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Nosocomial infections: prospective survey of incidence in five French intensive care units

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Abstract *Objective*: To assess the incidence and to evaluate the feasibility of inter-unit continuous surveillance of intensive care unit (ICU)-acquired infections.
Design: Prospective multicentre, longitudinal, incidence survey.
Setting: Five ICUs in university hospitals in western France.
Patients: All patients admitted to the ICU during two 3-month periods (1994–1995).
Measurements and results: The main clinical characteristics of the patients, ICU-acquired infections, length of exposure to invasive devices and the micro-organisms isolated were analysed. The study included 1589 patients (16970 patient-days) and the infection rate was 21.6% (13.1% of patients). The ventilator-associated pneumonia rate was 9.6%, sinusitis 1.5%, central venous catheter-associated infection 3.5%, central venous catheter-associated bacteraemia 4.8%, catheter-associated urinary tract infection 7.8% and bacteraemia 4.5%. The incidence density rate of ICU-acquired infections was 20.3‰ patient-days. Ventilator-associated pneumonia and sinusitis rates were 9.4 and 1.5‰ ventilation-days, respectively. Central venous catheter-associated infection and central venous catheter-associated bacteraemia rates were 2.8 and 3.8‰ catheter-days, respectively. The catheter-associated urinary tract infection rate was 8.5‰ urinary catheter-days and the bacteraemia rate 4.2‰ patient-days. Six independent risk factors for ICU-acquired infection were found by stepwise logistic regression analysis: absence of infection on admission, age > 60 years, length of stay, mechanical ventilation, central venous catheter and admission to one particular unit. A total of 410 strains of micro-organisms were isolated, 16.8% of which were *Staphylococcus aureus* (58.0% methicillin-resistant).
Conclusion: This prospective study using standardised collection of data on the ICU-acquired infection rate in five ICUs identified six risk factors. It also emphasized the difficulty of achieving truly standardised definitions and methods of diagnosis of such infections.

Key words Epidemiology · Incidence study · Intensive care · Nosocomial infection

Introduction

A frequent problem in intensive care units (ICUs) is a high rate of incidence of nosocomial infections, rates being as high as 36 to 54‰ patient-days in surgical ICUs and 23 to 47‰ patient-days in medical ICUs [1], because of the severity of illness and the many invasive devices used. The aims of an infection control programme in the ICU are awareness of the prevention of ICU-acquired infections by initiating programmes of surveil-

lance with standardised methods [2], comparison over time and between units and hospitals [3], analysis of risk factors by prospective epidemiological studies and microbiological surveillance in order to detect outbreaks or emerging resistance.

In order to achieve greater efficacy, programmes could be reduced to a specific procedure or a specific subpopulation, according to the results of surveillance, and could lead to modification of practice and prevention policies. The aims should be evaluation of quality of care and motivation of teams for the prevention of nosocomial infections.

The main nosocomial infection rates are correlated [4–8] with average length of ICU stay, which is possibly an indirect indication of the severity of the illness (intrinsic risk factor), and with exposure to invasive devices (extrinsic risk factors). Two designs can be used to study nosocomial infections: a cross-sectional design (prevalence studies) or a longitudinal design (incidence studies). Nosocomial infection rates in ICUs are variable according to severity of disease and exposure to risk factors, which can be different from unit to unit or in the same unit at different periods. Longitudinal studies therefore seem to be more useful to assess rates and risk factors for nosocomial infections.

Measuring incidence density is the first method of adjustment, using total number of patient-days as the denominator. With this variable, the National Nosocomial Infections Surveillance System [3] showed a correlation between density of incidence of nosocomial infection and length of stay or length of exposure to invasive devices. Device-associated incidence densities could also be used with adjustment for total number of days of exposure to a specific invasive device.

Infection surveillance and prevention programmes (SENIC Project) [9] have reduced infection rates in hospitals in the United States [10–13]. The studies and findings of the Centers for Disease Control specifically in ICUs [7] have taken into account risk factors such as length of exposure to invasive devices (mechanical ventilation, central venous catheters, urinary catheters), but the results have not been sufficiently conclusive to prove their efficacy for inter-unit comparison. We therefore conducted a prospective multicentre, longitudinal, incidence survey in five ICUs in western France. The aim was to evaluate the feasibility of a standardised protocol of continuous surveillance of ICU-acquired infections and to evaluate the use of descriptors of hospitalisation to stratify risks and compare data during different periods and in different units. The final aim was to organise a survey network of ICU-acquired infections in western France.

