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American Journal of Infection Control

journal homepage: www.ajicjournal.org

Brief report

Health care–acquired infections in neonatal intensive care units: Risk factors and etiology



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Key Words:

Hospital infections
Intensive care units
Neonatal

A 1-year prospective cohort study of health care–acquired infections was conducted at the neonatal intensive care unit of the University Clinical Centre Kragujevac, Serbia. The incidence rate of neonates with health care–acquired infections was 18.6%, and the incidence rate of the infections themselves was 19.4%. The incidence density of the health care–acquired infections was 9.1 per 1,000 patient days. The independent risk factors for health care–acquired infections were birth weight, length of hospitalization, duration of mechanical ventilation, and Apgar score. More than half of all isolated microorganisms were *Klebsiella-Enterobacter* (39.3%) and *Escherichia coli* (25.0%).

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Health care–acquired infections (HAIs) in neonatal intensive care units (NICUs) significantly increase morbidity and mortality rates, prolonging hospitalization and increasing total treatment costs.^{1,2} The incidence of HAIs among neonates admitted to the hospital can be as high as 30%.³

Most studies of the risk factors for HAIs have been conducted in developed countries in sophisticated medical environments that are well-equipped and resourced. Serbia is a country in socio-economic transition, faced with many problems in its health care system. The national HAI surveillance system was established only 10 years ago, and many hospitals still do not have infection control teams.

The aims of this study were to estimate the incidence of HAIs, to highlight risk factors for the emergence of HAIs, and to describe the most frequent causative agents of HAIs.

METHODS

Our study was a prospective cohort study that was conducted in the 30-bed Neonatology Department of the University Clinical

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Conflicts of interest: None to report.

Funding/support: This study was supported by the Serbian Ministry of Education through research grant number 175007 and through a grant from the Ministry of Science, Montenegro.

Centre, Kragujevac, Serbia, from January 1–December 31, 2012. Data were collected for all neonates hospitalized for >48 hours at the NICU during the study period. HAI was diagnosed, and its site was determined according to the Serbian translation of the standard diagnostic criteria from the U.S. Centers for Disease Control and Prevention.⁴ Data on the neonates were collected from their files and from interviews with their physicians. The causative agents were isolated and identified at the microbiology laboratory of the Clinical Centre Kragujevac, using conventional biochemical techniques.

The incidence of neonates with HAIs and the infections themselves were calculated as the number of neonates with an infection or the number of HAIs divided by all neonates included in the study ($\times 100$). The incidence density of HAIs was calculated by dividing the number of episodes of infection by the number of days at risk during the NICU stay. The Ethics Committee of the Clinical Centre Kragujevac approved the study.

The collected data were subjected to descriptive statistical analysis. The differences between the means in the neonates with infections and those without were tested using Student *t* test, and the differences in frequencies was determined using a χ^2 test. Independent variables that were detected as significant predictors during univariate analysis were later entered into a multivariate logistic regression model; the level of significance was set at $P \leq .05$. All calculations were made using the SPSS version 18 statistical software (SPSS Inc, Chicago, IL).

Table 1
Risk factors for HAIs in the neonatal intensive care unit (univariate logistic regression analysis)

Variable	Neonates		Test value	P value
	With HAI (n = 71)	Without HAI (n = 310)		
Maternal age (years)	28.13 ± 6.04	28.85 ± 5.78	t = -0.945	.345
Length of hospitalization (days)	35.06 ± 27.49	18.14 ± 9.91	t = 8.680	<.001*
Gestational age (weeks)	34.30 ± 4.43	36.29 ± 3.37	t = -4.220	<.001*
Rupture of membranes	21 (29.6)	62 (20.0)	χ ² = 3.110	.078
Caesarean section	29 (40.8)	131 (42.3)	χ ² = 0.047	.828
Changed amniotic fluid (milky, meconial, green)	14 (19.7)	33 (10.6)	χ ² = 4.938	.036*
Maternal disease in pregnancy [†]	16 (22.5)	36 (11.6)	χ ² = 5.848	.016*
Male sex	40 (56.3)	178 (57.4)	χ ² = 0.028	.868
Birth weight ≤1,500 g	17 (23.9)	22 (7.1)	χ ² = 17.844	<.001*
Apgar score in the first minute after birth	6.48 ± 2.59	7.53 ± 1.78	t = -4.072	<.001*
Apgar score in the fifth minute after birth	6.45 ± 1.78	7.73 ± 1.41	t = -6.482	<.001*
Asphyxia	31 (43.7)	97 (31.3)	χ ² = 3.963	.046*
Aspiration	5 (7.0)	17 (5.5)	χ ² = 0.258	.612
Congenital anomalies [‡]	5 (7.0)	23 (7.4)	χ ² = 0.012	.913
Intracranial hemorrhage	6 (8.5)	17 (5.5)	χ ² = 0.896	.344
Length of mechanical ventilation (days)	14.46 ± 12.30	6.76 ± 4.13	t = 3.443	.001*
Thoracic drainage	7 (9.9)	7 (2.3)	χ ² = 9.430	.002*

NOTE. Results are presented as mean ± SD, n (%), or as otherwise indicated.

