Increasing pressure has recently been placed on health care providers to increase the measurement of outcomes, while decreasing complications and improving “quality” across all spectrums of patient care. The creation of the National Neurosurgery Quality and Outcomes Database by the American Association of Neurological Surgeons is evidence of this movement within neurosurgery.

**Increasing pressure has recently been placed on health care providers to increase the measurement of outcomes, while decreasing complications and improving “quality” across all spectrums of patient care.**

However, there is a shortage of evidence-based quality improvement initiatives that have shown positive outcomes in the neurosurgical patient population.

Urinary tract infections account for approximately 40% of all hospital-acquired infections annually. Urinary tract infections are also the most common health care–associated infection in the ICU, accounting for 23% of hospital-acquired infections among adult ICU patients in the US; fully 80% of these hospital-acquired UTIs are attributable to indwelling urethral catheters.

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**Object.** To date, there has been a shortage of evidence-based quality improvement initiatives that have shown positive outcomes in the neurosurgical patient population. A single-institution prospective intervention trial with continuous feedback was conducted to investigate the implementation of a urinary tract infection (UTI) prevention bundle to decrease the catheter-associated UTI rate.

**Methods.** All patients admitted to the adult neurological intensive care unit (neuro ICU) during a 30-month period were included. The study consisted of two 1-month preintervention observation periods (approximately 1200 catheter days) followed by a 30-month intervention phase (20,394 catheter days). A comprehensive evidence-based UTI bundle encompassing avoidance of catheter insertion, maintenance of sterility, product standardization, and early catheter removal was enacted.

**Results.** The urinary catheter utilization rate dropped from 100% to 73.3% during the intervention phase (p < 0.0001) without any increase in the rate of sacral decubitus ulcers or other skin breakdown. The rate of catheter-associated UTI was also significantly reduced from 13.3 to 4.0 infections per 1000 catheter days (p < 0.001). There was a linear relationship between the decreased quarterly catheter utilization rate and the decreased catheter-associated UTI rate (r² = 0.79, p < 0.0001).

**Conclusions.** This single-center prospective study demonstrated that a comprehensive UTI prevention bundle along with a continuous quality improvement program can significantly reduce the duration of urinary catheterization and rate of catheter-associated UTI in a neuro ICU.

(See the corresponding editorial in this issue, pp 909–910. This article contains some figures that are displayed in color online but in black and white in the print edition.)
As many as 5 million urinary catheters are placed annually in the US. Between 12% and 25% of all hospitalized patients will receive a urinary catheter during their hospital stay, with as many as half of these placed without an appropriate indication. In one study, almost 40% of attending physicians of patients with unnecessary urinary catheters were unaware that the patient had a urinary catheter. The NHSN is a voluntary, secure, internet-based surveillance system managed by the Division of Healthcare Quality Promotion at the CDC. Among other responsibilities, they are tasked with monitoring the magnitude of adverse events and hospital-acquired infections as well as monitoring prevention practice adherence data among health care facilities in the US. According to the NHSN data from 2006 to 2007, catheter-associated UTI rates ranged from 3.1 infections per 1000 catheter days in medical/surgical ICUs to 7.7 in burn ICUs and 6.8 in neuro ICUs. Rates on general care wards actually tend to be higher, ranging from 4.7 infections per 1000 catheter days in adult stepdown units to 16.8 infections in rehabilitation units. According to Saint et al., 17% of health care-associated cases of bacteremia are attributable to catheter-associated UTIs, second only to central line infections. It is well established that the risk of developing a UTI is directly related to the duration of catheterization, with the risk of 3%–10% per day of catheterization. When a catheter remains in place for up to 1 week, the risk of bacteriuria, but not necessarily a UTI, increases to 25%; at 1 month this risk is nearly 100%. Other risk factors include female sex (RR 1.7–3.7), age > 50 years (RR 2), serum creatinine > 2 mg/dl (RR 2.1), diabetes mellitus (RR 2.3), severe underlying illness (RR 2.5), hospitalization on an orthopedic (RR 5.1) or urological (RR 4) service, insertion outside an operating room (RR = 5.3), and insertion after the 6th day of hospitalization (RR 8.6). Among those with bacteriuria, 10% will develop symptoms of UTI (fever, dysuria, urgency, frequency, and suprapubic tenderness) and as many as 3% will further develop bacteremia. Of these risk factors, catheter placement is the most readily modifiable risk factor identified to date. Beginning in October of 2008, the CMS stopped offering additional reimbursements for patients discharged with a diagnosis of catheter-associated UTI. Among the 10 hospital-acquired conditions selected by CMS, catheter-associated UTI received a high priority due to its high cost and high volume, and because it can be reasonably prevented through application of accepted evidence-based prevention guidelines. Since this time, numerous prospective studies have examined the impact of a range of interventions including nurse and physician education, electronic reminders, nurse-driven protocols, surveillance and feedback, condom catheters, closed catheter systems, and antimicrobial catheters for the reduction of catheter-associated UTI. These studies have achieved reductions in catheter-associated UTI rates ranging from 46% to 81%, With these studies have generally looked at all ICUs, no study to date has investigated neuro ICU patients specifically. This is despite the fact that neuro ICUs have the second highest rates of catheter-associated UTI among ICUs. Among neuro ICU patients, UTI is the most frequent hospital-acquired infection (36.6%) followed by pneumonia and central venous line infection. Unfortunately, the neurocritical care–specific literature has focused primarily on surveillance or the use of bladder scanning to prevent UTIs. No study to date has evaluated the implementation of a comprehensive UTI prevention bundle in the neuro ICU.

