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Original Article

Nosocomial infections and antibiotic resistance in a tertiary university hospital pediatric intensive care unit

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Abstract

Aim: Nosocomial infections (NI) cause failed treatments and long hospitalization periods in pediatric intensive care units (PICUs), leading to severe rates of mortality, morbidity and high hospitalization costs. This study intends to offer a retrospective review of the types of NI, active pathogens as well as antibiotic resistance profiles of inpatients followed up and treated in the PICU of a tertiary university hospital.

Material and Methods: In this study, in-patients who were treated in an intensive care unit between January 2014 and June 2018 were evaluated retrospectively. Patients' data were obtained from the Infection Control Committee database. Based on this data, the rate of NIs, the distribution of NIs by the systems, the invasive device-related infection rate, the infectious agents and the antibiotic resistance of these agents at the PICU were determined within the specified time-frame.

Results: In this study, 536 patients receiving treatment at a PICU between January 2014 and June 2018 were examined. A NI episode developed in 69 (12.6%) of these patients. The NI rate was 12.87/100 applications. The mean hospitalization length of stay of the patients was 17.65 days. Bloodstream infections due to the use of central venous catheters were the most common form of NI. In this study, of all the NI agents, Gram (-) microorganisms were isolated the most. The most commonly isolated microorganism was *Acinetobacter baumannii (A. baumannii)*. The rate of carbapenem resistant *A. baumannii* was 85%.

Conclusion: In PICUs, surveillance measures for infection control and rational use of antibiotics are important in terms of preventing high mortality and morbidity rates and hospitalization costs due to resistant microorganisms.

Keywords: Nosocomial infection; bloodstream infections; pediatric Intensive care unit

INTRODUCTION

The World Health Organization (WHO) defines nosocomial or hospital infections as the kind of infections that a patient does not have at the time of admission to hospital, including the incubation period, only appearing approximately 48 hours after hospital admission. In addition, infections occurring within 10 days after discharge are considered as nosocomial infections (NI) (1). According to data from the WHO, nosocomial infections are more common in developing countries affecting about 15% of inpatients (2). According to data from the United States, 25% of the NIs were reported to originate from intensive care units (3). It was first reported in the 1980s that the incidence of NIs in pediatric units was higher than in adult units (4). The prevalence in pediatric units in developed countries ranges from 6.9% to 8.7% (5,6). Nosocomial infections cause prolonged hospitalization periods, increased antimicrobial resistance and mortality, leading to a significant increase in treatment costs (2). Since the prevalence and distribution of nosocomial infections and the resistance patterns of microorganisms show geographical distinctions with variations across different centers, each center should establish its own antimicrobial treatment policy. This is the only way to reduce the incidence of nosocomial infections, and the associated mortality rates and treatment costs (7).

This study intends to offer a retrospective review of the types of NI, pathogenic agents, and antibiotic resistance profiles of inpatients followed up and treated in the PICU of a tertiary university hospital between January 2014 June and 2018.

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MATERIAL and METHODS

The Pediatric Intensive Care Unit of xxx University's Medical Faculty has six beds where an average of 120 patients are followed up annually. In this study, in-patients who were treated in an intensive care unit between January 2014 and June 2018 were evaluated retrospectively. In our hospital, the Infection Control Committee (ICC) has been conducting active and patient-based surveillance since 2008 and patient data was obtained via the database of the committee. Because of this data, the rate of NIs, the distribution of NIs by the systems, the invasive device-related infection rate, the infectious agents and the antibiotic resistance of these agents at the PICU were determined within the specified time frame.

The NI diagnosis was made according to the definitions of Centers for Disease Control and Prevention (CDC). Antibiotic susceptibilities were determined using the disk diffusion method according to the criteria of The Clinical and Laboratory Standards Institute (CLSI) (8).

The infection rate (nosocomial infection/length of patient stay) was calculated using the formula x 1000, while the medical device-related infection rate (number of episodes/number of days the medical device was used) was calculated using the formula x 1000.

RESULTS

In this study, 536 patients who received treatment at a PICU between January 2014 and June 2018 were examined (9465 patient days). A NI episode developed in 69 (12.6%) of these patients. The NI rate was 12.87%. Table 1 shows the distribution of the nosocomial infection rate by year.

