Nosocomial urinary tract infection in the intensive care unit: when should *Pseudomonas aeruginosa* be suspected? Experience of the French national surveillance of nosocomial infections in the intensive care unit, Rea-Raisin

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Abstract

Individual and ward risk factors for *P. aeruginosa*-induced urinary tract infection in the case of nosocomial urinary tract infection in the intensive care unit were determined with hierarchical (multilevel) logistic regression. The 2004–2006 prospective French national intensive care unit nosocomial infection surveillance dataset was used and 3252 patients with urinary tract infection were included; 16% were infected by *P. aeruginosa*. Individual risk factors were male sex, duration of stay, antibiotics at admission and transfer from another intensive care unit. Ward risk factors were patient turnover and incidence of *P. aeruginosa*-infected patients.

Keywords: Hospital-acquired (nosocomial) infection, intensive care unit, *Pseudomonas aeruginosa*, surveillance, urinary tract infection

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Rates of urinary tract infection (UTI) remain high in intensive care units (ICUs) despite major advance in infection control measures and antimicrobial therapy [1–3]. *Pseudomonas aeruginosa* UTIs are associated with high mortality and morbidity and require the use of a limited number of antibiotics [1,4]. A delay in administration of effective therapy may cause severe adverse outcomes and overuse of anti-Pseudomonal agents may lead to increased resistance rates and limit future treatment options [5,6]. Therefore, in the case of a nosocomial UTI, it would be useful for empirical therapy to distinguish between patients with and without *P. aeruginosa*. This study investigated patient and ICU (ward) risk factors for *P. aeruginosa*-induced UTI in nosocomial UTI.

The national French nosocomial infection surveillance in the ICU (REA-RAISIN: REAnimation Réseau d'Alerte Investigation et Surveillance des Infections Nosocomiales) 2004–2006 dataset was used [7]. Participating ICUs prospectively collected four nosocomial infections (pneumonia, UTI, catheter-related infection and bacteraemia) with micro-organism and drug resistance patterns. Patients admitted for more than 48 h were included and followed-up until discharge. On admission, the following patient characteristics were collected: age, gender, diagnosis (medical, surgical), immunodeficiency status, Simplified Acute Physiology Score (SAPS II score), antibiotic treatment and trauma. Information on where the patient came from was also collected (origin from another ICU, medical or surgical unit or from home). Invasive devices (mechanical ventilation, urinary catheter, central vascular catheter) were recorded daily during the ICU stay. The number of beds and the type of ICU (medical, surgical and polyvalent, i.e. medical and surgical) were collected for each ICU. Monthly patient turnover in the ICU was calculated from the ratio of the number of patients admitted per month to the number of beds in the ICU; the mean incidence of *P. aeruginosa*-infected patients was calculated from the ratio of the number of patients with a *P. aeruginosa* infection (not only UTI) to the total number of patients (percentage).

Nosocomial urinary tract infection was defined as a UTI occurring 48 h after ICU admission. Patients had at least one of the following signs or symptoms with no other recognized cause: fever (>38°C), urgency, frequency or suprapubic tenderness and a positive urine culture (with urinary catheter, $\geq 10^5$ microorganisms/mL of urine with no more than two species of microorganisms; without urinary catheter, $\geq 10^3$ microorganisms/mL with no more than two species of microorganisms and $\geq 10^4$ WBC/mL) [3,8].

Only the first UTI was studied. Patients with *P. aeruginosa* UTI were compared with patients with non-*P. aeruginosa* UTI. Hierarchical (two levels, patient and ICU) logistic regression was performed with MLwiN version 2.15, centre for multilevel modelling University of Bristol. We first estimated an 'empty' model (model A), which only included a random intercept and allowed us to detect the existence of

a possible contextual dimension for *P. aeruginosa* UTI. Thereafter, we included the individual characteristics in the model (model B) to investigate the extent to which ICU level differences were explained by the individual composition of the ICU. Finally, we added the ICU variables (model C) to investigate whether *P. aeruginosa* UTI was conditioned by specific ICU characteristics [9].

A total of 195 different ICUs were included: 75% polyvalent ICU, 13% medical ICU and 12% surgical ICU. Geographical distribution was representative of national ICU distribution. Median duration of stay for these ICUs (all patients included) was 11 days (5–57 days), median proportion of patients with a urinary catheter was 80% (13–98), median patient turnover was four patients per bed per month (0.6–11), and median incidence of *P. aeruginosa*-infected patients was 3% (0–14%).

We found 3252 patients with UTI and 525 (16%) with *P. aeruginosa* UTI. Nine per cent of *P. aeruginosa* UTI were followed by *P. aeruginosa* pneumonia (median delay of occurrence after the UTI, 9 days) and 3% by *P. aeruginosa* bacteraemia (median delay of occurrence after the UTI, 4 days). Patients' characteristics and results of univariate analysis are reported in Table 1. Results of multivariate analysis are presented in Table 2. Probability of *P. aeruginosa* UTI was associated with male sex, transfer from another ICU, duration of ICU stay before UTI, antibiotics at admission, ICU incidence of *P. aeruginosa*-infected patients and ICU patient turnover. The residual heterogeneity between ICUs (MOR = 1.47) was of greater relevance than the impact of the length of stay before UTI (OR = 1.02) and of the same relevance as antibiotics at admission (OR = 1.47).

