Catheter-Associated Urinary Tract Infections among Trauma Patients: Poor Quality of Care or Marker of Effective Rescue?

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Abstract

Background: Catheter-associated urinary tract infection (CAUTI) is associated generally with worse outcomes among hospitalized patients, but the impact of CAUTI on clinical outcomes is poorly described in trauma patients. We hypothesized that trauma patients with CAUTI would have worse outcomes such as longer length of stay (LOS), fewer discharges to home, and higher outcome of death.

Methods: Patients with LOS >2 d in the 2016 Trauma Quality Improvement Program (TQIP) database were included. Patients with and without CAUTI were matched 1:1 via a propensity score using patient, injury, and hospital factors as covariates. Matched pair analysis was performed to compare difference in clinical outcomes between patients with and without CAUTI.

Results: There were 238,274 patients identified, of whom 0.7% had a diagnosis of CAUTI. Prior to matching, CAUTI patients had a higher mortality rate (6.6% vs. 3.4%, $p < 0.01$), but groups differed significantly. There were 1,492 matched pairs created, with effective reduction in bias; post-match propensity score covariates all had absolute standardized differences < 0.1 . In matched pair analysis, CAUTI patients had lower outcome of death compared with patients without CAUTI (6.7% vs. 10.1%, $p < 0.01$). The CAUTI was associated with longer length of stay, more intensive care unit and ventilator days, more unplanned events, and fewer discharges to home (all $p < 0.01$).

Conclusions: Trauma patients with CAUTI had lower outcome of death compared with patients without CAUTI, despite worse clinical outcomes in all other aspects. This difference may be associated with “rescue” care in the form of unplanned events, and CAUTI may be an unintended consequence of this “rescue” care, rather than a marker of poor quality of care.

Keywords: catheter-associated urinary tract infection; trauma; Trauma Quality Improvement Program; urinary tract infection

CATHETER-ASSOCIATED URINARY TRACT INFECTIONS (CAUTIs) are considered a major public health problem and are among the most common health-care-associated infections (HAIs) reported by acute care hospitals [1–4]. According to one estimate in 2016, the attributable cost of a CAUTI ranged from \$876 to \$10,197 depending on patient population, acuity, and cost perspective, posing an economic burden of \$1.7 billion in the United States [5]. The rate of CAUTI has become an important quality metric, because these rates are reported publicly and used to compare hospitals [6]. These rates also impact hospital reimbursements.

In 2008, the Center for Medicare and Medicaid Services deemed it a “potentially preventable” hospital-acquired condition and discontinued reimbursements for these infections via the Hospital Acquired Conditions Reduction Penalty program [2,3,7]. As a result, CAUTIs pose a significant burden on the healthcare system, and considerable effort has been put forth to reduce the CAUTI rates. Multiple studies have focused on reducing the rate of CAUTIs by decreasing catheter use, employing “care bundles,” and changing culturing practices [8–12]. These efforts have resulted in decreased catheter days, but the overall rate of CAUTI has remained similar [2,8,13,14].

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The CAUTIs also pose a significant burden on patients. In general medical and surgical patients, CAUTI can lead to other complications, such as sepsis, bacteremia, and upper urinary tract infections, and result in an increased hospital length of stay (LOS), costs, and death [3,4,9]. Although the impact of CAUTIs on clinical outcomes in general is known, little data exist evaluating the impact of these infections in trauma patients, who are high risk for development of a CAUTI because of mobility restrictions, complex abdominal and pelvic injuries, and prolonged, and often multiple, procedures [15,16]. These patients also have altered physiologic and immunologic response that increases susceptibility to infection and urinary bacterial overgrowth [17,18].

The objective of our study was to evaluate clinical outcomes between patients with and without CAUTI matched using baseline admission characteristics. We hypothesized that trauma patients with CAUTI would have worse clinical outcomes, such as longer hospital LOS, fewer discharges to home, and a subsequent higher inpatient outcome of death.

