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Original Article

Evaluation of nosocomial infections and related risk factors in a neurosurgery intensive care unit

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Abstract: Nosocomial infections (NIs) cause increased morbidity, mortality, and hospital costs, particularly in intensive care units. Neurosurgery intensive care units (NICUs) differ from other intensive care units in several respects. The aim of this study was to examine NIs and related risk factors in our NICU. NICU records and the database of our hospital's infection control team from January 2010 to December 2014 were reviewed retrospectively. Type of NI and associated risk factors were subjected to statistical analysis. Demographic data, risk factors for NI development, presentation, length of NICU stay, and Glasgow Coma Scale (GCS) score were recorded and reviewed. One hundred and eighteen NI episodes were detected in 115 of 820 patients. The mean age of the patient population was 42.4 years (range 16-74 years). Of the infected patients, 55 were female and 60 were male. The mean length of hospital stay of these patients was 38.4 ± 21.8 days. The most common type of NI was ventilator-associated pneumonia, and the most frequently detected pathogen was *Acinetobacter* spp. GCS score, prior usage of broad-spectrum antibiotics, reoperation, mechanical ventilation, external lumbar or ventricular drainage, tracheostomy, and duration of NICU stay were significantly higher among infected patients. Univariate analysis identified low GCS score, longer NICU stay, use of mechanical ventilation, prior usage of broad-spectrum antibiotics, and reoperation as risk factors for NI.

Keywords: Nosocomial, infection, neurosurgery, intensive care unit

Introduction

Nosocomial infections (NIs) cause increased morbidity, mortality, length of hospitalization, and hospital costs, particularly in intensive care units (ICUs). The incidence of NIs is two- to fivefold higher in ICUs than in other hospital departments [1]. Neurosurgery ICUs (NICUs) differ from other ICUs in several respects, related to patients' levels of consciousness and the disruption of blood-brain barrier integrity by surgery or trauma involving intracranial pathology. Evaluation of risk factors in NICU patients is essential for the prevention of NI.

In this study, we prospectively examined the etiology and incidence of, and risk factors for, NIs in our NICU over a 4-year period.

Patients and methods

This study was conducted between January 2010 and December 2014 at Necmettin Erbakan University Hospital (NEUH). NEUH is a veterans' center with a high patient volume located in central Anatolia. The NICU at NEUH has nine fully equipped beds.

Our hospital's infection control team, which consists of an infectious disease specialist and two nurses, makes bedside visits three times per week; at each visit, NICU patient data are evaluated and recorded in detail. This infection control team performed active surveillance for NIs using the criteria proposed by the Centers for Disease Control and Prevention and the National Nosocomial Infections Surveillance System methodology.

Data from all NICU patients were recorded on a standard data collection form, which included each patient's name, age, sex, microbiological culture results, past medical history and underlying conditions, type of NI, central and/or peripheral intravenous access, external lumbar

Table 1. Type and distribution of infections

Type of infection	Number of infections	Percent of total infections
Bloodstream infection	21	17.8
Urinary tract infection	32	27.1
Ventilator-associated pneumonia	34	28.8
Nosocomial pneumonia	7	5.9
Surgical site infection	14	11.9
Soft tissue and skin infection	3	2.6
Nosocomial meningitis	3	2.6
Respiratory tract infection	3	2.6
Sepsis	1	0.8
Total	118	100.0

or ventricular drainage, nasogastric feeding, endotracheal intubation, mechanical ventilation, urinary catheter insertion, tracheostomy, total parenteral nutrition, surgical interventions received at the hospital, reason for hospitalization, Glasgow Coma Scale (GCS) [2] score at admission, previously administered antibiotics and other treatments (e.g., mannitol, steroids, phenytoin, H_2 antagonists, blood transfusion), medical and nursing notes, body temperature values, and length of stay in the NICU. Type of NI was classified as bloodstream infection, urinary tract infection, pneumonia related to mechanical ventilation, nosocomial pneumonia, surgical site infection, soft tissue and skin infection, nosocomial meningitis, other respiratory tract infection, and sepsis (**Table 1**).

In this study, we prospectively reviewed the data obtained from all NICU patients who experienced at least one NI during their NICU stays. The patients were followed until death or after discharge by prospective daily surveillance, and they received appropriate antimicrobial therapy based on local surveillance.

Statistical analysis

Continuous variables are presented as means and standard deviations. Categorical variables were analyzed using the chi-squared test or Fisher's exact test, and continuous variables were analyzed using Student's *t*-test or the Mann-Whitney *U*-test. Potential risk factors for NI were analyzed using a multivariate logistic regression model.

Odds ratios and 95% confidence intervals were calculated using binary logistic regression for each model. P values ≤ 0.05 were considered to indicate statistical significance. Statistical analyses were performed using SPSS version 15.0 (SPSS Inc., Chicago, IL, USA).

