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Catheter-associated urinary tract infection in a surgical intensive care unit

Infekcije urinarnog trakta kod bolesnika sa urinarnim kateterom u hirurškoj jedinici intenzivne nege

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Abstract

Background/Aim. Because patients in intensive care units usully have an urinary catheter, the risk of urinary tract infection for these patients is higher than in other patients. The aim of this study was to identify risk factors and causative microrganisms in patients with catheter-associated urinary tract infection (CAUTI) in the Surgical Intensive Care Unit (SICU) during a 6-year period. **Methods.** All data were collected during prospective surveillance conducted from 2006 to 2011 in the SICU, Military Medical Academy, Belgrade, Serbia. This case control study was performed in patients with nosocomial infections recorded during surveillance. The cases with CAUTIs were identified using the definition of the Center for Disease Control and Prevention. The control group consisted of patients with other nosocomial infections who did not fulfill criteria for CAUTIs according to case definition. **Results.** We surveyed 1,369 patients representing 13,761 patient days. There were a total of 226 patients with nosocomial infections in the SICU. Of these patients, 64 had CAUTIs as defined in this study, and 162 met the criteria for the control group. Multivariate logistic regression analysis identified two risk factors independently associated to CAUTIs: the duration of having an indwelling catheter (OR = 1.014; 95% CI 1.005–1.024; $p = 0.003$) and female gender (OR = 2.377; 95%CI 1.278–4.421; $p = 0.006$). Overall 71 pathogens were isolated from the urine culture of 64 patients with CAUTIs. *Candida* spp. (28.2%), *Pseudomonas aeruginosa* (18.3%) and *Klebsiella* spp. (15.5%) were the most frequently isolated microorganisms. **Conclusions.** The risk factors and causative microrganisms considering CAUTIs in the SICU must be considered in of planning CAUTIs prevention in this setting.

Key words:
urinary tract infections; cross infection; intensive care units; surgery department, hospital; risk factors; urinary catheterization.

Apstrakt

Uvod/Cilj. Rizik od infekcije urinarnog trakta je viši kod bolesnika u jedinicama intenzivne nege nego kod ostalih bolesnika zbog toga što oni obično imaju urinarni kateter. Cilj rada bio je da se ispitaju bolesnici sa infekcijom urinarnog trakta povezanom sa kateterom [*catheter-associated urinary tract infection* (CAUTI)] tokom 6 godina u Hirurškoj jedinici intenzivne nege (HJIN) da bi se utvrdili značajni faktori rizika i uzročnici oboljenja. **Metode.** Podaci su prikupljeni tokom prospektivnog epidemiološkog nadzora u periodu od 2006. do 2011. godine u HJIN Vojnomedicinske akademije, Beograd, Srbija. Studija slučaja i kontrola je obuhvatila bolesnike sa bolničkim infekcijama zabeleženim tokom epidemiološkog nadzora. Bolesnici sa CAUTI identifikovani su na osnovu definicije Centra za kontrolu i prevenciju bolesti. Kontrolna grupa je obuhvatila bolesnike sa drugim bolničkim infekcijama koji nisu ispunjavali definiciju CAUTI. **Rezultati.** Epidemiološkim nadzorom obuhvaćeno je 1 369 bolesnika i 13 761 bolničkih dana. Ukupno je zabeleženo 226 bolesnika u HJIN sa bolničkim infekcijama u posmatranom periodu. Među njima, 64 bolesnika imala su CAUTI i 162 su ispunjavala kriterijume za kontrolnu grupu. Multivarijantna logistička regresiona analiza identifikovala je dva faktora rizika nezavisno povezana sa CAUTI: dužina nošenja urinarnog katetera (OR = 1,014; 95% CI 1,005–1,024; $p = 0,003$) i ženski pol (OR = 2,377; 95% CI 1,278– 4,421; $p = 0,006$). Izolovan je ukupno 71 patogen iz urinokultura 64 bolesnika sa CAUTI. *Candida* spp. (28,2%), *Pseudomonas aeruginosa* (18,3%) i *Klebsiella* spp. (15,5%) bili su najčešće izolovani mikroorganizmi. **Zaključak.** Faktori rizika i uzročnici koji su povezani sa nastankom CAUTI u HJIN moraju biti uzeti u obzir pri planiranju mera prevencije CAUTI u ovom okruženju.

