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ORIGINAL COMMUNICATION

Markus Dettenkofer
Winfried Ebner
Thomas Els
Regina Babikir
Carl Lücking
Klaus Pelz
Henning Rüden
Franz Daschner

Surveillance of nosocomial infections in a neurology intensive care unit

Abstract To identify overall and site-specific nosocomial infection (NI) rates in patients receiving neurological intensive care therapy, a prospective study was started in 1997 in the ten-bed neurological intensive-care unit (NICU) of the University Hospital of Freiburg, Germany. Case records and microbiology reports were reviewed twice a week, and ward staff were consulted. NI were defined according to the Center for Disease Control and Prevention (CDC) criteria and were categorised by specific infection site. Within 30 months, 505 patients with a total of 4,873 patient days were studied (mean length of stay: 9.6 days). 122 NI were identified in 96 patients (74 patients with one, 18 with two and 4 with three infections. An incidence of 24.2/100 patients and incidence density of 25.0/1,000 patient days of NI in the neurological ICU were documented. Site-specific incidence rates and incidence densities were: 1.4 bloodstream infections per 100 patients (1.9 central line-associated BSIs per 1,000 central line-days), 11.7 pneumonias per 100 patients (20.4 ventilator-associated pneumonias per 1,000 ventilator-days), 8.7 urinary tract infections per 100 patients (10.0 urinary catheter-associated urinary track infections (UTIs) per 1,000 urinary catheter-days). Additionally, 0.4 cases of meningitis, 0.8 ventriculitis, and 1.2 other infections (catheter-related local infection, diarrhea) were documented per 1,000 patient days. 15 % of nosocomial pathogens were *A. baumannii* (due to a outbreak of an nosocomial pneumonia with *A. baumannii*), 13 % *S. aureus*, 10 % *E. coli*, 7 % CNS, 7 % *Bacteroides* spp., 7 % *Enterobacter* spp., 6, 5 % *Klebsiella* spp., 5.9 % *enterococci*, 5.9 % streptococci, and 4.7 % *Pseudomonas* spp. In eight cases of NI no pathogen could be isolated. In future, data on NI in NICUs should be assessed in greater detail, both to improve the quality of care and serve as a basis for identification and implementation of the most effective measures by which to prevent these infections in patients receiving intensive neurological care.

Key words Intensive care unit · Neurology · Nosocomial infection · Prevention · Surveillance

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Dr. M. Dettenkofer (✉) · W. Ebner · R. Babikir · F. Daschner
Institute of Environmental Medicine and Hospital Epidemiology
University Hospital of Freiburg, Germany
Hugstetterstr. 55
79106 Freiburg, Germany
Tel.: ++49-761/270-5483
Fax: ++49-761/270-5485
E-mail: mdet@iuk3.ukl.uni-freiburg.de

T. Els · C. Lücking
Department of Neurology and Neurophysiology
University Hospital of Freiburg, Germany

K. Pelz
Institute of Medical Microbiology
University Hospital of Freiburg, Germany

H. Rüden
Institute of Hygiene of the Free University of Berlin, Germany

M. Dettenkofer · W. Ebner · R. Babikir · H. Rüden · F. Daschner
National Reference Centre for Hospital Hygiene
Germany

Introduction

The high incidence of nosocomial infection (NI) is a common problem in intensive care medicine, which is especially due to the severity of illness of the patients treated and the high number of medical devices used [4, 24]. Today's hospital infection control initiatives include surveillance as a programme involving the systematic collection, tabulation, analysis and feedback of data on

the occurrence of NI. However, since its introduction in the 1960s, various methods of surveillance have been applied and studied [11, 12]. These differ primarily in the method of data collection and in their performance as prevalence or incidence surveys [7]. Surveillance of NI provides data useful for identifying patients who are infected, for determining the site of infection, and for identifying factors that contribute to the incidence of NI [5, 7, 11, 12, 25]. According to the 'Study on the Efficacy of Nosocomial Infection Control' (SENIC), well organised surveillance and control activities, an adequate number of trained infection control staff, and a system for reporting infection rates to medical staff are essential for nosocomial infection control programmes to be effective [14].

