Catheter-Associated Urinary Tract Infections at Intensive Care Unit in Bahrain

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Abstract

Background: The incidence of catheter-associated urinary tract infections (CAUTIs), and etiologic agents and antibiotic resistant patterns associated with CAUTIs in the intensive care unit at Salmaniya medical complex were recorded to identify risk factors associated with acquiring these infections and recommended treatment.

Methods: Prospective surveillance of CAUTIs was conducted from January 1, 2014 till December 31, 2015 using the standard Centers for Disease Control National Nosocomial Infection Surveillance (NNIS) case definitions. Rates were expressed as the number of infections per 1000 catheter days.

Results: During the study period, 1490 patients were monitored for a total of 11,602 patient days and 9,630 patient urinary catheter days. Fifty-one episodes of CAUTI were diagnosed, for an overall rate of 5.3/1000 catheter days. Compliance to the UTI prevention bundle was more than 90%. Male gender, older age, prolonged ICU stay, and medical rather than surgical admission were important risk factors associated with acquiring CAUTI. The most frequently isolated organisms were *E. coli* (28.8%), *Klebsiella* spp. (26.9%), and *Candida* (25%,), followed by *Pseudomonas* spp. (11.6%) and *Proteus mirabilis* (ESBL) spp. (7.7%).

Conclusion: Our incidence of ICU acquired CAUTIs was lower than previously reported in our center, which could be attributed to a significant increase in adherence to infection control policies and procedures. Significant risk factors for developing an ICU-acquired UTI were male gender, old age, prolonged ICU stay, and medical admission.

Meropenem as monotherapy or in combination with aminoglycoside seems to be the most appropriate empiric choice for the treatment of CAUTI among critically ill ICU patients; subsequent de-escalation after sensitivity testing of the causative organism is essential.

Keywords: *Catheter-Associated Urinary Tract Infection; Critical Care Unit; Urinary Tract Infection; Bahrain; Surveillance; Infection Control*

Introduction

Urinary tract infections (UTIs) are the most common hospital acquired infection worldwide, and are associated with increasing mortality, morbidity, duration of hospital stay, and health costs [1,2]. The most important risk factor for developing UTI is urinary catheterization; such infections are known as Catheter Associated Urinary Tract Infections (CAUTI) [1,2].

It is estimated that around 20% of all patients admitted to secondary care hospitals undergo urinary catheterization at least once during their hospital stay; patients admitted to intensive care units (ICU) are the most vulnerable group, due to the more frequent necessity of urinary catheterization and longer duration of catheter use [1,3].

In order to monitor the value of our infection control program and other measures to prevent UTI in the ICU, with the goal of reducing rates of UTI, it is important to know the current rate of CAUTI in our ICU and benchmark it internally and externally to international references.

For patients with severe sepsis, early initiation of appropriate antibiotic therapy is lifesaving. Therefore, choosing appropriate treatment based on local antimicrobial patterns should always be a priority, in order to initiate treatment prior to availability of urine culture results. There is insufficient data about the local antimicrobial trends in our ICU in relation to CAUTI. Accordingly, mapping the antimicrobial susceptibilities among uropathogens in our ICU would be of great concern for choosing appropriate empirical antibiotic therapy.

The aim of the present study was to evaluate the incidence of urinary tract infections among ICU patients, to identify risk factors, and to determine etiological microorganisms with their microbial sensitivity patterns. Moreover, compliance with the preventive bundle recommendations will be assessed and the trend of CAUTI will be analyzed and compared with previous national and international reports.

Materials and Methods

Study Population

All patients 14 years of age and older, admitted to ICU in Salmaniya Medical Center (SMC) between 1 January 2014 and 31 December 2015 were included in the study. SMC is the main governmental tertiary hospital in Bahrain and has a 1000 bed capacity. The intensive care unit at SMC is a closed unit with a capacity of 22 beds, the intensive care unit at SMC are closed unit staffed by fully trained intensivists with a capacity of 22 bed, specializes in the care of various patient populations including neurosurgery, trauma, medical and general surgery patients.

Protocol

Patient surveillance data were collected prospectively. Infection control nurses made daily visits to all adult ICU inpatients, using a special surveillance form containing demographic data such as age and gender, underlying diseases, date of hospital admission, date of ICU admission, reason for admission, date of insertion of urinary catheter (if there), and length of stay in the ICU in days.

