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National influences on catheter-associated bloodstream infection rates: practices among national surveillance networks participating in the European HELICS project

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Summary This study was performed to evaluate associations between organisational characteristics, routine practices and the incidence densities of central venous catheter-associated bloodstream infections (CVC-BSI rates) in European intensive care units (ICUs) as part of the HELICS project (Hospitals in Europe Link for Infection Control through Surveillance). Questionnaires were sent to ICUs participating in the national nosocomial infection surveillance networks in 2004. The national networks were asked for the CVC-BSI rates of the ICUs participating for the time period 2003–2004.

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Univariate and multivariate risk factor analyses were performed to identify which practices had the greatest impact on CVC-BSI rates. A total of 526 ICUs from 10 countries sent data on organisational characteristics and practices, demonstrating wide variation in care. CVC-BSI rates were also provided for 288 ICUs from five countries. This made it possible to include 1383 444 patient days, 969 897 CVC days and 1935 CVC-BSI cases in the analysis. Adjusted logistic regression analysis showed that the categorical variables of country [odds ratio (OR) varying per country from OR: 2.3; 95% confidence interval (CI): 0.5—10.2; to OR: 12.8; 95% CI: 4.4—37.5; in reference to the country with the lowest CVC-BSI rates] and type of hospital 'university' (OR: 2.08; 95% CI: 1.02—4.25) were independent risk factors for high CVC-BSI rates. Substantial variation existed in CVC-BSI prevention activities, surveillance methods and estimated CVC-BSI rates among the European countries. Differences in cultural, social and legal perspectives as well as differences between healthcare systems are crucial in explaining these differences.

Introduction

Central venous catheter-associated bloodstream infections (CVC-BSIs) are one of the most common nosocomial infections in intensive care units (ICUs). They are associated with a substantial mortality, prolongation of ICU stay and related costs.[1—4] It is well-known that up to 70% of these infections are preventable.[5,6] To understand which practices have the greatest impact on the development of CVC-BSI and to help the ICUs to better target their prevention measures, risk factor analyses are useful. These risk factor analyses should not only include a large number of institutions, they also require a wide variation of practices. Due to the relatively low heterogeneity of infection control measures within a given country, risk factor analyses on a European level seem to be effective for identifying the most relevant risk factors.

The HELICS project (Hospitals in Europe Link for Infection Control through Surveillance) as a supranational network offers the chance to collect data about infection control measures in various European countries (http://helics.univ-lyon1.fr/).[7] This project was initiated to encourage the development of surveillance systems for detection of healthcare-acquired infection (HCAI), to share expertise in surveillance for HCAI between countries, and to establish a European dataset on HCAIs.

This network was used to collect information about organisational and care practices in various European countries and to associate these data with CVC-BSI rates from the individual ICUs.

Methods

Organisational and patient care characteristics

A draft of the questionnaire was developed and sent to the national surveillance networks for comments. All comments were discussed and the final version of the questionnaire was established at the HELICS meeting in November 2003. The questionnaire contained questions about structure and size of the hospital/ICU, surveillance methods, CVC insertion techniques and CVC management.

All national nosocomial surveillance networks participating in HELICS were invited to participate in the study. Countries unable to send surveillance data were invited to participate in order to provide descriptive data for assessing the situation in the field of infection control. In 2004 the networks translated the questionnaire into their national language and sent it to the participating ICUs.

CVC-BSI rates

In order to associate the descriptive data with the analogous infection rates, the networks were also asked for CVC-BSI rates of the participating ICUs during the years 2003 and 2004. CVC-BSI cases were defined as primary BSI cases with a CVC use $\leq$48 h before onset of BSI symptoms. CVC-BSI rates were calculated as CVC-BSI cases per 1000 CVC days.

Data analysis

All data received from the questionnaires were checked for plausibility and entered into a database. In a first step, crude data were analysed descriptively. The results were given as feedback to the individual countries in order to validate them and to draw their own conclusions. In a second step, the data about organisational characteristics and patient care of the participating ICUs were associated with the corresponding CVC-BSI rates.

Univariate and multivariate analyses were carried out. In the multivariate analysis a logistic regression was performed using a stepwise forward variable selection with significance level of $P_{in} = 0.05$ for entering a variable in the model and $P_{out} = 0.10$ for excluding a variable. The outcome was a CVC-BSI rate above the 75th percentile of all ICUs included.