Patients and methods

Patients

We conducted a multicentre prospective study in five French medical or mixed ICUs for two different 3-month periods (1994–1995). The five units were located in university hospitals in western France (Angers, Nantes, Poitiers, Rennes, Tours) and randomly identified by the letters A to E. All patients admitted to these units were included. Surveillance was stopped 2 months after the end of the study period if the patient was still an inpatient of the unit. Data were collected on an anonymous standardised survey record form. The information collected for each patient comprised demographic status, manner of and reason for admission, presence or absence of community or nosocomial infection on admission, Simplified Acute Physiology score (SAPS II) [14], OMEGA score [15], exposure or absence of exposure to invasive devices such as mechanical ventilation, central venous catheter (CVC) and urinary catheter and outcome on discharge from ICU.

ICU-acquired infections

Information concerning ICU-acquired infections was also collected on the survey form (type, microbiological data and associated risk factors). ICU-acquired infection was defined as an infection which began at least 48 h after ICU admission, and all types of ICU-acquired infection were recorded. Definitions were based on the definitions of the Centers for Disease Control and Prevention [16] and modified by the REANIS group [17] according to the recent consensus conference recommendations [18, 19]. The main ICU-acquired infections recorded were bacteraemia, definite or probable pneumonia, sinusitis, CVC-related infection, CVC-related bacteraemia and urinary tract infection.

Bacteraemia was defined as at least one micro-organism isolated on blood culture, except for micro-organisms such as coagulase-negative *Staphylococcus*, *Aeromonas* and *Pseudomonas* other than *Ps. aeruginosa*, for which two blood cultures were required. Pneumonia was considered as definite if the chest X-ray revealed one or more persistent new opacities associated with the histological diagnosis (in vivo or post-mortem lung biopsy) or identification of a micro-organism by bronchoalveolar lavage ($\geq 5\%$ cells with micro-organisms or culture $\geq 10^4$ colony forming units (cfu)/ml), distal protected specimen brush or catheter (culture $\geq 10^3$ cfu/ml), abscess or culture from pleural effusion, sputum cultures with the same organism as that isolated from the blood culture, sputum culture for *Legionella*, *Aspergillus* and mycobacteria or by serology for *Legionella*. Pneumonia was considered probable if chest X-ray abnormalities were associated with purulent sputum, temperature $> 38\,^{\circ}C$ or hypothermia, white blood cell count $> 10 \times 10^9$/l or neutropenia or deterioration of blood gas results. Pneumonia was excluded when there was another diagnosis explaining the abnormalities, recovery without antimicrobial therapy, histology excluding pneumonia or negative sputum culture. In the analysis, definite and probable pneumonias were studied in the same group.

CVC-related infection was defined by a positive catheter culture (Brun-Buisson modified Cleri's method [20]) or a significant increase in quantitative blood cultures through the catheter compared to a peripheral vein (ratio of 5), and systemic or local signs of infection disappearing after catheter removal. CVC-related bacteraemia was considered as definite if catheter and blood cultures were positive with the same micro-organism. CVC-related bacteraemia was considered as probable if the catheter culture was negative or not done and the bacteraemia could not be directly attribut-

Table 1 Main characteristics of patients in the five units A–E over the two periods. Values are mean (95% CI)