HAI, health care-acquired infection.

*Significant difference.

[†]Diseases include colpitis, urine tract infection, anemia, gestational diabetes mellitus, hypertension, and hepatitis C.

[‡]Anomalies include heart defects, cleft palate, and locomotor system defects.

Table 2
Multivariate analysis, logistic regression of risk factors for health care-acquired infections in the neonatal intensive care unit

Risk factors	B	OR	95% CI	P value
Length of hospitalization (days)	0.046	1.047	1.003-1.093	.035
Birth weight ≤1,500 g	3.033	20.751	1.909-225.606	.013
Apgar score in the fifth minute after birth	-0.758	0.469	0.221-0.995	.049
Length of mechanical ventilation (days)	0.183	1.201	1.022-1.411	.026

NOTE: Only significant factors are presented.

B, coefficient of logistic regression analysis; CI, confidence interval; OR, odds ratio.

RESULTS

During the study period, 381 neonates were observed, with an average gestational age of 35.9 weeks (range, 23-42 weeks) and an average birth weight of 2,640.4 g (range, 500-4,550 g). The reasons for hospital admission included prematurity (58.0%), respiratory distress (46.2%), asphyxia (33.6%), neonatal infection (16.3%), and congenital anomaly (7.3%).

There were 74 HAIs in 71 neonates (3 neonates had 2 infections). The incidence rate of neonates with HAIs was 18.6%, and the incidence rate of the HAIs themselves was 19.4%. The incidence density of HAIs was 9.1 per 1,000 patient days. With regard to the infection site, the most frequent were pneumonia (64.9%), followed by urinary tract infection (20.3%), sepsis (9.5%), and omphalitis (5.4%).

The results of the univariate analysis of the risk factors for HAIs in newborns are shown in Table 1, whereas the results of the multivariate logistic regression are presented in Table 2. Independent risk factors for HAIs were birth weight, length of hospitalization, duration of mechanical ventilation, and Apgar score taken during the fifth minute after birth.

The causative agent was isolated in 56 (75.7%) of the HAIs. More than half of all registered HAIs were caused by *Klebsiella-Enterobacter* (39.3%) and *Escherichia coli* (25.0%); these were followed by *coagulase-negative staphylococci* (16.1%), *Acinetobacter* spp (10.7%), *Candida albicans* (5.4%), and *Stenotrophomonas maltophilia* (3.6%).

DISCUSSION

Developments in neonatal intensive care over the last few decades have increased the survival rate of neonates with low birth weight and preterm infants. The overall incidence of HAIs in our study was 19.4%. This rate is higher than the incidence reported from many developed countries² but is mostly in concordance with the results from developing countries,^{5,6} where HAIs in the NICU are still an unresolved and significant problem.

The HAI rates depend not only on host factors but on health care resources and practice patterns as well. Although we included data on vascular access in the study (only cannulation of peripheral veins is used at the facility), the manner of preparing intravenous infusions (prepared and administered by nurses at the bedside, under the supervision of pediatricians), the use of parenteral nutrition (only peripheral parenteral nutrition is used), and the type of milk used (mother's milk or commercial formula), these factors were not associated with HAI. It is worth mentioning that the facility has a local hand hygiene and glove policy in place and several standard operating procedures for general hygiene on the ward. Infants with surgical problems (eg, intestinal failure, bowel resections, gastroschisis, necrotizing enterocolitis) are treated at a special pediatric surgery intensive care unit, not at the NICU where the study was conducted. As a result, such cases did not enter the data set.

In our study, birth weight <1,500 g was found to be a significant risk factor for the occurrence of HAI. Although the results from different studies vary, low birth weight and prematurity are the most frequent risk factors for HAIs in the NICU.^{7,8} Prolonged mechanical ventilation, prolonged hospital stay, and low Apgar score during the fifth minute after birth also emerged as independent risk factors for HAIs in our study. The association of HAIs with prolonged hospital stay has already been described.⁶ Mechanical ventilation and its duration are well-known risk factors for hospital-acquired pneumonia, as shown in other studies.^{8,9} In our study, the neonates with HAIs spent twice as many days on mechanical ventilation as those without infections, and pneumonia was the most frequent HAI. In the NICU of South Korea University Hospital, the most frequent infection was pneumonia. The risk factors for development of HAI were birth weight <1500 g, gestational age <32 weeks, and lower Apgar score recorded during the first or the

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