Multilevel modelling allowed analyzing data in a simple and appropriate way [9]. Selection and measure biases were limited, as several ICUs participated with the same methodology.

There are few data available concerning predictive factors of *P. aeruginosa* in the case of nosocomial UTI in the ICU but

TABLE 1. Main characteristics of the 3252 patients according to their type of urinary tract infection (UTI); univariate analysis

Patient characteristics	Patient with *P. aeruginosa* UTI (*n* = 525)	Patient with non-*P. aeruginosa* UTI (*n* = 2727)	p
Sex-ratio (M/F)	2.0	0.9	$<10^{-2}$
	Mean (SD)*	Mean (SD)*	
Age (year)	64.5 (17.3)	63.8 (16.6)	ns
SAPS II score	57.6 (93.8)	53.9 (85.1)	ns
Duration of stay in the ICU before UTI (day)	23.5 (12.9)	15.2 (14.7)	$<10^{-2}$
Duration of urinary catheterization before UTI (day)	22.2 (18.4)	14.2 (14.1)	$<10^{-2}$
	n (%)	*n* (%)	
Origin at admission			
Patient with no hospitalization before admission	262 (50%)	1473 (55%)	–
Patient from medical or surgical unit	214 (41%)	1088 (40%)	ns
Patient from an ICU	45 (9%)	139 (5%)	<0.05
Antibiotics at admission	351 (67%)	1444 (54%)	<0.05
Trauma patient	62 (12%)	370 (13%)	ns
Type of diagnosis			
Medical	358 (68%)	1940 (71%)	ns
Surgical	166 (32%)	774 (29%)	
Immunodeficiency	458 (12%)	2383 (11%)	ns
Urinary catheterization before UTI	517 (98%)	2676 (98%)	ns
Mortality	131 (25%)	654 (24%)	ns

*SD, standard deviation; ns, non-significant.

TABLE 2. Risk factors for *P. aeruginosa* in the case of nosocomial urinary tract infection (UTI); multivariate analysis

	Model A	Model B	Model C
Intercept	−1.625 (0.060)	−2.359 (0.121)	−2.364 (0.124)
Individual (patient) level variables		OR (95% CI)	OR (95% CI)
Male sex		1.97 (1.61–2.42)	2.00 (1.62–2.47)
Origin at admission			
Patient from home		–	–
Patient from medical or surgical unit		1.03 (0.84–1.37)	1.07 (0.86–1.33)
Patient from an ICU		1.91 (1.29–2.81)	1.85 (1.24–2.77)
Antibiotics at admission		1.47 (1.19–1.83)	1.39 (1.11–1.73)
Duration of stay in the ICU before UTI		1.02 (1.02–1.03)	1.02 (1.01–1.03)
Ward (ICU) level variables			
Patient turnover			1.08 (1.02–1.15)
Incidence of *P. aeruginosa*-infected patients			1.09 (1.04–1.15)
MOR (95% CrI)	1.48 (1.38–1.60)	1.47 (1.37–1.56)	1.40 (1.30–1.51)
ICC	0.048	0.047	0.037

OR, odds ratio; 95% CI, 95% confidence interval; SE, standard error; MOR, median odds ratio; CrI, credible interval; ICC, intraclass correlation.

some patient factors were previously identified [10–14]. This study sought to create patient and ICU profiles associated with the risk of *P. aeruginosa* UTI. According to our results, ICU physicians facing a nosocomial UTI should suspect *P. aeruginosa* in the case of a male patient, transferred from another ICU with antibiotics at admission and long duration of stay, especially in an ICU with high patient turnover and high rates of *P. aeruginosa*-infected patients.

Neurogenic bladder, history of prostatic surgery, urinary tract procedures, a foreign body in the urinary tract, chronic corticosteroids and antibiotics during the stay were also found to be associated with the risk of *P. aeruginosa* UTI [10,13]. Neither antibiotic use during ICU stay nor type of antibiotics at admission was collected in REA-RAISIN. Many studies showed selection of *P. aeruginosa* by antibiotic use [10,11,13]. Imipenem, ciprofloxacin, levofloxacin, piperacillin, tazocillin, broad-spectrum cephalosporins, aminoglycosides and antibiotics inactive against *P. aeruginosa* were associated with high incidence rates of *P. aeruginosa* [11,15–17]. Antibiotic therapy could lead to an alteration in the resident microflora, facilitating colonization with *P. aeruginosa* prior to UTI [10].

This study determined ICU characteristics associated with *P. aeruginosa* UTI, even if individual characteristics remain predominant. Incidence of *P. aeruginosa*-infected patients is likely to be a marker of both ICU ecology (colonization pressure) and cross-transmission rates that are unique to each ICU. A high patient turnover can reduce the time available to perform environmental cleaning between two patients or can be a marker of elevated nurse staffing [18,19]. Previously, the number of *P. aeruginosa* carriers, nurse to patient ratio and compliance with infection control measures were related to *P. aeruginosa* acquisition [15,20].

To conclude, routine national nosocomial infection surveillances can help in detecting new risk factors for infections with specific microorganisms. We identified ward risk factors for *Pseudomonas aeruginosa* in the case of UTI in the ICU. More precise ward characteristics should be collected in other surveillance projects.

Transparency Declaration

None.

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