	Period 1					Period 2					Total
	A	B	C	D	E	A	B	C	D	E	
Number of patients	179	173	170	175	78	214	178	170	160	92	1589
Age (years)	51.8 (48.6 to 55.0)	56.2 (53.4 to 59.0)	49.8 (46.9 to 52.7)	54.1 (51.3 to 56.9)	59.2 (55.7 to 62.7)	55.0 (52.5 to 57.5)	52.4 (49.6 to 55.2)	51.2 (48.3 to 54.1)	58.1 (55.3 to 60.9)	57.3 (53.7 to 60.9)	54.1 (53.1 to 55.0)
SAPS II	39.3 (36.5 to 42.1)	38.2 (35.9 to 40.5)	34.2 (31.2 to 37.2)	37.7 (34.4 to 40.9)	38.0 (34.2 to 41.7)	37.3 (35.1 to 39.4)	35.2 (28.8 to 41.6)	32.2 (29.3 to 35.2)	41.9 (37.8 to 46.0)	38.0 (34.6 to 41.4)	37.1 (36.2 to 38.0)
OMEGA	125 (89 to 162)	115 (93 to 134)	134 (88 to 180)	127 (103 to 149)	228 (169 to 286)	112 (91 to 134)	122 (102 to 142)	127 (88 to 165)	174 (142 to 206)	203 (149 to 256)	137 (126 to 149)
Mortality (%)	16.0	23.7	14.1	18.3	21.8	27.1	23.6	12.9	22.5	28.3	20.6
Length of stay (days)	10.4 (7.7 to 13.0)	9.7 (7.8 to 11.6)	10.3 (7.7 to 12.9)	10.1 (8.3 to 11.9)	16.4 (12.5 to 20.3)	9.3 (7.5 to 11.1)	9.8 (8.3 to 11.4)	10.6 (10.1 to 11.1)	11.6 (9.0 to 14.2)	15.4 (11.7 to 19.2)	10.7 (10.3 to 11.1)
Duration of ventilation (days)	11.1 (6.6 to 15.7)	8.0 (6.3 to 9.7)	13.6 (8.5 to 18.7)	7.9 (6.5 to 9.3)	18.5 (13.5 to 23.5)	8.9 (6.6 to 11.2)	7.8 (6.1 to 9.5)	10.2 (4.4 to 15.9)	10.1 (7.3 to 12.9)	15.3 (12.5 to 18.1)	10.3 (9.4 to 11.2)
Duration of CVC (days)	10.2 (7.5 to 12.8)	10.0 (7.7 to 12.3)	11.1 (8.0 to 14.2)	13.2 (9.1 to 17.3)	17.6 (13.1 to 22.0)	12.3 (8.2 to 16.4)	9.9 (7.7 to 12.1)	14.4 (10.2 to 18.6)	14.9 (8.6 to 21.2)	12.3 (6.0 to 18.6)	12.4 (11.2 to 13.6)
Duration of urinary catheterisation (days)	10.7 (7.0 to 14.3)	7.2 (5.7 to 8.7)	8.5 (6.6 to 10.4)	7.4 (5.5 to 9.3)	14.9 (11.1 to 18.7)	8.4 (6.5 to 10.2)	7.7 (6.1 to 9.2)	8.0 (6.0 to 10.0)	10.1 (7.9 to 12.3)	14.7 (10.6 to 18.7)	9.1 (8.4 to 9.8)

ed to any other cause. In the analysis, definite and probable bacteraemias were studied in the same group.

Urinary tract infection was defined as a symptomatic urinary tract infection with a urine culture $\geq 10^5$ cfu/ml or a culture $\geq 10^3$ and a urine leucocyte count $\geq 10^4$/ml, or as asymptomatic bacteriuria with two urine cultures $\geq 10^5$ cfu/ml (same micro-organism) and with an indwelling urinary catheter with a urine culture $\geq 10^5$ cfu/ml. In the analysis, symptomatic and asymptomatic urinary tract infections were studied in the same group.

Sinusitis was defined by radiographic evidence of infection and one or more micro-organisms isolated from culture of purulent secretions obtained from the sinus cavity or clinical signs (fever > 38 °C, local pain, headache, purulent secretions and nasal obstruction).

Surveillance was conducted prospectively until 2 months after the end of the study period.

Indicators

Total and device-associated incidence rates and incidence densities were measured for each unit and each period. The incidence rate was defined as the number of new cases of infection divided by the number of patients studied. The incidence density was defined as the number of new cases of infection divided by the total number of patient-days in the population studied. The device-associated incidence rate was defined as the number of new cases of site infection divided by the number of patients exposed to the device. The device-associated incidence density was defined as the number of new cases of site infection divided by the number of device-exposed-days in the population studied.