The CAUTI prevention bundle consists of avoiding unnecessary insertion, aseptic technique during insertion, maintaining catheter care based on recommended guidelines, daily review of catheter necessity, and prompt removal. During their daily observational visits to the ICU, infection control nurses also collected data regarding compliance with the CAUTI prevention bundle, in addition to continuous monitoring of hand hygiene compliance by the ICU staff (doctors, nurses and others). The two groups of ICU population (with and without UTI) were compared to aid in identifying the risk factors for developing UTI.

Criteria for Diagnosis of CAUTI

CAUTI was diagnosed based on the definition of Centers for Disease Control/National Health Service Network (CDC/NHSN) [4], which

mandate presence of indwelling urinary catheter being in place for > 2 calendar days on the date of event of UTI, with day of device placement being Day 1, and an indwelling urinary catheter was in place on the date of event or the day before.

Symptomatic urinary tract infection was defined when a patient had at least one of the following signs or symptoms with no other recognized cause, accompanied by positive microbiology: fever > 38°C, suprapubic / costovertebral angle pain or tenderness or urgency with frequency, and dysuria if after catheter removal. Asymptomatic bacteremic urinary tract infection was defined as a patient with no signs or symptoms but a positive urine culture of > 105 CFU/ml with no more than two species of uropathogenic microorganisms, accompanied by a positive blood culture with at least one uropathogenic microorganism matching the urine culture [4].

Identification of causative agents and Testing for sensitivity to antibacterial agents

Bacterial identification was based on standard culture and biochemical characteristics of isolates. Antimicrobial susceptibility testing was done by the disk diffusion method, according to the Clinical and Laboratory Standards Institute (CLSI) recommendations, using Mueller–Hinton medium [5]. The tested antimicrobial agents were Augmentin, Cephalothin, Cefuroxime, Ceftriaxone, Ceftazidime, Meropenem, Imipenem, Amikacin, Gentamicin, Ciprofloxacin, Norfloxacin, Nitrofurantoin, Trimethoprim–Sulfamethoxazole, Tigecycline, and Colistin. The zone diameters of each drug were interpreted using the criteria published by CLSI, except for Tigecycline and Colistin in which Minimum Inhibitory Concentration (MIC) was identified using Etest strips (bioMe´rieux, Marcy l'Etoile, France), and interpreted using criteria published by Clinical and Laboratory Standards Institute (CLSI) or European Committee on Antimicrobial Susceptibility Testing (ECAST) [5,6].

Statistical Analysis

Data pertaining to microbial isolates and their antibiotic susceptibility were collected and recorded with all other patients' data on Microsoft Excel Data-base.

The following parameters were calculated for each year:

1. Device utilization ratio (DUR): determining the percentage of inpatients with urinary catheters. DUR= number of indwelling catheter-days/ total number of patient-days × 100
2. Incidence rate of CAUTI as events per 1,000 catheter-days

Incidence rate = total number of patients with UTIs/total number of catheter-days during the year of the study × 1000.

Results

Demographics

There were 1490 patients admitted to the ICU during the two years of the study period; 961 of them were male (64.5%).

The mean age was 48 ± 18.1 years. Sixty four percent of the patients were admitted to ICU for medical reasons. The average length of stay in the ICU was 8.8 ± 11.9 days.

Incidence of CAUTI

A total of 51 events of catheter associated urinary tract infections (CAUTI) were diagnosed over the surveillance period for a total duration of 11,602 inpatient days and 9,630 patient urinary catheter days with an overall rate of 5.3 CAUTIs per 1000 catheter days.

The incidence rate of CAUTI was 5.8/1000 catheter days (26 cases) during 2014 and 4.9 /1000 catheter days (25 cases) in 2015;with an overall rate of 5.3 CAUTIs per 1000 catheter days during the two years.

Urinary catheterization ratios in ICU during 2014 and 2015 were 83% and 82.9% respectively. ICU staff compliance with the UTI prevention bundle during the two years of the study period was more than 90%. Hand hygiene compliance rate in the unit was initially 50% in 2014 and increased to 80 % in 2015.

The duration of ICU admission before developing UTI event ranged from 1-90 days, with an average of 36 days, and an average 5 days length of stay in ICU before the event. The average period of catheterization before the UTI event was 11 days.

