Nosocomial Infection in a Pediatric Intensive Care Unit in a Developing Country

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Objective: Determine the rate and outcome of nosocomial infection (NI) in pediatric intensive care unit patients in a developing country. Design: Prospective cohort study using the Centers for Disease Control and Prevention definitions to diagnose nosocomial infection and NNISS (National Nosocomial Infection Surveillance System) methodology. Setting: São Paulo Hospital – Universidade Federal de São Paulo – Brazil, a 700-bed teaching hospital with an 8-bed pediatric intensive care unit. Participants: All 515 children consecutively admitted to the pediatric intensive care unit from April 1996 to October 1997. Results: The NI incidence was 18.3% and the mean infection rate per 1,000 patient days was 46.1; the ventilator-associated pneumonia rate was 18.7 per 1,000 ventilator days; the central line-associated bloodstream infection rate was 10.2 per 1,000 central line days; and the urinary tract catheter-associated infection rate was 1.8 per 1,000 catheter days. Pneumonia was the most common NI (31.6%), followed by bloodstream infections (17.3%), and surgical site infection (17.3%). Gram-negative bacterias were the most common pathogens identified in the NIs (54.8%), followed by Gram-positive bacterias (23.8%), and yeasts. Conclusion: Pneumonia was the most common type of NI. A high incidence of ventilator-associated pneumonia and central line-associated bloodstream infections was found, whereas the urinary tract catheter-associated infection rate was low. Gram-negative bacterias were the most common etiologic agents identified in the unit, and yeasts were frequently found. Pediatric patients have characteristics of their own, with major differences when compared to the adult population.

Key Words: Nosocomial infections, pediatric ICU, pneumonia.

Nosocomial infection (NI) is a major cause of morbidity and mortality in hospitalized patients. According to CDC estimates an NI event costs on average US$ 2,100, ranging from US$ 680 for urinary infections up to US$ 5,683 for respiratory infections [1].

Patients admitted to intensive care units (ICU) are more likely to acquire NI due both to their underlying disease, with resulting impairment of the humoral and cellular immunity, and the invasive procedures that they undergo, causing breakdowns in their natural defense barriers.

There are many studies on adult patients; several papers address NI location epidemiology, NI risk factors, as well as measures to prevent a patient from acquiring NI; however, studies focusing on the pediatric population, particularly in ICU, are quite limited.

In view of the limited literature on NI in pediatric ICUs, particularly in developing countries, an NI epidemiological study was conducted in the pediatric ICU of a university hospital in São Paulo, Brazil.

Materials and Methods

Patients and setting. An observational prospective study was conducted in the pediatric ICU of "Hospital São Paulo" from April 1996 to October, 1997.

Received on 15 April 2003; revised 01 September 2003.
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The Brazilian Journal of Infectious Diseases 2003;7(6):375-380

"Hospital São Paulo" is a 700-bed tertiary care university hospital, affiliated with the Federal University of São Paulo – "Escola Paulista de Medicina" (UNIFESP-EPM). The pediatric ward has 53 beds available to patients with renal, gastrointestinal, and pulmonary infections and malignant conditions.

Pediatric patients with complicated conditions are admitted to the emergency unit, as well as to the neuroclinical, neurosurgical, pediatric surgery and cardiac surgery wards.

"Hospital São Paulo" has a single pediatric ICU with eight beds, one of which is occupied by a chronic tetraplegic patient, who had suffered a car accident and was excluded from the study due to his long length of stay (hospitalized since 1993).

Surveillance procedures and definitions. Up to two days following discharge, all patients admitted to the unit were evaluated on a daily basis for NI, in compliance with NNISS (National Nosocomial Infection Surveillance System) methodology, by the same professional, a pediatric infection disease physician who had undergone training on NI identification during the previous year.

NI was defined based on standard definitions, taking into consideration if it was acquired in the unit, regardless of length of stay, provided there was no evidence of the infection being in incubation or a continuation of the disease that led to the hospitalization, or up to two days following discharge from the unit.

Infection site definitions were in agreement with CDC definitions [2]. Death occurring up to one week after diagnosis, with no further justifying causes, was considered associated mortality.

The following data were collected for all patients: age, gender, date of admission into the unit, underlying disease, date of discharge from the unit, PRISM (Pediatric Risk of Mortality) score and progress (either discharge or death).