Ključne reči:
urinarni trakt, infekcije; infekcija, intrahospitalna; intenzivna nega, odeljenja; bolnice, hirurško odeljenje; faktori rizika; kateterizacija urinarnog trakta.

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Introduction

Nosocomial infections (NIs) affect about 30% of patients in intensive-care units (ICU) [1]. It has been reported that ICUs account for 25% of NIs even though they occupy only approximately 10% capacity of a hospital [2]. The risk of NIs in ICU is 5–10 times greater than those acquired in general and surgical wards [3].

Urinary tract infections (UTIs) comprise 30% to 40% of all NIs, and 8% to 21% of all NIs are UTIs occurring in ICUs [4, 5]. Richards et al. [6, 7] found that UTI was responsible for 20–30% of NIs in medical/surgical ICUs. According to a large surveillance program in Europe UTIs were the third most common type of infection in ICUs after pneumonia and lower respiratory tract infections [3]. UTI is the most common NI in North America and among the most frequent NIs in critically ill patients [6, 8, 9].

The presence of a urinary catheter is associated with increased risk of nosocomial UTI and the incidence of UTIs among patients with urinary catheters is about 15% [10]. Because patients in ICUs usually have a urinary catheter, the risk of UTI for these patients is higher than in other patients.

Catheter-associated UTI (CAUTI) has been associated with increased morbidity, mortality, hospital cost, and length of stay [11, 12].

CAUTI is recognized as a leading cause of secondary nosocomial bloodstream infections and approximately 17% of nosocomial bacteremias are from a urinary source [13].

There has only been a limited number of studies on CAUTIs in ICUs. This case control study investigated patients with CAUTI over a 6-year period at the surgical ICU to identify significant risk factors and causative microorganisms.

Methods

All data was collected during prospective surveillance conducted from February 1, 2006 to December 30, 2011 at the 30 bedded Surgical Intensive Care Unit (SICU), Military Medical Academy (MMA), Belgrade, Serbia. All the patients admitted in SICU for more than 48 h were included and followed up. These critical patients were referred for monitoring, observation, and management from different surgical departments, *eg* general surgery, neurosurgery, urology, traumatology, etc.

The active prospective surveillance was performed by the hospital epidemiologist and infection control nurses following the recommendations of the Hospital in Europe Link for Infection Control through Surveillance (HELICS) and USA National Healthcare Safety Network (NHSN) [14, 15]. They visited the ICU daily, gathered information from medical records, microbiologic and X-ray reports, and interviews with nurses and physicians in charge. NIs were defined according to the diagnostic criteria of the Center for Disease Control and Prevention (CDC) [16, 17]. Collected variables included all NIs, demographic characteristics, admission diagnoses, exposure to invasive devices.

Microbiological testing was performed at the MMA's Institute of Medical Microbiology and all microbiological methods used were consistent with the current National Commitee for Clinical Laboratory Standards recommendations.

Retrograde analysis was performed in patients with NIs recorded during surveillance between February 1, 2006 and December 30, 2011 in SICU of MMA.

The patients with CAUTIs were, identified using definition of the CDC [18]. The control group consisted of ICU patients with other NIs who did not fulfill criteria for UTI according to the case definition.

According to CDC definition,[18] CAUTI is: "A UTI where an indwelling urinary catheter was in place for > 2 calendar days on the date of event, with the day of device placement being day 1, and an indwelling urinary catheter was in place on the date of event or the day before. If an indwelling urinary catheter was in place for > 2 calendar days and then removed, the UTI criteria must be fully met on the day of discontinuation or the next day".

