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Risk factors of nosocomial catheter-associated urinary tract infection in a polyvalent intensive care unit

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Abstract *Objective* To determine the risk factors for catheter-associated urinary tract infection in a polyvalent intensive care unit (ICU).

Design Prospective cohort study.

Setting Sixteen-bed polyvalent ICU in a French university hospital.

Interventions Prospective patient surveillance of patients included in two successive studies of two urine drainage systems.

Main outcome measures Bacteriuria occurrence in 553 ICU patients requiring a bladder catheter for longer than 48 h. The following variables were analyzed as possible risk factors: age, sex, severity score at admission, diagnosis on admission, duration of bladder catheterization, length of ICU stay, prior exposure to antibiotics, and system of urine drainage.

Results The frequency of catheter-associated bacteriuria was 9.6%. From the multivariate analysis, five independent risk factors were determined: female sex, length of ICU stay, use of an antimicrobial therapy, severity score at admission, and duration of catheterization.

Conclusion In our study, the drainage system did not influence the occurrence of bacteriuria. To decrease the rate of catheter-associated bacteriuria in polyvalent ICU patients, removal of the bladder catheter must be performed as soon as possible.

Keywords Catheter-associated urinary tract infection · Bacteriuria · Risk factor · Intensive care unit

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Introduction

Intensive care units (ICUs) represent a meeting point between the most severely ill patients receiving aggressive therapy and the most resistant pathogens which are selected by the use of broad spectrum antimicrobial therapy. ICU patients require indwelling devices involving an increase of infectious risk. Most patients who are hospitalized in ICUs receive an indwelling urinary catheter to monitor diuresis. Catheter-related urinary tract infection (UTI) remains a leading cause of nosocomial infections with significant morbidity, mortality, and additional hospital costs. The incidence of urosepsis, which is defined as an inflammation of the upper urinary tract that causes sepsis and bacteremia occurs in approximately 16% of an ICU patient population [1]. In addition, the presence of bacteria in the bladder constitutes a potential reservoir of multiresistant bacteria. For these reasons knowledge of risk factors of catheter-associated bacteriuria in ICU patients is of great interest to focus prevention on a subset of patients. These risk factors have been extensively studied in patients hospitalized in conventional wards or in medical ICUs [2, 3, 4, 5], but the results of these studies may not always be extrapolated to polyvalent ICU patients. The specific risk factors of catheter-associated bacteriuria have not been determined in a large cohort of such ICU patients.

The objective of this prospective study was to assess the independent risk factors for catheter-associated bacteriuria in polyvalent ICU patients previously included in two studies comparing two urine drainage systems [6, 7].

Methods

Patients

The study was carried out at Nord Hospital, a 700-bed tertiary care center affiliated to the University of the Mediterranean Sea within a 2-year period. The ICU has 16 beds, in individual-rooms, and medical, surgical, and trauma patients are admitted. During this period, we prospectively set up a database including all patients requiring an indwelling catheter for longer than 48 h. This database included patients enrolled in two clinical trials comparing a two-chamber drainage system and a complex closed drainage system [6, 7]. During the first study (1996), patients received successively the two systems during two 6-month periods [6]. In the second trial (1997–1999), patients received the two systems according to a randomization table [7].

To be eligible for evaluation, patients had to have an initial urine culture free of bacterial growth and an indwelling catheter inserted for more than 48 h. For each patient, the following variables were considered: age, sex, severity score at admission using the Simplified Acute Physiology Score, SAPS II [8], diagnosis on admission (medical, surgical or trauma), duration of bladder catheterization, length of ICU stay, prior exposure to antibiotics, and type of system of urine drainage used. Written protocols for the management of urinary catheters were followed, these protocols having been implemented in the ICU 5 years ago.

Study protocol

A team of trained nurses practiced catheterization and drainage system care according to the French National General Guidelines and Intensive Care Recommendations [9]. The aim of these recommendations is to obtain a non-traumatic, sterile catheterization. Careful attention is given to the drainage system, limiting the duration of catheterization, disposing of the urine accumulated in the collection bag, replacing a malfunctioning collecting system, and keeping the system closed when a closed system is used. Insertion of the indwelling urethral catheters was performed after surgical hand washing, wearing sterile gloves, a facemask, and a cap, and using sterile drapes. Routine meatal and perineal hygiene with povidone-iodine, water, and non-sterile gloves was performed once daily or more if the perineal zone was soiled. The catheter was fastened on the pubes as recommended by the French National General Guidelines and Intensive Care Recommendations [9].