In response to an unacceptably high rate of catheter-associated UTI as well as the impending CMS elimination of payment for preventable hospital-acquired complications, this center launched a 30-month interdisciplinary campaign to decrease catheter-associated UTI below the NHSN mean which began in November of 2007. In this paper we describe the design, implementation, and outcomes of a comprehensive UTI prevention bundle implementation while addressing possible obstacles to implementation.

**Methods**

Shands Hospital at the University of Florida is a 626-bed, tertiary-care medical center with 142 intensive care beds, 30 of which comprise the neuro ICU. The neuro ICU is overseen by an interdisciplinary team composed of vested members from neurosurgery, neurology, pharmacy, critical care medicine, social work, and nursing. Its membership includes staff nurses, nurse leaders, social workers, pharmacists, physician extenders (advanced registered nurse practitioner or physician assistant), and physicians.

**Study Population**

The study population consisted of all consecutive patients admitted to the neuro ICU during the period between August 2008 and December 2010. Patients with catheter-associated UTI that occurred less than 48 hours after admission to the ICUs were excluded. The study consisted of two 1-month preintervention surveillance periods (November 2007 and May 2008) followed by a 30-month prospective intervention phase (August 1, 2008, through December 31, 2010). The decision to insert a urinary catheter was made by physicians in the ICUs, which is a hybrid collaborative care unit, with only the critical care medicine or the primary service (Neurosurgery or Neurology) having ordering privileges.

**Catheter-Associated UTI**

Catheter-associated UTI was defined according to the NHSN criteria. A catheter-associated UTI was any infection that occurred while the patient had a urinary catheter in place or within 2 days of catheterization. Two possible definitions of UTI were accepted. The first definition included a patient who had at least 1 sign or symptom of UTI and a positive urine culture growing more than 10⁵ CFUs/ml with no more than 2 microorganisms. Signs and symptoms include temperature > 38°C, urinary urgency, urinary frequency, dysuria, and suprapubic tenderness. The second definition required the presence of at least 2 signs or symptoms but a less compelling laboratory finding such as a positive urinalysis for leukocyte esterase or nitrite, pyuria with ≥ 3 white blood cells/hpf.
positive Gram stain, and 2 urine cultures > 10^2 CFUs/ml of a single pathogen in a patient undergoing treatment using antimicrobials. Asymptomatic catheter-associated bacteriuria or candiduria was defined as a positive urine using antimicrobials. Asymptomatic catheter-associated bacteriuria or candiduria was not counted as catheter-associated UTI. Asymptomatic catheter-associated bacteriuria or candiduria was not counted as catheter-associated UTI in this study. Patients were not routinely monitored for asymptomatic bacteriuria. Urinalysis as well as urine and blood cultures were performed whenever the patients developed systemic or local signs of infection. These signs included fever (temperature > 38.5°C), urinary urgency, urinary frequency, dysuria, and suprapubic tenderness.

The infection control investigation of possible catheter-associated UTI was triggered by positive urine culture. An infection control nurse practitioner would then perform a chart review to gather data. These data were presented to the hospital epidemiologist to decide whether an infection based on NHSN definitions had occurred.

The rate of catheter-associated UTI was defined as the number of patients with catheter-associated UTI divided by the number of indwelling urinary catheter days multiplied by 1000. Catheter utilization was defined by the NHSN definition, which was the total number of catheter days divided by the total number of patient days multiplied by 100.

Pressure Ulcers

All pressure ulcers regardless of stage (“deep tissue injury” through Stage IV) were counted using the National Pressure Ulcer Advisory Panel standards (http://www.npuap.org/). The incidence of patients with pressure ulcers was determined through weekly skin care rounds by an Ostomy and Wound Liaison nurse. The denominator was the total number of patients admitted to the unit at the time of rounds. Averaged monthly values are presented.

Intervention

As part of a hospital-wide CQI program, a multidisciplinary team was formed and charged with the responsibility of examining the scope of the problem related to catheter-associated UTI, determining its impact, and defining the desired outcome. The FADE2 method (focus, analyze, develop, execute, and evaluate) was used. An extensive review of the literature was conducted, baseline data were collected, and an action plan was developed to execute a program aimed at reducing the number of catheter-associated UTIs below the NHSN mean for both ICU and medical-surgical groupings. This CQI initiative provided a constant feedback method, allowing for review and adaptation of interventions. Recommendations from this CQI team were then distributed to ICU and medical surgical nursing units for implementation. Study approval was granted by the Institutional Review Board at the University of Florida and Shands Hospital.

