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Brief Original Article

Drug-resistant bacteria screening and patient barrier precautions are associated with decreased neonatal nosocomial infection

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Abstract

Introduction: Neonates are at high risk of nosocomial infections, especially in developing countries. This study aimed to examine the effectiveness of drug-resistant bacteria (DRB) screening in combination with patient barrier precautions in controlling nosocomial infections in neonatal wards.

Methodology: The clinical data of neonates admitted to the Mianyang Central Hospital, Mianyang, China in 2010 and 2012 were retrospectively analyzed. In 2010, DRB screening was conducted using nasal and anal swabs. In 2012, in addition to the DRB screening, patient barrier precautions were implemented. The barrier precautions were lifted if the patients were negative for the DRB screening. Patients with DRB colonization were further isolated to reduce the risk of nosocomial infection. The rate of nosocomial infections in the two years was compared.

Results: A total of 1280 neonates in 2010 and 1504 neonates in 2012 were included in the analysis. No significant difference was noticed between the two years in gestational weeks, age, gender, and birth weight. The rate of nosocomial infections was reduced significantly from 2.34% in 2010 to 1.13% in 2012.

Conclusions: DRB screening in combination with the patient barrier precautions may reduce the risk of nosocomial infection in neonates.

Key words: hospital infection; intervention strategy; neonates.

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Introduction

Neonates suffering from illnesses have previously been exposed to potential nosocomial infections from various hospital sources including the delivery room, operating room, direct rooming-in ward, and newborn room before admission to a hospital. This accounts for the colonization of drug-resistant bacteria (DRB) in their skin, digestive tract, and respiratory tract. Previous studies demonstrated that the rate of nosocomial infections in neonates was about 2%–3% [1].

Neonates are at high risk of nosocomial infections due to their immature immune functions. Invasive diagnostic procedures and operations can cause damages and wounds in neonates, leading to nosocomial infections [2]. Outbreaks of nosocomial infections are more frequent in neonates than in adults [3]. Therefore, screening of potential nosocomial bacteria in neonates on admission has become very important. The presence of bacteria based on laboratory testing should be reported to the clinicians who should take appropriate measures for the management of DRB immediately and prevent the spread of infection in neonatal wards [4].

As part of the monitoring system for nosocomial infections, bacteria screening plays an important role in the prevention and control of nosocomial infections caused by methicillin-resistant *Staphylococcus aureus* (MRSA) [5]. Current screening strategies have been extended for the prevention and control of nosocomial infections caused by multi-drug resistant Gram-negative bacteria. The multi-drug resistant bacteria mainly refer to the bacteria that are resistant to commonly used three or more types of antibacterial drugs. Screening of carbapenem-resistant *Escherichia coli (E. coli)* (CRE) has now been applied using anal swabs [6,7].

Previously, the main source of information on the prevention and control of nosocomial infections was via the bacteria culture and drug resistance monitoring system [8]. Screening of DRB was introduced in January 2010 in our hospital. From January 2012, additional patient barrier precautions, before testing, were fully implemented. The aim of this study was to

compare the clinical data of the two years and confirm the effectiveness of DRB screening in combination with patient barrier precautions, before testing, in decreasing the rate of nosocomial infections.

Methodology

Study population

The data source analyzed in this study was from the monitoring data of nosocomial infections in neonates in 2010 and 2012 (from the nosocomial infection office of the hospital). The basic information of the neonates hospitalized in our hospital were analyzed, including gestational week, age, gender, and birth weight. Ethics approval was waived by the local ethics committee due to the retrospective nature of our study.

Conventional management in 2010

Screening of neonatal DRB was started from January 2010, including MRSA, VRE, ESBLs, MRAB, and other multi-drug resistant bacteria. The chief resident of the neonatal ward and five nurses with neonatal nursing experience were involved in our study. Before starting the study, unified training was conducted for the staff. The nursing knowledge training for new nurses within five years of admission by experienced nurses provided in-depth information on potential errors to avoid by nursing practices that may lead to potential nosocomial infections. In addition, hands-on training on relevant nursing skills to promote risk prevention for new nurses increased awareness for improved quality of care. The samples of nasal and anal swabs of the admitted neonates were collected, and the detection of DRB was performed. A sterile cotton swab soaked in normal saline was used to swab the nasal vestibule of the neonates (nasal swab) and the anal radius of 1 cm range (anal swab). The swabs were put into tubes, immediately sent to the microbiology laboratory, and swabs were plated out onto the multi-drug resistant bacteria color plate for bacterial culture (Marcel Mérieux, France).