Indications for placement of urinary catheters were [19–21]: acute urinary retention, acute bladder outlet obstruction, need for accurate measurements of urinary output in the critically ill, to assist in healing of open sacral or perineal wounds in incontinent patients, patient requires strict prolonged immobilization and selected perioperative needs [22, 23] [urologic surgery or other surgery on contiguous (adjacent) structures of the genitourinary tract, anticipated prolonged duration of surgery, large volume infusions or diuretics anticipated during surgery and need for intraoperative monitoring of urinary output].

Statistical analyses

Infection rate (IR) was expressed as the total number of UTI *per* 1,000 patient days. Also, we calculated device utilization rates for the period 2008–2011 by dividing the total number of devices days by the total number of ICU patient days [24]. Statistical analysis was performed by using the IBM SPSS ver. 20.0 (IBM Co., Armonk, NY, USA). The χ^2 test and Student's *t*-test were used for data analyses. Any *p*-values less than 0.05 were considered significant. Multivariate logistic regression analysis included only variables that showed a statistically significant association.

Results

We surveyed 1,369 patients representing 13,761 patient days (Table 1). During the period from 2006 to 2011, IR of UTI ranged from 1.1 in 2007 to 8.6 in 2010 with the average value of 4.7.

The device utilization rates from 2008 to 2011 are presented in Table 2. Catheter-associated IR was in range from 7.23 to 15.57 for period from 2008 to 2011 with the average value of 10.38. Urinary catheter days/ patient days ranged from 0.5 to 0.7.

Patient population

There were a total of 226 patients with NIS in our hospital's SICU between February 2006 and December 2011. Of these patients, 64 had CAUTI as defined in this study, and 162 met the criteria for the control group. The mean age of infected patient was 58.3 ± 20.4 (range, 15–92) years. Of 226

Table 1

Distribution of patients with surgical intensive care units, nosocomial infections and infection rate (IR) by year

Years of follow-up	Patients (n)	Patients-days (n)	UTI (IR*1000)
2006	201	1,900	3 (1.6)
2007	143	1,819	2 (1.1)
2008	255	2,263	12 (5.3)
2009	227	2,251	9 (4.0)
2010	234	2,905	25 (8.6)
2011	309	2,623	13 (5.0)
	Total: 1,369	Total: 13,761	Avarage: 64 (4.7)

UTI – urinary tract infection.

Table 2

Device utilization rates for urinary catheter (UC) from 2008 to 2011

Years of follow-up	UC-days	Patient-days	UC utilization	UTI	UC associated IR
2008	1,228	2,263	0.5	12	9.77
2009	1,054	2,251	0.5	9	8.54
2010	1,606	2,905	0.5	25	15.57
2011	1,797	2,623	0.7	13	7.23
	Total : 5,685	Total : 10,042	0.6	Total : 59	Average: 10.38

UTI – urinary tract infection; IR – infection rate.

patients, 141 (62.4%) were males and 85 (37.6%) were females. A total of 185 (81.9%) patients had surgery before their ICU admission and 41 (18.1%) did not; 30 (13.3%) patients had diabetes and 196 (86.7%) did not, and 38 (16.8%) patients had cancer. The mean duration of having an inserted catheter was 29.87 ± 35.11 days, and the mean duration of ICU stay was 20.94 ± 20.29 days.

Clinical factors

The results of χ^2 test and *t*-test to observe differences between the patients with CAUTI and the control group are shown in Table 3. The difference in the duration of having an indwelling catheter was statistically significant between the two groups ($p = 0.002$). The duration of having an indwelling catheter was longer in CAUTI patients (43.53 ± 45.26 days) than in the control group (24.47 ± 28.59 days). Female sex was also a significant risk factor for CAUTI (OR = 2.06; 95%CI 1.09–3.87; $p = 0.016$). Age also appear to be a significant risk factor ($p = 0.039$) in univariate analysis. Other factors were not significantly different between the groups ($p > 0.05$).