Statistical methods

Quantitative variables were expressed by mean and 95% confidence interval (CI). The characteristics of patients and ICU-acquired infections were compared among the five units for each period. The chi-square test was used for categorical variables. Mean *t*-test procedure and analysis of variance were used for quantitative parameters. A difference was significant if $p < 0.05$.

Logistic regression with the stepwise method of Hosmer and Lemeshow [21] was used to identify independent risk factors of ICU-acquired infection. The dependent variable was ICU-acquired infection. The explanatory variables were unit, period, sex, age (≤ or > 60 years), origin (home or other unit), reason for admission (medical or other), community infection on admission, nosocomial infection on admission, length of hospitalisation, SAPS II, OMEGA score, mechanical ventilation, urinary catheter and CVC exposure. Odds ratios (OR) and their CIs were calculated and presented to estimate the impact for risk factors.

Results

Patients (Table 1)

A total of 1589 patients were included involving 16970 patient-days. The mean age was 54.1 years (95% CI 53.1 to 55.0), 60.5% of patients were men and 50.4% were direct admissions. The reasons for admission were medical (67.1%), intoxication (18.4%), scheduled sur-

Table 2 Device-related incidence rates of the five units A–E for periods 1 and 2

	Period 1					Period 2					Total
	A	B	C	D	E	A	B	C	D	E	
Pneumonia (%)[a]	15.1	4.0	1.2	5.6	17.3	25.9	2.7	5.4	7.3	23.5	9.6
Sinusitis (%)[a]	6.5	0.0	0.0	0.8	3.8	1.8	0.7	0.0	2.1	1.5	1.5
Catheter-related infection (%)[b]	7.2	3.5	5.4	6.4	2.4	8.1	0.0	0.0	0.0	0.0	3.5
Catheter-related bacteraemia (%)[b]	12.0	5.2	5.4	6.4	0.0	4.0	3.2	5.3	3.4	0.0	4.8
Urinary tract infection (%)[c]	20.5	7.2	5.9	3.0	12.1	11.9	0.6	1.8	12.1	5.6	7.8
Bacteraemia (%)[d]	9.5	6.9	4.7	2.9	2.6	4.7	1.7	3.5	5.0	0.0	4.5

[a] Infections among ventilated patients
[b] Infections and bacteraemia among patients with CVCs
[c] Infections among patients with urinary catheters
[d] Bacteraemia among hospitalised patients

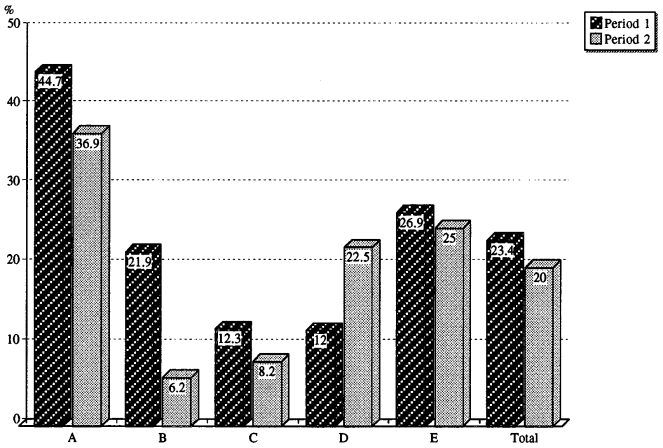

Fig. 1 Incidence rates in the five units for periods 1 and 2

gery (4.3%), emergency surgery (5.4%) and trauma (4.7%). On admission 21% of patients had a community infection and 8.3% a nosocomial infection. The mean SAPS II was 37.1 (95% CI 36.2 to 38.0), the mean OMEGA score was 137 (95% CI 126 to 149, median 58, range 4–4098) and the ICU mortality was 20.6%. Mean length of stay was 10.7 days (95% CI 10.3 to 11.1, median 5, range 1–191), 62.6% of the patients were mechanically ventilated for a mean duration of 10.3 days (95% CI 9.4 to 11.2), 44.6% of the patients had a CVC in place for a mean duration of 12.4 days (95% CI 11.2 to 13.6) and 74.3% of the patients had a urinary catheter in place for a mean duration of 9.1 days (95% CI 8.4 to 9.8).

