

Impact of Foley Catheter Placement by Medical Students on Rates of Postoperative Urinary Tract Infection



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- BACKGROUND:** The aim of this study was to evaluate the impact of medical student placement of Foley catheters on rates of postoperative catheter-associated urinary tract infection (CAUTI).
- STUDY DESIGN:** We included adult surgical patients in our institutional National Surgical Quality Improvement Program (NSQIP) database, and defined CAUTI according to NSQIP criteria. A multivariable model risk-adjusting for patient and operative variables associated with CAUTI in univariate analysis (exploratory $p < 0.20$) evaluated the independent effect of medical student placement of Foley catheters on the odds of CAUTI.
- RESULTS:** There were 891 patients who had a Foley catheter placed by a surgical resident (61%; $n = 547$), operating room nurse (25%; $n = 227$), or medical student (13%; $n = 117$). After risk-adjustment, patients with Foleys placed by medical students were at a more than 4-fold increased risk of CAUTI (odds ratio [OR] 4.09, $p = 0.02$) compared with patients with catheters placed by nurses. Patients with catheters placed by residents did not have an increased risk-adjusted odds of CAUTI (OR 2.16, $p = 0.15$). Other significant predictors of postoperative CAUTI included female sex (OR 2.61, $p = 0.01$), partial/total functional dependence (OR 4.81, $p = 0.008$), blood transfusion (OR 34.7, $p = 0.02$), and increased length of Foley stay (OR 1.06, $p < 0.001$).
- CONCLUSIONS:** Surgical patients with Foley catheters placed by medical students are at increased risk-adjusted odds of postoperative CAUTI. More intense supervision of medical students during urinary catheter insertion in the operating room and improved education regarding sterile technique may be important factors in reducing rates of postoperative CAUTI in academic institutions. (J Am Coll Surg 2018;227:496–501. © 2018 by the American College of Surgeons. Published by Elsevier Inc. All rights reserved.)

Urinary tract infection is the most common type of health care-associated infection, comprising nearly 40% of the 1.7 million cases in the United States each year.^{1–3} Urinary

tract infections associated with an indwelling catheter, known as catheter-associated urinary tract infections (CAUTI), represent 80% of all urinary tract infections and cost roughly \$400 million per year.^{1,4} In 2008, the Centers for Medicare and Medicaid Services instituted a nonpayment policy for CAUTIs.⁵ This has underscored the importance of CAUTI prevention from an institutional standpoint.

Although risk factors for CAUTI have been identified, there remains a lack of widely implemented strategies to prevent its occurrence, and the most commonly used practices are used in only a minority of hospitals.² One factor that may affect CAUTI rates, but has not been previously studied, is the placement of the Foley catheter. The aim of this study was to evaluate the effect of medical student placement of the Foley catheter on rates of postoperative CAUTI.

Disclosure Information: Nothing to disclose.

Disclaimer: The ACS NSQIP and the hospitals participating in the ACS NSQIP are the source of the data used herein; they have not been verified and are not responsible for the statistical validity of the data analysis or the conclusions derived by the authors.

Received July 17, 2018; Revised August 9, 2018; Accepted August 10, 2018.

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METHODS

Data source

In this study, we used our institutional National Surgical Quality Improvement Program (NSQIP) database. The NSQIP registry contains prospectively collected patient-level data, including preoperative risk factors and intraoperative variables. The dataset also contains surgical outcomes including 30-day mortality and morbidity. The institutional review board approved this study.

Data analysis

The primary outcome for this study was postoperative CAUTI, which was defined according to NSQIP criteria. More specifically, in addition to a urine culture with $> 10^5$ colonies/mL of urine with no more than 2 species of organisms, one of the following criteria was required to be met within 30 days of the operation: fever ($>38^\circ\text{C}$), urinary urgency, frequency, dysuria, or suprapubic tenderness. Alternatively, one of the above (fever, urgency, frequency, dysuria, or suprapubic tenderness) and one of the following criteria could be used: urinalysis positive for leukocyte esterase and/or nitrate, pyuria, organisms seen on Gram stain of unspun urine, 2 urine cultures with repeated isolation of the same uropathogen with > 100 colonies/mL in nonvoided specimens, urine culture with $<10^5$ colonies/mL of a single uropathogen in a patient being treated with appropriate antibiotics, physician's diagnosis, or physician instituting appropriate antimicrobial therapy.

