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Urinary tract infections in intensive care unit patients — a single-centre, 3-year observational study according to the INICC project

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Abstract

Background: Urinary tract infections (UTI) in patients with urinary catheters could be a serious complication of hospitalisation in the intensive care unit (ICU).

Methods: A prospective study (01.01.2012–31.12.2014) was conducted in the 20-bed ICU of the University Hospital in Wroclaw, Poland. The frequency (density, incidence) and aetiology of UTI as well as prophylactic method compliance were estimated in patients of the ICU according to the INICC project.

Results: Among 1261 ICU patients, urinary tract infections were diagnosed in 91 (7%). The incidence index was 7.25/100 admissions to the ICU. CA-UTI constituted 36% of the device-associated, healthcare-associated infections (n = 255). A urinary catheter was used in 92.21 ± 4.51% of patients during 14,006 patient-days and 12,917 urinary-catheter-days. The density of CA-UTI/1000 catheter-days was 6.44, 6.84, 7.16 during the years 2012, 2013, and 2014, respectively. The main pathogens of CA-UTI were *Enterococcus spp.* (22%), *Acinetobacter baumannii* (20%), *Klebsiella pneumoniae* (18%), *Pseudomonas aeruginosa* (13%), and *Candida spp.* (13%). Only in four elements of the "Urinary Catheter Bundle" was 100% compliance noted.

Conclusions: In the observed period of time, the incidence of CA-UTI was higher than in the INICC (2014) report and the NHSN/CDC (2012) report. Analysis of compliance with a "Urinary Catheter Bundle" to prevent UTI shows low implementation of preventative methods with the INICC protocol.

Key words: intensive care unit, hospital-acquired infections, urinary tract infections

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Catheter-associated urinary tract infections (CA-UTIs) are a common complication among patients with indwelling catheters. They constitute over 40% of all device-associated, healthcare-associated infections (DA-HAIs) and 23% of hospital-acquired infections (HAIs) in intensive care units (ICUs) [1, 2]. The data of the National Sepsis Registry obtained in Polish ICUs from 2003–2009 have revealed that of 4999 severe sepsis patients, 6% were affected by urinary tract infections [3]. Similar findings were presented in the French study, where urinary tract infections were the cause of septic shock in 8.4% of patients [4]. In Canada and the United States, this percentage was found to be 14.7%; in Saudi Arabia, –18.3% [5]; and in Australia and New Zealand, –30.2% [6]. In the European Centre for Disease Prevention and Control (ECDC), with a point prevalence survey involving 2946 hospitals in 30 European countries from 2011-2912, HAIs were diagnosed in 5.7% of patients (in ICUs in 19.5%). Using the same survey, UTIs were detected in 19% of patients with HAIs [7].

The data published have demonstrated that the incidence of CA-UTIs in Polish ICUs was 1.9–2.4/1000 catheter-days [8–9], compared to 6.4–12/1000 catheter-days according to the SPIN-UTI Project of the Italian Nosocomial Infections Surveillance in ICUs [10] and 1.46–0.57/1000 catheter-days reported by the Krankenhaus Infections Surveillance System (KISS) [11]. The study by Rosenthal et al. [12] that was conducted in 10 developing countries has revealed that CA-UTI increases the risk of death by 15%. Although urinary tract infections only slightly prolong the length of hospitalisation (by 1.5 day on average), they are a reservoir for multi-resistant, Gram-negative and Gram-positive bacteria in the hospital setting [12, 13]. Moreover, each episode of CA-UTI increases treatment costs by $600 and, in sepsis originating from the urinary tract, by $2800 [14]. Nevertheless, mortality rates, estimated at 10–20% amongst patients diagnosed with septic shock during the course of urinary tract infections, are lower than in sepsis of any other aetiology [15]. To improve the safety of patients by reducing the risk of exposure to hospital-acquired infections, including CA-UTIs, many recognised international organisations and scientific societies developed appropriate preventive recommendations [16, 17], among them the Centers for Disease Control and Prevention (CDCP), ECDC, Society of Healthcare Epidemiology of America (SHEA), Infectious Diseases Society of America (IDSA) in developed countries and the International Nosocomial Infection Control Consortium (INICC) in developing countries. The list of preventive recommendations based on CDC guidelines was called a "urinary catheter bundle" or "bladder bundle" by the Institute for Healthcare Improvement (IHI) [18]. Under the auspices of the National Institute of Drugs, Polish recommendations for prophylaxis of ICU infections were designed [19]. The prophylactic recommendations listed most commonly include observance of aseptic principles while inserting the urinary catheter, single-use lubrication, local anaesthetic gels, catheterisation only when absolutely indicated, use of sterile closed systems of urine evacuation, avoidance of catheter disconnection, control of urine outlet patency, a drainage bag below the bladder level, emptying the bag at a volume that is > 75% of its total volume, supervision of prophylactic recommendations, and monitoring of urinary tract infections [20]. The data from the literature show that the occurrence of CA-UTIs was frequently successfully reduced or even temporarily eliminated [21]. Surveillance of urinary tract infections in catheterised patients and the application of prophylactic measures reduced the incidence of ITUs by 37%, thus contributing to the improved safety of patients and lower costs of treatment [22]. The aim of the present study was to evaluate the incidence of urinary tract infections in ICU patients, to determine their aetiological factors and to assess compliance with the preventive recommendations used in 2014. Moreover, the trend of CA-UTIs was analysed and compared with international reports and findings from our earlier studies.