Methods

Study design and patient population

We performed a secondary analysis of the American College of Surgeons (ACS) Trauma Quality Improvement Program (TQIP) database for the year 2016. The TQIP is one of the largest databases of trauma patients [19]; in 2016, the database comprised 300,841 de-identified patients 16 years of age and older from 463 participating centers. It was designed to allow participating trauma centers to recognize and stratify their outcomes for the purpose of identifying opportunities for improvement. Patient- and institutional-level variables allow for risk adjustment and subsequent benchmarking with the goal of improving quality of care at participating centers [20].

Data are extracted at each participating center by trained personnel and are validated externally on a quarterly basis. Standardized definitions for comorbidities and complications are used, and most definitions in the TQIP database overlap with the National Trauma Data Bank definitions. Patients were excluded if the hospital LOS was less than 2 d or not recorded, or if greater than 7% of observations in the baseline variables were missing. Because of stringent data requirements that prevent submission of incomplete datasets to the TQIP database, no relevant data points had to be excluded for missing data.

Data points and outcomes

Variables pertaining to patient, injury, hospital characteristics, and outcomes were queried from the TQIP database. For each patient, this included age, gender, race, mechanism of injury, Injury Severity Score (ISS), Abbreviated Injury Scale (AIS) score for each body region, comorbidities, and hospital teaching status. In TQIP, the age for all patients more than 90 years is recorded as a binary variable; therefore, to analyze age as a continuous variable, patients more than 90 years old were re-assigned an age of 90 years.

The primary outcomes were hospital LOS, discharge disposition, and in-patient death. Discharge disposition for survivors was categorized as home or not home. Secondary outcomes were intensive care unit (ICU) days, ventilator days, unplanned events (ICU admission, intubation, operation), and complications: severe sepsis, CAUTI, central line

associated blood stream infection (CLABSI), ventilator associated pneumonia (VAP), deep venous thrombosis (DVT), pulmonary embolism (PE), myocardial infarction (MI), and stroke. To better characterize the hospital course of patients, we obtained the rates of “unplanned” interventions for patients, collected in TQIP as unplanned admission to ICU, unplanned intubation, and unplanned operation.

Definitions

The 2016 TQIP database utilized the January 2015 Centers for Disease Control and Prevention (CDC) definition of CAUTI. According to this definition, a patient must meet the following three criteria to have a diagnosis of CAUTI: (1) Patient has an indwelling catheter in place for the entire day on the date of event, and such catheter had been in place for more than two calendar days on that date, or patient had an indwelling catheter in place for more than two calendar days that was removed on the day of, or day before the day of event; (2) patient has at least one of the following signs of symptoms: fever, suprapubic tenderness with no other recognized cause, or costovertebral angle pain or tenderness with no other recognized cause; and (3) patient has a urine culture with no more than two species of organisms, at least one of which is a bacterium $>10^5$ colony forming units/mL. Similarly, CLABSI and VAP were defined by the 2016 TQIP database according to the January 2014 and January 2015 CDC definitions, respectively.

An unplanned admission to the ICU was defined by an admission to the ICU after initial transfer to the floor, or an unexpected return to the ICU after initial ICU discharge; this excluded a patient in whom an ICU admission was necessitated for post-operative care of a planned surgical procedure. An unplanned intubation was defined by a patient necessitating placement of an endotracheal tube and mechanical or assisted ventilation because of the onset of respiratory or cardiac failure manifested by severe respiratory distress, hypoxia, hypercarbia, or respiratory acidosis. In patients who were intubated in the field or emergency department, or those intubated for a surgical procedure, unplanned intubation occurred if they required reintubation >24 h after extubation. Unplanned operation was defined by an unplanned return to the operating room after initial operative management for a similar or related previous procedure [21].

Data analysis

All patients included in this study were stratified into two cohorts: Patients with the diagnosis of CAUTI and patients without the diagnosis of CAUTI. Bivariable analysis was performed to identify differences in baseline patient, injury, hospital characteristics, and outcomes between the two unmatched groups.