Results

Descriptive analysis

Ten national networks (Belgium, Finland, France, Germany, Hungary, Lithuania, Poland, Slovenia, Sweden and Spain) sent descriptive data from 526 ICUs. The organisational characteristics are described in Table I. Most of the participating ICUs were from Germany, France, Belgium and Hungary. The size of the participating ICUs varied from median six beds in Poland to median 12 beds in Lithuania. There were substantial differences concerning the percentage of ventilated patients in the ICUs, varying from 28% to 79%, reflecting the differences in patients' severity of illness. Patients stayed in the ICUs from a median of two days in Sweden to seven days in France and Poland. The nurse:patient ratio was very similar between the various ICUs with the exception of Finland, where there were more nurses per patient. The overview of the patient care parameters in Table II shows considerable differences between countries. The average frequency of blood cultures varied widely, from ~16 blood cultures per 1000 bed days taken in Poland, to ~164 in Belgium and France. Additionally there were differences in the changing intervals of IV sets in respect of compliance with the instructions for maximal barrier precautions during catheter insertion. Some ICUs still perform scheduled CVC changes. Minor differences could be observed concerning the existence of written policies for insertion and catheter care. CVC-BSI surveillance, mainly based on microbiology results and chart review, was predominantly performed by infection control nurses.

Association analysis

Five networks sent data for calculating CVC-BSI rates. Overall data of 288 ICUs with 1383 444 patient days, 969 897 CVC days and 1935 CVC-BSI cases were analysed. The median CVC use rate was 68.8 CVC days/100 patient days. The median CVC-BSI rate was 1.5 CVC-BSI/1000 CVC days. The countries' median CVC-BSI rates varied from 0.93 to 3.27 CVC BSI/1000 CVC days (Figure 1).

In the multivariate risk factor analysis of all five countries only two factors remained significant: the categorical variable country and the university-affiliated ICU (Table III).

Discussion

In this surveillance-based study, organisational characteristics and patient care parameters concerning CVC use were described at a European level. Parameters were also associated with CVC-BSI rates in order to identify further risk factors of CVC-BSI. Since the CVC management was a matter of particular interest in the present study, countries were asked for ICUs' CVC-BSI rates as described above instead of BSI rates following the HELICS protocol. The HELICS protocol offers various definitions of bloodstream infection whereby definitions are based on blood cultures and clinical signs or symptoms mirroring the CDC definitions.[8] The protocol also provides an identification of CVC-related BSIs, but not all participating countries were using this particular definition.

An international study has several advantages. Firstly, a high number of participating ICUs, secondly, a wide variation of nosocomial infection rates reflecting a wide variation of infection control practices and thirdly, small within-country variability. Such a study reflects the situation at a broader level and offers the chance to use this information for an identification of further risk factors for CVC-BSI. On the other hand, interpretation of data from an international study can be difficult since the participating ICUs are not necessarily representative of a country, or for Europe as a whole. The acquired data for this study may rather overestimate incidence densities since all participating ICUs attended a national surveillance network and therefore may have instituted more advanced infection control measures due to a greater focus on

Table I Organisational characteristics of the participating intensive care units (ICUs) ($N = 526$)

National network	Belgium	Finland	France	Germany	Hungary	Lithuania	Poland	Slovenia	Spain	Sweden	All ICUs	All ICUs with outcome data
No. of participating ICUs	72	14	82	201	72	8	27	12	35	3	526	288
Median no. of hospital beds	325	339	464	522	636	1003	300	310	453	464	464	450
University hospitals (%)	7	64	32	20	4	63	4	17	46	0	20	22
Type of ICU (%)												
Medical	24	14	36	19	11	25	67	33	22	50	26	25
Surgery	32	14	14	22	17	25	7	50	10	50	23	22
Trauma	4	14	1	7	7	0	11	0	10	0	6	6
Neurosurgery	0	7	2	5	3	13	0	0	7	0	4	5
Cardiac surgery	3	7	1	3	0	12	7	0	7	0	3	3
Coronary care	6	7	0	8	1	0	0	0	13	0	5	5
Paediatric	0	14	0	3	3	12	0	0	3	0	2	3
General	31	23	46	33	58	13	8	17	28	0	31	32
ICU characteristics (median)												
No. of beds	9	8	10	10	8	12	6	11	12	10	10	10
Single rooms (%)	67	15	100	25	20	8	5	13	45	31	33	33
Length of stay (days)	4	4	7	4	6	3	7	6	6	2	5	5
Ventilated patients (%)	28	75	59	38	34	50	79	30	40	42	28	45
ICU staff availability (median)												
24 h availability of physicians (%)	75	43	96	76	99	63	100	75	100	67	84	82
Typical no. of nurses per bed (daytime)	0.5	0.9	0.3	0.5	0.5	0.5	0.5	0.6	0.5	NA	0.5	0.5
Typical no. of nurses per bed (night-time)	0.3	0.6	0.3	0.3	0.3	0.4	0.5	0.3	0.4	NA	0.3	0.4

NA = no answer.