ICU-acquired infections

Total and device-associated incidence rates (Table 2)

A total of 344 infections (21.6%) were reported in 208 patients (13.1%). Ventilator-associated pneumonia and sinusitis rates were 9.6 and 1.5%, respectively; CVC-associated infection occurred in 3.5% of catheterised patients, CVC-associated bacteraemia in 4.8%; and the catheter-associated urinary tract infection rate was 7.8%. The bacteraemia incidence rate was 4.5% patients.

Comparative analysis of the total incidence rates (Fig. 1) between periods 1 and 2 showed a significant difference for units B and D, with incidence rates of 21.9 and 6.2% for unit B ($p < 0.01$) and incidence rates of 12.0 and 22.5% for unit D ($p < 0.01$), respectively. Analysis also showed a "unit factor" in both periods: 44.7% for unit A and 16.9% for the other units during period 1 ($p < 0.01$), 36.9% for unit A and 14.0% for the other units during period 2 ($p < 0.01$).

Total and device-associated incidence densities (Table 3)

Incidence density was 20.3‰ patient-days. Ventilator-associated pneumonia and sinusitis incidence density were 9.4 and 1.5‰ ventilation-days, respectively, CVC-associated infection 2.8‰ catheter-days, CVC-associated bacteraemia 3.8‰ catheter-days, catheter-associated urinary tract infection 8.5‰ urinary catheter-days and bacteraemia 4.2‰ patient-days.

Risk analysis

For each reference model (B, C, D, E) only unit A was different, with a higher risk of ICU-acquired infections. Conversely, if the reference model was unit A, a significant difference was found from all the other four units. Therefore, unit A was the final reference for the five units. Stepwise logistic regression analysis yielded six independent variables significantly associated with ICU-acquired infections (Table 4), i.e. admission to unit A, absence of infection on admission, age > 60 years, length of stay, mechanical ventilation and CVC. The "period factor" disappeared after adjustment according to other variables, as did sex, origin, reason for admission, nosocomial infection on admission, SAPS II, OMEGA score, urinary catheter exposure. Risk of

Table 3 Device-related incidence densities in the five units A–E for periods 1 and 2

	Period 1					Period 2					Total
	A	B	C	D	E	A	B	C	D	E	
Pneumonia (‰)[a]	13.5	5.0	0.9	7.1	9.3	29.1	3.5	5.3	5.8	15.4	9.4
Sinusitis (‰)[a]	5.8	0.0	0.0	1.0	2.1	2.0	0.9	0.0	1.7	1.0	1.5
Catheter-related infection (‰)[b]	7.1	3.6	4.9	4.8	1.4	6.6	0.0	0.0	0.0	0.0	2.8
Catheter-related bacteraemia (‰)[b]	11.8	5.3	4.9	4.8	0.0	3.3	3.2	3.6	2.3	0.0	3.8
Urinary tract infection (‰)[c]	19.2	9.9	7.0	4.1	8.1	14.2	0.8	2.3	12.0	3.8	8.5
Bacteraemia (‰)[d]	9.2	7.1	4.6	2.8	1.6	5.0	1.7	3.7	4.3	0.0	4.2

[a] ‰ ventilation-days
[b] ‰ CVC-days
[c] ‰ urinary catheter-days
[d] ‰ hospitalisation-days

Table 4 Stepwise logistic regression analysis, six independent risk factors for ICU-acquired infection. Unit A was taken as the reference in the analysis. All variables were categorical except length of stay, which was a continuous variable

Variable	Odds ratio	95 % CI	*p* value
Unit B	0.182	0.111 to 0.297	< 0.001
Unit C	0.135	0.072 to 0.250	< 0.001
Unit D	0.187	0.111 to 0.317	< 0.001
Unit E	0.217	0.120 to 0.392	< 0.001
Infection on admission	0.498	0.319 to 0.778	0.002
Length of stay	1.113	1.097 to 1.129	< 0.001
Age > 60 years	1.539	1.080 to 2.191	0.017
Mechanical ventilation	3.064	1.858 to 5.051	< 0.001
Central venous catheter	3.177	2.125 to 4.749	< 0.001

