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Research Progress in the Prevention and Control of Hospital-acquired Infections in Neonatal Units

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Abstract

Neonatal hospital-acquired infections are an important problem affecting the health and life safety of newborns. This paper reviews the research progress on the prevention and control of hospital-acquired infections in neonatology, discusses the risk factors of hospital-acquired infections in neonatology, summarizes the effective preventive and control measures such as strengthening the training and education on hospital-acquired infections, reducing invasive diagnostic and therapeutic operations, implementing disinfecting and isolating measures, rationally using antibiotics, and improving immunity for newborns, etc., and introduces common monitoring and detection techniques such as bacterial culture and drug susceptibility testing, molecular biology testing techniques, and biomarker detection and application. marker detection and application, and other commonly used surveillance and detection techniques. Future research should focus on strengthening the monitoring and study of pathogen resistance, optimizing the diagnosis and treatment process, strengthening the infection prevention and control training for healthcare workers, improving the infection prevention and control system in neonatal hospitals, and carrying out multidisciplinary collaborative research, so as to effectively reduce the incidence of infections and safeguard the health and safety of neonates.

1. Introduction

As medical technology continues to advance and the level of neonatal care improves significantly, the problem of neonatal hospital-acquired infections is increasingly attracting widespread attention. According to statistics, the incidence of hospital-acquired infections in neonatology is as high as 10-20 per cent, and even higher in some special cases, such as very low-birth-weight infants in intensive care

units. Such infections not only increase the length of hospital stay and healthcare costs for newborns, but can also lead to serious complications such as sepsis, meningitis and pneumonia, or even be life-threatening (JIANG, LI, LIAO, CHEN, & ZENG, 2023).

Pathogens of neonatal hospital-acquired infections mainly include bacteria, viruses and fungi, with bacterial infections being the most common, accounting for about 70-80% of neonatal hospital-acquired infections. Staphylococcus aureus, Escherichia coli and Klebsiella pneumoniae are common bacterial pathogens. These bacteria are usually highly drug-resistant, making infection control and treatment more difficult. Therefore, an in-depth study of preventive and control measures for hospital-acquired infections in neonatology is of great significance for safeguarding the health and life safety of newborns.

The purpose of this paper is to review the research progress on the prevention and control of hospital-acquired infections in neonatology, to explore the risk factors of hospital-acquired infections in neonatology, to summarise the effective preventive and control measures and to look forward to the future direction and trend of development. Through in-depth research and extensive publicity, we hope to raise the attention of healthcare institutions and healthcare workers to hospital-acquired infections in neonatology, strengthen the implementation of infection control measures, reduce the incidence of hospital-acquired infections in neonatology, and provide a better guarantee for neonatal health and life safety.

2. Overview of Neonatal Hospital-acquired Infections

2.1 Risk Factors for Neonatal Hospital-acquired Infections

The occurrence of neonatal hospital-acquired infections is associated with a number of factors, including the physiological characteristics of newborns, diagnostic and treatment operations and equipment use in healthcare facilities, poor hand-washing and glove use by healthcare workers, and unclean and incomplete disinfection of the ward environment (LI, LU, CAIn, WU & XU, 2020). These risk factors interact with each other to increase the risk of hospital-acquired infections in neonatology.

Firstly, the immune system of newborns is not yet fully developed and their resistance is weak, making them susceptible to infections. The immune system of newborns matures gradually after birth, but in the early stages of life, as the function of the immune system has not yet been perfected, the resistance of newborns is relatively low, and they are susceptible to infection by various pathogens. In addition, the skin and mucous membrane barrier function of newborns is weak, making them susceptible to invasion by bacteria and viruses and increasing the risk of infection. According to statistics, the incidence of hospital-acquired infections in neonatology is as high as 10-20 per cent, and in some special cases, such as very low-birth-weight babies in intensive care units, the incidence is even higher (Kong, Jiang, & Kong, 2019).

Secondly, the diagnostic and therapeutic operation and equipment use in medical institutions may increase the risk of infection. In neonatal units, some diagnostic operations and equipment use are

necessary, such as central venous catheters and ventilators. However, the use of these operations and equipment may also lead to the invasion of bacteria and viruses, increasing the risk of infection. For example, the use of central venous catheters may lead to bacterial infections, while the prolonged use of ventilators may lead to the development of ventilator-associated pneumonia. Statistically, the incidence of hospital-acquired infections in neonates with central venous catheters ranges from 3-10 per cent, while the incidence of hospital-acquired infections in neonates on ventilators ranges from 12-28 per cent (Niu, Cheng, Chen, Hu & Luo, 2019).