Propensity score matching was performed to control for confounding variables between the two unmatched groups. A propensity score model was generated to predict the likelihood of developing a CAUTI using age, gender, race, mechanism of injury, ISS, AIS score for each body region, comorbidities, and hospital teaching status as covariates. Nearest neighbor matching was performed in a 1:1 ratio, without replacement using a caliper of 0.1 to create a matched cohort of patients with CAUTI and patients without CAUTI.

Balance of covariates used for estimating propensity scores was assessed using absolute standardized difference (ASD) [22]. For a given variable, an ASD of <0.1 was considered to indicate a good balance between the two groups. Matched pair analysis was performed between the matched cohorts to identify difference in baseline characteristics and outcomes.

Statistics analysis was performed using Stata[®] version 14 (StataCorp, College Station, TX). Data are presented as median (interquartile range) or frequency (n, %). Unmatched

cohorts were analyzed using the chi-square test for categorical variables and the Mann-Whitney U test for continuous variables. Matched cohorts were analyzed using the exact McNemar test for categorical variables and Wilcoxon matched-pairs signed rank test for continuous variables. A two-tailed p-value of <0.05 was considered significant for all tests. This study was considered exempt by the local Institutional Review Board because of the deidentified nature of the TQIP database.

TABLE 1. COMPARISON BETWEEN BASELINE VARIABLES FOR UNMATCHED PATIENTS WITH AND WITHOUT CATHETER-ASSOCIATED URINARY TRACT INFECTIONS

	No CAUTI (n = 236,532)	CAUTI (n = 1,742)	p*
Median age (IQR), y	59 (37–78)	60 (37–77)	1.00
Gender			<0.01
Male	142,716 (60.3%)	852 (48.9%)	
Female	93,816 (39.7%)	890 (51.1%)	
Race			<0.01
White	173,607 (73.4%)	1,185 (68.0%)	
African American	29,885 (12.6%)	249 (14.3%)	
Asian/Pacific Islander	5,373 (2.3%)	70 (4.0%)	
Other	19,417 (8.2%)	131 (7.5%)	
Comorbidity			
Alcohol use	18,985 (8.0%)	174 (10.0%)	<0.01
Congestive heart failure	10,222 (4.3%)	84 (4.8%)	0.31
Current smoker	48,146 (20.4%)	309 (17.7%)	<0.01
Chronic kidney disease	4,677 (2.0%)	26 (1.5%)	0.15
History of stroke	7,316 (3.1%)	71 (4.1%)	0.02
Diabetes	35,483 (15.0%)	288 (16.5%)	0.08
Disseminated cancer	1,649 (0.7%)	15 (0.9%)	0.41
Functionally dependent	18,473 (7.8%)	105 (6.0%)	<0.01
History of MI	2,855 (1.2%)	22 (1.3%)	0.83
Hypertension	90,713 (38.4%)	659 (37.8%)	0.66
COPD	18,145 (7.7%)	148 (8.5%)	0.20
Steroid Use	2,122 (0.9%)	18 (1.0%)	0.55
Cirrhosis	2,509 (1.1%)	26 (1.5%)	0.08
Dementia	14,804 (6.3%)	78 (4.5%)	<0.01
Major psychiatric disease	26,823 (11.3%)	240 (13.8%)	<0.01
Illicit Drug Use	15,375 (6.5%)	114 (6.5%)	0.94
Mechanism of injury			<0.01
Blunt	194,729 (91.9%)	1,466 (94.6%)	
Penetrating	17,200 (8.1%)	84 (5.4%)	
Median ISS (IQR)	13 (9–18)	21 (14–29)	<0.01
Median AIS (IQR)			
Head	0 (0–3)	2 (0–4)	<0.01
Face	0 (0–0)	0 (0–1)	<0.01
Neck	0 (0–0)	0 (0–0)	<0.01
Thorax	0 (0–3)	1 (0–3)	<0.01
Abdomen	0 (0–0)	0 (0–1)	<0.01
Spine	0 (0–0)	0 (0–2)	<0.01
Upper Extremity	0 (0–1)	0 (0–2)	<0.01
Lower Extremity	1 (0–3)	1 (0–3)	0.04
Unspecified	0 (0–0)	0 (0–0)	<0.01
Hospital teaching status			<0.01
Community	88,762 (37.5%)	566 (32.5%)	
Non-Teaching	29,302 (12.4%)	201 (11.5%)	
University	118,466 (50.1%)	975 (56.0%)	