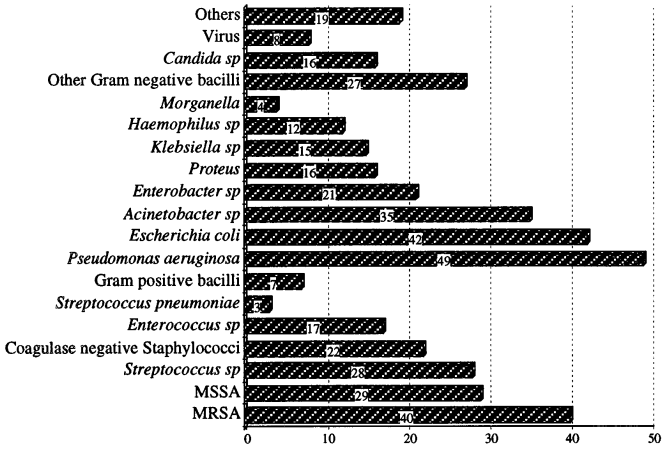

Fig. 2 Microbiological data. A total of 410 micro-organisms found in all sites of ICU-acquired infection. *MSSA* methicillin-sensitive *S. aureus*, *MRSA* methicillin-resistant *S. aureus*

ICU-acquired infection in unit A was eight to nine times higher than in other units. Community infection on admission "protected" against ICU-acquired infection (OR = 0.498; 95 % CI 0.319 to 0.778). Patients older than 60 years had an increased risk (OR = 1.539; 95 % CI 1.080 to 2.191). Length of ICU stay was a determinant, the risk of ICU-acquired infection being increased by 1.113 per day. The other risk factors were two invasive devices: mechanical ventilation increased the risk by 3.064 and CVC by 3.177.

Microbiological data

A total of 410 micro-organisms were isolated in the five units for the two periods (Fig. 2), 35.6 % of which were gram-positive cocci, 53.9 % gram-negative bacilli and 3.9 % *Candida species*. The main micro-organisms were *Staphylococcus aureus*, which was isolated in 16.8 % (58 % of which were methicillin-resistant), *Pseudomonas aeruginosa* in 11.9 %, *Escherichia coli* in 10.2 % and *Acinetobacter* species in 8.5 %. The rates of the main micro-organisms responsible for nosocomial infections in ICUs (*Staph. aureus*, *Ps. aeruginosa* and *Acinetobacter* sp) were 29.1 % of the strains in unit A, 50.0 % in unit B, 42.5 % in unit C, 44.3 % in unit D and 42.9 % in unit E (Table 5).

Discussion

This prospective study resulted in a standardised collection of data on nosocomial infections in five ICUs with measurement of incidence rates and densities. Such comparisons are more accurate than when performed in heterogeneous units, or with incidence rates not adjusted for severity and length of exposure to risk factors.

Analysing risk factors requires multivariate analysis, which makes it possible to find real independent risk factors without the confounding effects of multiple variables. Differences between rates in several units could represent the efficacy of various prevention prac-

Table 5 Main micro-organisms responsible for nosocomial infections in the five units A–E (152 of 410 micro-organisms)

	A *n* (%)	B *n* (%)	C *n* (%)	D *n* (%)	E *n* (%)
Staphylococcus aureus (1)	24 (12)	8 (15)	12 (32)	18 (30)	6 (11)
Pseudomonas aeruginosa (2)	15 (7)	9 (17)	4 (11)	8 (13)	13 (23)
Acinetobacter sp. (3)	20 (10)	9 (17)	0	1 (2)	5 (9)
Total (1 + 2 + 3)	59 (29)	26 (50)	16 (43)	27 (45)	24 (43)

tices. Nevertheless, simple comparisons between the usual findings lead to significant errors because of the different techniques of data collection, different definitions of nosocomial infections and absence of adjustment for intrinsic and extrinsic risk factors.