Nosocomial infection rates mainly depend on the severity of illness and the exposure to invasive devices (especially ventilator use, central venous catheters, urinary catheters). The US 'National Nosocomial Infections Surveillance' System (NNIS) provides regularly updated data on the use of these devices and on the incidence of NI associated with their use (pneumonia, bloodstream infection – BSI, urinary tract infection – UTI) [2, 20]. Today, surveillance according to this system is used in many countries, including Germany [13, 28, 29]. Its accuracy has been assessed in the USA [9].

For patients receiving intensive care there are particular risk factors for acquiring one or more nosocomial infections. However, there are only very limited data available on the incidence of NI in neurology and especially in the neurological ICU-setting [27]. Therefore, in order to assess the incidence of NI and to identify overall and site-specific infection rates, in February 1997 a prospective study was started as part of the nosocomial infection surveillance system (KISS) of the German National Reference Centre for Hospital Hygiene in the ten-bed neurological ICU (NICU) of the University Hospital of Freiburg, Germany (UHF). The UHF is one of the largest German hospitals and has 1,700 beds. In 1999, 52,940 patients were admitted with a total of 485,470 inpatient days.

Methods

Ward and study population

This prospective study was carried out in the ten-bed NICU of the University Hospital of Freiburg. The NICU is a referral centre that serves approx. 1.5 million people in South-West Germany. In conformity with the general situation of NICUs in Germany, the main primary diagnoses of patients treated include ischemias and intracerebral bleeding [15]. Data on all patients with a stay of at least 24 hours were collected. A total of 505 patients were surveyed from 14 February 1997 to 31 July 1999.

Surveillance

A trained and experienced infection control practitioner (R. B.) visited the ward twice a week in the morning. General data obtained included name, age, sex, reason for hospitalisation and type of operation for all patients. Nursing notes, medical notes, microbiology reports, temperature charts and antibiotic treatment charts were reviewed to determine if a patient had symptoms and signs of infection. In addition, the nursing and medical staff were consulted if queries regarding such symptoms and signs arose. The number of ventilator-days, central line-days and urinary catheter-days were recorded. The infection control practitioner filled out a worksheet for every patient (infected and not infected) and once a week these worksheets were reviewed by a physician trained in infection control. Because resources were limited it was not possible to carry out a post-discharge follow-up. Further details on the surveillance method used have been described by Emmerson [7] and by Perl [22].

In addition to surveillance with this reference method, the time required for data collection and analysis was assessed in comparison with a selective method derived from the NNIS Intensive Care Unit (ICU) component [1].

Definitions of nosocomial infections

Infections occurring during the study period were categorised by specific infection sites according to standard Center for Disease Control and Prevention (CDC) definitions that include clinical and laboratory criteria [10, 12]. In line with these definitions results of chest radiographs were taken into account for the diagnosis of nosocomial pneumonia. Infections occurring at more than one site in the same patient were reported as separate infections. To classify an infection as being nosocomial in origin, there must be no evidence that it was present or being incubated at the time of admission to the ICU. This implied that each infection had to be assessed for evidence linking it to hospitalisation.

Statistics

Device utilisation ratios, site-specific incidence rates per 100 patients, and site-specific incidence densities per 1,000 days at risk (use of ventilator, central line, and urinary catheter, respectively) or per 1,000 patient days were calculated (see Fig. 1) [20].

Results

Over the 30-month study period, 505 patients with a total of 4,873 patient days were studied. Of these 224 were female and 281 male. The mean age was 59.2 years (range: 14–93) and the mean length of stay in the NICU 9.6 days (range: 1–95). The patients' primary diagnoses are shown in Table 1.