Results

During the 4-year study period, 118 NI episodes were detected in 115 of 820 patients. The mean age of the patient population was 42.4 years (range 16-74 years). The study involved all patients who were hospitalized in the NICU for > 24 h and who were over 16 years of age. Of the infected patients, 55 were female and 60 were male. The mean length of hospital stay of these patients was 38.4 ± 21.8 days.

The most common types of NI were ventilator-associated pneumonia (28.8%), bloodstream infection (21%), and urinary tract infection (27.1%; **Table 1**). The most common pathogens were *Acinetobacter* spp. (n = 32), *Pseudomonas aeruginosa* (n = 26), *Klebsiella* spp. (n = 18), and methicillin-resistant *Staphylococcus aureus* (n = 17; **Table 2**).

One hundred and ten uninfected patients were selected as controls to identify the risk factors for NI and determine differences between groups. No statistically significant difference was detected between patients who were and were not infected in terms of sex, age, nasogastric feeding, urinary catheter insertion, total parenteral nutrition, mannitol use, steroid use, phenytoin use, H_2 antagonist use, blood transfusion, or central intravenous access (P > 0.05).

GCS score, prior usage of broad-spectrum antibiotics, reoperation, mechanical ventilation, external lumbar or ventricular drainage, tracheostomy, and duration of NICU stay were significantly higher among infected patients (P < 0.05; **Table 3**).

Univariate analysis identified low GCS score, longer NICU stay, use of mechanical ventilation, prior usage of broad-spectrum antibiotics, and reoperation as risk factors for NI (**Table 3**).

Discussion

A previous study reported that 10-35% of patients admitted to the ICU will experience NI

Table 2. Type and distribution of pathogens

Type	*n*	%
Pseudomonas aeruginosa	26	23.2
Acinetobacter spp.	32	28.5
Klebsiella spp.	18	16.1
Escherichia coli	3	2.6
Methicillin-sensitive *S. aureus* (MSSA)	1	0.8
Methicillin-resistant *S. aureus* (MRSA)	17	15.1
Methicillin-sensitive coagulase-negative staphylococci (MSKNS)	2	1.7
Methicillin-resistant coagulase-negative staphylococci (MRKNS)	4	3.5
Vancomycin-sensitive *Enterococcus* spp. (VSE)	3	2.6
Vancomycin-resistant *Enterococcus* spp. (VRE)	2	1.7
Enterobacter spp.	1	0.8
Candida spp.	1	0.8
Providencia spp.	1	0.8
Serratia spp.	1	0.8
Total	112	100

[3]. Patients with NIs have increased mortality [3, 4]. The establishment of NI depends on two main pathophysiological factors: decreased host defenses and colonization by pathogenic, or potentially pathogenic, bacteria. Although these two factors can arise independently, both must be present to some degree for infection to result [3]. NICUs differ in some respects from general ICUs. The blood-brain barrier integrity of NICU patients is generally disrupted by surgery, trauma, or invasive interventions. In addition, NICU patients with severe conditions are unconsciousness or require prolonged sedation, and tend to have prolonged hospital stays.

Evaluation of infections acquired in NICUs, determination of their risk factors, and establishment of appropriate treatment protocols are important steps in the prevention and treatment of NICU infections. In this study, we analyzed our records in detail for this purpose.

In neurosurgical practice, the GCS [2] is a commonly used indicator of the severity of disease and the conscious state of the patient. According to our results, the incidence of NI was higher in patients with low GCS scores ($P < 0.05$). Severity scores cannot serve as independent predictors of infection; however, the severity of disease, as determined by these scores, in association with other risk factors, has been associated with NI development [5].

In our study, the frequencies of mechanical ventilation, intubation, and tracheostomy were significantly higher among infected patients, and ventilator-associated pneumonia was the most frequently detected infection. Consistent with our results, the European Prevalence of Infection in Intensive Care (EPIC) study showed that pneumonia comprises 46% of intensive care infections [6].

Pneumonia is the most important type of infection, as it prolongs hospitalization and increases the mortality rate [4]. Richards et al. [7] reported that 86% of nosocomial pneumonia cases were related to mechanical ventilation. Head elevation, respiratory exercise, early pulmonary rehabilitation, regular postural drainage, and aspiration are important measures for the prevention of nosocomial pneumonia [4].