Factors associated with the development of an ICU acquired UTI

Several factors were associated with increased incidence of ICU-acquired UTI. Table 1 describes the variables evaluated as potential risk factors.

Possible risk factors	UTI (n = 51)	Non-UTI (n = 1439)	
Male:Female (Male %)	43:8 (85%)	918:521 (54%)	P = 0.011
Mean age (years)	55 ± 16	42 ± 14	P < 0.0001
Medical:Surgical (Medical %)	43:8 (85%)	918:521 (54%)	P = 0.011
Mean length of ICU Stay (days)	14.6 ± 7.9	7 ± 9.2	P < 0.0001

Table 1: Univariate analysis of risk factors for intensive care unit acquired urinary tract infection.

A significant association between ICU length of stay and development of an ICU-acquired UTI was observed. The mean length of ICU stay among patients with ICU-acquired UTI was 14.6 ± 7.9 days compared with 7± 9 days for those without infection (P < 0.0001).

Age was a significant risk factor; the mean age among patients with CAUTI was 55± 16 year compared with 42 ± 14 year for those without (P < 0.0001).

Other risk factors that were associated with increasing risk of developing CAUTI were gender and reason for admission to ICU (medical vs. surgical category). Men were at a higher risk for getting ICU-acquired UTI compared to women (relative risk [RR] 2.9; 95% confidence interval [CI] 1.4016 to 6.2461; P = 0.011). Significantly higher rate of development of UTI was observed among patients admitted for medical conditions in comparison to patients admitted for surgical reasons (P = 0.011).

Micro-organisms and Microbial Sensitivity Patterns

Of 51 CAUTIs, 38 cases (75%) were due to gram-negative bacteria, and 13 cases (25%) due to *Candida* spp. The most frequently isolated causative agent was *E. coli* (28.8% of cases) followed by *Klebsiella* spp. (26.9% of the cases), *Pseudomonas* spp. (11.6% of cases), and *Proteus* spp. (7.7%) as shown in Table 2.

	Candida	*Klebsiella*	*Proteus* (ESBL)	*E. coli*	*Pseudomonas*	Total
Number (% from all isolates)	13 (25%)	14 (26.9%)	4 (7.7%)	15 (28.8%)	6 (11.6%)	52 (100%)
Aug		S (23%)	S (0%)	S (29%)	-	
Cephalothin		S (36%)	S (0%)	S (31%)	-	
CXM		S (39%)	S (0%)	S (58%)	-	
CRO		S (43.28%)	S (0%)	S (61.6%)	-	
CPM		S (43.28%)	S (0%)	S (61.6%)	S (100%)	
CAZ		-	-	-	S (100%)	
MEM		S (69%)	S (100%)	S (100%)	S (100%)	
IMP		-	-	-	S (100%)	
SXT		S (0%)	S (0%)	S (0%)	-	
CIP		-	-	-	S (100%)	
NOR		S (25%)	S (0%)	S (0%)	S (100%)	
Nit		S (25%)	S (0%)	S (100%)	-	
TAZ		S (33.8%)	S (0%)	S (71.6%)	S (100%)	
CN		S (60%)	S (100%)	S (100%)	S (100%)	
AK		-	-	-	S (100%)	
Tig		S (100%)	-	S (100%)	-	
Cl		S (100%)	-	-	-	

Table 2: The etiological agents for CAUTI. The most common organisms causing CAUTI and their antimicrobial susceptibility pattern.

S: Susceptibility Percentage

Aug: Augmentin; CXM: Cefuroxime; CRO: Ceftriaxone; CPM: Cefepime; CAZ: Ceftazidime; MEM: Meropenem; IMP: Imipenem; SXT: Trimethoprim-sulfamethoxazole; CIP: Ciprofloxacin; NOR: Norfloxacin; Nit: Nitrofurantoin; TAZ: Piperacillin/Tazobactam; CN: Gentamicin; AK: Amikacin; Tig: Tigecycline; CL: Colistin

E. coli and *Klebsiella* were found to produce extended spectrum B-lactamase in 38.4% and 56.7% of cases respectively. No Carbapenem Resistant Enterobacteriacae (CRE) strains were obtained from *E. col*i isolates, while 31% of *Klebsiella* strains were resistant to Carbapen-

ems (CRE strain). All of the Carbapenem resistant *Klebsiella* spp. isolates retain their sensitivity to Colistin. Both organisms were 100% resistant to Cotrimoxazole but retain full sensitivity to Tigecycline.