Primary stratification was by personnel inserting the Foley catheter. Cohorts included surgical residents, operating room nurses, and medical students. Baseline patient characteristics were compared between cohorts using analysis of variance or the chi-square test. Baseline patient characteristics included: age, sex, race, BMI, diabetes mellitus, smoking status, partial/total functional dependence, steroids, weight loss $>10\%$ in the last 6 months, transfusion of more than 4 units packed blood cells in 72 hours before surgery, type of operation (upper gastrointestinal, colorectal, or other), elective vs urgent/emergent status, wound classification (clean, clean/contaminated, contaminated, or dirty/infected), and length of Foley stay.

To evaluate the impact of Foley placer on the risk-adjusted odds of postoperative CAUTI, a multivariate logistic regression model was constructed. The model included risk factors that were associated with CAUTI in univariate logistic regression analysis, with an exploratory value of $p < 0.20$. All of the variables listed under the baseline characteristics comparison above were tested for potential inclusion in the model. Two-tailed values of $p < 0.05$ were considered statistically significant in the

multivariable model. Categorical data were presented as number (percentage) and continuous data as mean $\pm$ standard deviation. All data and statistical analyses were performed using version 11 STATA software (StataCorp LP).

RESULTS

Study population

A total of 891 surgical patients were included in the analysis. The average age was 54.5 ± 15.3 years, with 23.9% ($n = 213$) more than 65 years old (Table 1). The majority of patients were female (57.1%; $n = 509$) and Caucasian (73.9%; $n = 658$). The average BMI was 27.4 ± 6.4 kg/m², with 28.0% ($n = 240$) being obese or morbidly obese. Diabetes mellitus and cigarette use were each present in approximately 15% of the study population. Partial or total functional dependence, steroid use, or weight loss $>10\%$ in the last 6 months were infrequent (each $<10\%$).

Most cases were performed on a nonemergent basis (93.7%; $n = 835$) (Table 2). The most frequent operations were upper gastrointestinal (41.6%; $n = 371$), followed by colorectal (32.2%; $n = 287$) and other nonalimentary tract general surgical or vascular operations (26.2%; $n = 233$). Most commonly, cases were classified as clean-contaminated (63.1%; $n = 562$) or clean (25.1%; $n = 224$).

Placer of the Foley catheter

Foley catheters were placed most commonly by surgical residents (61%; $n = 547$), followed by operating room nurses (25%; $n = 227$) and medical students (13%; $n = 117$). All of the baseline patient characteristics that were evaluated

Table 1. Patient-Related Characteristics of the Study Population

Patient characteristic	Study population (n = 891)
Age, y, mean $\pm$ SD	51.7 $\pm$ 13.1
Female sex, n (%)	509 (57.1)
Race, n (%)	
Caucasian	658 (73.9)
African American	148 (16.6)
Asian	31 (3.5)
American Indian or Alaskan	2 (0.2)
Unknown	52 (5.8)
BMI, kg/m ² , mean $\pm$ SD	27.4 $\pm$ 6.4
Diabetes mellitus, n (%)	131 (14.7)
Smoker, n (%)	129 (14.5)
Partial/total functional dependence, n (%)	39 (4.4)
Steroid use, n (%)	83 (9.3)
Transfusion > 4 U blood in last 72 h, n (%)	15 (1.7)
Weight loss $> 10\%$ in last 6 mo, n (%)	45 (5.1)

Table 2. Operative Characteristics of the Study Population

Operative characteristic	Study population, n (%) (n = 891)
Emergent case	56 (6.3)
Type of operation	
Upper gastrointestinal	371 (41.6)
Colorectal	287 (32.2)
Other	233 (26.2)
Wound classification	
Clean	224 (25.1)
Clean-contaminated	562 (63.1)
Contaminated	67 (7.5)
Dirty/infected	38 (4.3)

were comparable between the cohorts (Table 3). These included both patient-related and operative variables.