The mean hospitalization length of stay of the patients was 17.65 days. When invasive device usage rates and invasive device-related hospital infection rates were examined, the highest value was the rate of bloodstream infections, due to the use of central venous catheters. Ventilator-associated pneumonia (VAP) ranked second, while urinary system infections due to the use of urinary catheters ranked third. Although the rate of ventilator use has not changed over the years, the rate of VAP has increased over the last 2 years. The rate of invasive device use along with invasive device-related hospital infection rates are summarized in Table 2.

In this study, Gram (-) microorganisms were isolated the most as NI agents. The distribution of isolated microorganisms by years is summarized in Table 3. The antibiotic resistance profiles of Gram (-) microorganisms that were isolated are summarized in Table 4. When the resistance profiles of Gram (+) microorganisms are examined, one out of every two isolated microorganisms was the methicillin resistant coagulase negative *staphylococcus* isolated in 2014. The other Gram (+) microorganism, *Staphylococcus aureus*, was susceptible to methicillin.

Table 1. Nosocomial infections developing in the pediatric intensive care unit between 2014-2018.

Year	Number of in-patients	Length of patient stay	Number of NI	NI rate (%)
2014	131	2077	20	15.27
2015	141	1927	11	7.8
2016	111	1984	18	16.22
2017	119	2290	15	12.61
2018*	34	1187	5	14.71
Total	536	9465	69	12.87

* 6-month data

Table 2. The rate of invasive devices used along with invasive device-related hospital infection rates by years

	2014	2015	2016	2017	2018**
VAP rate	0	0	2.11	5.97	4.01
RVU	0.66	0.65	0.72	0.73	0.84
USI	1.28	1.8	3.28	1.5	0
RUCU	0.75	0.87	0.93	0.87	0.49
CVC-BSI	4.1	1.99	4.6	0.99	0.97
Rate of CVC	0.59	0.78	0.88	0.88	0.87

VAP rate: ventilator-associated pneumonia rate; RVU: rate of ventilator use; USI: urinary system infection; RUCU: rate of urinary catheter use; CVC-BSI: Central venous catheter-associated bloodstream infection; Rate of CVC: central venous catheter use.
** 6-month data

Table 3. Distribution of microorganisms responsible for nosocomial infection					
Active microorganism	2014	2015	2016	2017	2018*
P. aeruginosa	4	-	3	6	2
A. baumanii	9	3	7	8	1
K. Pneumonia	6	5	5	2	2
E. coli	-	-	1	2	-
S. maltophilia	1	-	-	-	-
S. aureus	-	-	-	1	-
CNS	1	-	-	-	-
C. albicans	-	1	-	-	-
Non albican candida	2	-	2	-	-

CNS: Coagulase negative *staphylococcus*.
* 6-month data

Table 4. Resistance profile of Gram (-) microorganisms responsible for nosocomial infections				
	P. aeruginosa Resistance: n (%)	*A. baumannii* Resistance: n (%)	*K. Pneumonia* Resistance: n (%)	*E. coli* Resistance: n (%)
Piperacillin-tazobactam	5 (33.3)	13 (46.4)	9 (45)	3 (100)
Ceftazidime	5 (33.3)	9 (32.1)	12 (60)	3 (100)
Cefepime	8 (53.3)	11 (39.2)	12 (60)	3 (100)
Amikacin	6 (40)	19 (67.8)	3 (15)	2 (66.6)
Colistin	0 (0)	0 (0)	0 (0)	-
Meropenem	9 (60)	24 (85.7)	7 (35)	2 (66.6)
Imipenem	8 (53.3)	24 (85.7)	7 (35)	2 (66.6)
Ciprofloxacin	6 (40)	19 (67.8)	7 (35)	-
Total	15 (100)	28 (100)	20 (100)	3 (100)