Resistance to Piperacillin/tazobactam was documented among *E. coli* and *Klebsiella* isolates in 28.4% and 66.2% respectively. All E.coli isolates were sensitive to Norfloxacin while 75% of Klebsiella isolates were resistant to it.

Pseudomonas aeruginosa was found to be sensitive to all antipseudomonal drugs tested, including Ceftazidime, Piperacillin-tazobactam, and Carbapenems.

All *Proteus* isolates were ESBL producers, sensitive only to Meropenem and Gentamicin, but resistant to all other tested antibiotics.

Discussion

Most ICU patients need an indwelling urinary catheter insertion during their stay in the unit. We found that the necessary catheterization in our study population, measured by the device utilization ratio, was similar to the ratios observed by other studies [7-9].

The first available data regarding CAUTI in our center, reported in 2009 [10], revealed an incidence of 14.1/1000 catheter-days. From 2010 to 2013, the rate ranged between 8.5 and 5.9/1000 catheter days (Graph 1), showing a generally downward trend. The incidence of CAUTIs during the current study, comprising 2014 and 2015, was lower than these reports. The decreasing rate is attributed to improving adherence of the staff to the CAUTI prevention bundle and other infection control measures, as compliance to the bundle improved from 70% in 2009 to > 90% in 2014 and in 2015 was accompanied improved adherence to proper hand hygiene practice in the unit (50% in 2014 to 80 % in 2015).
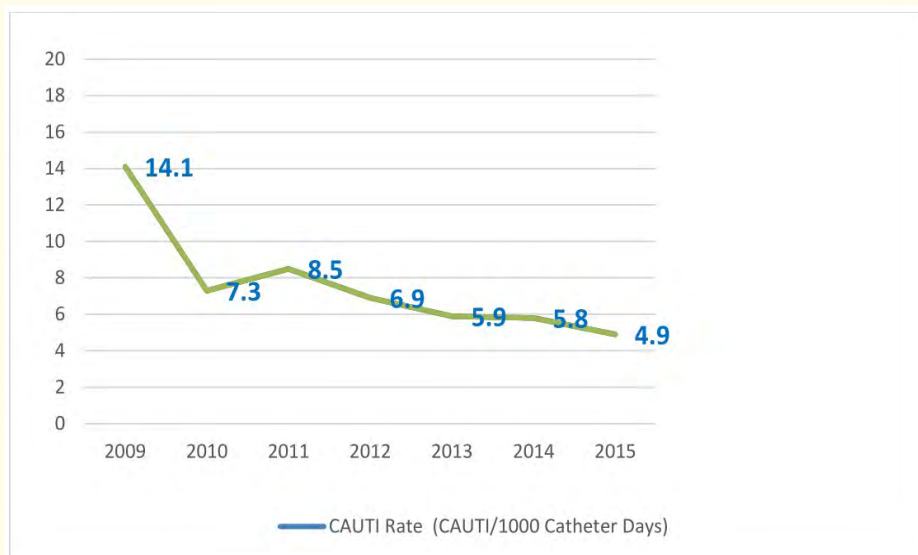
Graph 1: *Rate of CAUTI in Bahrain (2009 - 2015).*

Different countries reported high variabilities of CAUTI incidence during their surveillance (Table 3). The rate found in this study was approximately similar to that reported for other developing countries [11-19], but fourfold higher than that published by the American NHSN report [20].

Study (year of surveillance)	Incidence of CAUTI /1000 catheter -days
NHSN 2012 (28)	1.2
Wrocław, (2012 - 2014) [Reference 11]	6.81
International Nosocomial Infection Control Consortium (INICC) (2007 - 2012) [Reference 12]	5.3
India (2010 - 2011) [Reference 13]	9.08
Greek (2009 - 2010) [Reference 14]	4.2
China (2008 - 2010) [Reference 15]	1.29
Egypt (2007 - 2008) [Reference 16]	15.7
Cyprus (2007) [Reference 17]	2.8
India (2007) [Reference 18]	4
China (2004 - 2009) [Reference 19]	6.4

Table 3: *Incidence of CAUTI in different countries.*

The main risk factor linked with health-care-associated urinary tract infections in our study was the length of ICU stay, which has also been cited in many other studies as the most important reason for development of infection [21-24]. The longer the patient stays in ICU, the higher the chances of getting colonized with multidrug-resistant bacteria and higher chance of acquiring infection.