Evidence-Based Best-Practices Recommendations

A literature review including a Cochrane Database search was used to develop best-practices and evidence-based medicine UTI “bundle.” A bundle is a set of evidence-based practices that are implemented together to affect a disease process. The UTI prevention bundle focused on 4 key factors to reduce the incidence of catheter-associated UTI: 1) avoidance of catheter insertion, 2) product standardization, 3) maintenance of catheter sterility, and 4) timely removal of catheters. Avoidance of catheter insertion was accomplished by development of criteria for insertion of urinary catheters and default removal of catheters postoperatively if not explicitly ordered otherwise. Product standardization resulted in the use of antimicrobial catheters and closed systems. Maintenance of sterility was accomplished through nursing education. Lastly, timely removal of catheters was accomplished by a nurse-driven removal protocol. Each aspect of this bundle and the particular method of implementation are detailed below. The UTI prevention bundle was distributed to each ICU and medical-surgical unit to implement and adapt the recommendations to their unit according to what their data profile indicated as opportunities for improvement.

Avoidance of Insertion. Appropriate indications for urinary catheter placement were also discerned from the literature and distributed to the individual units (Table 1). Alternative methods to indwelling catheters were explored. Intermittent or “in and out” catheterization in conjunction with frequent bladder scanning was promoted as the preferred method for bladder management over indwelling catheterization.

Product Standardization. A single closed catheter system was adopted hospital-wide. This adoption prevented the use of incompatible parts resulting in breakage of sterility and makeshift compatibility. A hospital-wide adoption of the Bardex IC silver hydrogel Foley catheter system was recommended. In addition, the StatLock Foley catheter stabilization system for securing catheters to the leg was implemented to reduce urethral trauma.

Maintenance of Catheter Sterility. If a catheter was deemed necessary, every effort was made to place the catheter aseptically and maintain the sterility of the catheter while it was in place. Guidelines stated that collecting bags should remain below the level of the bladder to prevent reflux of urine into the bladder and should be emptied routinely. Additionally all collection bags were to be placed on the door side of the bed to ensure dependent drainage and continuous visualization of the system. Finally, dependent loops in collection system tubing were discouraged, collection bags were to be kept below the level of the blad-

<table>
<thead>
<tr>
<th>TABLE 1: Approved indications for urinary catheter placement</th>
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<tbody>
<tr>
<td>periop use for selected surgical procedures &gt;3 hrs</td>
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<tr>
<td>urine output monitoring in critically ill patients for a finite period</td>
</tr>
<tr>
<td>management of acute urological conditions when “in &amp; out” catheterization is not prudent</td>
</tr>
<tr>
<td>neurogenic bladder or retention only if “in &amp; out” catheterization fails</td>
</tr>
<tr>
<td>assistance in severe pressure ulcer healing (nonhealing Grade 3 or 4)*</td>
</tr>
<tr>
<td>comfort during end of life</td>
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</table>

* According to National Pressure Ulcer Advisory Panel standards.
nder during transport, individual emptying containers were used, and proper hand hygiene was emphasized. It has been previously shown that only skilled, dedicated health care personnel should insert urinary catheters. Therefore, each nurse in the neuro ICU completed an online educational module for UTI rate reduction prior to implementation.

**Timely Removal of Catheters.** In an effort to promote early catheter removal, catheters had to be justified by selection of one of the approved indications for placement from preprinted progress notes. At the beginning of the initiative, the target for catheter removal was 4 days after placement. The slogan accompanying this goal was “Day 4, Foley no more” and was adopted house-wide. Nurses were educated that catheters were to remain in place no more than 4 days unless indicated, and nurses and physician staff were educated about the documentation requirements. In response to the CMS changes, in October of 2009 the Surgical Care Improvement Process measure was implemented; this required specific documentation by a medical doctor, physician assistant, or advanced registered nurse practitioner if a catheter was left in place for longer than 48 hours. This necessitated a reduction in the acceptable time frame for catheterization to 48 hours and the slogan was changed to “Day 2, no Foley for you.” As awareness grew, the time frame for Foley catheter removal was later shortened again to 24 hours and then again to immediately postoperatively for specific patient populations. It became more and more common for elective craniotomies of relatively short duration (< 4 hours) not to involve catheters at all during surgery.

Despite increased awareness, Foley catheter utilization continued to remain somewhat elevated near the 50th percentile nationally. Therefore, in October 2009, a systems improvement measure was implemented to facilitate nurse-driven catheter removal. Clinical Nurse Leaders began rounding on every patient in the neuro ICU for a 6-month window and focused on indications for each catheter placed. This was referred to as “Foley Rounds.” Each patient was reviewed, as was their indication or for removal were followed by physicians. Information of patient hospital days was provided electronically by Shands Hospital at University of Florida Decision Support Services. The number of catheter-associated UTIs were developed, additional recommendations were incorporated into our existing UTI prevention bundle.

**Continued Process Review**

Interventions were first implemented in September 2008. However the interdisciplinary neuro ICU infection control team continued to meet monthly with UTI infections discussed as a standing agenda item. A unit-based “drill down” was performed for each UTI with a root cause analysis predominantly focusing on protocol adherence and barriers to implementation (Appendix 4). Common themes were identified and brought back to the committee for policy changes. Also, as the formal recommendations from the Institute for HealthCare Improvement and American Practitioners in Infection Control were developed, additional recommendations were incorporated into our existing UTI prevention bundle.