Statistical analysis. The Mann-Whitney test, Pearson's Chi-squared test, Student-t test and comparison of proportions tests (Fischer and Chi-squared) were used; $P < 0.05$ was considered significant.

Results

During the study, data on about 515 patients, 3,072 patient days, 2,120 central line days, 2,120 ventilator days, 676 urinary catheter days and 139 NI in 94 patients was evaluated.

Table 1 shows the underlying diseases of the patients. A large number of the patients had surgical conditions, particularly cardiac and neurological.

The most common NI sites were the lungs (31.6%), followed by primary bloodstream infection (17.3%) and surgical site infection (17.3%).

The mean overall patient NI rate was 27.2 per 100 discharges, with a incidence of 18.3% (patients with NI), and the mean infection rate per 1,000 patient days was 46.1. The rates of central line-associated bloodstream infection, ventilator-associated pneumonia and urinary catheter-associated infection per 1,000 devices were 10.2, 18.7 and 1.8, respectively.

Patients with NI were significantly younger (mean age 29.2 months) compared with patients without NI (mean age 43.8 months) ($P=0.006$); the median age in months of the patients with NI was seven and of patients without NI was 17.2.

Patients without NI had a mean length of stay of 4.1 days, while patients with NI were hospitalized for 15.7 days ($P=0.0000$).

PRISM could be calculated in only 25% of the patients and it was significantly higher in patients with NI (17.1), compared to those without NI (10.0) ($P=0.0002$).

Nosocomial-related mortality was 21.3%, the pneumonia-associated mortality rate was 11.4% and the primary bloodstream infection-associated mortality rate was 33.3%. Mortality was significantly higher in patients with NI, compared to patients without NI.

Pathogens were identified in blood culture, secretions (except tracheal secretions), spinal fluid, urine and peritoneum. Forty-two pathogens were identified. Gram-negative bacterias were the most common pathogens identified in the NIs (54.8%), followed by Gram-positive bacterias (23.8%), and yeasts. The most common species identified were *Acinectobacter baumannii* and *Klebsiella pneumoniae* (Table 4).

Table 1. Underlying diseases provoking hospitalization in the Pediatric Intensive Care Unit

Underlying disease	**N**	**%**
Surgical	267	52.7
- cardiac	118	-
- neurosurgical	69	-
- pediatric surgery	56	-
- others	24	-
Urgency	162	31.8
- emergency unit	91	-
- ward	71	-
Cancer	30	5.9
Neurological	20	3.9
Nonsurgical cardiology	20	3.9
Others	8	1.8
Total	**508**	**100.0**

Table 2. Nosocomial infection sites and mortality in the 506 in-patients

Nosocomial infection	**N**	**%**	**Mortality**
Bloodstream infection	24	17.3	33.3
Surgical site infection	24	17.3	8.3
*Gastrintestinal tract infection	19	13.7	NR
**Others	16	11.5	NR
Upper respiratory tract infection	12	8.6	8.3
Total	**139**	**100.0**	**21.3**

*Gastrintestinal infections: severe diarrhea (16), enterocolitis (2), peritonitis (1).
** Others: conjunctivitis (3); urinary tract infections (3); undefined (2); ventriculitis (2); catheter related infection (2); abscess (1); infected bed sore (1); osteomyelitis (1); cellulitis (1).
NR: not referred.

Table 3. In-patients' characteristics

	Mean with NI	Mean without NI	P value
Age (months)	29.7	43.8	*0.006
Length of stay (days)	15.7	4.1	*0.0000
PRISM	17.1	10.0	*0.0002
Mortality (%)	28.3	14.6	*0.00546

*P value < 0.05 – significant. NI: Nosocomial infection. PRISM: Pediatric Risk of Mortality.

Table 4. Pathogens identified in the nosocomial infections

	Blood culture	Secretion	Spinal fluid	Urine	Peritoneum	Total (%)
Gram-negative	4	13	2	2	2	23 (54.8)
A. baumannii	2	4	1	-	1	8 (19.0)
K. pneumoniae	2	2	1	1	1	7 (16.7)
E. coli	-	2	-	1	-	3 (7.1)
P. aeruginosa	-	2	-	-	-	2 (4.8)
Enterobacter spp.	-	2	-	-	-	2 (4.8)
Citrobacter spp.	-	1	-	-	-	1 (2.4)
Gram-positive	3	4	1	-	2	10 (23.8)
S. aureus	2	2	-	-	1	5 (11.9)
S. epidermidis	1	1	-	-	1	3 (7.1)
Enterococcus spp.	-	1	1	-	-	2 (4.8)
Yeasts	6	2	-	-	1	9 (21.4)
Total	**14**	**18**	**3**	**2**	**5**	**42 (100.0)**

Discussion

Despite the importance of NIs in patients admitted to ICU, there are few studies on the pediatric population.