CAUTI=catheter-associated urinary tract infection; IQR=interquartile range; MI=myocardial infarction; COPD=chronic obstructive pulmonary disease; ISS=Injury Severity Score; AIS=Abbreviated Injury Scale.

*Groups compared using chi-square test for categorical variables and Mann-Whitney U test for continuous variables. A two-tailed p-value of less than 0.05 was considered significant.

TABLE 2. COMPARISON BETWEEN OUTCOMES FOR UNMATCHED PATIENTS WITH AND WITHOUT CATHETER-ASSOCIATED URINARY TRACT INFECTIONS CAUTI

	No CAUTI (n = 236,532)	CAUTI (n = 1,742)	p*
Median hospital LOS (IQR), d	6 (4–10)	20 (12–34)	<0.01
Median ventilator days (IQR), d	0 (0–0)	5 (0–15)	<0.01
Median ICU days (IQR), d	0 (0–4)	11 (4–20)	<0.01
Unplanned events			
Intubation	4,563 (1.9%)	194 (11.1%)	<0.01
Operation	2,202 (0.9%)	72 (4.1%)	<0.01
ICU admission	6,043 (2.6%)	200 (11.5%)	<0.01
Complications			
Severe sepsis	1,498 (0.6%)	112 (6.4%)	<0.01
CLABSI	199 (0.1%)	21 (1.2%)	<0.01
VAP	2,981 (1.3%)	265 (15.2%)	<0.01
DVT	3,661 (1.6%)	144 (8.3%)	<0.01
PE	1,760 (0.7%)	60 (3.4%)	<0.01
MI	799 (0.3%)	18 (1.0%)	<0.01
Stroke	1,247 (0.5%)	46 (2.6%)	<0.01
Disposition			
Inpatient death	8,124 (3.4%)	115 (6.6%)	<0.01
Discharge home	92,701 (39.2%)	185 (10.6%)	<0.01
Discharge not home	135,705 (57.4%)	1,442 (82.8%)	<0.01

CAUTI=catheter-associated urinary tract infection; LOS=length of stay; IQR=interquartile range; ICU=intensive care unit; CLABSI=central line associated blood stream infection; VAP=ventilator associated pneumonia; DVT=deep venous thrombosis; PE=pulmonary embolism; MI=myocardial infarction.

*Groups compared using chi-square test for categorical variables and Mann-Whitney U test for continuous variables. A two-tailed p-value of less than 0.05 was considered significant.

Results

A total of 238,274 patients were included in this study, of which 1,742 (0.7%) patients had a diagnosis of CAUTI. Table 1 compares baseline patient, injury, and hospital characteristics between patients with and without CAUTI before matching. There was a statistically significant difference in gender, race, some comorbidities, and all injury and

hospital characteristics between the two groups. Table 2 compares outcomes between patients with and without CAUTI before matching. There was a statistically significant difference noted in all outcomes between the two groups (all $p < 0.01$). The CAUTI group had longer hospital LOS, more ventilator and ICU days, more unplanned events and complications, fewer discharges to home, and higher inpatient death compared with patients without CAUTI.

FIG. 1. Absolute standardized differences between patients with and without catheter-associated urinary tract infection before and after propensity score matching.