Catheter-associated urinary tract infection

The overall rate of CAUTI at our institution over the study period was 2.4%. In univariate analysis, patients with Foley catheters placed by medical students were at increased risk of CAUTI as compared to those who had Foley catheters

placed by nurses (Table 4). Other variables that met entry criteria for the multivariable model in univariate analysis included age, sex, diabetes mellitus, partial/total functional dependence, blood transfusion, wound classification, operation type, and length of Foley stay. In multivariate analysis, significant independent predictors included female sex, partial/total functional dependence, blood transfusion, and increasing length of Foley stay (Table 4). In multivariable analysis, patients with Foley catheters placed by medical students were at a more than 4-fold increased risk of CAUTI as compared with patients in whom nurses had placed the Foley catheter (Table 4). When surgical residents were used as the reference cohort instead of nurses, the same finding was demonstrated, with medical student placement of the Foley catheter posing an increased risk of CAUTI compared with resident placement (odds ratio [OR] 1.99, $p = 0.04$).

DISCUSSION

With an increasing emphasis on cost containment in health care, it is not surprising that CAUTI has been targeted as a nonpayment complication. Postoperative CAUTIs

Table 3. Comparison of Baseline Characteristics Between Study Cohorts

Baseline characteristic	Surgical resident (n = 547)	Operating room nurse (n = 227)	Medical student (n = 117)	p Value
Age, y, mean $\pm$ SD	55.3 $\pm$ 14.8	54.1 $\pm$ 15.5	52.3 $\pm$ 17.0	0.14
Female sex, n (%)	312 (57.0)	129 (56.8)	68 (58.1)	0.97
Race, n (%)				0.74
Caucasian	403 (73.7)	170 (74.9)	85 (72.7)	
African American	89 (16.3)	37 (16.3)	22 (18.8)	
Asian	20 (3.7)	5 (2.2)	6 (5.1)	
American Indian or Alaskan	2 (0.4)	0 (0)	0 (0)	
Unknown	33 (6.0)	15 (6.6)	4 (3.4)	
BMI, kg/m ² , mean $\pm$ SD	27.4 $\pm$ 6.4	27.6 $\pm$ 6.5	26.9 $\pm$ 6.4	0.96
Diabetes mellitus, n (%)	76 (13.9)	38 (16.7)	17 (14.5)	0.60
Smoker, n (%)	84 (15.4)	31 (13.7)	14 (12.0)	0.59
Partial/total functional dependence, n (%)	20 (3.7)	12 (5.3)	7 (6.0)	0.39
Steroid use, n (%)	50 (9.1)	16 (7.1)	17 (14.5)	0.08
Transfusion > 4 U in last 72 h, n (%)	5 (0.9)	6 (2.6)	4 (3.4)	0.07
Weight loss > 10% in last 6 mo, n (%)	27 (4.9)	14 (6.2)	4 (3.4)	0.53
Emergent case, n (%)	32 (5.9)	16 (7.1)	8 (6.8)	0.79
Type of operation, n (%)				0.51
Upper gastrointestinal	221 (40.4)	104 (45.8)	46 (39.3)	
Colorectal	183 (33.5)	63 (27.8)	41 (35.0)	
Other	143 (26.1)	60 (26.4)	30 (25.6)	
Wound classification, n (%)				0.89
Clean	135 (24.7)	60 (26.4)	29 (24.8)	
Clean-contaminated	351 (64.2)	138 (60.8)	73 (62.4)	
Contaminated	41 (7.5)	16 (7.1)	10 (8.6)	
Dirty/infected	20 (3.7)	13 (5.7)	5 (4.3)	

Table 4. Univariate and Multivariate Logistic Regression Analysis for Catheter-Associated Urinary Tract Infection