Patients received either a two-chamber drainage system (TCDS) urinary drainage system 'Appareil pour la diurèse ouverte' (964.00) (Vygon, Ecouen, France) containing a Foley catheter connected to an output measure recipient and a urine collection bag, or a complex closed system (CCDS) 'Curity Infection Control System' (8120) (Kendall Company, Boston, Mass., USA) comprising a preconnected coated latex catheter, a tamper-discouraging seal at the catheter-drainage tubing junction, a drip chamber, an anti-reflux valve, a drainage bag vent, and a povidone-iodine releasing cartridge at the drain port of the urine collection bag [6, 7]. Both devices used for bladder catheterization allowed urine sampling without disconnection. Bladder pressure measurements were not performed during the study period. Disconnections, obstructions, and catheter care violations were not collected.

A urine sample was obtained aseptically within 24 h of catheter insertion, then weekly for the duration of catheterization, and within 24 h after removal of the catheter and each time symptoms of urinary infection were suspected. A catheter-associated bacteriuria was defined as $=10^5$ cfu.ml^{-1}, with no more than two different species of organisms, according to the CDC criteria [10]. Standard culture and bacteriological techniques were used to identify isolated organisms.

Statistical analysis

Statistical analysis was performed using the Statistical Analysis System software package (SAS version 5, SAS Institute, Cary, N.C., USA). Univariate analysis was conducted to determine potential risk factor of bacteriuria occurrence. Chi-square tests or Fisher's exact tests were used for qualitative variables and Student *t*-tests were used for quantitative variables. The required significance level was set at a P value <0.05. A multivariate analysis was conducted to quantify the respective role of each variable on the occurrence of bacteriuria. A stepwise logistic regression was performed (forward method, likelihood ratio). The following were included as explanatory variables in the logistic regression: 1) variables identified as potential risk factors by the univariate analysis (cut-off: *P* <0.2); and 2) variables known as risk factors by the scientific community. The condensed model was presented with a crude odds ratio and 95% confidence interval.

Results

Patients

During the 2-year period, 1,987 consecutive patients admitted in the polyvalent ICU were prospectively evaluated. Five hundred and fifty-three patients with a SAPS II of 27±18 received a urinary catheter for more than 48 h; 389 patients (70.3%) were men and 164 (29.7%) women. The ICU admission was related to medicine (35.6%), surgery (13.7%), or trauma (50.6%). The mean duration of catheterization was 8.4±7.8 days for a mean length of ICU stay of 11.5±10.7 days. A TCDS and a CCDS were used in 296 and in 257 patients, respectively. Two hundred and seventy-six patients (49.9%), of whom 142 (48%) were in the group TCDS and 134 (52%) in the group CCDS, received antibiotics during their period of catheterization.

Bacteriuria

Fifty-three patients (9.6%) who received an indwelling urinary catheter acquired a urinary tract infection on day 12±7. The isolated pathogens among patients with bacteriuria were essentially *Escherichia coli* (39%), *Pseudomonas aeruginosa* (22%), *Enterobacter aerogenes* (15%), *Acinetobacter acinus* (11%), *Klebsiella* spp (11%), and *Proteus* spp (11%). The results of the univariate analysis are reported in Table 1. Patients with bacteriuria had significantly greater SAPS II scores, longer duration of catheterization, and length of stay in hospital, compared to patients who did not acquired bacteriuria. Female sex was a significant risk factor. Thirty out of 53 patients with bacteriuria (55%) received antibiotics before the occurrence of bacteriuria. We analyzed a subgroup of patients who did not receive antibiotics and developed a bacteriuria. There were significantly fewer patients with bacteriuria in the TCDS group not receiving antibiotics than in the CCDS group (3.2% versus 15.4%, $P = 0.000$). This difference was not found in the subgroup of patients who received antibiotics. For the multivariate analysis, the entered variables were: gender, SAPS II, admission diagnosis, use of CCDS, and duration of catheterization, length of ICU stay, and use of antibiotics prior to the occurrence of bacteriuria for infected patients. The last two criteria were chosen because they have been established as well-known risk factors in previous studies. The condensed model is presented in Table 2. The multivariate analysis allowed the identification of five risk factors: female sex, length of ICU stay, SAPS II, prior antimicrobial therapy exposure, and duration of catheterization before the occurrence of infection (Table 2).

[Table 1. will appear here. See end of document.]