TABLE 3. COMPARISON BETWEEN BASELINE VARIABLES FOR MATCHED PATIENTS WITH AND WITHOUT CATHETER-ASSOCIATED URINARY TRACT INFECTIONS

	<i>No CAUTI</i> (<i>n</i> = 1,492)	<i>CAUTI</i> (<i>n</i> = 1,492)	<i>p</i> *
Median age (IQR), y	61 (38–79)	60 (37–79)	0.15
Gender			0.14
Male	692 (46.4%)	731 (49.0%)	
Female	800 (53.6%)	761 (51.0%)	
Race			0.86
White	1,049 (70.2%)	1,028 (68.9%)	
African American	209 (14.0%)	207 (13.9%)	
Asian/Pacific Islander	49 (3.3%)	55 (3.7%)	
Other	94 (6.3%)	107 (7.2%)	
Comorbidity			
Alcohol use	144 (9.7%)	154 (10.3%)	0.58
Congestive heart failure	75 (5.0%)	69 (4.6%)	0.67
Current smoker	264 (17.7%)	265 (17.8%)	1.00
Chronic kidney disease	15 (1.0%)	20 (1.3%)	0.50
History of stroke	67 (4.5%)	57 (3.8%)	0.39
Diabetes	239 (16.0%)	245 (16.4%)	0.80
Disseminated cancer	19 (1.3%)	14 (0.9%)	0.49
Functionally dependent	82 (5.5%)	81 (5.4%)	1.00
History of MI	22 (1.5%)	20 (1.3%)	0.87
Hypertension	579 (38.8%)	555 (37.2%)	0.36
COPD	130 (8.7%)	120 (8.0%)	0.55
Steroid use	15 (1.0%)	15 (1.0%)	1.00
Cirrhosis	27 (1.8%)	22 (1.5%)	0.57
Dementia	74 (5.0%)	61 (4.1%)	0.26
Major psychiatric disease	227 (15.2%)	205 (13.7%)	0.27
Illicit drug use	93 (6.2%)	96 (6.4%)	0.88
Mechanism of injury			0.94
Blunt	1,410 (94.5%)	1,409 (94.4%)	
Penetrating	82 (5.5%)	83 (5.6%)	
Median ISS (IQR)	21 (13–29)	22 (14–29)	0.03
Median AIS (IQR)			
Head	2 (0–4)	2 (0–4)	0.74
Face	0 (0–1)	0 (0–1)	0.81
Neck	0 (0–0)	0 (0–0)	0.69
Thorax	1 (0–3)	2 (0–3)	0.10
Abdomen	0 (0–1)	0 (0–2)	0.79
Spine	0 (0–2)	0 (0–2)	0.45
Upper extremity	0 (0–1)	0 (0–2)	0.11
Lower extremity	1 (0–3)	1 (0–3)	0.88
Unspecified	0 (0–0)	0 (0–0)	0.33
Hospital teaching status			0.39
Community	504 (33.8%)	472 (31.6%)	
Non-teaching	146 (9.8%)	161 (10.8%)	
University	842 (56.4%)	859 (57.6%)	

CAUTI=catheter-associated urinary tract infection; IQR=interquartile range; MI=myocardial infarction; COPD=chronic obstructive pulmonary disease; ISS=Injury Severity Score; AIS=Abbreviated Injury Scale.

*Groups compared exact McNemar test for categorical variables and Wilcoxon matched-pairs signed rank test for continuous variables. A two-tailed *p*-value of less than 0.05 was considered significant.

From the initial study population, 1,492 pairs were matched from each group giving a cohort of 2,984 patients for analysis. The propensity match produced well-balanced groups, with ASD of <0.1 for each covariate used in the propensity score match (Fig. 1). Table 3 compares baseline patient, injury, and hospital characteristics between matched patients with and without CAUTI. There was no statistically significant difference between the two matched groups for the majority of the baseline variables. The ISS was the only

baseline variable with a statistically significant difference after matching (22 in CAUTI group vs. 21 in non-CAUTI group, *p*=0.03). The AIS scores were not different between the two groups for all body regions.