**Data Collection**

Catheter days were determined manually by charge nurses during their acuity classification of patients and totaled in the WinPFS system (Medicus). The total number of patient hospital days was provided electronically by Shands Hospital at University of Florida Decision Support Services. The number of catheter-associated UTIs were tracked by Infection Control and reported back to the neuro ICU team as well as the individual departments monthly. Clinical Nurse Leaders rounded on each patient daily in the neuro ICU (Foley Rounds). They recorded the indication for each catheter placed and compliance with the UTI bundle and tracked whether recommendations for removal were followed by physicians. Information was collected daily and analyzed quarterly.

**Statistical Analysis**

Categorical data are presented as absolute values and percentages. Significant changes in UTI rate and catheter utilization rate were determined by linear regression with the rate as the response variable and time as the independent variable. Pearson product moment correlation was
used to assess the correlation between quarterly catheter utilization, the rate of catheter-associated UTI, and pressure ulcer incidence. A p value < 0.05 was considered statistically significant.

**Results**

In November 2007 the national average for catheter-associated UTI among neuro ICUs was 6.8%. Preintervention data, totaling more than 1200 catheter days, showed that the UTI rate at Shands Hospital at the University of Florida was 13.8% in all ICUs and 13.3% within the neuro ICU. It was also discovered that no universal standard of practice existed in either antiseptic insertion or maintenance of urinary catheters. As has been shown in other studies, placement of most catheters occurred in the emergency department or operating rooms. In our institution, catheters in these locations were supplied by different vendors. A patient who had clinical needs such as a catheter with a temperature probe might not have been identified as such when the urinary catheter was initially placed; therefore a catheter placed in the emergency department was not compatible with the collection system in the neuro ICU. This resulted in open and noncompatible collection systems. While closed systems were available in certain areas, only 2 sizes were stocked. Product standardization to increase the availability of the right products and to maintain the integrity of a closed catheter system was a key part of the UTI prevention bundle.

**Decreased Utilization of Urinary Catheters**

For the intervention period of August 2008 through December 2010, the mean number of catheters per day in the 30-bed neuro ICU decreased from 25.8 to 18.5 (Fig. 2A). Likewise at the initiation of the study, virtually 100% of patients had urinary catheters in the neuro ICU (Fig. 2B). It should be noted that since charge nurses counted the number of catheters per room, if 2 patients with a urinary catheter inhabit the same room in 1 day (during transition), then 2 catheters were recorded for that room. This explains the greater than 100% utilization present in Fig. 2B and presents the distinct possibil-
ity that utilization rates could be even lower. Six months after initiation of the UTI prevention bundle, the utilization rate had fallen significantly to 92% and continued to fall to 75% at 15 months, and an absolute low of 73.3%, following the initiation of Foley Rounds ($r^2 = 0.794$, $p < 0.0001$; Fig. 2A and B). This was below the NHSN catheter utilization benchmarks of 88%, 82%, and 77% for the 75th, 50th, and 25th quartiles, respectively. After the 6 months of Foley Rounds were completed, this utilization rate remained stable, likely indicating a culture change. Currently, Clinical Nurse Leaders perform UTI prevention bundle/Foley Rounds twice weekly and periodically remind the critical care medicine team of indications as necessary, but no ongoing evaluation is performed outside of tracking UTI and catheter days.

It was anticipated that compliance with the UTI prevention bundle would be challenging prior to initiation. However during the 6 months in which Foley Rounds occurred daily, the monthly compliance with the UTI bundle ranged from 96% to 100%. Previous studies have shown that only 46% of patients who undergo catheterization have a correct indication and only 13% of patients who undergo catheterization have a documented reason for placement. After intervention this number steadily increased with the implementation of the Surgical Care Improvement Process measure that mandated the requirement for documentation. If documentation was lacking, the indication was listed in the subsequent progress notes. The indications for catheter placement during the study period are shown in Table 2. There tended to be little month-to-month variability of these indications. The number of catheters recommended for removal by the Clinical Nurse Leaders during Foley Rounds varied greatly between 6% and 32%.

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Fig. 2. Graphs showing reductions in urinary catheter utilization and catheter-associated UTI over time (months). Note that in all graphs, the time zero corresponds to October 2008. **A:** Average number of urinary catheters per day present in the 30-bed neuro ICU per quarter. **B:** The rate of urinary catheter utilization measured as a percentage of ICU patient beds, both 9 months prior to intervention and 30 months postintervention. **C:** Decrease in the total number of UTIs during the same period. This decrease correlates strongly with the UTI rate because the number of patients in the neuro ICU remained relatively constant through the study period. Note that the total numbers of UTIs during the preintervention 1-month study periods were normalized to reflect a quarterly amount. **D:** Catheter-associated UTI (CAUTI) rate tracked through the same time period. Note that the CAUTI rate fell prior to official implementation of the UTI bundle. Lines in panels B and D are the 25th, 50th, and 75th quartiles from the NHSN.
of catheters present on the 30-bed unit. Of these recommendations, physicians complied with removal 81.6% of the time. In the remaining cases, physicians provided additional documentation to clarify the indication.