Fig. 1 Formulas used for calculation of device utilisation ratios and device-associated infection rates [20]

$$\text{Device utilisation ratio (DU)} = \frac{\textit{number of device-days}}{\text{number of patient days}}$$

$$\text{Device-associated infection rates} = \frac{\textit{number of device-associated infections for a specific site}}{\text{number of device-days}} \times 1{,}000$$

Table 1 Primary diagnoses of the 505 patients included

Ischaemias		*190*
supratentorial	124	
infratentorial	66	
Intracerebral bleeding		*99*
supratentorial	89	
infratentorial	10	
Subarachnoid haemorrhage		*41*
Inflammatory diseases		*36*
Epilepsy		*34*
Multifocal neurological diseases and diseases of the peripheral nerves and muscles		*25*
Encephalopathies		*21*
Spinal cord compression		*13*
Persistent vegetative state (locked-in-syndrome)		*13*
Intracranial neoplasia (tumours)		*13*
Cranio-cerebral trauma		*10*
Hydrocephalus		*6*
Diverse neurological diseases		*4*

Device utilisation/Nosocomial infections

The ratios for urinary catheter, central line, and ventilator utilisation are shown in Table 2.

Altogether 122 nosocomial infections were identified in 96 patients (74 patients with one, 18 with two and 4 with three infections). The overall incidence of NI in the neurological ICU was 24.2 per 100 patients and the incidence density 25.0 per 1,000 patient days. Table 3 shows site-specific incidence rates (NI/100 patients) and incidence densities (NI/1,000 days at risk). Of the 59 nosocomial pneumonias documented, 37 (63 %) were non ventilator-associated.

Table 2 Ratios of device utilisation (DU); NNIS data for medical ICUs given for comparison [20]

Ventilator utilisation:	0.22 (ventilator-days/patient days) (NNIS median: 0.45)
Central line utilisation:	0.75 (central line-days/patient days) (NNIS median: 0.48)
Urinary catheter utilisation:	0.86 (urin.cath.-days/patient days) (NNIS median: 0.73)

As reported elsewhere in detail, the time required to collect data in the NICU using the surveillance method described above and to analyse these data was given as being 171 minutes per week, a figure that corresponds to 3.4 h per 10 beds per week [1].

The primary diagnoses of patients with one or more nosocomial infections were mainly ischaemic stroke, vascular malformations and inflammatory diseases (Table 4).

Microbiology

As shown in Table 5 in descending order of frequency and related to the site-specific infections, a total of 170 pathogenic microorganisms were isolated. In 8 cases of nosocomial infection no pathogen could be isolated (pneumonia: 6; meningitis: 2).

Discussion

In the last decade, specific neurological intensive-care has gained in importance [15, 26]. However, information on the occurrence of nosocomial infections in this setting is very limited [17, 18, 27]. Therefore, the study presented here was initiated to assess in greater detail data on the incidence of NI in a NICU. As the use of uniform definitions is critical for purposes of comparison, infections were categorised by specific infection sites, whereby standard CDC-definitions for nosocomial infection were strictly adhered to [10]. According to these definitions, colonisation (the presence of microorganisms that are not causing adverse clinical signs or symptoms) and inflammation are not infections [11]. As a referral centre the study ward (NICU of the University Hospital of Freiburg) represents one of the 64 institutions of its kind in Germany, and the primary diagnoses of the patients treated correspond to these (see Table 1).

The most important database documenting the occurrence of NI in ICUs is provided by the US 'National

Table 3 Nosocomial infections in a German neurological ICU: site-specific incidence rates and incidence densities (NNIS data for comparison)

Type of NI	No.	NI/100 patients	NI/1000 days at risk X	NNIS (median)[3]	X
Bloodstream Infection	7	1.4	1.9	5.4	*Central line-associated BSIs*/1,000 central line-days
Pneumonia[1]	59	11.7	20.4	7.3	*Ventilator-assoc. pneumonias*/1,000 ventilator-days
Urinary Tract Infection[2]	44	8.7	10.0	7.0	*Urinary catheter-assoc. UTIs*/1,000 urinary catheter-days
Meningitis	2	0.4	0.4	–	*Nosocomial infections*/1,000 patient days
Ventriculitis	4	0.8	0.8	–	*Nosocomial infections*/1,000 patient days
Others (catheter related local infection, diarrhoea)	6	1.2	1.2	–	*Nosocomial infections*/1,000 patient days
All NI	122	24.2	25.0	–	*Nosocomial infections*/1,000 patient days