Table II Process of care parameters of the participating intensive care units (ICUs) ($N = 526$)

	Belgium	Finland	France	Germany	Hungary	Lithuania	Poland	Slovenia	Spain	Sweden	All ICUs	All ICUs with outcome data
Surveillance since (median)	1998	1980	1997	2001	2000	2003	2000	2001	1997	1985	2000	1999
Documentation of infections by (%)[a]												
Infection control nurse	50	43	21	75	78	38	100	71	14	100	59	60
Infection control doctor	42	29	16	24	26	63	4	43	60	0	28	22
ICU nurse	42	86	18	7	25	13	4	57	3	0	19	14
Attending ICU physician	49	43	79	41	43	50	22	57	3	0	50	51
Method of surveillance (%)[a]												
Chart review	57	71	62	79	82	38	96	43	49	100	71	76
Ward rounds	38	100	41	45	69	75	85	57	51	0	51	48
Microbiology results	78	86	65	94	96	63	85	100	86	0	86	84
Changes of IV sets (%)												
$<$24 h	0	0	4	3	29	25	0	0	3	0	7	2
Every 24 h	5	21	20	14	60	50	100	58	17	0	26	19
All 48 h	20	14	18	12	11	13	0	17	23	33	15	15
All 72 h	50	64	35	60	0	13	0	17	46	67	41	50
$>$72 h	25	0	24	11	0	0	0	8	11	0	12	14
Median no. of blood cultures per 1000 bed days	164	87	164	55	56	82	16	108	67	28	73	82
Predominant use of impregnated catheters ($\geq$50%) (%)	11	50	4	16	21	25	37	8	0	33	15	12
Maximal barrier precautions for CVC insertion (%)	82	86	95	89	61	75	100	83	91	67	85	91
Written policies for insertion and catheter care (%)	89	100	100	95	86	100	100	92	77	100	93	98
Scheduled change of CVCs (%)	31	7	18	9	72	50	96	33	6	33	28	17

[a] Multiple answers possible.

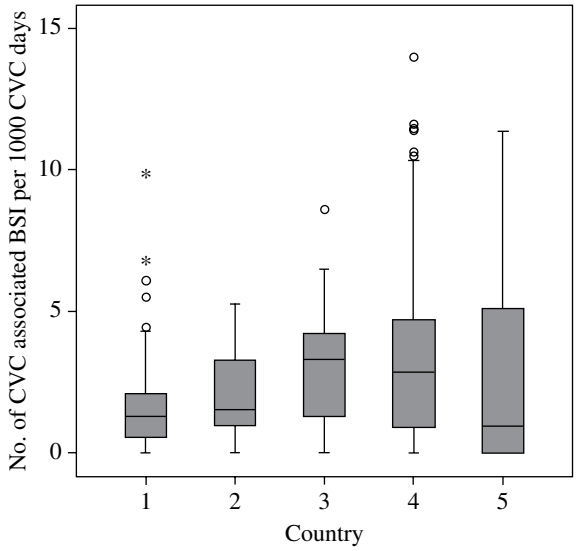

Figure 1 Central venous catheter (CVC)-associated bloodstream infection (BSI) rates of the five analysed countries. ○ represent participating ICUs with outlier values (= values that are one and a half times to threefold out of the normal length of the box). * represent participating ICUs with extreme values (= values that are more the threefold out of the normal length of the box).

surveillance. This study was based on questionnaires rather than on observation, and respondents may have recorded more infection control procedures than were actually accomplished. The questionnaire results are interesting nevertheless. A large variation in patient care quality parameters in European ICUs was apparent. Variations in infection control practices are nothing new.[9–11] Regional variations in Europe concerning the compliance with recommended patient care practices were demonstrated by Moro and Jepsen who surveyed 1005 ICUs of 14 countries.[12] In an international observational study performed in 55 hospitals Braun *et al.* found substantial variation in CVC insertion practice and BSI prevention activities.[13]