Table 4 compares outcomes between matched patients with and without CAUTI. Matched patients with CAUTI had a longer hospital LOS, more ICU and ventilator days, and more unplanned events (intubations, operations, and ICU admissions) compared with patients without CAUTI (all

TABLE 4. COMPARISON BETWEEN OUTCOMES FOR MATCHED PATIENTS WITH AND WITHOUT CATHETER-ASSOCIATED URINARY TRACT INFECTIONS

	<i>No CAUTI</i> (<i>n</i> = 1,492)	<i>CAUTI</i> (<i>n</i> = 1,492)	<i>p</i> *
Median hospital LOS (IQR), d	8 (5–16)	20 (12–34)	<0.01
Median ventilator days (IQR), d	0 (0–5)	6 (0–15)	<0.01
Median ICU days (IQR), d	3 (0–9)	12 (5–20)	<0.01
Unplanned events			
Intubation	39 (2.6%)	172 (11.5%)	<0.01
Operation	25 (1.7%)	65 (4.4%)	<0.01
ICU admission	37 (2.5%)	177 (11.9%)	<0.01
Complications			
Severe sepsis	23 (1.5%)	91 (6.1%)	<0.01
CLABSI	1 (0.1%)	16 (1.1%)	<0.01
VAP	58 (3.9%)	223 (14.9%)	<0.01
DVT	40 (2.7%)	126 (8.4%)	<0.01
PE	16 (1.1%)	49 (3.3%)	<0.01
MI	7 (0.5%)	15 (1.0%)	0.13
Stroke	15 (1.0%)	37 (2.5%)	<0.01
Disposition			
Inpatient death	150 (10.1%)	100 (6.7%)	<0.01
Discharge home	384 (25.7%)	153 (10.3%)	<0.01
Discharge not home	958 (64.2%)	1239 (83.0%)	<0.01

CAUTI=catheter-associated urinary tract infection; LOS=length of stay; IQR=interquartile range; ICU=intensive care unit; CLABSI=central line associated blood stream infection; VAP=ventilator associated pneumonia; DVT=deep venous thrombosis; PE=pulmonary embolism; MI=myocardial infarction.

*Groups compared using exact McNemar test for categorical variables and Wilcoxon matched-pairs signed rank test for continuous variables. A two-tailed *p*-value of less than 0.05 was considered significant.

$p < 0.01$). With the exception of myocardial infarction, there was a statistically significant increase in complications among matched patients with CAUTI. The rate of discharge to home was lower among matched patients with CAUTI (25.7% vs. 10.3%, $p < 0.01$). Despite longer hospital stay, however, more unplanned events and complications, there was a statistically significant decrease in death among matched patients with CAUTI compared with patients without CAUTI (10.1% vs. 6.7%, $p < 0.01$).

Discussion

We utilized the ACS TQIP national trauma database for the year 2016 to evaluate THE difference in clinical outcomes between patients with and without CAUTI. Patients were propensity matched using baseline admission characteristics to identify outcomes that were related to or co-occurred with the development of CAUTI. The incidence of CAUTI was 0.7% among the 238,274 patients included in this study. After controlling for all baseline patient, injury, and hospital factors, 1,492 matched pairs were identified.

As hypothesized, patients with CAUTI had evidence of more complex hospitalizations, with longer hospital LOS, more ICU and ventilator days, more unplanned events (intubations, operations, ICU admissions), and a higher incidence of other HAIs. While these outcomes may not be attributable to CAUTI itself, it is plausible that longer, more complex hospitalizations with more complications lead to more catheter days and more CAUTIs. We also identified a significantly lower mortality in patients with CAUTI compared with patients without CAUTI.

To our knowledge, this is the first study to evaluate clinical outcomes in a national cohort of trauma patients with CAUTI since the CDC CAUTI surveillance definition change in January 2015 [6]. Several other studies have evaluated CAUTIs among trauma patients [8,9,15–18]; however, only one study employed the current CDC surveillance definition for CAUTI [9]. The incidence of CAUTI observed in our study was 0.7%, which is similar to the rate of 0.3%–1.3% observed by Elkbulli et al. [9] over a previous 4 years. Others have reported an incidence of 3%–14%, although these studies utilized various definitions for diagnosing CAUTI; some used older CDC surveillance definitions [8,15,17], while others used institutional definitions with a combination of clinical and laboratory findings to define CAUTI [16,18].