**Decreased UTI Rate and Total Number of UTIs**

Not surprisingly both the total number of UTIs as well as the UTI rate decreased significantly following the intervention ($r^2 = 0.695, p < 0.001$). The total number of UTIs per quarter in the neuro ICU fell from a high of 32 to 7 infections per quarter over a 40-month period (Fig. 2C). Similarly UTI rates fell from a preintervention high of 13.3 infections per 1000 catheter days to a current and sustained low of approximately 4 infections per 1000 catheter days (Fig. 2D). This compares quite favorably to the NHSN benchmarks of 9.0, 7.3, and 4.4 infections per 1000 catheter days for the 75th, 50th, and 25th quartiles nationally, respectively. There was also a strong linear correlation between the quarterly catheter utilization rate and catheter-associated UTI ($r^2 = 0.695, p < 0.001$). Hospital-wide, a significant decline in urinary catheter utilization rates from 100% to 73.3% resulted in a decrease in the risk of urinary catheter-associated UTI from 100% to 73.3%. Third, decreases in utilization rates correlated strongly with a drop in the catheter-associated UTI rate from 13.3 to 4.0 infections per 1000 catheter days. Finally, decreased catheter utilization did not result in an increase in pressure ulcer formation.

**TABLE 2: Indications for urinary catheterization in the neuro ICU**

<table>
<thead>
<tr>
<th>Indication</th>
<th>Percentage</th>
</tr>
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<tbody>
<tr>
<td>strict “in &amp; out”</td>
<td></td>
</tr>
<tr>
<td>polyuria or oliguria</td>
<td>39</td>
</tr>
<tr>
<td>hemodynamic instability</td>
<td>19</td>
</tr>
<tr>
<td>invasive procedures</td>
<td>9</td>
</tr>
<tr>
<td>hyper- or hyponatremia</td>
<td>4</td>
</tr>
<tr>
<td>Stage III or IV pressure ulcers*</td>
<td>6</td>
</tr>
<tr>
<td>urinary obstruction</td>
<td>5</td>
</tr>
<tr>
<td>comfort during end of life</td>
<td>4</td>
</tr>
<tr>
<td>unstable spine requiring immobility</td>
<td>2</td>
</tr>
</tbody>
</table>

* According to National Pressure Ulcer Advisory Panel standards.

As in other published studies, *Escherichia coli* was the predominant organism (33%) in this population of patients with UTIs. This was followed by *Klebsiella* (12%), *Candida* (11%), *Pseudomonas* (11%), *Enterococcus* (10%), *Proteus* (6%), *Enterobacter* (5%), *Citrobacter* (2%), and *Serratia* (2%). A steady decrease in the frequency of *E. coli* was noted throughout the study while temporary outbreaks of *Proteus* and *Pseudomonas* species were noted during the 30-month study (Fig. 3).

**Fig. 3. Graph showing the frequency of pathogens responsible for UTI during the study period.** Note the continual decline of *E. coli* with the periodic increases of *Proteus* and *Pseudomonas* and relative stability of *Enterococcus*, *Candida*, and *Klebsiella* species. “Other” pathogens include *Serratia*, *S. aureus*, *Morganella*, and *Stenotrophomonas*.

**Discussion**

In this study we report our experience with implementation of an evidence-based UTI prevention bundle in the neuro ICU setting. Our data allow us to comment on several points. First, this study shows that implementation of evidence-based guidelines, as set forth by the American Hospital Association, The Joint Commission, NHSN, and CDC is possible. Second, these changes resulted in a significant decline in urinary catheter utilization rates from 100% to 73.3%. Third, decreases in utilization rates correlated strongly with a drop in the catheter-associated UTI rate from 13.3 to 4.0 infections per 1000 catheter days. Finally, decreased catheter utilization did not result in an increase in pressure ulcer formation.

The Society for Healthcare Epidemiology of America and the Infectious Diseases Society of America, in partnership with The Joint Commission, American Practitioners in Infection Control, and American Hospital Association, recently published a compendium entitled *Strategies to Prevent Catheter-Associated Urinary Tract Infections in Acute Care Hospitals.* It summarizes current recommendations based on review of the evidence by national clinical experts in infection control and prevention. It is reassuring to find that, through similar methods of literature review, the UTI prevention bundle developed by this institution in 2008 is nearly identical to these recommendations. Additionally, the execution of these recommendations with quantifiable results again demonstrates their effectiveness and adds validity to their recommendations.

Prior studies have shown that the most effective strategy for prevention of catheter-associated UTI is avoidance of urinary catheterization unless indicated. Several hospital-based studies of medical ICUs have shown that 21%–54% of urinary catheters were found to be inappropriately placed and between 38% and 50% of catheters have no indication for placement at all. Development of appropriate indications for catheter placement is...
Education regarding the care and maintenance of urinary catheters has been shown to reduce catheter-associated UTI. A prospective single-institution open trial by Rosenthal et al. compared rates of catheter-associated UTI after implementing education and performance feedback. While more modest in their educational goals of hand washing and ensuring free flow of urine, catheter-associated UTI rates dropped from 21.3 to 12.39 infections per 1000 catheter days. A more comprehensive education program was used in our study, which targets not just physicians but nurses and patients as well. Much like the Rosenthal study, feedback was also incorporated into this intervention, with monthly updates of current infections and targets, as well as the percentage compliance with the UTI prevention bundle and Foley Rounds recommendations.