Covariate	Univariate analysis	p Value	Multivariate analysis	p Value
Foley placer				
Nurse	Reference	Reference	Reference	Reference
Resident	1.02 (0.55–1.86)	0.96	2.16 (0.75–6.21)	0.15
Medical student	2.12 (1.14–3.95)	0.02	4.09 (1.22–13.7)	0.02
Age (increasing, per y)	0.99 (0.97–1.00)	0.10	0.99 (0.97–1.02)	0.57
Female sex	1.97 (1.15–3.37)	0.01	2.61 (1.22–5.55)	0.01
Race				
White	Reference	Reference	—	—
Black	0.78 (0.39–1.57)	0.48		
Asian	0.74 (0.17–3.19)	0.69		
BMI (increasing, per kg/m ²)	1.00 (0.96–1.04)	0.97	—	—
Diabetes mellitus	1.82 (1.01–3.29)	0.04	1.18 (0.47–2.96)	0.72
Smoker	0.64 (0.28–1.42)	0.27	—	—
Partially/totally dependent	4.55 (2.12–9.77)	<0.001	4.81 (1.52–15.3)	0.008
Steroid use	0.91 (0.38–2.16)	0.82	—	—
Blood transfusion >4 U in last 72 h	4.46 (1.38–14.4)	0.01	34.7 (1.74–693)	0.02
Weight loss >10% in last 6 mo	1.15 (0.40–3.32)	0.79	—	—
Emergent case	0.90 (0.31–2.56)	0.84	—	—
Wound classification				
Clean	Reference	Reference	Reference	Reference
Clean-contaminated	2.23 (1.11–4.46)	0.02	6.78 (0.96–48.1)	0.06
Contaminated	2.50 (0.91–6.84)	0.08	5.83 (0.64–53.1)	0.11
Dirty/infected	None had CAUTI	N/A	None had CAUTI	N/A
Operation type				
Other	Reference	Reference	Reference	Reference
Upper gastrointestinal	1.62 (0.81–3.23)	0.17	0.65 (0.13–3.21)	0.60
Colorectal	1.99 (0.99–4.01)	0.05	1.20 (0.24–6.02)	0.83
Length of Foley stay (increasing, per d)	1.05 (1.03–1.07)	<0.001	1.06 (1.03–1.09)	<0.001

CAUTI, catheter-associated urinary tract infection.

represent a significant health care cost burden of roughly \$400 million per year, and although measures have been identified to reduce rates of CAUTI, only a small portion of hospitals have instituted these measures.^{1,2,4,5} One factor that may affect rates of CAUTI at academic institutions, but has not been evaluated in a large-cohort study, is the placer of the Foley catheter. As such, in this study, we reviewed the effect of medical student placement of the Foley catheter on rates of postoperative CAUTI. The principal finding was that medical students placing the Foley catheter portended a more than 4-fold increased risk of CAUTI as compared with nurses placing catheters, and nearly a 2-fold increased risk of CAUTI as compared with residents placing catheters, after risk-adjusting for other important patient and operative variables.

Study implications

These data are not meant to impugn, but rather, to shed more insight into risk factors for CAUTI. Our findings

are analogous to those from multiple previous studies that have been published regarding improved outcomes with increasing operator volume in a variety of procedures.^{6–10} Intuitively, there is some sense to these findings in as much as more experience with a procedure should theoretically lead to improved performance of that procedure.

The same probably applies with Foley catheter placement. An experienced operating room nurse or a surgical resident who has placed hundreds of Foleys probably adheres to sterile technique much better than medical students placing their first Foley catheter. As their experience with the procedure increases, one would expect their performance of the task to improve as well.

One implication of our analysis is that medical student supervision during Foley catheter placement should be intensified. Many times, medical students are assumed to know how to place a Foley catheter, and the resident or nurse is busy performing some other task in the operating room and does not guide them through the procedure.

Medical students may also be afraid to ask for help or fear that they may appear weaker if they voice concern regarding their ability to place the Foley with sterile technique. For these reasons, stricter supervision during Foley placement for all medical students, regardless of perceived skill, may be a strategy to reduce rates of CAUTI.

Another implication of these data relates to simulation modules. Simulation is increasingly being recognized as an important tool in surgical education.¹¹ Although no data currently exist to demonstrate that it is effective in improving rates of sterile placement of Foley catheters, it is certainly conceivable that practicing on a manikin with equipment that would be used in the operating room would increase comfort levels and improve ability to correctly perform the task. Feedback regarding placement could also be provided to students in a learning environment, where mistakes in technique would result in no harm to the patient.