In addition, poor hand washing and glove use by healthcare workers are important risk factors for neonatal hospital-acquired infections. Healthcare personnel should strictly observe hand hygiene norms when contacting neonates, washing hands and changing gloves in a timely manner to reduce the transmission of pathogens and the occurrence of infections. However, in practice, due to busy workloads and inadequate hand-washing facilities, healthcare workers may have irregular hand-washing and improper use of gloves, increasing the risk of infection. According to statistics, hospital-acquired infections caused by irregular hand hygiene among healthcare workers account for 30-40 per cent of all hospital-acquired infections (WU, JIN, LI, TAN, & TIAN, 2018).

Finally, uncleanliness and incomplete disinfection of the ward environment are also important risk factors for hospital-acquired infections in neonatal units. The ward environment is an important place for neonates to live and be treated, and if the environment is not clean and disinfected thoroughly, it may lead to the spread of pathogens and the occurrence of infections. For example, incomplete cleaning and disinfection of items such as bed linen, clothing and toys may lead to the spread of bacteria and viruses. According to statistics, hospital-acquired infections due to unclean and incomplete disinfection of the ward environment account for 20-30% of all hospital-acquired infections (Dang, Sun, & Chen, 2017).

Therefore, the risk factors for hospital-acquired infections in neonatology mainly include the physiological characteristics of newborn babies, diagnostic and treatment operations and use of equipment in healthcare institutions, irregular hand-washing and use of gloves by healthcare personnel, as well as unclean and incomplete disinfection of the ward environment. Through in-depth study and understanding of these risk factors, we can take corresponding preventive and control measures to reduce the occurrence of neonatal hospital infections and protect the health and life safety of newborns.

2.2 Major Pathogens of Neonatal Hospital-acquired Infections

The main pathogens of neonatal hospital-acquired infections include bacteria, viruses and fungi. These pathogens may be transmitted through multiple routes, including contact, droplet, and vertical transmission, increasing the risk of infection and the difficulty of control. Understanding these pathogens is important for the prevention and control of neonatal hospital-acquired infections.

Bacterial infections are the most common type of pathogen in neonatal hospital infections, accounting for approximately 70-80% of all infections. Common bacterial pathogens include Staphylococcus aureus, Escherichia coli and Klebsiella pneumoniae (Liu, Qiao, Xu, Yan, Zhang, Li, Yang, & Sun,

2017). Staphylococcus aureus is an important pathogen that can cause skin and soft tissue infections, pneumonia and septicaemia. Escherichia coli and Klebsiella pneumoniae are common enteric bacteria that may cause serious infections such as diarrhoea and septicaemia in newborns. These bacteria are often highly drug resistant, making control and treatment of infections more difficult.

Viral infections are also one of the most important pathogens of neonatal hospital-acquired infections. Common viruses include respiratory syncytial virus, cytomegalovirus and influenza virus. Respiratory syncytial virus is one of the major pathogens causing respiratory tract infections in newborns, which may lead to symptoms such as pneumonia and respiratory distress. Cytomegalovirus is a common virus that can be transmitted through the vertical transmission route, causing damage to the liver, lungs and immune system of newborns. Influenza virus is also a common respiratory virus that may cause symptoms such as fever, cough and breathing difficulties in newborns.

Fungal infections are relatively rare among neonatal hospital-acquired infections, but are still more common in immunocompromised neonates. Candida is one of the most common pathogens in fungal infections and may lead to oral and intestinal infections. In addition, fungi such as Aspergillus and Candida albicans may also cause infections in neonates.

3. Preventive Measures and Detection Techniques

3.1 Existing Preventive Controls

Prevention and control of neonatal hospital-acquired infections is an important measure to protect the health and life safety of newborns. With the continuous progress of medical technology and research development, significant progress has been made in preventive and control measures for neonatal hospital-acquired infections.

1) Strengthening hospital infection training and education: Studies have shown that strengthening healthcare personnel's understanding of hospital infection and their awareness of prevention and control is the key to preventing and controlling neonatal hospital infections. By providing systematic training and education to healthcare workers and raising their level of awareness of hospital-acquired infections, the incidence of infections can be reduced. For example, training courses on infection control, regular seminars and training courses on infection control are organised to improve the prevention and control awareness and skills of healthcare workers.

