

Healthcare-associated infections in a neonatal intensive care unit

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Abstract

Introduction: Healthcare-associated infection is a common problem in patients from neonatal intensive care units and it is one of the leading causes of death in this group of patients. Healthcare-associated infections are associated with increases in mortality, morbidity, and prolonged length of hospital stay. The aim of the study was to assess the incidence, clinical presentation, mortality and aetiology of healthcare-associated infections in newborns in a neonatal intensive care unit between 2005 and 2010.

Material and methods: The research involved documentation of 2610 neonates hospitalized in this period in the Neonatal Intensive Care Unit, Dr Jan Biziel University Hospital No. 2 in Bydgoszcz. The incidence, clinical presentation, mortality and causative factors of healthcare-associated infections were assessed.

Results: The prevalence of healthcare-associated infections was 7.32%. The most frequent healthcare-associated infections were bloodstream infection (65.4%) and urinary tract infection (22.5%). The mortality rate was 2.1%. The most frequent pathogens were coagulase-negative staphylococci (36.1%) and *Klebsiella pneumoniae* (29.3%).

Conclusions: The rate of healthcare-associated bloodstream infections in the analysed department is low, taking into consideration the specificity of the department. There is a necessity to establish convenient definitions of various kinds of healthcare-associated infections in neonates, especially those born preterm.

Key words: healthcare-associated infections, newborn, neonatal intensive care unit.

Introduction

Healthcare-associated infection (HAI) is a serious problem in neonates who are admitted to the neonatal intensive care unit (NICU). The HAI is associated with increases in mortality, morbidity, and prolonged length of hospital stay.

The rate of healthcare-associated infections (HAIs) increases with the degree of both prematurity and low birth weight. There are many risk factors of healthcare-associated infections in this group of patients, including immaturity of the immune system, barrier functions of the skin and gastrointestinal tract, and the invasive diagnostic and therapeutic procedures which newborns undergo [1-3].

Monitoring infection rates is an important contributor to safe and high quality health care [4]. In our hospital the Nosocomial Infection Control Committee (NICC) has implemented a registration of HAIs since 2004. The registration is based on nosocomial infection suspected or diagnosed by a system of physicians and liaison nurses.

The aim of the study was to assess the incidence, clinical presentation, mortality and etiology of healthcare-associated infections in newborns in the Neonatal Intensive Care Unit in Dr Jan Bizieli University Hospital in Bydgoszcz between 2005 and 2010.

Material and methods

Data about HAIs were collected both from Nosocomial Infection Control Committee reports and from the medical charts of 2610 neonates hospitalized in the NICU Dr Jan Bizieli University Hospital No. 2 in Bydgoszcz from January 1, 2005 to December 31, 2010. Our NICU is a level III NICU. The incidence, clinical presentation, mortality and causative factors of HAIs were assessed, and a retrospective analysis was performed.

A case of HAI, also called a nosocomial infection, was defined as a localized or systemic condition which results from an adverse reaction to the presence of an infectious agent and was neither present nor incubating at the time of admission to the hospital [5]. Blood cultures and complete blood counts were taken from every infant after birth in the NICU. Patients who were not infected or were not in the incubation period at the time of admission and had a positive culture after the third day of admission were defined as patients with HAIs in the present study. We recognized HAIs only if we obtained a positive culture of biological material from the newborn.

Although infections acquired by infants during passage through the birth canal are considered HAIs, we did not take them into consideration; we only analysed infections connected with hospitalization in our unit.

We analysed the most frequent types of HAIs, i.e. bloodstream infection, urinary tract infection and pneumonia; meningitis was also included in the analysis. This is in accordance with reports both from our local Nosocomial Infection Control Committee and from neonatologists.

A case of healthcare-associated bloodstream infection was defined as one or more positive blood cultures obtained over 72 h after admission to the NICU, and the presence of clinical symptoms or signs suggestive of infection. The blood cultures were processed in a BacT/Alert automated system. We use one bottle system. The neonatologist drew 0.5 ml or more of blood with a syringe and needle

from the newborn with suspected septicaemia. The dominant presenting features of septicaemia include increasing apnoea, feeding intolerance, lethargy, hypotonia, need for increased respiratory support, cardiovascular depression and laboratory values (leukocytosis, immature white blood cells, neutropenia, elevated C-reactive protein and procalcitonin). A case of fungal bloodstream infection was diagnosed when a fungal pathogen was isolated from the blood culture. We do not use a special fungal culture medium, so we could only diagnose *Candida* spp. infections.

A case of healthcare-associated urinary tract infection was diagnosed when one or more positive urine cultures were obtained over 72 h after admission to the NICU. Urine cultures were obtained by bladder catheterization.

A case of healthcare-associated pneumonia was defined as pneumonia that occurs 72 h after admission to the NICU and when positive cultures of deep tracheal aspirate material were obtained.

A case of healthcare-associated meningitis was diagnosed if the patient had elevated protein and an increased amount of white cells in the cerebrospinal fluid and organisms were cultured from the cerebrospinal fluid.