[Table 2. will appear here. See end of document.]

Discussion

The main result of the present study is that in polyvalent ICU patients female sex, length of ICU stay, prior use of antibiotic, severity score at admission, and duration of catheterization were independently associated with an increased risk of catheter-associated bacteriuria. Admission diagnosis, age, and the type of urinary drainage systems used were not found as significant risk factors. The present study focuses the analysis on a large cohort of well-defined patients who differ from those hospitalized in conventional wards because of their severity, their monitoring, and their localization.

Our results underline the necessity to reduce the duration of catheterization to avoid the occurrence of bacteriuria in ICU patients. Indeed, among the independent risk factors that we isolated, the duration of catheterization is the only variable that ICU physicians can modulate. As reported in several other studies, we found that giving antibiotics was a significant protective factor [2, 3, 4, 5]. However, the use of an antibiotic treatment decreases the risk of bacteriuria only during the first days of catheterization [2]. Given the fact that the broad prescription of antibiotics increases the selection pressure, leading to the emergence of multiresistant bacteria, this protective factor cannot be considered in clinical practice [11, 12].

Female sex was the major independent risk factor for catheter-associated bacteriuria in the present study. Several studies have prospectively evaluated risk factors for urinary catheter-related UTI and highlighted the role of sex in the occurrence of bacteriuria [2, 3, 4, 5, 13]. This increased risk in women is probably the consequence of easier access of the perineal flora to the bladder along the outside of the catheter as it traverses the shorter female urethra [14].

In the present study, higher severity score at admission was a significant risk factor for bacteriuria. This result is not in agreement with that obtained in medical ICU patients [5]. One explanation is that the number of patients in the latter study was not large enough to achieve statistical significance. In another study including 405 patients, the presence of a rapidly fatal underlying illness increased the risk of urinary infection by 2.5 [2]. Patients with a high severity score may have a state of relative immunosuppression characterized by a decreased response of both humoral and cell-mediated immunity, with the degree of suppression of the immune system correlating directly with the severity of injury [15]. One hypothesis could be that the bacterial

colonization of the bladder may be favored by the presence of immunosuppression in the patients with the most severe condition.

No difference was noted between the two systems of urine drainage in the rate of urinary tract infections. The influence of antibiotics on the occurrence of bacteriuria might be a confounding factor, since the prescription of systemic antibiotics during bladder catheterization has been shown to independently decrease the rate of bacteriuria [16]. In our study, 48% of the patients in the TCDS group versus 52% in the CCDS group received antibiotics, and no significant difference was observed between the two groups. However, the patients in the CCDS group not receiving antibiotics developed bacteriuria more frequently than those in the TCDS group. Platt et al. found that among patients not taking systemic antibiotics, those assigned to sealed junction catheters had fewer infections and deaths compared to those assigned to unsealed catheters [16]. These conflicting data may have several explanations. First, the present study was not designed to specifically evaluate the impact of urine drainage system on the rate of infection. Second, the study power was very low (22% for a bilateral test, a = 0.05, ß = 0.2) with a subgroup of patients including only five patients. Third, in terms of statistical methods, the analysis of a subgroup is not appropriate in the absence of significant results in the entire population.

The present study has several limitations. Catheter care violations and accidental disconnections were not taken into account. We did not perform a daily quantitative urine culture. The analysis did not consider factors like diabetes mellitus, site of injury of trauma or serum creatinine concentration, because we elicited to consider only universal criteria and avoid subgroup analysis.

The clinical relevance of bacteriuria in ICU patients is often discussed. However, the presence of bacteria in the bladder may generate urosepsis and extend hospital stay, and constitutes a reservoir of multiresistant bacteria. The case-fatality rate from UTI-related nosocomial bacteremia is approximately 13%, with the severely ill at highest risk. In conclusion, in the study patients, female sex, hospitalization length of stay, prior antimicrobial use, severity score, and duration of catheterization were identified as independent risk factors for catheter-associated bacteriuria. Our results emphasize that reducing the duration of catheterization appears as the most important clinical implication that can be identified for prevention.