2) Reduce invasive treatments and operations: invasive treatments and operations are important risk factors for hospital-acquired infections in neonatal units. Therefore, reducing invasive treatments and operations is one of the important measures to prevent and control neonatal hospital infections. Studies have shown that the proportion of invasive treatments and operations can be reduced by optimising the diagnostic and treatment process and adopting non-invasive diagnostic techniques, thus reducing the risk of infection. In addition, the strict implementation of aseptic operation procedures and operation norms is also an important means to reduce infections caused by invasive treatments and operations (Yu, Liu, & Yang, 2017).

3) Implementation of disinfection and isolation measures: Disinfection and isolation is a basic measure for the prevention and control of hospital-acquired infections in neonatology. Studies have shown that strengthening the cleaning and disinfection of the ward environment and regularly testing and replacing medical equipment can effectively reduce the spread of pathogens and the occurrence of infections. In addition, medical institutions should establish a perfect disinfection and isolation system, strengthen the hygiene guidance and supervision of healthcare workers, patients and visitors, and ensure the implementation of disinfection and isolation measures.

4) Reasonable use of antibiotics: Reasonable use of antibiotics is important for the prevention and control of neonatal hospital infections. Studies have shown that overuse and misuse of antibiotics may lead to an increase in bacterial resistance, making treatment of infections more difficult. Therefore, healthcare organisations should choose antibiotics reasonably according to the results of drug sensitivity tests of pathogens and strictly implement the antibiotic use standard. In addition, strengthening the regulation and management of antibiotics and avoiding unnecessary antibiotic use are also one of the important measures to prevent and control hospital-acquired infections in neonatology (XU, JIA, REN, YANG, YANG, LU, LIU, & LI, 2016).

5) Improve the immunity of neonates: the immune system of neonates is not yet fully developed, and their resistance is weak, making them susceptible to infections. Therefore, improving the immunity of newborns is one of the important means of preventing and controlling neonatal hospital infections. Studies have shown that the immunity of newborns can be enhanced and the occurrence of infections reduced through measures such as reasonable nutritional support and vaccination. In addition, strengthening the health management of newborns and conducting regular health check-ups and assessments are also one of the important measures for the prevention and control of neonatal hospital-acquired infections.

3.2 Surveillance and Detection Techniques for Hospital-acquired Infections in Neonatal Units

Surveillance and detection techniques for neonatal hospital-acquired infections play a crucial role in the prevention and control of infections. Timely and accurate surveillance and detection of pathogens can help to rapidly identify the source of infection, develop effective prevention and control strategies, and reduce the risk of infection transmission. The following are some of the commonly used surveillance and detection techniques and their rationale:

(1) Bacterial culture and drug sensitivity testing

Practice: Bacterial culture is performed to detect and identify pathogenic bacteria by culturing samples (e.g., blood, urine, throat swabs, etc.) of suspected infections. Drug susceptibility testing, on the other hand, involves testing the cultured bacteria for antibiotic susceptibility to determine which antibiotics are effective against the pathogenic bacteria (JIANG, WANG, WANG, LI, MAI, & LIN, 2014).

Principle: Bacteria grow and multiply on a suitable culture medium. By observing the morphology, colour and other characteristics of the colonies, the bacterial species can be initially identified. Drug sensitivity testing, on the other hand, is used to determine the sensitivity of bacteria to various

antibiotics by comparing the inhibitory effects of different antibiotics on bacterial growth.

(2) Molecular biology testing techniques (e.g., PCR, gene sequencing, etc.)

Approach: Polymerase Chain Reaction (PCR) is a technique used to amplify specific DNA sequences for rapid and sensitive detection of pathogens. Gene sequencing, on the other hand, identifies and analyses the species and characteristics of pathogens by determining their gene sequences.

Principle: PCR uses DNA polymerase to amplify the target DNA sequence under specific conditions and analyses the amplified product by fluorescent labelling or electrophoresis to detect pathogens. Gene sequencing, on the other hand, determines the species and characteristics of pathogens by measuring their gene sequences and comparing them with known databases.

(3) Detection and application of biomarkers

Approach: Biomarkers are molecules or substances that appear in the body in a specific disease or pathological state. By detecting biomarkers in samples such as blood and urine, the presence and severity of an infection can be indirectly determined.