METHODS

A prospective study was performed in the 20-bed surgical-medical ICU between 01.01.2012 and 31.12.2014. All patients with indwelling urinary catheters hospitalised for longer than 48 hours were included. The necessary data were recorded daily in the infection surveillance cards, designed for noting the number of treated patients and use of medical devices, i.e., the data needed to calculate person-days of hospitalisation and catheter-days. Urinary tract infections in catheterised patients were recorded in the hospital infection control checklist and diagnosed based on the Centers for Disease Control/National Health Service Network (CDC/NHSN) and INICC guidelines [23, 24]. The detailed data regarding patient identification, clinical characteristics, duration of catheterisation, microbiological results and time of infection diagnosis were also entered into the INICC electronic system and were part of the hospital-acquired infection monitoring strategy. UTI monitoring was based on basic INICC indices: incidence density of CA-UTI/1000 catheter-days, incidence of CA-UTI/100 ICU admissions, urinary catheter utilisation ratio (UCU-R) and the microbiological profile of infections. To monitor the occurrence of CA-UTIs, the following were calculated once a month:

1. device utilisation ratio (DUR): determining the percentage of patients with urinary catheters
   UCU-R = number of indwelling catheter-days/
   /total number of patient-days × 100
2. incidence density of UTIs
   UTI density ratio = number of patients with UTIs/
   /total number of catheter-days × 1000,
3. incidence rate, i.e., number of new cases per unit of time – a year (2012, 2013, 2014) – per 100 ICU admissions.

CLINICAL AND MICROBIOLOGICAL DIAGNOSIS OF URINARY TRACT INFECTIONS

Urine samples collected through the urinary catheter were subjected to laboratory and microbiological diagnostic tests. The material was collected and sent for examination in accordance with hospital procedures. The BacT/Alert kit (Biomerieux, France) and API Candida system (Biomerieux, France) were used for cultures/isolation of bacterial strains and fungi; the YST card was applied for yeast-like fungi. Drug susceptibility was tested using E-tests; for *Candida* yeasts, the dilution method in the Vitek 2 system was employed (the AST-YS01 card). The results were interpreted according to the EUCAST recommendations. Urinary tract infections were diagnosed in patients with a body temperature > 38°C, elevated WBC > 12.0 G L^{-1}, increased concentration of

Table 1. Characteristics of patients

Year	2012	2013	2014	2012–2014
Number of patients	495	397	369	1261
Number of person-hospitalisation days	5327	4445	4234	14006
Female/Male [%]	39/61	38/62	37/63	38/62
Surgical patients	396 (80%)	330 (83%)	213 (58%)	940
Medical patients	99 (20%)	67 (17%)	156 (42%)	321

Table 2. Analysis of prevalence, incidence of urinary tract infections, catheter utilisation and number of catheter-days. The data are presented as numerical values, percentage, median (IQR) or the means ± SD