Multivariate logistic regression analysis (Homer-Lemeshow Goodness of Fit test) identified two risk factors independently associated with CAUTI: the duration of having an indwelling catheter (OR = 1.014; 95% CI 1.005–1.024; $p = 0.003$) and female gender (OR = 2.377; 95%CI 1.278– 4.421; $p = 0.006$). Age did not appear to have a significant effect.

Table 3

Results of univariate analysis of factors contributing to catheter-associated urinary tract infection (CAUTI) occurrence

Clinical factors	CAUTI (n = 64)	Controls (n = 162)	*p* value
Sex, n (%)			0.016
male	32 (50)	109 (67.28)	
female	32 (50)	53 (32.72)	$\chi^2 = 5.84$; OR = 2.06 (1.09–3.87)
Age (years), mean ± SD (SE)	53.84 ± 21.08 (2.635)	60.06 ± 19.94 (1.567)	0.039
Diabetes mellitus, n (%)			
diabetic patient	9 (14.4)	21 (13.0)	0.826
nondiabetic patient	55 (85.9)	141 (87.0)	
Cancer, n (%)			
cancer patient	13 (20.3)	25 (15.4)	0.377
noncancer patient	51 (79.7)	137 (84.6)	
Recent surgery, n (%)			
yes	54 (84.4)	131 (80.9)	0.537
no	10 (15.6)	31 (19.1)	
Duration of ICU stay (days), mean ± SD (SE)	25.28 ± 25.20 (3.151)	19.22 ± 17.79 (1.398)	0.082
Duration of catheterization (days), mean ± SD (SE)	43.53 ± 45.26 (5.658)	24.47 ± 28.59 (2.247)	0.002

The values are presented as number (%) or mean ± standard deviation (SD); SE – standard error; ICU – intensive Care Unit.

Microbiological factors

Overall 71 pathogens were isolated from the urine culture of 64 patients with CAUTI. *Candida* spp. was the most frequently isolated microorganisms (20 patients, 28.2%) (Table 4). Of the *Pseudomonas aeruginosa* isolates, second most frequently causative agent (13 patients, 18.3%), 69.2 % (9/13) and 46.1% (6/13) were resistant to ciprofloxacin, and imipenem, respectively. Other found species were *Klebsiella* spp. (11 patients, 15.5%), out of which 81.8% (9/11) were the third generation of cephalosporin resistant, and *Eneterococcus* spp (9 patients, 12.7%). Among the enterococcal isolates, vancomycin resistance was found in 11.1% (1/9). Carbapenem-resistant *Klebsiella* spp. was first reported in urine culture in 2011 (1 patient, 9.0%).

Table 4

Etiology of catheter-associated urinary tract infections in the Surgical Intensive Care Unit of the Military Medical Academy, Belgrade, Serbia

Pathogen	No. of isolates (%)
Gram-negative bacteria	41 (57.7)
Pseudomonas aeruginosa	13 (18.3)
Klebsiella spp.	11 (15.5)
Escherichia coli	8 (11.3)
Acinetobacter spp.	5 (7.0)
Proteus spp.	3 (4.2)
Pseudomonas spp.	1 (1.4)
Gram-positive bacteria	10(14.1)
Enterococcus spp.	9 (12.7)
Staphylococcus aureus	1 (1.4)
Fungi	20 (28.2)
Candida spp.	20 (28.2)
Total	71 (100)

Discussion

The catheter-associated IR was in the range from 7.23 to 15.57 (10.38) infections *per* 1000 catheter days for the period from 2008 to 2011. Summary of device-associated infections data collected and reported by hospitals participating in the NHSN from January through December 2006 showed that pooled mean CAUTI rates ranged 3.1–7.5 infections *per* 1,000 catheter days [25]. Finklestein et al [26] found the incidence of 10–14 UTI *per* 1,000 catheter days among 337 patients in a single Israeli ICU.