Mortality due to HAIs was defined as death occurring within 7 days from the onset of infection episodes.

Results

During the study period, from January 1, 2005 to December 31, 2010, 2610 neonates were hospitalized in our NICU, including 482 in 2005, 474 in 2006, 436 in 2007, 365 in 2008, 421 in 2009 and 432 in 2010. The HAIs were diagnosed in 191 cases, including 38 episodes in 2005, 33 in 2006, 18 in 2007, 25 in 2008, 50 in 2009 and 27 episodes in 2010. The HAI patient rate over the 6-year period was 7.32%. In 2005 the HAI patient rate was 7.88%, in 2006 6.96%, in 2007 4.13%, in 2008 6.85%, in 2009 11.88% and in 2010 6.25 % (Table I).

The most frequent HAIs were the bloodstream infection (65.4%) and the urinary tract infection (22.5%) (Table II).

The most common HAIs pathogens in all neonates were coagulase-negative staphylococci (36.1%) and *Klebsiella pneumoniae* (29.3%). If we take into consideration two groups of microorganisms, Gram-negative rods and Gram-positive rods, then Gram-negative rods dominated (106/191) and among them *Klebsiella pneumoniae*, mostly ESBL(+) (extended-spectrum β -lactamase producing), in 45 from 56 cases (80.4%). Gram-positive rods caused 74 HAIs and in 64 cases coagulase-negative staphylococci were a causative factor. Fungi caused 11 cases of HAIs. Among all of the candidaemia cases reported, *Candida albicans* were the most com-

Table I. Healthcare-associated infection rates in the neonatal intensive care unit, 2005-2010

Year	No. of admitted patients in NICU	No. of healthcare-associated infections	Healthcare-associated infection patient rate [%]
2005	482	38	7.88
2006	474	33	6.96
2007	436	18	4.13
2008	365	25	6.85
2009	421	50	11.88
2010	432	27	6.25
Total	2610	191	7.32

Table II. Clinical presentation of neonatal healthcare-associated infections, 2005-2010

Year	Bloodstream infections	Urinary tract infections	Meningitis	Pneumonia	Total
2005	35 (92%)	3 (8%)			38
2006	28 (85%)	5 (15%)			33
2007	8 (45%)	10 (56%)			18
2008	12 (48%)	8 (32%)		5 (20%)	25
2009	27 (54%)	13 (26%)	2 (8%)	8 (16%)	50
2010	15 (55%)	4 (15%)		8 (30%)	27
Total	125 (65.4%)	43 (22.5%)	2 (1.1%)	21 (11%)	191

mon (6 cases), followed by *Candida krusei* (4 cases) and *Candida parapsilosis* (1 case).

During the study period 4 newborns died of HAIs, 2 in 2006, 1 in 2009 and 1 in 2010. Overall mortality rate was 2.1%. The cause of death of three neonates was a bloodstream infection caused by *Klebsiella pneumoniae* ESBL(+) and in one case it was a bloodstream infection caused by *Candida parapsilosis*.

The distribution of pathogens associated with HAIs is shown in Table III.

Discussion

Neonatal HAIs is an important cause of immediate morbidity and mortality; it is associated with an increased risk of long-term neurological sequelae and is also a major contributor to additional healthcare costs.

The HAI patient rate over the 6-year period in the NICU of Dr Jan Biziel University Hospital No. 2 was 7.32%. The highest HAI patient rate was in 2009 (11.88%). The incidence of HAIs in other NICUs has been reported in up to 50% of all neonates [6, 7].

There are significant differences in methodology in various studies, so it is difficult to compare infection rates between studies. Some authors include only microbiologically proved infections, whereas others recognize infections due to clinical features and/or microbiological tests. Diagnosis of infection in neonates, especially preterm-born, is

difficult because of non-specific symptoms of infection in this group of patients. The definitions of Centers for Disease Control and Prevention (CDC) for nosocomial infection in children aged less than 1 year are less suitable in this patient population. Symptomatology of infection is different in this type of patient [5].

The prevalence of HAIs is strongly connected with length of hospital stay, so it could be better to assume the rate of HAIs for baby-days.

The incidence of recognized HAIs in the analysed NICU seems to be too low when taking into consideration data from other NICUs. It may be due to the definition of HAIs established in our investigation; HAIs were diagnosed only if we had obtained microbiological confirmation, while other investigators recognized HAIs also due to clinical features without any positive cultures. Another reason is that patients in the NICU usually have a course of antibiotics after delivery and it can disturb the microbiological culture procedure.

The most frequent HAIs were bloodstream infections, 125 cases out of 2610 newborns hospitalized in the NICU (4.8%). Previous studies have reported that the rates of healthcare-associated bloodstream infection in the NICU ranged from 5% to 32% [8, 9].