	2012	2013	2014	2012-14
Incidence density of UTI/1000 catheter days	6.44 (5.64–8.42)	6.84 (6.02–7.76)	7.16 (3.02–9.18)	6.81 (3.02–9.18)
Number of catheter-days	4871	4034	4012	12917
Number of patients with CA-UTIs	34	29	28	91
Urinary catheter utilisation ratio (%)	91.06 ± 5.94	90.86 ± 4.24	94.72 ± 3.37	92.21 ± 4.51
Incidence rate of CA-UTI/100 hospitalised patients	6.87	7.3	7.59	7.25

procalcitonin or CRP, pH changes in standard urinalysis, macroscopically detected opacification and microscopically detected leukocyturia (≥ 10 leukocytes w 1 mL of urine or ≥ 3 leukocytes in the visual field, leukocytal agglutinates). For microbiological testing of urinary tract infections, the quantitative method was used. According to the definition, UTI was diagnosed in catheterised patients with cultures containing $>10^5$ CFU mL^{-1} of no more than 2 microorganisms. Moreover, the infection was diagnosed when repeated urine tests showed Gram-negative and Gram-positive bacteria or *S. saprophyticus* in the amount of 10^2 CFU mL^{-1} and when one pathogen was cultured in the urine of patients receiving antibacterial treatment (Gram-negative bacterium or *S. saprophyticus*) in the amount of $\leq 10^5$ CFU mL^{-1} [10, 23, 24].

RESULTS

Analysis involved clinically and microbiologically confirmed catheter-associated urinary tract infections. Cases of asymptomatic bacteraemia were excluded.

Among 1261 patients treated in the ICU during 14006 person-days of hospitalisation, UTIs were diagnosed in 91 patients (7%). The patient characteristics are listed in Table 1. The incidence rate was 7.22/100 patients admitted to the ICU. CA-UTIs constituted 36% of the total number of hospital-acquired infections (n = 255) over the study period. The total number of catheter utilisation days was 12,917. The incidence of CA-UTI/1000 catheter-days and central catheter utilisation [(median/IQR) and (mean ± SD)] were 6.81(3.02–9.18)/1000 catheter-days and 92.21 ± 4.51%, respectively. The data regarding CA-UTI prevalence, incidence, device utilisation ratio, and number of catheter-days over the period of observation are presented in Table 2. CA-UTI incidence rates in the individual months of observation are presented in Fig. 1. The major pathogens of CA-UTIs were multi-resistant Gram-negative bacteria (64%), followed by Gram-positive bacteria (23%) and *Candida spp.* (13%). The aetiological factors of CA-UTIs in our centre are listed in Fig. 2. Analysis of CA-UTI prevalence**,** incidence rates, urinary catheter utilisation ratio, and number of catheter-days in our centre in various periods of observation compared to international reports is given in Table 3.

Furthermore, the data concerning the use of urinary catheter bundles to prevent CA-UTIs collected over three months of 2014 were analysed. The percentages of compliance with individual elements of urinary tract infection prevention were evaluated.

During visits to evaluate compliance with prophylactic recommendations, 622 patients were examined; 100% compliance was observed with only four elements of prevention. The bundle element most strictly observed was the prevention of improper catheter location, enabling the re-entry of urine to the urinary bladder. Analysis of compliance with individual elements of UTI prophylaxis is presented in Table 4.

DISCUSSION

Urinary tract infections in catheterised individuals can develop in patients treated in ICUs, after surgical procedures (especially urological ones), and in medical or chronically ill patients. The necessary catheterisation in the study population, measured by the device utilisation ratio, does not differ from the results of studies in patients of other ICUs [8–10]. The risk of urinary tract infections is connected with the duration of catheterisation and increases by 5% each day. In cases with catheters indwelling for longer than 28 days, urinary tract infections have been diagnosed in 100% of patients [29]. In our centre, closed system catheters were

