio of 0.62 (Table 1). In ICU phase 2, there were 27,584 patient-days and 14,577 UC-days, for a UC utilization ratio of 0.53. In SDU phase 1, there were 36,454 patient-days and 6,633 UC-days, for a UC utilization ratio of 0.18, and in SDU phase 2, there were 34,661 patient-days and 4,041 UC-days, for a CVC utilization ratio of 0.12.

The majority of CAUTIs were monomicrobial infections in both phases in the ICU and SDUs (Table 1). In phase 2, we assessed compliance with the UC checklist in 90.5% (2,105/2,327) of catheter insertions in the ICU and in 89.0% (1,744/1,959) of those in the SDUs. Compliance with the process measures for catheter insertion is summarized in Table 1.

Using Poisson regression, we found a statistically significant reduction in the CAUTI rate in the ICU, from 7.6 per 1,000 catheter-days (95% confidence interval [CI], 6.6-8.6) before the intervention to 5.0 per 1,000 catheter-days (95% CI, 4.2-5.8) after the intervention (P < .001). We also found a statistically significant reduced CAUTI rate in the SDUs, from 15.3 per 1,000 catheter-days (95% CI, 13.9-16.6) before the intervention to 12.9 per 1,000 catheter-days (95% CI, 11.6-14.2) after the intervention (P = .014).

Microbiological features

As shown in Table 2, 67.0% (81/121) of all microorganisms identified in ICU phase 1 were gram-negative. Other microorganisms included fungi (22.3%; 27/121) and gram-positive organisms (10.7%; 13/121). In ICU phase 2, the distribution of microorganisms was 72.1% (57/79) gram-negative, (15.2%; 12/79) fungi, and (12.7%; 10/79) gram-positive. In SDU phase 1, the majority (71.4%; 90/126) of microorganisms were gram-negative, with smaller proportions of gram-positive organisms (15.1%; 19/126) and fungi (13.5%; 17/126). In SDU phase 2, these proportions were 83.0% (49/59) gram-negative, 10.2% (6/59) gram-positive, and 6.8% (4/59) fungi.

Pseudomonas aeruginosa, Klebsiella pneumoniae, and Escherichia coli accounted for >70% of the gram-negative pathogens detected in both phases in the ICU and SDUs. Non-albicans Candida was more prevalent than C albicans in both care settings. The most prevalent gram-positive pathogen was Enterococcus faecalis.

DISCUSSION

Our hospital is engaged in a patient safety program that is a resource from the Institute for Healthcare Improvement. We previously demonstrated that it is
possible to reduce the incidence of ventilator-associated pneumonia and central line–associated bloodstream infections to zero for certain periods.\(^\text{10,11}\) This was one of the reasons for adopting the “getting to zero” goal as a quality indicator for patient safety in our ICU and SDUs. However, eliminating health care–associated infections (HAIs) includes difficulties with the case definition (CDC definition) and risk adjustment (severity ill patients, urinary catheters and so on). The surveillance National Healthcare Safety Network definition of CAUTI includes all UTIs occurring in symptomatic patients with an indwelling UC;\(^\text{9}\) however, this definition lacks specificity, given the difficulty of localizing urinary signs and symptoms with a catheter in situ.\(^\text{12}\) That is, the surveillance definition overestimates the true incidence of CAUTI because of the high prevalence of bacteriuria in patients with an indwelling catheter.\(^\text{13}\) Moreover, Edmond\(^\text{14}\) has pointed out that a “getting to zero” approach might be associated with adverse unintended consequences.

Eliminating HAIs has been identified as an important priority in many hospitals,\(^\text{5,15}\) especially since Medicare no longer provides increased payments for treatment of CAUTIs. This is not the situation in Brazilian hospitals, although our hospital’s chief executive officer and senior management are responsible for ensuring that the health care system supports an infection prevention and control program to effectively prevent CAUTIs.\(^\text{4}\) In our hospital, the prevention of CAUTIs in the ICU and SDUs is a quality indicator that affects employees’ annual bonuses.