The second most frequent type of HAIs was urinary tract infections, 43 cases (43/2610 – 1.6%). Van der Zwet *et al.* reported that the most frequent HAIs among 742 neonates hospitalized in the NICU were

Table III. Distribution of pathogens associated with healthcare-associated infections, 2005-2010

Pathogen	No. of isolates (%)						Total no. of isolates (%)	Rank
	2005	2006	2007	2008	2009	2010		
Gram-positive:								
<i>Staphylococcus aureus</i>	0	1	0	0	0	1	2	8
Enterococcus	1	0	0	1	0	1	3	7
CONS	22	11	4	8	10	14	69 (36.1%)	1
Total Gram-positive							74 (38.7%)	
Gram-negative:								
<i>Klebsiella pneumoniae</i>	1	14	5	12	21	3	56 (29.3%)	2
<i>Enterobacter cloacae</i>	7	1	2	1	1	3	15 (7.9%)	3
<i>Escherichia coli</i>	2	1	3	1	4	2	13	4
<i>Serratia marcescens</i>	1	3	0	2	6	1	13	4
<i>Acinetobacter baumannii</i>	0	1	0	0	3	0	4	6
<i>Pseudomonas aeruginosa</i>	0	0	2	0	0		2	8
<i>Stenotrophomonas maltophilia</i>	0	0	0	0	2	1	3	7
Total Gram-negative							106 (55.5%)	
Fungi:								
<i>Candida albicans</i>	2	0	1	0	2	1	6	5
<i>Candida krusei</i>	2	1	1	0	0	0	4	6
<i>Candida parapsilosis</i>	0	0	0	0	1	0	1	9
Total fungi							11 (5.8%)	
Total no. of isolates	38	33	18	25	50	27	191	

bloodstream infection (138/742 – 18.6%) and pneumonia (69/742 – 9.3%), which is much more often than in our NICU. They diagnosed nosocomial urinary tract infection in 10 cases (10/742 – 1.3%) [6].

In our study, we recognized healthcare-associated pneumonia only in 21 cases (21/2610 – 0.8%). This may be due to the fact that we recognized healthcare-associated pneumonia only in cases when we obtained positive cultures of tracheobronchial aspirates. We did not recognize healthcare-associated pneumonia when we had clinical symptoms and laboratory tests, including chest radiograph, without positive cultures of respiratory secretion. Chest X-ray is often difficult to assess for infiltrates in the presence of respiratory distress syndrome, so the presence of infiltrates is not a good criterion for pneumonia in preterm neonates. Nevertheless, when we diagnosed health-care associated pneumonia only in cases when we obtained positive cultures of tracheobronchial aspirates we underestimated the frequency of this illness. Van der Zwet *et al.* had 26% culture negative cases of pneumonia in their report [6]. To recognize healthcare-associated pneumonia we use deep tracheal aspirates. It is worth mentioning the weakness of this test: its inability to differentiate between the organism responsible for causing the

pneumonia and harmless colonizers. Until 2008 we used deep tracheal aspirate culture very rarely, so we did not identify cases of health-care associated pneumonia with positive cultures of aspirate.

Since we collected data about HAIs primarily from Nosocomial Infection Control Committee reports, we had no reports about other nosocomial infections such as eye infection, skin infection and others, because we found none about these kinds of HAIs. It is connected with procedures in our NICU. We do not conduct microbiological tests in cases of less serious infections, such as skin infection or eye infection. These infections may not be life-threatening themselves, but they can be an important reservoir of pathogenic microorganisms [10].

The predominant HAI pathogens in our report were coagulase-negative staphylococci and *Klebsiella pneumoniae*, mostly ESBL(+). Similar data were obtained by Battista *et al.* and by Nagata *et al.* [7, 11]. Gray found that coagulase-negative staphylococci were the predominant nosocomial pathogens of HAIs [10].

In our study, we did not analyse precisely which microorganisms are the most frequently occurring in given kinds of infections. Overall, CONS are predominant pathogens in bloodstream infections, but

healthcare-associated pneumonia is more often caused by Gram-negative rods.

The mortality rate was low in this study; the overall mortality rate was 2.1%. The cause of death of three neonates was a bloodstream infection caused by *Klebsiella pneumoniae* ESBL(+) and in one case a bloodstream infection caused by *Candida parapsilosis*. Gram-negative bloodstream infection often presents a more rapid clinical deterioration and is commonly associated with shock and coagulation problems. Other authors have reported that mortality caused by Gram-negative pathogens is much higher than in our report, about 26% to 40% [12-14].

According to Makhoul *et al.*, mortality after Gram-negative sepsis (26.2%) and *Candida sepsis* (27.6%) is similar, and it is significantly higher than after Gram-positive sepsis (8.7%) [13]. However, the virulence of organisms such as coagulase-negative staphylococci may be underestimated since many cultures that grow Gram-positive bacteria represent skin contaminants rather than true blood-stream infections.

In conclusion, the rate of healthcare-associated infections in the analysed department is low when taking into consideration the specificity of the department. There is a necessity to establish convenient definitions of various kinds of HAIs in neonates, especially in preterm neonates. A proper infection surveillance programme could reduce the incidence of HAIs.

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