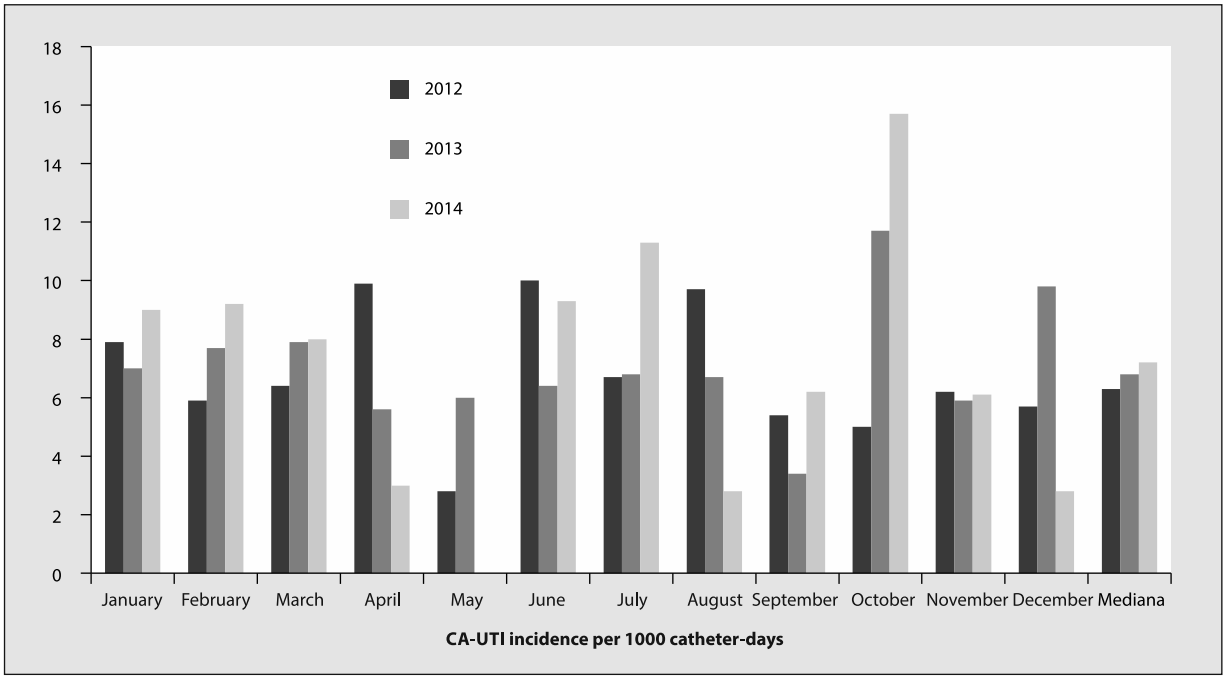

Figure 1. Analysis of UTI incidence rates in individual months of observation based on UTI density ratio

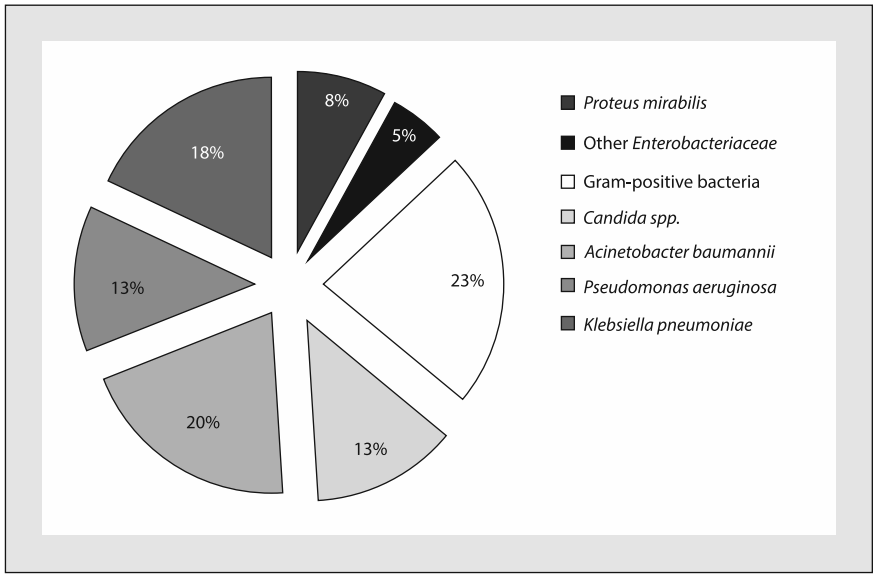

Figure 2. Aetiological factors of UTIs

Table 3. Incidence rates of urinary tract infections in our material and international studies. The data are presented as the median (IQR or 95% CI)

Study (years of surveillance)	Incidence density of CA-UTI/1000 catheter-days
ICU, Wrocław (2012–2014)	6,81 (3.02–9.18)
ICU, Wrocław (2007) [25]	6.8 (5.3–8.6)
ICU, Wrocław (2007–2010) [26]	4.8 (95%CI; 3.5–6.5)
INICC report (2007–2012) [27]	5.3 (95%CI; 5.2–5.8)
NHSN report (2012) [28]	1.2 (95%CI; 1.2–1.3)

Table 4. Analysis of compliance with individual elements of UTI prevention. The data are presented as the number of patients included in the study and percentage of compliance, n (%) in individual months