Urinary catheter days/patient days ranged from 0.5 to 0.7 in our study. Between 15% and 25% of hospitalized patients may receive indwelling urinary catheters [27, 28]. In many cases, catheters are placed for inappropriate indications or there is a prolonged, unnecessary use of catheters [29–31]. In a NHSN report in 2006, pooled mean urinary catheter utilization ratios in ICU was in the range from 0.29 to 0.91 urinary catheter-days/patient-days [25].

The urinary catheter provides a route for bacterial entry along both its external and internal surfaces (extraluminal and intraluminal route of microorganism migration) [32]. Contamination of urine in the drainage bag can allow organisms to access the bladder through the drainage tube and the catheter lumen.

The formation of biofilms on the surface of the catheter and drainage system is associated with prolonged durations of catheterization [33]. Microorganisms that colonize the periurethral skin can migrate into the bladder through a biofilm that forms between the epithelial surface of the urethra and the catheter. Also, the presence of the catheter itself impairs many of the normal defense mechanisms of the urinary tract.

In this study, two risk factors (duration of catheterization and female gender) were found to be independently associated with infection. Female gender was a significant factor associated with UTI in several other studies also [34–37]. Increased duration of catheterization was identified as independently associated with CAUTI in this study and in some other [38–40]. Rosser et al. [41] found that the length of catheterization was one of the independent factors associated with the development of nosocomial UTI. The daily risk of bacteriuria with catheterization is 3% to 10% [42, 43], approaching 100% after 30 days [44].

The most common microorganisms responsible for ICU-acquired UTIs in this study were *Candida* spp., *Pseudomonas aeruginosa*, and *Klebsiella* spp.

The most frequent pathogens associated with CAUTI according to summary of data that hospitals reported to NHSN from January 2006 through October 2007 were *Escherichia coli* (21.4%) and *Candida* spp. (21.0%), followed by *Enterococcus* spp. (14.9%), *Pseudomonas aeruginosa* (10.0%), and *Enterobacter spp.* (4.1%) [45].

Similarly to data in our study, the most common causative microorganism of ICU-acquired UTI was *Candida* spp. in study of intensive care unit-acquired UTIS in Singapore [46].

Laupland et al. [47] found that the most frequent microorganisms in ICU-acquired UTIs were *Escherichia coli* (23%), *Candida albicans* (20%), *Enterococcus* spp. (15%) and *Pseudomonas aeruginosa* (10%).

Antimicrobial resistance among nosocomial pathogens is the increasing problem in our hospital, especially in SICU [48, 49]. Resistance of gram-negative pathogens to third-generation cephalosporin and ciprofloxacin was few times higher than in NHNS reported during the three periods, 1992–2004, 2006–2007 and 2008–2009 [15, 45, 50]. In our SICU carbapenem-resistant *Klebsiella* spp. was first reported in urine culture in 2011. Prevention is a top priority for reducing person-to-person transmission of carbapenem-resistant *Klebsiella* spp. and will be a challenge for all healthcare workers in our hospital in future. This is especially true because there are very limited treatment options to use after the development of carbapenem-resistance.

Candida spp. is unusual cause of UTI in healthy individuals, but common causes of UTI in the hospital setting. Most of the patients in our study received broad-spectrum antibiotics in the ICU. This could have resulted in decolonization of normal bacterial flora, allowing *Candida* spp. to grow and become the dominant microorganism.

Conclusion

The results of the case-control study confirm that a critical illness is commonly complicated by the development of nosocomial CAUTI. The length of urinary catheterization and female gender are significant risk factors of

CAUTI. The most frequently isolated microorganisms responsible for SICU acquired CAUTI in this study were *Candida* spp., *Pseudomonas aeruginosa*, and *Klebsiella* spp.

Risk factors and causative microorganisms associated with CAUTI in SICU patients must be considered in planning of preventive measures against urinary tract infections in this setting.

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