Improved management in 2012

In addition to the DRB screening, patient barrier precautions were implemented in 2012. Briefly, a dedicated isolation area was marked on the ground of each ward, and the patients newly admitted were placed in this area. The patients were clinically managed based on the laboratory results including the presence of any DRB. The samples of nasal swab and anal swab were collected for testing of the DRB. Isolation was lifted for the neonates with negative results for DRB within 2 days. The neonates with DRB colonization were transferred to another isolation room for continuous case management of DRB. These neonates were managed with higher levers of hygiene, such as more frequent hand washing, isolation of cases with DRB to prevent nosocomial infection, and environmental disinfection. No prophylactic antibiotics were used for the patients during 2010 and 2012.

Diagnostic criteria of nosocomial infection

Nosocomial infection was diagnosed according to the *Diagnostic Criteria of Nosocomial Infection 2001 (Trial implementation)* issued by the National Ministry of Health of China [8]. The diagnostic criteria were as follows: (1) the infection occurred 48 h after admission; (2) new infection occurred in any other parts of the body based on the original infection site caused by known bacteria; (3) infections acquired during delivery or the postpartum period; and (4) infections caused by diagnostic or treatment procedures, such as herpes virus and *Mycobacterium tuberculosis* [9].

Table 1. Characteristics of the neonates.

	2010 (*n* = 1280)	2012 (*n* = 1504)	*p*
Gestational weeks	**37.3 ± 4.9**	**37.7 ± 5.3**	**0.909**
< 37	445	511	
37-42	825	981	
> 42	10	12	
Age (day)	**6.5 ± 3.7**	**5.4 ± 2.5**	**0.429**
< 7	870	1001	
7–28	410	503	
Gender (male, %)	**701 (54.8%)**	**833 (55.4%)**	**0.743**
Birth weight (g)	**2.7 ± 0.96**	**2.8 ± 0.89**	**0.891**
< 1500	102	118	
1500–2500	392	481	
2500–4000	783	902	
> 4000	3	3	

Statistical analysis

SPSS 22.0 (IBM, Armonk, USA) was used for statistical analysis. The proportion or rate between the groups was compared using the *chi-square* test of independent samples. p-value less than 0.05 indicated a statistically significant difference.

Results

General information

A total of 1280 neonates in 2010 and 1504 neonates in 2012 were included in the analysis. No statistical difference was noticed between the two years in gestational weeks, age, gender, and birth weight (Table 1).

DRB colonization results

In 2010, single-drug-resistant bacteria colonization were detected in 260 neonates and multiple-drug-resistant bacteria colonization were detected in 146 neonates, which was not significantly different from that in 2012 (Table 2).

A total of 164 strains of DRB were detected in 1280 patients (12.8%) in 2010 versus 161 strains in 1504 patients (10.7%) in 2012 (Table 3). *E. coli*, *Klebsiella pneumoniae*, and *Staphylococcus epidermidis* were detected in both the years. *Staphylococcus hominis*, *Staphylococcus warneri*, *Klebsiella oxytoca*, *Enterococcus faecium*, *Staphylococcus xylosus*, and *Staphylococcus haemolyticus* were detected in 2010 only. In contrast, *Staphylococcus aureus*, *Acinetobacter baumannii*, *Aerobacter cloacae*, and *Enterococcus* were detected in 2012 only. In addition, two other bacterial species were detected in 2012 (Table 3).

Neonatal nosocomial infections

Nosocomial infection rate was significantly decreased from 2.34% (30/1280) in 2010 to 1.13% (17/1504) in 2012 ($p = 0.013$). There was no significant difference between the two years in the types of the responsible pathogens ($p = 0.764$, Table 4).

Discussion

Neonates hospitalized in the neonatal intensive care units are at increased risk for healthcare-associated infections because of their poor immune defense. Related risk factors include gestational age, surface colonization of pathogens, exposure to antibiotics, invasive procedures, and frequent contacts with health

Table 2. Neonates with drug-resistant bacteria colonization in 2010 and 2012.