Many hospitals have increased the size and the numbers of their ICUs\(^\text{15}\) and have added SDUs to provide appropriate care for patients whose illness acuity falls between that of ICU patients and that of ward patients. Weber et al\(^\text{7}\) demonstrated that infection rates in SDUs are more similar to those in the ward setting than those in ICUs. We decided to apply the bladder bundle in our SDUs even though there is good evidence supporting this infection control practice only in ICU patients.\(^\text{5,6}\)

### Table 2. Characteristics of pathogens causing CAUTIs in the ICU and SDUs during the 2 study phases

<table>
<thead>
<tr>
<th>Pathogen</th>
<th>ICU</th>
<th>SDUs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>P1</td>
<td>%</td>
</tr>
<tr>
<td>Gram-positive</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Enterococcus faecalis</td>
<td>10</td>
<td>76.9</td>
</tr>
<tr>
<td>E faecium</td>
<td>1</td>
<td>7.7</td>
</tr>
<tr>
<td>Streptococcus spp</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Staphylococcus aureus</td>
<td>1</td>
<td>7.7</td>
</tr>
<tr>
<td>S aureus coagulase-negative</td>
<td>1</td>
<td>7.7</td>
</tr>
<tr>
<td>Gram-negative</td>
<td>81</td>
<td>100</td>
</tr>
<tr>
<td>Pseudomonas aeruginosa</td>
<td>25</td>
<td>30.9</td>
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<tr>
<td>Klebsiella pneumoniae</td>
<td>16</td>
<td>19.8</td>
</tr>
<tr>
<td>Enterococcus faecalis</td>
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<td>9.9</td>
</tr>
<tr>
<td>Enterobacter spp</td>
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<td>7.4</td>
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<tr>
<td>Burkholderia cepacia</td>
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<td>3.7</td>
</tr>
<tr>
<td>Serratia marcescens</td>
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<td></td>
</tr>
<tr>
<td>Morganella morgani</td>
<td></td>
<td></td>
</tr>
<tr>
<td>K azonae</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Citrobacter spp</td>
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<td>1.2</td>
</tr>
<tr>
<td>Stenotrophomonas maltophilia</td>
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<td>1.2</td>
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<tr>
<td>Fungi</td>
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<td></td>
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<tr>
<td>Candida albicans</td>
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<td>C glabrata</td>
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<td>C tropicalis</td>
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<td>18.5</td>
</tr>
<tr>
<td>C parapsilosis</td>
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<td>11.1</td>
</tr>
<tr>
<td>C krusei</td>
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<td>3.7</td>
</tr>
<tr>
<td>C guillermondii</td>
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<td></td>
</tr>
<tr>
<td>Trichosporon beigeli</td>
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<td>3.7</td>
</tr>
<tr>
<td>Total identified agents</td>
<td>121</td>
<td>100</td>
</tr>
</tbody>
</table>

*Including 1 case of VRE.
CAUTI rate was higher in the SDUs than in the ICU, in disagreement with the findings of Weber et al., who reported a higher rate of all device-associated HAIs in ICUs than in SDUs. We also found a statistically significant difference in CAUTI rates after applying the bladder bundle in our SDUs. Of note, we achieved monthly zero infection rates by applying all of the CAUTI prevention measures recommended in the literature in 9 of 31 months in phase 2 of this study.

Early studies of impregnated silver-coated UCs found a lower CAUTI rate compared with standard catheters. Although silver-coated UCs are more expensive than standard catheters, a cost-effectiveness analysis found that their use actually reduced costs, given the lower costs associated with treatment.

Other recent studies have shown no change in CAUTI rates with the use of impregnated catheters. Interestingly, in a systematic review and meta-analysis, Meddings et al. found that a dramatically reduced CAUTI rate in ICU patients without the use of coated catheters could be achieved simply by evaluating the need for a UC each day. We do not use impregnated, silver-coated UCs in our ICU and SDUs. To the best of our knowledge, the present study is the first to evaluate CAUTI preventive measures for SDU patients that also have been applied to ICU patients.

This study has several limitations. First, this was not a randomized trial, but rather a quasi-experimental, interrupted time series study. Quasi-experimental study designs are frequently used when conducting a controlled trial is not logistically feasible. Thus, other unmeasured factors might have occurred coincident with the interventions that were implemented in January 2008 (ie, the bladder bundle), resulting in a decreased CAUTI rate in our ICU. This seems unlikely, however, given the fact that no decrease in CAUTI rate had been seen over the previous several years (Fig 1). Second, we collected data only in small audits (ie, no continuous data collection) on preintervention process measure compliance, and the resulting lack of data hindered our ability to evaluate the full impact of bundle implementation. However, a significant difference in CAUTI rates was demonstrated between the ICU and the SDUs, and we achieved a zero infection rate by applying the CAUTI prevention measures recommended in the literature.

Finally, this study was performed at a single medical center, and our results might not be generalizable to other hospitals, given differences in staffing, patient populations, and resources.

In conclusion, the process measures for CAUTI presented here are derived from published guidelines and other relevant literature. Interventions to reduce CAUTI should be a priority not only for all inpatient settings including ICUs, but also for SDUs. Further research into CAUTI prevention is still needed.
References