Frequent and improper use of broad-spectrum antibiotics before identification of the responsible microorganisms also contributes to the risk of infection [4]. In our study, prior usage of broad-spectrum antibiotics was significantly more frequent among infected patients. Use of broad-spectrum antibiotics not only increases the risk of infection, but also contributes to development of antimicrobial resistance. In our study, we identified 17 methicillin-resistant *S. aureus*, 4 methicillin-resistant coagulase-negative staphylococci, and 2 vancomycin-resistant *Enterococcus* strains. Legras et al. [8] reported that 58% of *S. aureus* strains detected in their study were methicillin resistant. Trouillet et al. [9] found that prior antibiotic usage and duration of mechanical ventilation were associated significantly with the development of ventilator-associated pneumonia due to resistant microorganisms. Vincent [5] suggested that antibiotic treatment should begin only after narrow-spectrum identification of a definite infectious process.

External ventricular drainage (EVD) and external lumbar drainage (ELD) are effective procedures that are performed commonly in daily neurosurgical practice. However, EVD- and

Table 3. Variables investigated to determine their relationships to infection in NICU patients

Variable	Infected patients *n* = 115	Uninfected patients *n* = 110	*β*	OR (95% CI)	*p*
Age (years)	38.2 ± 14.4	42.3 ± 23.8	0.158	1.17 (1.04-1.31)	0.358
Sex					
Male	60	60	-0.461	0.63 (0.25-1.54)	0.313
Female	55	50			
Duration of NICU stay (days)	38.4 ± 21.8	15.8 ± 8.4	0.029	5.95 (1.85-18.55)	< 0.001
GCS score	9.6 ± 2.8	12.6 ± 2.4	-0.611	0.73 (0.97-1.15)	< 0.001
Nasogastric feeding (%)	64.8	62.1	3.644	38.26 (0.34-4265.43)	0.130
Urinary catheter (%)	67.6	64.4	-20.59	0.00 (0.00-...)	0.998
Total parenteral nutrition (%)	48.4	46.2	-2.773	0.062 (0.02-0.18)	0.231
Mannitol (%)	55.4	53.2	-2.442	0.08 (0.01-0.39)	0.472
Steroid (%)	70.2	68.4	2.751	15.66 (0.27-883.39)	0.181
Phenytoin (%)	56.2	45.4	4.095	60.03 (11.58-311.11)	0.151
H_2 antagonists (%)	78.6	77.4	-0.957	0.86 (0.45-3.67)	0.999
Blood transfusion (%)	51.2	38.4	-0.830	0.43 (0.05-3.79)	0.452
Central intravenous access (%)	74.2	56.8	19.70	360,515 (0.00-...)	0.998
Prior usage of broad-spectrum antibiotics (%)	66.2	23.4	-3.663	17.56 (2.85-88.52)	< 0.001
Mechanical ventilation (%)	82.4	21.5	-4.196	5.75 (1.75-20.25)	0.003
External ventricular & lumbar drainage (%)	46.4	12.8	1.830	6.23 (1.43-27.00)	0.014
Tracheostomy (%)	35.8	10.2	0.492	1.63 (0.33-7.87)	0.027
Reoperation (%)	78.2	38.4	-7.002	1.35 (0.83-2.15)	0.001

Goodness-of-fit of model: Hosmer & Lemeshow chi-squared = 0.197; -2LL = 32.85.

ELD-related infections are important problems associated with significant mortality and morbidity [10]. The infection rate has been reported to be in the range of 5-20% [11]. We found significant differences between groups according to EVD and ELD usage. Duration of EVD, frequency of cerebrospinal fluid sampling, intraventricular hemorrhage, and surgical technique have been reported to be risk factors for EVD-related meningitis; *Staphylococcus epidermidis* is the most frequently responsible pathogen [11]. While the duration of external drainage and usage of antibiotic-, antimicrobial- or silver-impregnated drains remain controversial [10, 12-14], early, appropriate broad-spectrum antibiotic treatment and removal of an infected drain when necessary are important factors that contribute to a good prognosis.

The rate of reoperation was higher in the infected group in this study. Ventriculoperitoneal shunt revisions and re-operation due to surgical-site problems (e.g., hematoma, cerebrospinal fluid leakage) promote the development of infection.

Prolonged hospitalization was an important risk factor for infection in ICUs in this study and previous reports. These patients generally have severe disease and require more-invasive procedures. The risks of colonization and infection with resistant bacteria are considerable in ICU patients [4].

Conclusion

Low GCS score, longer NICU stay, use of mechanical ventilation, prior usage of broad-spectrum antibiotics, and reoperation were risk factors for NI in this study. We cannot change the admission score of a patient. However, we suggest that reducing performance of unnecessary invasive procedures, removing mechanical ventilators when possible, and making every effort to discharge the patient from the NICU as soon as possible may prevent NI development. Treatment with broad-spectrum antibiotics should begin in these patients in accordance with the infection control team's precaution, and only upon identification of the responsible organism. This approach will decrease infection rates and the development of antimicrobial resistance.

Disclosure of conflict of interest

None.

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