Unforeseen difficulties were encountered while implementing this program, most related to the increased utilization of in-and-out catheterization. First, a subjective observation from nursing staff suggests that patient satisfaction may have decreased with intermittent catheterization. It is believed that this was due to both modesty and interruption of sleep schedules, which are already altered in the ICU setting. Second, it is unknown if the rates of urethral trauma or secondary urinary retention increased with serial in-and-out catheterization. Third, the routine use of bladder scanning to detect urine volumes prior to in-and-out catheterization was put in place as a means of avoiding urinary retention. However, in the postoperative setting, bladder scanning is rarely viewed with the same priority as other postanesthesia recovery "tasks." Therefore, fewer catheters placed during short surgical cases resulted in postoperative patients with relatively full bladders for extended periods of time. Within our institution a Urinary Retention team has been formed to investigate these issues.

Specific challenges related to the neuro ICU also exist when implementing the UTI bundle. It is believed that increased frequency of UTIs among this population is most likely secondary to neurological deficits. One of the main difficulties with implementation of the UTI bundle is the definition of catheter-associated UTIs, which relies on patient-reported symptoms. Many neurosurgical patients are unable to reliably report UTI symptoms either due to underlying illness or use of sedative medications, which eliminates the use of urinary urgency and frequency, dysuria, and suprapubic tenderness in diagnosis and limits the definition to fever in the setting of bacteriuria. This limitation suggests that the rate of UTIs among this population could be even higher than reported in this study.

The current study has several limitations. First, as a tertiary referral center, a large percentage of our patients arrive already catheterized, and the rate of outside catheter placement was not controlled for. For this reason, a urinalysis on admission has been incorporated into our admission screening for patients with a catheter in place on arrival. Second, the greatest limitation of this study was the incremental and adaptive feedback design; accordingly, the efficacy of each intervention is indeterminable. This is demonstrated by the fact that urinary catheter utilization dropped most precipitously from 3 to 12 months after implementation. However, total UTIs and the UTI rate fell at a more constant rate over the 30
Catheter-associated UTIs in the neuro ICU

months evaluated. While undoubtedly utilization did play a role in reduction, other factors such as improvements in equipment, education in sterile insertion, and continual methods improvement through feedback and drill-down tools played a large part as well.

Third, the economic costs of this program were only retrospectively monitored. The conversion to closed, silver-alloy impregnated urinary catheters did coincide with an increased cost of $5.60 per unit above standard silicone catheters at our center. With approximately 111 units used per quarter, this resulted in an increased cost of $621 per quarter within the neuro ICU. The use of in-and-out catheters increased from virtually none to 904 devices per quarter. Accordingly, this resulted in an increased cost of $1000 per quarter. Therefore the total increased materials cost was a nominal $1621 for all patients in the neuro ICU per quarter. However, in-and-out catheterization is substantially more labor intensive than indwelling catheterization. While nursing staffing remained the same during the study period, a request has since been made for more nursing staff. The cost of additional staff will be the largest cost of this initiative should it be approved.

In our study the price of materials was far offset by the reduction in the cost of infections. A similar study involving all ICU patients in a hospital-wide effort decreased the monthly cost of antibiotics for catheter-associated UTI by 69%. Each episode of symptomatic UTI is expected to carry an additional cost between $589 and $676. If the patient develops bacteremia secondary to catheter-associated UTI, which was not monitored in this study, estimates of cost per case increase to between $2500 and $3000. Comparing the first 2 quarters and the last 2 quarters of the study period, this intervention resulted in a decrease of 17 catheter-associated UTIs per quarter. Utilizing the cost of UTI from the literature, this intervention resulted in an estimated savings of $8500 to $12,000 per quarter for the neuro ICU. After taking into account the increased cost of materials, a savings of $6800–$10,200 is still realized. With an incidence of greater than 1 million cases annually, CMS has concluded that the annual cost of nosocomial UTI due to indwelling catheters is between $424 and $451 million. In this era of tight budgets, this savings is a significant financial benefit.

Conclusions

As many as 5 million urinary catheters will be placed annually in the US. Furthermore, 12%–25% of all hospitalized patients will receive a urinary catheter during their hospital stay. Urinary tract infections are the most common health care–associated infection in the ICU, accounting for 23% of hospital-acquired infections in the critically ill. With these large numbers, catheter-associated UTIs represent the “low-hanging fruit” in our effort to control hospital-acquired infections. This study demonstrated that implementation of an evidenced-based UTI prevention bundle can substantially reduce catheter utilization. Our program, which encompassed continuous quality improvement, physician and nursing reminders for early catheter removal, proper indications for catheter insertion, product standardization, and improvements in sterile catheter insertion, maintenance, and early removal, significantly reduced the urinary catheter utilization rate without increasing the rate of pressure ulcers. Most importantly, a significant decrease in the rate of catheter-associated UTI was observed. Furthermore, the rate of UTI has continued to decline, even after discontinuation of daily monitoring. This suggests a long-lasting and durable culture change.