	Neonates in 2010 (n = 1280)	Neonates in 2012 (n = 1504)	p
Single-drug-resistant bacteria	**260 (20.3%)**	**285 (18.9%)**	**0.366**
ESBL-producing *Escherichia coli*	95	106	
ESBL-producing *Klebsiella pneumoniae*	86	94	
Vancomycin-resistant *Enterococcus faecium*	35	38	
Methicillin-resistant *Staphylococcus aureus*	33	38	
Vancomycin-resistant *Enterococcus faecalis*	11	9	
Multi-drug-resistant bacteria	**146 (11.4%)**	**179 (11.9%)**	**0.685**

Table 3. Detected drug-resistant bacteria strains in 2010 and 2012.

	Strains	
	2010	**2012**
Escherichia coli	61 (37.2%)	53 (32.9%)
Klebsiella pneumoniae	37 (22.6%)	49 (30.4%)
Staphylococcus epidermidis	15 (9.1%)	8 (5.0%)
Staphylococcus hominis	4 (2.4%)	-
Staphylococcus warneri	4 (2.4%)	-
Klebsiella oxytoca	2 (1.2%)	-
Enterococcus faecium	2 (1.2%)	-
Staphylococcus xylosus	2 (1.2%)	-
Staphylococcus haemolyticus	37 (22.6%)	-
Staphylococcus aureus	-	15 (9.3%)
Acinetobacter baumannii	-	5 (3.1%)
Aerobacter cloacae	-	4 (2.5%)
Enterococcus	-	25 (15.5%)
Other bacteria	-	2 (1.2%)
Total	**164**	**161**

Table 4. Nosocomial infections and pathogens in 2010 and 2012.

	2010 (*n* = 30)	2012 (*n* = 17)	*p*
Thrush, *Candida albicans*	15	9	
Skin infection, *Staphylococcus epidermidis*	6	4	
Pneumonia, *Klebsiella pneumoniae*	3	2	
Sepsis, *Acinetobacter baumannii*	3	2	
Necrotizing enterocolitis, *Aerobacter cloacae*	3	0	

caregivers. Continuous educational strategies could improve hand hygiene and contribute to reduce the rate of neonatal infections [10]. A study emphasized the importance of infection prevention and control practices, and the role of trained professionals studying the transmission and prevention of infections in the healthcare setting [11]. Early detection of drug-resistant pathogens could aid in early implementation of appropriate antimicrobial therapy, thereby reducing morbidity and mortality [12].

In our study, DRB screening in the newly admitted neonates revealed that nearly one third of them had DRB colonization. Patients with gram-negative DRB colonization (*K. pneumoniae* and *E. coli*) accounted for 63.3%. These results were consistent with previous findings that the most common bacteria causing nosocomial infections in the neonates were gram-negative bacilli, especially multidrug-resistant strains [11,13]. It has been shown that bacterial strains isolated from blood cultures were mostly gram-negative bacteria (*Pseudomonas* species, *Salmonella* spp, *Acinetobacter baumannii*, *E. coli*, and *Klebsiella* spp), and that gram-negative bacteria outnumbered gram-positive ones in bloodstream infections [14]. Behzadnia et al. demonstrated that all the gram-negative and gram-positive bacterial species exhibited high resistance to antibiotics [15]. Nosocomial transmission might lead to nasal carriage of *Staphylococcus aureus*, which could cause *S. aureus* infection [16].

In 2012, the neonates with DRB colonization were transferred to the isolation room for continuous management of drug-resistant bacteria [17]. The rate of nosocomial infection was 2.34% in 2010 and 1.13% in 2010, which were slightly lower than that reported in the national hospital infection monitoring network data [18]. In our study, using newly admitted patient barrier precautions while waiting for test results significantly decreased the nosocomial infection rate from 2.31% in 2010 to 1.11% in 2010. In addition, education of hand washing, appropriate medical area, strict disinfection and isolation measures, and proper use of antibiotics are also essential measures in controlling infections. Closed suction systems, hand hygiene, and early weaning from the respirator are acceptable methods of preventing lower respiratory tract infection associated with mechanical ventilation in neonates with respiratory distress syndrome [19].

Our study has limitations. First, this is a retrospective study and lacks a proper control group. Second, our study was a single-center study with a limited sample size. All these limitations may introduce unrecognized confounding factors into our study. Therefore, our findings should be confirmed in future large-scale, multicenter studies.

Conclusion

DRB screening in combination with newly admitted patient barrier precautions may reduce the risk of neonatal nosocomial infections. This infection control system is inexpensive and easy to employ, therefore has its value for the developing countries where medical resources are often limited. However, further prospective investigation with a larger sample size is needed to verify our results.

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