If we compare our results to Jarvis et al.'s study [7], the incidence densities were similar (20.3 vs 24‰ days of hospitalisation) despite different incidence rates (21.6 vs 9%). The differences between these results confirm the need to compare incidence adjusted for length of exposure and not only crude incidence rates [9]. It is also often difficult to compare studies because of differences in the definitions of nosocomial infection, in type of unit (medical, surgical or mixed) and in populations studied (all patients or only patients hospitalised for more than 48 h).

Stepwise logistic regression revealed six independent variables in our study which were associated with higher rates of incidence of ICU-acquired infections. There was a "unit factor", with a higher incidence in one unit compared with the other four. It was not explained by differences in severity of disease or by more frequent use of invasive devices. This result could suggest that data collection was different in this unit, either because of different interpretations of the definitions or more exhaustive exploration in the diagnosis of nosocomial infections. Nevertheless, the definitions which were used were common to the five units and were defined before beginning the study. More exhaustive exploration was another possibility, but the incidence rates and densities were higher in this unit for all types of infection, even for bacteraemia. The incidence of bacteraemia, although not free from bias, is probably the best infection to use to compare incidence rates, because of less variability and fewer errors in diagnosis and definition. The hypothesis of an outbreak in this unit could also be suspected, but no predominant micro-organism was found and the frequency with which strains of *Staph. aureus*, *Ps. aeruginosa* and *Acinetobacter* sp were found was lower (Table 5). If these three areas of bias are excluded, these results suggest that incidence rates were really higher in one unit. Nevertheless, the differences among the five units emphasise the difficulties in collecting data with homogeneous methods (diagnostic methods and intensity of research). The absence of community infection on admission was found to be a risk factor for infection during the ICU stay, which was surprising in view of the frequently greater severity of illness on admission. Several studies have found the same risk factor, especially for nosocomial pneumonia [22–24]. One explanation might be that antimicrobial therapy had an effect for these patients. On the other hand, Koleff [25] found that antimicrobial therapy was a risk factor for acquisition of nosocomial infection with resistant micro-organisms. It might therefore only be a diagnosis bias, also due to the therapy, which can make the diagnosis of nosocomial infection more difficult. No conclusion was possible concerning this risk factor, and further information concerning community-acquired infections was not collected (diagnosis, severity, antimicrobial therapy on admission).

As frequently found in other studies [4–6, 8], a further risk factor was the length of stay, due to severity of illness, duration of patient care and exposure to invasive devices. Severity of illness was not always associated with length of stay, explaining why SAPS II was not found to be a risk factor in our study, and, similarly, the Acute Physiology and Chronic Health Evaluation II score was not found in the final analysis in the multicentre European Prevalence of Infection in Intensive Care (EPIC) study [8] or in Craven et al.'s study [4] to be a risk factor. The National Nosocomial Infections Surveillance System [3] revealed no association between severity of illness scores and device-associated infection rates.

The other risk factors were two invasive devices. Mechanical ventilation and CVCs were independently associated with a higher risk of ICU-acquired infections, as in the studies of Craven et al. [4] and Vincent et al. [8]. Surprisingly, urinary catheters were not shown to be an independent risk factor, although the incidence density was high.

The micro-organisms found in this study were mainly gram-negative bacilli but *Staph. aureus* (16.8%) was the most common micro-organism, followed by *Ps. aeruginosa*, *E. coli* and *Acinetobacter* species. The pattern of antimicrobial resistance was only recorded for *Staph. aureus*, which was methicillin-resistant in 58%, as in the results of the EPIC study [26]. Coagulase-negative *Staphylococcus* and *Candida* species were not often isolated (3.9%), in contrast to other studies [26–28] in which an increased rate was found for these micro-organisms.

In conclusion, longitudinal surveys are important in ICUs to assess the incidence of nosocomial infections

and to determine risk factors. They are more accurate than prevalence studies, but it takes longer to collect and analyse the data. Efficacy depends on early analysis and conveying the information to the ICU team. Our study determined incidence rates and risk factors and also evaluated the feasibility of routine surveillance of nosocomial infections in ICUs. The main difficulty highlighted by this study was that of achieving truly standardised definitions and methods of diagnosis of ICU-acquired infections which could be applied by several units.

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