[1] 22 pneumonias were device-associated
[2] 42 UTIs were device-associated
[3] NNIS median for medical ICUs (no data available for neurological ICUs) [20]

Table 4 Primary diagnoses of patients with NI (n = 96)

NI	No. of patients	No. of infections	Pneumonia device-ass.	Pneumonia non dev.-ass.	UTI dev.-ass.	UTI non dev.-ass.	BSI dev.-ass.	Meningitis	Ventriculitis	Others
Ischaemias										
supratentorial	18	24	4	6	12	0	1	0	1	0
infratentorial	14	18	4	3	7	1	1	0	0	2
Intracerebral bleeding										
supratentorial	27	35	3	12	10	1	4	1	3	1
infratentorial	1	1	0	1	0	0	0	0	0	0
Inflammatory diseases	9	10	4	3	2	0	0	0	0	1
Subarachnoid haemorrhage	6	7	2	2	1	0	1	1	0	0
Multifocal neurological diseases	4	5	3	1	1	0	0	0	0	0
Transverse lesions	4	5	0	2	2	0	0	0	0	1
Persistent vegetative state	4	5	1	1	3	0	0	0	0	0
Encephalopathies	3	3	1	2	0	0	0	0	0	0
Cranio-cerebral trauma	3	5	0	2	3	0	0	0	0	0
Intracranial neoplasia	2	3	0	1	1	0	0	0	0	1
Epilepsy	1	1	0	1	0	0	0	0	0	0

Table 5 Pathogens isolated causing nosocomial infections in the NICU

Pathogen	Total no. (%)	BSI	Pneumonia	UTI	Ventriculitis	Others
Acinetobacter spp.	25 (14.7 %)	0	22 (22.4 %)	2 (4.1 %)	0	1 (10 %)
S. aureus	22 (12.9 %)	1 (11.1 %)	16 (16.3 %)	2 (4.1 %)	1 (25 %)	2 (20 %)
E. coli	17 (10 %)	0	2 (2 %)	15 (30.6 %)	0	0
Bacteroides spp.	12 (7.1 %)	1 (11.1 %)	11 (11.2 %)	0	0	0
CNS	12 (7.1 %)	3 (33.3 %)	0	3 (6.1 %)	3 (75 %)	3 (30 %)
Enterobacter spp.	12 (7.1 %)	0	6 (6.1 %)	5 (10.2 %)	0	1 (10 %)
Klebsiella spp.	11 (6.5 %)	1 (11.1 %)	7 (7.1 %)	3 (6.1 %)	0	0
Enterococci	10 (5.9 %)	1 (11.1 %)	1 (1 %)	8 (16.3 %)	0	0
Streptococci	10 (5.9 %)	1 (11.1 %)	7 (7.1 %)	2 (4.1 %)	0	0
Pseudomonas spp.	8 (4.7 %)	0	3 (3.1 %)	4 (8.2 %)	0	1 (10 %)
H. influenzae	7 (4.1 %)	0	7 (7.1 %)	0	0	0
Proteus spp.	5 (2.9 %)	0	3 (3.1 %)	2 (4.1 %)	0	0
Citrobacter spp.	2 (1.2 %)	0	0	2 (4.1 %)	0	0
C. difficile	1 (0.6 %)	0	0	0	0	1 (10 %)
Others	7 (4.1 %)	1 (11.1 %)	6 (6.1 %)	0	0	0
Yeasts	9 (5.3 %)	0	7 (7.1 %)	1 (2 %)	0	1 (10 %)
Total (= 100 %)	170	9	98	49	4	10

Nosocomial Infections Surveillance'-system (NNIS) [20]. Pooled data of the surveillance activities in participating North American ICUs are published annually. However, as no special information regarding neurology intensive-care medicine is provided, data representing the medical ICU setting (more than 120 units with a total of 1,055 251 patient-days from 1992–1999) can be used for comparison, although caution should be exercised. A moderate to high overall incidence (24.2 %) and incidence density (25.0/1,000 patient days) of NI in the NICU of the UHF could be documented. Compared with the data for medical ICUs reported by NNIS, the device-associated infection rates (Table 3) were in the upper range (pneumonias, urinary tract infections) or in the lower range (bloodstream infections) [20].

