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Original

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

Marc Leone (✉) · Jacques Albanèse · Franck Garnier · Christophe Sapin · Karine Barrau · Marie-Christine Bimar · Claude Martin

M. Leone · J. Albanèse · F. Garnier · M.-C. Bimar · C. Martin
Intensive Care Unit and Trauma Center, Nord Hospital AP-HM, Marseilles University Hospital System, Marseilles School of Medicine, 13915 Marseille cedex 20, France

C. Sapin · K. Barrau
Laboratory of Epidemiology and Statistics, Marseilles University Hospital System, Marseilles School of Medicine, 13915 Marseille cedex 20, France

✉ M. Leone
Phone: +33-49-1968650
Fax: +33-49-19682818
E-mail: marc.leone@ap-hm.fr

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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 and setting Prospective cohort study in a 16-bed polyvalent ICU in a French university hospital.

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

Measurements and results 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. The frequency of catheter-associated bacteriuria was 9.6%. From the multivariate analysis, five independent risk

factors were determined: sex female, length of ICU stay, use of an antimicrobial therapy, severity score at admission, and duration of catheterization.

Conclusions 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) are 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 in infectious risk. Most patients who are hospitalized in an ICU 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 ICU patients [1]. In addition, the presence of bacteria in the bladder constitutes a potential reservoir of multiresistant bacteria. These risk factors of catheter-associated bacteriuria define a subset of ICU patients in which prevention must be particularly focused. These risk factors have been extensively studied in patients hospitalized in conventional wards and 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 and materials

Patients

The study was carried out in a 2-year period at Nord Hospital, a 700-bed tertiary care center affiliated with the University of the Mediterranean Sea. 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. 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 previously.

Of the 1987 patients admitted to the polyvalent ICU during the 2-year period 553 with a SAPS II of 27±18 received a urinary catheter for more than 48 h (389 men, 164 women). The ICU admission was related to medicine in 35.6%, surgery in 13.7%, and trauma in 50.6%. The mean duration of catheterization was 8.4±7.8 days, with a mean length of ICU stay of 11.5±10.7 days.

Study protocol

A team of trained nurses practiced catheterization and drainage system cares according to the French National General Guidelines and Intensive Care Recommendations [9]. The aim of these recommendations is to obtain nontraumatic, 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. The indwelling urethral catheters were inserted after surgical hand washing, wearing sterile gloves, facemask, and cap and using sterile drapes. Routine meatal and perineal hygiene with povidone-iodine, water, and nonsterile gloves was performed once daily or

more frequently 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 the two-chamber drainage system (TCDS; *n*=296) 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 the complex closed drainage system (CCDS; *n*=257) Curity Infection Control System (8120; Kendall, Boston, Mass., USA) comprising a preconnected coated latex catheter, tamper discouraging seal at the catheter-drainage tubing junction, drip chamber, antireflux valve, drainage bag vent, and 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 was not measured during the study period. Data on disconnections, obstructions, and catheter care violations were not collected. Antibiotics were administered during the period of catheterization to 48% of patients in the TCDS group (142/296) and to 52% in the CCDS group (134/257).

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 or higher, with no more than two different species of organisms, according to the criteria of the Centers for Disease Control [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 (version 5, SAS Institute, Cary, N.C., USA). Univariate analysis was conducted to determine potential risk factor of bacteriuria occurrence. The χ^2 or Fisher's exact test was used for qualitative variables, and Student *t* test was used for quantitative variables. The required significance level was set at a *p* value less than 0.05. Multivariate analysis quantified the respective effect of each variable on the occurrence of bacteriuria. Stepwise logistic regression was performed (forward method, likelihood ratio). Explanatory variables in the logistic regression were: (a) variables identified as potential risk factor by the univariate analysis (cutoff $p<0.2$) and (b) variables known as risk factors by the scientific community. The condensed model was presented with crude odds ratio and 95% confidence interval.

Results

Bacteriuria

Fifty-three patients (9.6%) who received an indwelling urinary catheter acquired a UTI on day 12±7. The pathogens isolated among patients with bacteriuria were *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 longer of stay in hospital than patients who did not acquired bacteriuria. Female sex was a significant risk factor. Of 53 patients with bacteriuria 30 (55%) received antibiotics before the occurrence of bacteriuria.

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

We analyzed a subgroup of patients who did not receive antibiotics and developed bacteriuria. There were significantly fewer patients with bacteriuria in the TCDS group not receiving antibiotics than in the CCDS group (3.2% vs. 15.4%, p=0.000). This difference was not found in the subgroup of patients who received antibiotics. In 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 latter two criteria were chosen because they have been established as risk factors in previous studies. The condensed model is presented in Table 2. The multivariate analysis identified five risk factors: sex female, length of ICU stay, SAPS II, prior antimicrobial therapy exposure, and duration of catheterization before the occurrence of infection (Table 2).

[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, monitoring, and 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 was the only variable that ICU physicians can determine. 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 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 likely 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 by 2.5 the risk of urinary infection [2]. Patients with 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 is that the bacterial colonization of the bladder is favored by the presence of immunosuppression in the most severe patients.

No difference was noted between the two systems of urine drainage in the rate of UTIs. The influence of antibiotics on the occurrence of bacteriuria might be a confounding factor since the prescription of systemic antibiotic 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 vs. 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. [16] found that among patients not taking systemic antibiotics those assigned to sealed junction catheters had fewer infections and deaths than those with unsealed catheters. These conflicting data may have several explanations. First, the present study was not designed specifically to evaluate the impact of urine drainage system on the rate of infection. Second, the study power was very low (22% for a bilateral test,

α=0.05, β=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 such factors as diabetes mellitus, site of injury of trauma, and serum creatinine concentration because we chose 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 severely ill at highest risk [17]. In conclusion, this study identified sex female, hospitalization length of stay, prior antimicrobial use, severity score, and duration of catheterization as independent risk factors for catheter-associated bacteriuria. Our results emphasize that reducing the duration of catheterization is the most important clinical factor in preventing bacteriuria.

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Table 1. Results of the univariate analysis in patients with and without bacteriuria (*SAPS II* Simplified Acute Physiology Score II; *CCDS* complex closed drainage system)

	Without bacteriuria (*n*=500)	With bacteriuria (*n*=53)	*p*
Women (%)	27.6	49.1	<0.001
Age (years)	46.0±19.6	46.2±17.7	0.94
Admission diagnosis (%)			0.65
Medicine	36.0	32.1	
Surgery	14.0	11.3	
Trauma	50.0	56.6	
Use of antibiotic[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 (day)	7.3±6.8	18.6±9.4	<0.001
Length of ICU stay (day)	10.0±8.8	25.3±15.9	<0.001

[a]Prior the occurrence of bacteriuria for infected patients

Table 2. Risk factors for catheter-associated bacteriuria determined by multivariate analysis. Logistic regression: condensed model [variables: (a) cutoff <0.2: gender, SAPS II, complex closed drainage system, length of ICU stay, duration of catheterization; (b) previous known risk factors: admission diagnosis, use of antibiotics; *SAPS II* Simplified Acute Physiology Score II]

	Odds ratio	95% CI	*p*
Gender	3.48	1.72–7.06	<0.001
Length of ICU stay (day)	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