DISCUSSION

Nosocomial Infections have caused hospitals to implement their own infection control programs, as they lead to increased morbidity and mortality levels, along with increased antimicrobial resistance and prolonged hospitalization rates. It is important that each hospital carries out regular surveillance to have an understanding of its own flora and antibiotic resistance. Intensive care units where broad-spectrum antibiotic therapies and multiple invasive procedures are performed, particularly those occupied by oncology and transplant patients, have led to the development of resistant infections (9). The prevalence of NI in PICUs is 4% according to data from the USA, compared to 5.7% in the UK (10-12). In a study conducted with 17 centers in Europe, the prevalence of NI in PICUs was reported to be 23.6%, while a similar study in Turkey conducted to pinpoint the prevalence of NI in 50 PICUs reported an NI rate of 37% (13,14). While this study reported a NI rate of 12.87 for 100 applications in PICUs in concordance with NI prevalence rates in developing countries. Similar studies have shown infection rates in PICUs to range between 9.1% and 42.5% (13,15-19). While an evaluation of the infection rates as the hospital, where the study was carried out according to years has shown that the rates have remained at approximately the same levels after 2015. Although it is pleasing to see lower rates compared to similar studies, these rates have been found to not show a declining trend over the years, despite an infection control program that has been implemented for 11 years now.

In this study, the most common invasive device-related infection was a bloodstream infection due to the use of central venous catheters. When evaluated together with annual rates of central venous catheter use, the rates of use were approximately similar on a yearly basis, while the rate of infections has decreased dramatically over the last 2 years. VAP ranked second, while urinary system infections due to the use of urinary catheters ranked third. Contrary to this study, a multicenter study conducted by Kepenekli et al. in Turkey found that the most common invasive device associated infection was VAP, while bloodstream infection was found to be the second most common infection (14). Similar studies have shown that VAP is the most common invasive device-related infection in PICUs (20-22). This study has found that the rate of VAP has increased over the last 2 years, as opposed to catheter infection rates. While the increase in the rate of ventilator-associated pneumonia correlates with an increase in ventilator utilization rates, a reduction in central venous catheter-associated bloodstream infections despite an increase in the use of central venous catheters may be interpreted as demonstrating the success of precautionary measures adopted by our hospital.

As the implementation of infection control policies for the last 15-20 years and antimicrobial developments primarily targeted Gram (+) bacteria, the incidence of Gram (-) bacterial infections has increased during this period (21). When the general distribution of the microorganisms isolated in this study is examined, it is seen that Gram (-) agents were isolated first, followed by fungi and Gram (+) agents. The increase in the antimicrobial resistance of Gram (-) bacteria in both developed and developing countries is a serious problem, particularly for intensive care units, limiting the treatment options of resistant pathogens (21,23). In this study, the most commonly isolated microorganism was *Acinetobacter baumannii (A. baumannii*). The rate of carbapenem resistant *A. baumannii* was 85%. (24 of the 28 patients were resistant to carbapenem). Similar studies have shown that carbapenem resistance is on a trend of increase worldwide (24-26). According to data from the USA, carbapenem resistance increased from 5.2% to 40.8% in the period extending from 1999 to 2010 (27). Similarly, according to 2012 data from Europe, 68.8% of *A. baumannii* infections were reported to be carbapenem resistant. It is thought that the high rate of *A. baumannii* related NI's in this study may be associated with the high number of invasive procedures, prolonged hospitalization periods and frequent use of carbapenems due to the fact that the patients had different hospitalization stories as the hospital is a tertiary intensive care center and they had high rates of antibiotic resistance. All the *A. baumannii* infections isolated in this study were susceptible to colistin. Nevertheless, it is considered that the uncontrolled and widespread use of colistin may complicate the treatment of *A. baumannii* infections.

As infection control measures and antimicrobial developments over the last 15-20 years have mostly targeted Gram (+) agents, they have become less prevalent (21). In this study, only 2 NI agents were Gram (+). Methicillin resistance was detected in one agent. The presence of methicillin resistance despite a reduction in the prevalence of Gram (+) agents may be due to the widespread use of glycopeptide antibiotics.

This being a retrospective study, it has its limitations. The limitations include the lack of knowledge about the critical clinical scores of patients included in the study, history of underlying diseases, previous hospitalizations, antibiotic use and length of their hospitalization periods.

To conclude, the increasing prevalence of resistant microorganisms in PICUs, particularly Gram (-) pathogens, leads to failed treatments causing higher rates of mortality, morbidity and hospitalization costs. Therefore, taking into account the fact that each hospital has its own unique flora, surveillance measures should be implemented by hospitals for holding infections in check and a further understanding of the antibiotic resistance profile of microorganisms should be developed and supported by strategic policies in that regard.

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