Harris emphasizes the need to develop specific strategies for the prevention and control of NI in children. Measures include: development of surveillance methods using underlying disease risk stratification, identification of infection-specific risk factors as well as type and incidence of resistent microorganisms [3].

The NI rates in pediatric ICU range from 3% to 27%, depending on the hospital studied [4-9]. Differences among the patients render the comparison of NI among different hospitals difficult. Despite the control measures taken, higher incidences generally are found in units where in-patients have a more severe underlying disease or undergo either non-elective or high risk surgeries.

In the pediatric ICU of our department most of the children admitted presented with severe underlying diseases, such as: liver diseases, chronic pulmonary

disease, renal failure and primary or secondary immunodeficiency, in addition to post-operative complications, particularly following cardiac and neurosurgical procedures.

The most common types of NI in the pediatric ICU are pneumonia and primary bloodstream infection [5,6,8,10,11], also found in our study. The high incidence of surgical site infections could be explained by the high rate of admission of surgical patients and the high complexity of the surgical procedures.

Bhattacharya, in a study of 608 pediatric patients undergoing surgery, found a 6.2% NI rate, 32% of which were surgical site infections [12].

A low incidence of urinary tract catheter infection-associated infection was found. The rational use of urinary catheters was the major factor accounting for this low incidence.

Most NI events occurred in children under two years of age, which is explained by the immunity deficiency characteristic of that age range, which agrees with data found in literature [3,5,8,13].

According to NNISS, an NI rate of 9.2% and a mean infection rate per 1,000 patient days of 23.7 were found in 79 pediatric ICU in US hospitals, between 1986 and 1990 [7]. The ventilator associated pneumonia rate was 5.7 per 1.000 ventilator days and the central line-associated bloodstream infection rate was 5.7 per 1.000 central line days [14].

The incidence of NI observed in the unit was higher than that reported in the literature. The central line-associated bloodstream infection rates and the ventilator-associated pneumonia rates also showed higher values than those reported in the literature.

The major risk factors for acquisition of NI in pediatric patients comprise: age less than two years, severity of underlying disease, presence of invasive procedures, long length of stay, high population density, and patient-nursing contacts.

"Hospital São Paulo" is a tertiary university hospital, where patients with severe underlying diseases are referred, compared to general hospitals. Thus, the severity of the cases of the patients admitted to the unit could explain the high rates found.

Further factors that could explain the rates observed are: high rate of utilization of invasive procedures, presence of professionals in training, lowers salaries for expert professionals, compared to private service; shortage of proper material for procedures and surgeries; and the long average length of stay.

PRISM was calculated in a small number of patients, and the major limiting factors were considered to be the admission of large numbers of patients with cyanotic congenital heart disease, chronic lung disease and neurological conditions. Nevertheless, statistical analysis was possible, and showed significantly greater PRISM scores in patients with NI as compared to patients without NI, which agrees with published data.

NI is an important cause of morbidity, mortality and increased length of stay for pediatrics patients.

NI-associated mortality is multifactorial, and depends on the patients' characteristics, infection site, etiologic agent and adequate use of initial empirical antibiotic therapy.

Bowen-Jones et al. analyzed mortality rates in children admitted to the ICU and found 41% mortality rate in the presence of NI and a mortality rate of 18% in children without NI [15]. Ashkenazi et al, in a study in a Israeli hospital, reported yeast-associated mortality of 42% and 60% in *Acinectobacter sp*. bacteremia [16].

NI-associated mortality observed over the study period was 21.3%, higher than the mortality rate of 10% reported by the European Study Group [10].

Hospital pneumonia-associated mortality during the study period was low (11.3%), as opposed to that observed in adult patients, however it was similar to the rate reported by Fayon et al. [17]. Further studies are required.

Gram-negative bacteria were the most common microorganisms identified. Yeasts were an important etiological agent, agreeing with literature data.

NI in the pediatric population has characteristics of its own, often different from the adult population, as reported by Harris [3] and Richard et al. [11], and in our study, which means that studies should be oriented towards this group of patients.

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