Procedure	n (%)		
	October (n = 131)	November (n = 248)	December (n = 243)
Use of sterile techniques during catheter insertion	131 (100)	248 (100)	243 (100)
Use of single-use lubricating-anaesthetising gel during catheter insertion	131 (100)	248 (100)	243 (100)
Use of catheters when unnecessary	131 (100)	248 (100)	243(100)
Proper catheter protection	131 (100)	248 (100)	243 (100)
Sterile, closed drainage system	126 (96)	238 (96)	224 (92)
Never-disconnected catheter	127 (97)	248 (100)	243 (100)
Free outflow of urine from the bladder	121 (92)	223 (90)	211 (87)
Drainage bag placed below the bladder	121 (92)	218 (88)	233 (96)
Drainage bag filled to less than 75% of volume	114 (87)	216 (87)	219 (90)

most commonly used. Catheters were exchanged in cases of asymptomatic bacteraemia or urinary tract infection. According to the international guidelines for CA-UTI prevention, the routine exchange of catheters is not recommended [16, 20]. Strictly defined definitions are the basis for properly recording infections in each programme of infection control. Uniform principles of recognition and diagnostic procedures and the use of the same epidemiological concepts allows the comparison of the incidence rates of infections in various medical centres and the determination of trends in a given department or hospital. The first data regarding urinary tract infections in our centre recorded in 1995/1996 reveal that UTIs were diagnosed in 16% of hospitalised patients. This incidence was almost twofold higher compared to recent findings [30]. The subsequent data (2002) demonstrate high urinary catheter utilisation ratios (85–83%) and over twofold higher incidences of CA-UTIs, compared to the present findings, i.e., 13–15/1000 catheter-days [31]. Thanks to the formation of the team responsible for infection surveillance and participation in DA-HAI monitoring within the ICU-HELICS programme on the initiative of the National Working Group on Nosocomial Infections and National Institute of Public Health, we were able to observe the trend of CA-UTI occurrence in 2007/8 of 8.6–5.3/1000 catheter–days and 92% urinary catheter utilisation [25]. The findings of multiple-year monitoring of DA-HAIs, conducted by the same group in the INICC project, indicate that the surveillance of nosocomial infections and the implementation of preventive procedures can reduce the frequency of these infections, which was confirmed in our study focusing on bloodstream infections and ventilator-associated pneumonia (VAP) [32]. Many-year monitoring of CA-UTIs in our material demonstrates their reduced rates of incidence from 2002–2010; however, an upward trend is presently observed [26, 31]. Since 2010, monitoring has been conducted in a different hospital, which offers a different specificity and epidemiology of the unit, different working conditions or changes in the management and surveillance of infections. According to the studies published, compliance with the guidelines for the prevention of urinary tract infections can produce notable effects, although these effects are less commonly observed than in other forms of DA-HAIs. In countries with low infection ratios, UTI monitoring is optional [11]. It has been demonstrated that in countries with lower budget capacities and worse sanitary conditions, the implementation of procedures for urinary catheter insertion and its care result in reduced rates of incidence of CA-UTIs [22, 27]. The incidence density of CA-UTIs in our material was 50% higher than that observed from 2007–2010 [26], approximately 25% higher than in developing countries [27] and over fivefold higher than the data published in the American NHSN report of 2012 [28]. The aetiological factors of CA-UTIs in our study do not differ considerably from the microbiological profile of urinary tract infections diagnosed in patients of other Polish and foreign ICUs, where multiresistant Gram-negative bacteria predominant [8, 9, 13, 15]. It is difficult to compare the 87–100% compliance with individual prophylactic recommendations with the results of other publications with a compliance of 42.5–99.6, in which only selected prophylaxis elements were monitored [21]. The study limitations, e.g., a single-centre study, short time of observation, no risk monitoring and no evaluation of the effects of urinary catheter bundles on the incidence of CA-UTIs, result from our decision to constrain the study to the basic monitoring of infections.

CONCLUSIONS

1. The systematic control of urinary tract infections in ICU patients demonstrates that UTIs constitute a serious and increasing hospitalisation-related problem.
2. In the study period, approximately 7% of patients developed urinary tract infections, and the incidence was

higher than that found in INICC, NHSN/CDC reports and in our earlier studies.

3. Compliance with prophylactic recommendations is found to be unsatisfactory; therefore, it is essential to implement urgent repair processes at the unit and hospital levels.

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