Struelens *et al.* described the situation in 169 acute care hospitals from 32 European countries and found regional differences concerning hand hygiene and the presence of written protocols for infection control procedures.[14] Great differences in infection control practices and organisation of infection control programmes were also described by Beaujean *et al.*, who surveyed 10 randomly selected hospitals in seven different European countries.[15] Differences in the European healthcare systems, regional distinctions of resources as far as plurality of guidelines or recommendations and a controversial discussion of prevention measures were discussed as possible reasons for these variations.[12,14,15]

In the present study the surveillance data from five countries participating in the HELICS network were used for a supplemental analysis. In this investigation multivariate analysis revealed two factors that were significantly associated with the extent of the CVC-BSI rate: ICU affiliated to a university hospital; and the country itself. Higher rates in university hospitals may predominantly be due to higher severity of illness levels. The country itself was also a risk factor for high CVC-BSI rate. The CVC-BSI rates of three countries were significantly higher than that of country 1 which had the lowest CVC-BSI rate, defined as the reference value.

What are the reasons for these significant differences in infection rates? In our opinion the major factors causing these differences between countries are methodological differences in the surveillance of nosocomial infections. Although surveillance is performed according to a standardised surveillance protocol, minor or major modifications may cause differences in infection rates, as previously described for the surveillance of surgical site infections.[16,17] The extent to which variation in infection control procedures explains differences in rates between countries is difficult to quantify. The wide range in frequency of collection of blood cultures should be considered when CVC-BSI rates are compared. Nevertheless, the number of blood cultures is a crucial factor since it is difficult to distinguish between (i) high BSI rates due to high frequencies of collecting blood cultures, and (ii) high frequencies of cultures due to a high incidence of BSI. In a univariate analysis we looked for factors that may influence the lowest rate of CVC-BSI in country 1. One factor was that the surveillance data in

Table III Results of the adjusted logistic regression analysis with the outcome high incidence density of central venous catheter (CVC)-associated bloodstream infection per 1000 CVC days (CVC-BSI rate)[a]

Characteristic	Odds ratio (95% CI)	*P*-value
ICU in university hospital	2.08 (1.02–4.25)	0.045
Country 2[b]	2.34 (0.54–10.15)	0.256
Country 3[b]	12.78 (4.36–37.52)	<0.001
Country 4[b]	7.00 (3.53–13.88)	<0.001
Country 5[b]	7.16 (2.36–21.68)	<0.001

ICU, intensive care unit; CI, confidence interval.
[a] High CVC-BSI rate was defined as above the 75th percentile (288 ICUs in five countries).
[b] Compared with country 1.

country 1 were significantly more often collected by infection control personnel (ICP) instead of healthcare workers (HCWs) in the ICU. ICP's attending ICUs may affirmatively influence the awareness of prevention measures and also their performance. In addition, the frequency of scheduled CVC changes and also of CVC changes per guidewire was significantly lower in country 1. These factors could not be affirmed in the multivariate analysis.

Differences in healthcare systems and budgets between participating countries may affect nosocomial infection rates, e.g. budgets and healthcare policies influence education. In a comparison of American and German medical students and physicians, Gluck *et al.* found differences in the knowledge of infectious diseases. Greater knowledge of infectious diseases demonstrated by physicians and medical students in the USA was presumably due to better training in this field during medical school and residency.[18] Differences in the knowledge of infection control issues between countries were also found in an international survey among students described by Harbarth *et al.*[19] Knowledge of best practices and policy alone, however, may not lead to improved patient care in the absence of effective implementation, documentation and feedback to staff.[11] Factors that influence the extent of implementation of recommended practices concerning CVC management have been described by Krein *et al.*; hospitals with a higher safety culture score, a certified ICP and participating in an infection prevention collaboration were more likely to use prevention practices.[20] Furthermore, external forces, such as public reporting, can influence infection prevention activities.[21]

Variation in epidemiology of antibiotic resistant organisms leads to regional and national distinctions in the intensity of infection control measures.[22] In a review concerning the control of multi-resistant cocci, Harbarth *et al.* illuminated several factors that may contribute to these epidemiological differences. Among others, cultural factors related to healthcare and the legal system were considered.[23]

Uniform surveillance standardised for European networks will be affected by local differences. To counter these differences surveillance data need to be validated. Some networks have already conducted validation studies.[24] An international comparison and validation should be performed to identify data quality issues at this level. Since many CVC-BSIs are preventable and the opportunities for a decrease of CVC-BSI rates seem to be greatest when multi-module programmes are applied, surveillance as a crucial element of multi-module interventions should offer appropriate reference data.[5,6,25] These data must also be appropriate for international networking in infection control. Until validation of the European data is carried out, the infection rates from participating countries should be compared with caution.

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