The current routine use of indwelling catheters for ICU patients needs to be changed, and it is our hope that our work will form a road map that helps other centers to make similar strides.

Disclosure

Dr. Mocco received support for this study from ev3. He also serves as a consultant to Actelion; serves on the advisory board of Lazarus Effect, Edge Therapeutics, and N Focus; and has ownership in Codman Neurovascular.

Author contributions to the study and manuscript preparation include the following. Conception and design: Mocco, Titsworth, Hester, Correia, Reed, Guin, Layon, Archibald. Acquisition of data: all authors. Analysis and interpretation of data: Titsworth, Hester, Williams, Guin, Archibald. Drafting the article: Mocco, Titsworth, Hester. Critically revising the article: Mocco, Titsworth, Hester, Williams, Guin, Layon, Archibald. Reviewed submitted version of manuscript: Mocco, Titsworth, Guin, Layon, Archibald. Statistical analysis: Titsworth. Administrative/technical/material support: Titsworth. Study supervision: Mocco, Titsworth.

Appendices

This article contains appendices that are available only in the online version of the article.

References

Catheter-associated urinary tract infections in the ICU

Appendix 1

Quality Neuro Matters
Your Brain Bit Guide

Did You Know...
The most common site of healthcare-associated infection is the urinary tract.

February 2010 Feature: Prevention of UTI’s

Shands Best...
- Hand hygiene, alcohol hand sanitizer
- Maintaining unobstructed urine flow
- Urinary catheter reminders, nursing feedback
- Keep collection bag below the level of the bladder at all times
- Maintain a sterile, continuously closed drainage system
- Keep catheter properly secured to prevent movement/ traction
Most Important Action to Avoid UTI

AVOID indwelling catheters whenever possible and remove them as soon as possible!!!!!!

SCIP measures require removal by day 2 or MD,PA, or ARNP documentation required! justly longer!

Some Food For Thought: CAUTI

Catheter Associated Urinary Tract Infections accounts for about 1 million hospital acquired infections, a year, with an estimated cost of $500-$3000 per case. Following simple rules and guidelines on catheter improvements can significantly decrease these statistics. According to the CDC, IHI, SHEA and APIC collectively agree that some practices should be avoided on a routine basis. These practices include:

- Irrigating catheters, except in cases of catheter obstruction
- Disconnecting the catheter from the drainage tubing
- Replacing catheters routinely (in the absence of obstruction or infection); if the collection system must replaced, use aseptic technique.

The risk for CA-UTI increases the longer the catheter is in place. Due to the risk of infectious complications, urinary catheters should be used after considering all the alternatives.

Evidence Review:


Appendix 2

Notes:

Prevention of Urinary Catheter Associated Infection Control Fact Sheet

Consequences of Foley Catheter Associated Urinary Tract Infections (CA-UTIs)

➢ CA-UTIs are the common cause of healthcare associated infections.
➢ CA-UTIs are the second leading cause of bloodstream infections (secondary to the CA-UTI).
➢ The average cost of treating a UTI is $1,000 and secondary bloodstream infections, $36,441.
  o CA-UTIs lead to prolonged hospital stays.
  o The mortality of secondary healthcare associated bloodstream infections is 15% to 25%.
  o The risk of developing a CA-UTI increases 9% to 10% per day with each day of catheterization.

References:
4. Best Education - Foley catheter picture

“Bladder Bundle”
• Aseptic insertion and proper maintenance is paramount
• Bladder ultrasound may avoid indwelling catheterization
• Condom or intermittent catheterization in appropriate patients
• Do not use the indwelling catheter unless you must!
• Early removal of the catheter using reminders or stop orders appears warranted.

Courtesy of Sanjay Saint, MD, MPH
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Professor of Internal Medicine, University of Michigan Medical School
Catheter-associated urinary tract infections in the ICU

Appendix 3

Bacteria and the Urinary Catheter
- Bacteruria > 10^8 occurs within 24-48 hours of urinary catheter placement.
- Routine bladder scanning and I & O catheterization are preferred over indwelling catheters for treatment of failure to void due to lower UTI risk.
- Bacteria can travel through the extra-luminal and intra-luminal surfaces of the catheter and contaminate the bladder.
- Prevent backflow of urine into the bladder by keeping drainage bag placement below the bladder.

CMS Impact and CA-UTIs
- CMS will no longer provide reimbursement for the cost of care associated with selected hospital acquired infections including UTIs.
  - CA-UTIs are now considered "never events".
  - CMS rules are driving changes to improve patient outcomes.

Catheter Management: Key Points
- Catheter Removal
  - Daily assess the need for an indwelling catheter and the possibility of removal.
  - Routine changing of catheter is not recommended unless mechanical obstruction or encrustations is an issue.
  - Catheters should NOT be changed as part of a fever work-up.
  - Catheters should NOT be changed for patients admitted from nursing homes or other hospitals. Instead, send a U/A and C & S.