Patient age was strongly linked as an important risk factor in our study as well as in other similar studies [3,25-27]. Other risk factors were male gender and medical rather than surgical reason for admission, as patients in this category usually have other comorbidities and are older in age.

Gram-negative bacteria were the most common isolates from cases of health-care-associated urinary tract infections. *E. coli* and *Klebsiella* are widely known to be the most common cause of CAUTI and were also found to be the most culpable organisms in our ICU (28.8 % and 26.9% respectively). A similar pattern, with predominance of *E. coli*, has been observed by most other similar studies among ICU patients [28-31].

Candida found to be the third common organism causing UTI in our study. Variable rates of *Candida* contribution were observed in different studies among ICU patients. Talaat., *et al.* [16] reported *Candida* as the causative organism in 50% of UTI cases in their study. Some studies [2,3,32] reported *Candida* as the most common organism implicated in CAUTI-related infections among ICU patients, present in 20 - 30% of their isolates. On the other hand, other studies like Al-Hazmi's study in Saudi Arabia reported a very low rate of *Candida* (2%) as a contributing cause of UTI [33].

As predicted, a high drug resistance rate and limited drug treatment options for these patients were observed. Production of large spectrum beta-lactamase (ESBL strain) was observed among the majority of isolates (100% of *Proteus*, 71% of *E. coli*, and 77% of *Klebsiella* spp.). These findings are in agreement with a study conducted in North Egypt by Talaat., et al. [16], who reported production of large spectrum beta-lactamase by 78.6% and 56% of *E. coli* and *Klebsiella* spp. isolates, respectively, in their study.

Our study showed that *Klebsiella* spp. was resistant to carbapenem in 31% of cases, which is high in comparison to an NHSN study that reported a 10.1% resistance carbapenem resistance rate of *Klebsiella* spp [34].

Most of the implicated organisms for CAUTI in our study (except pseudomonas) showed high resistance to quinolones, making this group of antibiotics an inappropriate choice for empiric therapy of urosepsis in our ICUs.

Resistance to piperacillin-tazobactam was also frequently observed among isolates (100% of *Proteus*, 67% of *Klebsiella*, and 28.4% of *E. coli*), limiting their importance as single drug empirical therapy to treat CUATI among our ICU patients.

In view of the previous results of causative organisms and their recent antibiotic susceptibility patterns in our ICU population, we recommended monotherapy with meropenem as the first appropriate option for the empirical treatment of urosepsis among ICU patients. The other alternative option, particularly among critically ill patients, is combination therapy of meropenem and gentamicin, in view of the relatively high proportion (30%) of carbapenemase producing isolates among *Klebsiella*. It should be kept in mind that once culture and susceptibility results are available, the antimicrobial regimen should be tailored to the specific organism isolated.

This study had several limitations. Firstly, the results were based on a single group of patients from a single institution. Therefore, the finding may not be representative of all ICU patients in Bahrain hospitals. Small sample size, short study period and the observational nature of this study may also have affected the findings of this study. Future studies should involve more ICUs from more than one institution; treatment regimens and comparisons of antibiotic resistance patterns between ICUs and general wards and across institutions should also be carried out to further evaluate patients with ICU-acquired UTI in Bahrain.

Conclusions

The rate of CAUTIs in our ICU was 5.3 per 1000 catheter days. The rate is lower than previous reports from our center, an improvement we believe is mainly due to improved adherence of ICU staff to the recommended infection control measures. Further tailored intervention strategies need to be implemented to reduce the rates of CAUTIs in our ICU to reach the NHSN mean.

Significant risk factors for developing an ICU-acquired UTI were male gender, older age, prolonged ICU stay, and admission for medical conditions.

Meropenem as monotherapy or in combination with gentamicin seems to be the most appropriate empiric choice for the treatment of CAUTI among critically ill ICU patients.

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Conflict of Interest

No Conflict of interest.

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