Principle: Infection by different pathogens will cause different immune responses in the body and produce specific biomarkers. By detecting these biomarkers, the occurrence of infection can be detected at an early stage and timely intervention can be taken.

4. Case Studies

Infection control in neonatal sepsis

In a neonatal unit, a newborn was diagnosed shortly after birth with sepsis, a blood infection caused by bacteria, fungi or viruses. As the neonate's immune system is not yet fully developed, sepsis can deteriorate rapidly, making prompt and effective management essential.Infection management process:

(1) Rapid recognition and diagnosis

The healthcare provider assesses the newborn immediately after the onset of symptoms such as unstable temperature, shortness of breath, and loss of appetite.

Blood cultures and routine blood tests are performed rapidly to determine the presence of infection and possible pathogens.

(2) Isolation Measures

The affected child is immediately isolated to prevent transmission of the infection to other newborns.

Implement contact precautions to ensure that hand hygiene and the wearing of personal protective equipment (e.g., gloves, isolation gowns) are strictly adhered to by all healthcare workers who come into contact with the child.

(3) Antimicrobial therapy

Based on the initial diagnosis, immediately begin empirical antibiotic therapy to cover possible pathogens.

Once blood culture results are returned, the antibiotic regimen is adjusted based on drug sensitivity testing to ensure targeted treatment.

(4) Supportive Treatment

Provide necessary life support such as oxygen therapy, intravenous nutrition, and equipment to maintain body temperature.

Regularly monitor the child's vital signs and laboratory indicators to assess the effectiveness of treatment and adjust the treatment plan.

Environmental disinfection and device management:

Cleanliness and disinfection of the ward environment, especially the children's bed units and surroundings, were reinforced.

All medical devices used undergo strict cleaning, disinfection and sterilisation procedures.

(5) Monitoring and feedback

Continuous monitoring of the clinical progress of the child and regular assessment of the effectiveness of infection control measures.

Feedback and re-education were provided to all relevant healthcare workers to ensure that they were aware of and adhered to best practices in infection prevention and control.

(6) Results

As a result of these treatments, the child's infection was controlled and symptoms gradually improved. During subsequent surveillance, no other neonates were found to be infected, indicating that isolation and infection control measures were effective.

(7) Lessons learnt

Rapid recognition and diagnosis are critical, and prompt treatment can significantly improve the prognosis of the child.

Strict isolation measures and personal protection are important to prevent the spread of infection.

Ongoing surveillance and feedback helps to optimise infection control strategies and ensure that healthcare workers are following best practice.

5. Conclusions and outlook

5.1 Conclusions

Neonatal hospital-acquired infections are an important problem affecting the health and life safety of newborns. With the advancement of medical technology and the development of research, significant progress has been made in the prevention and control of neonatal hospital-acquired infections. However, neonatal hospital-acquired infections still face many challenges, such as pathogen resistance, insufficient medical resources, and insufficient awareness of infection prevention and control among healthcare workers.

5.2 Outlook

Strengthen pathogen resistance monitoring and research: Establish a comprehensive pathogen resistance monitoring system, conduct in-depth research on drug resistance mechanisms, and develop new antibiotics and antiviral drugs to cope with the increasingly serious drug resistance problem.

Optimise diagnostic and treatment processes and reduce invasive operations: Promote non-invasive diagnostic and treatment techniques, shorten the duration of invasive operations and reduce the risk of infection.

Strengthen infection prevention and control training for healthcare workers: improve the infection prevention and control awareness and skills of healthcare workers, and standardise hand hygiene, disinfection and isolation operations to reduce the risk of infection transmission.

Improve the infection prevention and control system of neonatal hospitals: establish and improve the infection prevention and control management system of neonatal hospitals, strengthen environmental cleaning and disinfection, optimize the allocation of medical resources, and improve the ability of infection prevention and control.

Carry out multidisciplinary research: Combine experts from clinical medicine, microbiology, epidemiology and other disciplines to carry out in-depth research on the prevention and control of hospital-acquired infections in neonatal hospitals, so as to provide a scientific basis for clinical practice.

By strengthening the prevention and control of hospital-acquired infections in neonatology, the incidence of infections can be effectively reduced, the health and life safety of newborns can be safeguarded, and contribution can be made to the improvement of the quality of medical care in neonatology.

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