- Product Selection
  - Only closed systems with silver impregnated catheters should be used whenever available.
  - Use the Stat lock@ urinary catheter securement device to prevent movement and urethral traction and to help prevent abrasions to the urethra which increases risk for UTIs.

- Proper Bag Placement
  - Proper placement of the catheter drainage bag is below the bladder, at the foot of the bed with no dependent loops.
    - Maintain the drainage bag in this position at all times: including transport, transfer, and in the O.R.
    - Never put the bag on top of bed or patient.

- Patient Education
  - Patient awareness of urinary catheter care is essential in preventing UTI; instruct patient to:
    - avoid touching the catheter,
    - always keep the drainage bag below the bladder while in bed or chair, during transport or ambulation, and
    - protect the closed system from disconnection.

Appropriate catheter use includes:
- Perioperative use for selected surgical procedures longer than 3 hours.
- Urine output monitoring in critically ill patients for a finite time period.
- I & O catheter regimens if urinary retention and / or neurogenic bladder occurs.
- Management of acute urological conditions such as urinary obstruction, when I & O catheterization is not prudent.
- Assistance in severe pressure ulcer healing (grade 3 or 4).
- Comfort during end-of-life.

What efforts are effective in reducing CA-UTIs?
- Initiatives such as the "Day Four Foley No More" program have been found to be effective in decreasing the rate of catheter acquired UTIs.
- Studies show reductions in CA-UTI rates of 48-81% through the use of:
  a. Daily reminders
  b. Nurse-driven protocols
  c. Reduction in duration of catheter days
- Routine bladder scanning and I & O catheterization are preferred over indwelling catheters for treatment of failure to void due to lower UTI risk.

Catheters should NOT be used for urinary incontinence or staff convenience.
Appendix 4

Urinary Catheter Fact Sheet

Consequences of Foley Catheter Associated Urinary Tract Infections (CA-UTIs)

- CA-UTIs are the second leading cause of blood infections.
- The average cost of treating a urinary tract infection is $1,006 and secondary blood stream infections, $36,441.
  - Secondary healthcare associated blood stream infections carry a mortality rate of 15% to 25%.
  - Risk of developing a CA-UTI increases with the duration of catheterization.
  - The risk of UTI increases 3% to 10% per day an indwelling urinary catheter is in place.

Bacteria and the Urinary Catheter

- Bacteruria > 10^5 occurs within 24-48 hours of having a urinary catheter placed.
- Prevent backflow of urine into the bladder since bacteria can travel through the extra-luminal and intra-luminal surfaces of the catheter and contaminate the bladder.

CMS Impact and Catheter Associated Urinary Tract Infections

- CMS will no longer provide reimbursement for the cost of care associate with selected hospital acquired infections including UTIs.
  - CA-UTIs are now considered “never events”.
  - CMS rules are driving change to improve patient outcomes

Managing the Catheter Tips

- Catheter Removal
  - Need for an indwelling catheter should be assessed daily for removal.
  - Routine changing of catheter is not recommended unless mechanical obstruction or crustaceans is an issue.
  - Catheters should NOT be changed as part of a fever work-up.
  - Catheters should NOT be changed for patients admitted from nursing homes or other hospitals. Instead, send a U/A and C & S.

- Product Selection
  - Only closed systems with silver impregnated catheters should be used whenever available.
  - Use the Stat lock® urinary catheter securement device to prevent movement and urethral traction and to help prevent abrasions to the urethra which increases susceptibility to UTIs.

- Proper Bag Placement
  - Proper placement of the catheter drainage bag is below the bladder, at the foot of the bed with no dependent loops.
    - Maintain the drainage bag in this position at all times: including transport, transfer, and in the O.R.- Never put the bag on top of bed or patient.

- Patient Education
  - Patient awareness of urinary catheter care is essential in preventing UTI; instruct patient to:
    - avoid touching the catheter,
    - always keep the drainage bag below the bladder while in bed or chair, during transport or ambulation, and
    - protect the closed system from disconnection.

- Routine bladder scanning and I &O catheterization are preferred over indwelling catheters for treatment of failure to void due to lower UTI risk.
- Studies show reductions in catheter associated UTI rates of 48-81% through the use of:
Catheter-associated urinary tract infections in the ICU

- Daily reminders
- Nurse-driven protocols
- Reduction in duration of catheter days

Initiatives such as the “Day Four Foley No More” program have been found to be effective in decreasing the rate of catheter acquired UTIs.

- **Appropriate catheter use includes:**
  - Perioperative use for selected surgical procedures longer than 3 hours
  - Urine output monitoring in critically ill patients, for a finite time period. Catheters should NOT be used for urinary incontinence or staff convenience.
  - I and O cathing regimens for if urinary retention and/or neurogenic bladder occurs.
  - Management of acute urological conditions such as urinary obstruction, when I&O catheterization is not prudent.
  - Assistance in pressure ulcer healing for severe pressure ulcers, grade 3 and 4
  - Comfort during end-of-life care.