References

1. Rosser CJ, Bare RL, Meredith JW (1999) Urinary tract infections in the critical ill patient with a urinary catheter. Am J Surg 177:287–290
2. Garibaldi RA, Burke JP, Dickman ML, Smith CB (1974) Factors predisposing to bacteriuria during indwelling urethral catheterization. N Engl J Med 291:215–219

3. Platt R, Polk BF, Murdock B, Rosner B (1986) Risk factors for nosocomial urinary tract infections. Am J Epidemiol 124:977–985

4. Saint S, Lipsky BA (1999) Preventing catheter-related bacteriuria. Should we? Can we? How? Arch Intern Med 159:800–808

5. Tissot E, Limat S, Cornette C, Capellier G (2001) Risk factors for catheter-associated bacteriuria in a medical intensive care unit. Eur J Clin Microbiol Infect Dis 20:260–262

6. Leone M, Garnier F, Dubuc M, Bimar MC, Martin C (2001) Prevention of nosocomial urinary tract infection in ICU patients. Comparison of effectiveness of two urinary drainage systems. Chest 120:220–224

7. Leone M, Garnier F, Antonini F, Bimar MC, Albanèse J, Martin C (2003) Nosocomial urinary tract infection in intensive care unit: comparison of effectiveness of two urinary drainage systems in intensive care unit. A prospective, randomized clinical trial. Intensive Care Med (in press)

8. Le Gall JR, Lemeshow S, Saulnier F (1993) A new Simplified Acute Physiology Score (SAPS II) based on an European/North American multicenter study. JAMA 270:2957–2963

9. REANIS (1994) Prevention of nosocomial urinary tract infections In: REANIS (ed) Guidelines for the prevention of nosocomial infections in intensive care unit. Arnette, Paris, pp 40–52

10. Garner JS, Jarvis WR, Emori TG, Horan TC, Hughes JM (1988) CDC definitions for nosocomial infections. Am J Infect Control 16:128–140

11. Schaberg DR, Weinstein RA, Stamm WE (1976) Epidemics of nosocomial urinary tract infection caused by multiply resistance gram-negative bacilli: epidemiology and control. J Infect Dis 133:363–366

12. Hyams KC (1987) Inappropriate urine cultures in hospitalized patients receiving antibiotic therapy. Arch Intern Med 147:48–49

13. Johnson JR, Roberts PL, Olsen RJ, Moyer KA, Stamm WE (1990) Prevention of catheter associated urinary tract infection with a silver oxide-coated urinary catheter: clinical and microbiological correlates. J Infect Dis 162:1145–1150

14. Stamm WE (1990) Catheter-associated urinary tract infections: epidemiology, pathogenesis, and prevention. Am J Med 91[Suppl 3B]:65–71

15. Ferguson NR, Galley HF, Webster NR (1999) T helper cell subset ratios in patients with severe sepsis. Intensive Care Med 25:106–109

16. Platt R, Polk BF, Murdock B, Rosner B (1983) Reduction of mortality associated with nosocomial urinary tract infection. Lancet 1:893–897

17. Bryan CS, Reynolds KL (1984) Hospital-acquired bacteremic urinary tract infection: epidemiology and outcome. J Urol 132:494–498

Table 1. Results of the univariate analysis. (*SAPS* simplified acute physiology score, *CCDS* complex closed drainage system)

	Patients without bacteriuria (*n*=500)	Patients with bacteriuria (*n*=53)	P value
Female sex (%)	27.6	49.1	<0.001
Age (years)	46.0±19.6	46.2±17.7	0.94
Admission diagnosis:			
Medicine (%)	36.0	32.1	0.65
Surgery (%)	14.0	11.3	
Trauma (%)	50.0	56.6	
Use of antibiotics[a] (%)	49.4	54.7	0.46
SAPS II	26.5±18.7	30.3±15.5	0.05
CCDS (%)	45.6	54.7	0.19
Duration of catheterization (days)	7.3±6.8	18.6±9.4	<0.001
Length of ICU stay (days)	10.0±8.8	25.3±15.9	<0.001

[a]Prior the occurrence of bacteriuria for infected patients

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Table 2. Risk factors for catheter-associated bacteriuria determined using multivariate analysis. Logistic regression: condensed model (Variables: 1. Cut-off <0.2: gender, SAPS II, complex closed drainage system, length of ICU stay, duration of catheterization; 2. Previous known risk factors: admission diagnosis, use of antibiotics). (*SAPS* simplified acute physiology score)

	Odds ratio (95% CI)	P value
Gender (men/women)	3.48 (1.72–7.06)	<0.001
Length of ICU stay (days)	1.09 (1.04–1.15)	<0.001
Duration of catheterization	1.07 (1.01–1.13)	<0.05
SAPS II	1.02 (1.00–1.04)	<0.05
Antibiotic use	0.40 (0.19–0.85)	<0.05