The 2015 CDC surveillance definition for CAUTI excluded funguria and lower urine-culture colony counts. This change resulted in marked reduction in CAUTI events compared with studies utilizing the older surveillance definitions [6] and could also explain the lower incidence of CAUTI observed in our study and by Elkbulli et al. [9] compared with other studies using older definitions.

The lower mortality observed among matched patients with CAUTI, despite worse clinical outcomes in all other aspects, was surprising to us and contrary to our hypothesis. Previously published work supports the idea that CAUTI is associated with an increased risk for death. Bottiggi et al. [15] and Monaghan et al. [18] reported an increase in death among patients with CAUTI, while Elkbulli et al. [9] reported no difference in deaths. The baseline characteristics among patients with and without CAUTI, such as age, gender, and ISS, differed in all three studies. These are known confounders and could explain the mortality difference observed in these studies.

The presence of confounding variables could also explain the increase in death observed in the unmatched CAUTI group in our study. Once matched for baseline characteristics, however, deaths were lower in the CAUTI group. We theorize that this decrease in death may be related to unmeasured confounders, such as differences in practice patterns between trauma centers, rather than attributable to the CAUTI itself.

Propensity score matching provided us with 1,492 pairs of patients with similar baseline patient, injury, and hospital characteristics. Despite baseline similarities between groups, clinical outcomes differed significantly. The greater number of unplanned events observed in the CAUTI group suggests that these patients diverged from the expected clinical course and received “rescue” care in the form of unplanned intubations, operations, and/or ICU admissions. The increase in hospital LOS, greater ICU and ventilator days, and increase in other complications, along with decreased inpatient death may be associated with this rescue care. Further, the association between CAUTI and increased unplanned events suggests that CAUTI may be an unintended consequence of the aggressive rescue interventions in these patients.

Our study is not without limitations. It is a secondary analysis of a prospectively maintained national database, and as such, we were unable to account for differences in practice patterns between trauma centers, and unmeasured variables such as the presence and duration of urinary catheterization, which are known risk factors for the development of CAUTI. There may have also been reporting bias; institutions with systems in place that identify and manage CAUTI may be different, with different treatment algorithms, from institutions that do not diagnose or report CAUTI. We also did not have any antibiotic data, which can influence culture results.

The TQIP database does not record long-term data, and therefore no data are available regarding complications after discharge, re-admissions, and 30- or 90-d deaths. Because of the nature of this database, we identified associations between measured variables but could not draw causal conclusions or suggest preventive strategies. Using propensity score matching allowed us to mitigate some of these limitations by identifying matched cohorts likely to undergo similar care.

Conclusion

Matched trauma patients with CAUTI had lower inpatient deaths despite more unplanned events, longer hospital LOS, more ICU and ventilator days, and more complications. This difference in deaths may be associated with rescue care in patients with multiple complications. In other words, development of a CAUTI may be an unintended consequence of other complications for which unplanned rescue care is administered, such as transfer to the ICU, surgical procedures, or intubations, which are also higher in the CAUTI population. It is clear that further studies are warranted to better understand the incidence of CAUTI and its bias for patients with complex and prolonged hospitalizations.

The results of this study bring into question the current thinking that CAUTIs are independently troubling outcomes. Further, our analysis challenges the dogma that CAUTIs are a sign of poor quality of care; instead, we should consider the possibility that CAUTIs may be an

unintended consequence of effective, lifesaving care of patients with prolonged and complicated hospitalizations.