We propose taking a 3-pronged approach for catheter insertion that may have an impact on reducing CAUTI. First, gloving and sterile technique should be emphasized because there is no formal education process at most medical schools for this. Scrub technicians and nurses often glove medical students in the operating room, and proper self-gloving should be formally taught, which could mitigate break in sterile technique. Second, it is important that a chief resident or an attending surgeon supervise the first 10 catheter insertions, ideally with the same faculty member or chief resident for the first 10 insertions. This will allow for consistent feedback to the medical student, therefore providing an opportunity for concrete improvement. Third, medical students who place Foley catheters should keep a record of those patients and should review the patient record weekly for the first 30 days, specifically looking for NSQIP criteria for CAUTI, as defined above. This will allow for "ownership" on behalf of the student if a CAUTI were to develop, and would provide the student with, perhaps, the best kind of feedback. This has not been validated or studied at our institutions, but we plan to initiate this proposal to study its impact after implementation of this program.

Other risk factors for catheter-associated urinary tract infection

Several other risk factors for CAUTI were identified in this study. The increased risk of CAUTI with women is well documented and confirmed in our analysis.^{12,13} Similarly, length of Foley stay correlates with CAUTI risk, and this association is well established.¹² In our multivariable model, each additional day that the catheter remained was associated with a 6% incremental risk of CAUTI. This emphasizes the importance of removing Foley

catheters as soon as possible. Many institutions, including our own, have incorporated reminders into their electronic medical record system to notify providers when a patient still has an indwelling urinary catheter.

The finding that partial or total functional dependence was associated with increased CAUTI risk is not unexpected. Debilitated patients tend to be more frail, with less than ideal nutrition and associated impaired immune function.¹⁴ Blood transfusion just before surgery was used in a small minority of patients in our study population, but was associated with a significant increase in CAUTI risk. An increasing amount of data has accumulated regarding the deleterious effects of blood transfusion, with immunosuppression being one of these adverse consequences.¹⁵ Although incompletely understood, potential mechanisms for immunomodulation implicate immunologically active donor white blood cells, soluble white blood cell-derived immune mediators in stored blood, and soluble human leukocyte antigen peptides circulating in allogeneic plasma.¹⁶ Previous studies have indeed demonstrated higher rates of bacterial infection and cancer recurrence in patients receiving blood transfusions, supporting the notion that immunosuppression may occur in this clinical setting.¹⁷

Interestingly, other factors that have been shown to correlate with infection risk in other scenarios did not affect rates of CAUTI in our risk-adjusted analysis. Diabetes mellitus is associated with increased risk of infection and infection-related mortality at multiple sites.¹⁸ Although it met entry criteria for our model, it did not affect odds of CAUTI after adjusting for other confounding variables. The type of operation and wound classification also had no impact, although one may have presumed that cases with higher rates of infections at remote sites, or cases in which preventing contamination may be more challenging, would be associated with a higher likelihood of CAUTI.

Limitations

There are several limitations to this study. Foremost, our analysis was limited to variables available in the NSQIP dataset, although there may be other confounding variables unaccounted for that affect CAUTI rates. The number of times the student, resident, or nurse had placed a Foley catheter previously was also not available. It is certainly conceivable that the number of times a person has placed a Foley is a stronger predictor of sterile technique and CAUTI risk than status (ie student, resident, or nurse). A new surgical intern who has placed only a few Foley catheters may, in fact, have higher CAUTI rates than a fourth year medical student who has placed many. An additional limitation is that other CAUTI-related outcomes such as

rates of urosepsis, costs attributable to this complication, and other morbidity or mortality resulting from the CAUTI were not evaluated, but are important.

CONCLUSIONS

This study demonstrates that medical student placement of the Foley catheter in surgical patients is associated with a significant increase in risk-adjusted odds of postoperative CAUTI. In addition to its impact on patient care, these data are important from an institutional standpoint given the heightened national emphasis on reducing complication rates with nonpayment for certain complications such as CAUTI. Potential strategies to reduce CAUTI rates may include more intense supervision of medical students during Foley catheter placement and urinary catheter insertion simulation modules. Evaluating whether these strategies reduce rates of CAUTI in an evidence-based manner is certainly prudent before advocating its widespread implementation.

Author Contributions

Study conception and design: Sultan, Arman Kilic

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Drafting of manuscript: Sultan, Arnaoutakis, Arman Kilic

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