Given the comparably low figure for ventilator use (device-utilisation ratio: 0.22, corresponding to 10 % NNIS percentile for medical ICUs), more than half the cases of nosocomial pneumonia in the NICU surveyed were non ventilator-associated (n=37, see Table 3). Heckmann and co-workers assessed the incidence of nosocomial pneumonia in 217 NICU patients and documented a high figure of 31 % compared with 12 % in our study [17]. In a subgroup of patients treated in a NICU for acute cerebral ischemia, Hilker and co-authors found an even higher incidence of pneumonia of 42 % [18]. Hsieh et al. documented a 41 % pneumonia rate in patients with closed head injury [19]. These data and our results corroborate observation that nosocomial pneumonia is a frequent complication in neurological intensive care, accounted for by the known high risk for patients with a depressed level of consciousness [3].

The low incidence of bloodstream infections may partly be due to the relatively high device-utilisation ra-

tio. However, because blood cultures have been missed in some cases of a febrile episode in NICU patients with a CVC in place, some underreporting cannot be ruled out.

In addition, the fact that no post-discharge follow-up was performed in this study may have led to underreporting. However, the majority of patients who developed NI after being discharged from the neurological ICU were transferred back to this unit to manage the infection, which was then categorised as nosocomial. Because it has been shown that only approximately 11 % of all ICU-associated NIs are missed if no post-discharge follow-up is undertaken, a labour-intensive follow-up cannot be generally recommended [13].

We found a comparably low incidence of nosocomial meningitis (0.4 per 100 patients) [21] and a low incidence of ventriculitis (0.8 per 100 patients). With *A. baumannii* at the top, the distribution of the broad spectrum of microorganisms isolated from patients with NI is unexpected (Table 5). However, to our knowledge there are no published data available for comparison with other neurological ICUs. The relatively high figure for *A. baumannii* (14.7 %) mainly represents respiratory tract infections due to an outbreak and later high endemic rate of nosocomial pneumonia with this germ in the NICU [16]. According to surveillance data on NI occurring in patients treated in the neurosurgical ICU of the UHF, 14.6 % of isolated pathogens were *E. coli*, 10.2 % *enterococci*, 9.6 % *S. aureus*, 6.4 % CNS, 6.4 % *Klebsiella* spp., 5 % *Enterobacter* spp. and 5 % *Pseudomonas* spp. [6].

Because of limited resources, in clinical practice total surveillance of NI should be replaced by surveillance systems targeted to specific outcome objectives ('surveillance by objectives') [7, 14]. With the reference surveillance method used in this study the time required for data collection in a neurological ICU and for data analysis (3.4 h per 10 beds per week) was three times higher than that required by a selective method [8] derived from the NNIS ICU-component (1.1 h per 10 beds per week), with only a small decrease of sensitivity and specificity in detecting device-related NI [1]. Since data collection is very time-consuming, selective surveillance methods are necessary for small infection control teams to operate on a daily basis and to optimise cost-effectiveness [5, 1].

Considering the relatively high frequency of nosocomial pneumonia, special efforts should be made to prevent this infection. Observance of the corresponding guidelines published by the Centers for Disease Control and Prevention (CDC, Atlanta – USA) is strongly recommended [3]. As poor hand hygiene is the most important single cause of transmission of NI, special emphasis should be given to effective staff education and the preferential use of bedside, alcohol-based hand disinfectants [23]. Hence to prevent NI in patients receiving intensive neurological care, and to implement the most effective measures leading to this goal, more detailed data on the occurrence of these infections in different NICU settings should be made available in the future.

The results of this study were presented in part at the 4th Decennial International Conference on Nosocomial and Healthcare-Associated Infections, Atlanta, March 5–9, 2000.

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