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References

1. Magill SS, O’Leary E, Janelle SJ, et al. Changes in prevalence of health care–associated infections in U.S. hospitals. *N Engl J Med* 2018;379:1732–1744.
2. Letica-Kriegel AS, Salmasian H, Vawdrey DK, et al. Identifying the risk factors for catheter-associated urinary tract infections: A large cross-sectional study of six hospitals. *BMJ Open* 2019;9:e022137.
3. Shuman EK, Chenoweth CE. Urinary catheter-associated infections. *Infect Dis Clin North Am* 2018;32:885–897.
4. Dellinger EP. Prevention of hospital-acquired infections. *Surg Infect* 2016;17:422–426.
5. Hollenbeak CS, Schilling AL. The attributable cost of catheter-associated urinary tract infections in the United States: A systematic review. *Am J Infect Control* 2018;46:751–757.
6. Advani SD, Fakhri MG. The evolution of catheter-associated urinary tract infection (CAUTI): Is it time for more inclusive metrics? *Infect Control Hosp Epidemiol* 2019;40:681–685.
7. Moghadamyeghaneh Z, Stamos MJ, Stewart L. Patient comorbidity and functional status influence the occurrence of hospital acquired conditions more strongly than hospital factors. *J Gastrointest Surg* 2019;23:163–172.
8. Davies PE, Daley MJ, Hecht J, et al. Effectiveness of a bundled approach to reduce urinary catheters and infection rates in trauma patients. *Am J Infect Control* 2018;46:758–763.
9. Elkbulli A, Miller A, Boneva D, et al. Targeting catheter-associated urinary tract infections in a trauma population: A 5-S bundle preventive approach. *J Trauma Nurs* 2018;25:366–373.
10. Tedja R, Wentink J, O’Horo JC, et al. Catheter-associated urinary tract infections in intensive care unit patients. *Infect Control Hosp Epidemiol* 2015;36:1330–1334.
11. Stovall RT, Haenal JB, Jenkins TC, et al. A negative urinalysis rules out catheter-associated urinary tract infection in trauma patients in the intensive care unit. *J Am Coll Surg* 2013;217:162–166.
12. Golob JF Jr, Claridge JA, Sando MJ, et al. Fever and leukocytosis in critically ill trauma patients: It’s not the urine. *Surg Infect* 2008;9:49–56.

13. Metersky ML, Eldridge N, Wang Y, et al. National trends in the frequency of bladder catheterization and physician-diagnosed catheter-associated urinary tract infections: Results from the Medicare Patient Safety Monitoring System. *Am J Infect Control* 2017;45:901–904.
14. Tominaga GT, Dhupa A, McAllister SM, et al. Eliminating catheter-associated urinary tract infections in the intensive care unit: Is it an attainable goal? *Am J Surg* 2014;208:1065–1070.
15. Bottiggi AJ, White KD, Bernard AC, Davenport DL. Impact of device-associated infection on trauma patient outcomes at a major trauma center. *Surg Infect* 2015;16:276–280.
16. Zielinski MD, Kuntz MM, Polites SF, et al. A prospective analysis of urinary tract infections among elderly trauma patients. *J Trauma Acute Care Surg* 2015;79:638–642.
17. Polites SF, Habermann EB, Thomsen KM, et al. Urinary tract infection in elderly trauma patients: Review of the Trauma Quality Improvement Program identifies population at risk. *J Trauma Acute Care Surg* 2014;77:952–959.
18. Monaghan SF, Heffernan DS, Thakkar RK, et al. The development of a urinary tract infection is associated with increased mortality in trauma patients. *J Trauma* 2011;71:1569–1574.
19. Hashmi ZG, Kaji AH, Nathens AB. Practical guide to surgical data sets: National Trauma Data Bank (NTDB). *JAMA Surg* 2018;153:852–853.
20. Hemmila MR, Nathens AB, Shafi S, et al. The Trauma Quality Improvement Program: Pilot study and initial demonstration of feasibility. *J Trauma* 2010;68:253–262.
21. ACS NTDB National Trauma Data Standard: Data Dictionary 2016 Admissions. 2015. (Last accessed May 16, 2019). www.facs.org/~media/files/quality_programs/trauma/ntdb/ntds/data_dictionaries/ntds_data_dictionary_2016.ashx
22. Rosenbaum PR, Rubin DB. Constructing a control group using multivariate matched sampling methods that incorporate the propensity score. *Am Stat* 1985;39:33–38.

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