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Substantial Decreases in Catheter-Related Bloodstream Infections among Neonates: A Descriptive Study

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Abstract

Introduction: The colonization of intravascular catheters, leading to subsequent bloodstream infections, is a common cause of nosocomial infections in newborns. This study aimed to assess the microbial colonization of intravascular catheters in newborns admitted to the Special Care Baby Unit (SCBU) at a 550-bed Children's Hospital in Mandalay during the period from January to September 2015.

Methods: A total of 84 newborns, with or without clinical sepsis, were selected for the study. The intravascular catheters were cultured using a semi-quantitative (roll plate) method. Additionally, peripheral blood samples were collected from 35 patients with clinical sepsis and intravascular catheters for conventional culture. Antimicrobial susceptibility testing was conducted following CLSI guidelines.

Results: Microbial colonization occurred in 17.9% (15/84) of cases, with no instances of catheter-related bloodstream infection (CRBSI) identified. The predominant microorganism was coagulase-negative staphylococci (CoNS) in 53.3%, followed by Staphylococcus aureus (33.3%), Enterococcus species (6.7%), and Enterobacter species (6.7%). Methicillin resistance was observed in 25% of CoNS, and methicillin-resistant Staphylococcus aureus (MRSA) was present in 80% of the Staphylococcus aureus isolates. Isolated Enterococcus species exhibited resistance to cloxacillin and oxacillin, while Enterobacter species were resistant to gentamicin and cefotaxime.

Conclusions: This study highlights the occurrence of microbial colonization on intravascular catheters in newborns, along with the susceptibility patterns of the identified microorganisms. The findings contribute valuable insights for pediatricians in antibiotic selection and offer practical healthcare guidance for controlling nosocomial bloodstream infections.

Keywords: Colonization; CRBSI; Newborn babies.

Introduction

Intravascular catheters play a crucial role in the medical care of hospitalized patients. However, a significant drawback of these medical devices is the potential colonization by bacteria or fungi, leading to catheter infections and severe bloodstream infections. This consequence represents a major source of nosocomial illness and, in some cases, fatal outcomes [1].

Neonates, whether born at term or preterm, face an elevated risk of nosocomial infections due to their reduced immunity. In neonatal intensive care units (NICUs), nosocomial infections, including bloodstream infections (BSIs), predominantly catheter related (CRBSI), pose a significant challenge [2].

Vascular access is indispensable in modern neonatal intensive care, with intravascular catheters disrupting the skin's protective barrier, providing a pathway for microorganisms to enter the bloodstream [3]. For microorganisms to cause CRBSI, they must initially gain access to the catheter's external or internal

surfaces, forming a biofilm that facilitates sustained infection and hematogenous dissemination [4]. The skin insertion site is a major source of colonization for short-term catheters, with organisms migrating along the external surface and subcutaneous segments, potentially leading to catheter tip colonization and bloodstream infection [5]. Fibrin sheath and biofilm production occur within 24 hours of catheter placement [6].

Given that patient skin and medical personnel hands are primary sources of catheter colonization, staphylococci—especially coagulase-negative staphylococci and Staphylococcus aureus—are leading causes of CRBSIs. Most gram-negative bacilli causing CRBSIs are acquired from the hospital environment, and Candida species, associated with glucose-containing infusions and total parenteral nutrition, also colonize on medical personnel hands [5]. The presence of central venous catheters stands out as the most crucial risk factor for nosocomial candidemia and Staphylococcus aureus bacteremia [4]. Preterm infants face a higher infection risk due to immature immune responses, decreased immunoglobulin concentrations, and compromised gut barrier function. The breakdown of the skin's barrier function adds to the host-related factors contributing to the risk of nosocomial sepsis and CRBSI [2].

Very low birth weight infants (VLBW) are particularly susceptible to infections, with the smallest and least mature infants facing the highest risk. Catheter-related bloodstream infections significantly contribute to elevated morbidity and mortality, prolonged hospital stays, and the necessity for additional therapies [7]. In recent years, the escalating incidence of antimicrobial resistance has emerged as a serious global threat. The rates of methicillin-resistant Staphylococcus aureus (MRSA), vancomycin-resistant enterococci (VRE), and other resistance patterns have been on the rise worldwide [8].

Diagnosing nosocomial infections, including catheter-related bloodstream infections (CRBSI), in neonates poses a challenge for pediatricians in the Neonatal Intensive Care Unit (NICU). Neonates with sepsis often present with nonspecific symptoms and detecting infectious foci can be challenging. Interpreting the clinical significance of microbiological results, especially coagulase-negative staphylococci (CoNS), is also a complex task [2]. Catheter-related bloodstream infections are frequently challenging to treat, with antimicrobial prophylaxis and treatment becoming increasingly difficult due to multidrug-resistant organisms. Timely and accurate epidemiological information is crucial for guiding appropriate empirical therapy.

Therefore, this study aimed to isolate and identify microorganisms colonizing intravascular catheters and causing CRBSI in neonates. Additionally, drug-resistant microorganisms were identified, and antimicrobial susceptibility testing was conducted to determine the in vitro activities of antimicrobial agents against local isolates as promptly as possible.

Methods and Materials

A case-series observational descriptive study was conducted in the Special Care Baby Unit (SCBU) of a 550-bedded Children's Hospital in Mandalay from January to September 2015. The study aimed to investigate bacterial colonization of intravascular catheters in newborns. Eighty-four newborns, with or without clinical sepsis, were selected for detecting bacterial colonization. Among them, only neonates with clinical sepsis, determined by pediatricians in the presence of an intravascular catheter, were chosen for blood culture to detect catheter-related bloodstream infection (CRBSI). Contaminated catheters during removal and neonates with clinical sepsis upon admission were excluded during the study period.

From each patient, one intravascular catheter tip was collected under aseptic conditions, whether routinely replaced every 3 days or removed after signs of inflammation appeared. The distal end was cut with sterile scissors, placed in a sterile container, and promptly transported to the laboratory. Each catheter tip was cultured using the semi-quantitative (roll plate) method on blood agar media. Colonization of bacteria was considered when more than 15 colony forming units (CFUs) were found in culture after overnight incubation. Siliconized intravascular catheter tips made of Teflon were collected every Monday and Tuesday.

When bacterial growth was observed from catheter tip cultures, colonial morphology, haemolysis pattern, and gram-stained smears were examined. The representative colony was subcultured on appropriate culture media for identification. Various tests, including catalase, slide and tube coagulase, bile esculin, indole, Methyl Red, Voges-Proskauer, citrate utilization, urease, sugar fermentation, and motility tests, were performed for the identification of isolated microorganisms.

Peripheral blood samples from 35 patients with clinical sepsis, as determined by pediatricians in the presence of an intravascular catheter, were cultured using the conventional method. Approximately 1 ml of blood was collected under aseptic conditions, added to a sterile blood culture bottle with brain heart infusion broth, and promptly transported to the laboratory. Inoculated blood culture bottles were incubated and examined daily for up to 7 days for signs of bacterial growth (Figure 1).

Upon visible growth, gram-stained smears were conducted, and subcultures were performed on appropriate culture media. If no visible growth occurred, a blind subculture was done on blood agar and MacConkey agar media on the seventh day. Antimicrobial susceptibility tests were conducted using the modified Kirby-Bauer disc diffusion method. The Clinical and Laboratory Standards Institute (CLSI) zone size interpretation charts were utilized to identify susceptible and resistant isolates. Data were collected in a proforma, entered into a data master sheet, and analyzed using STATA13 statistical software after ensuring data completeness.

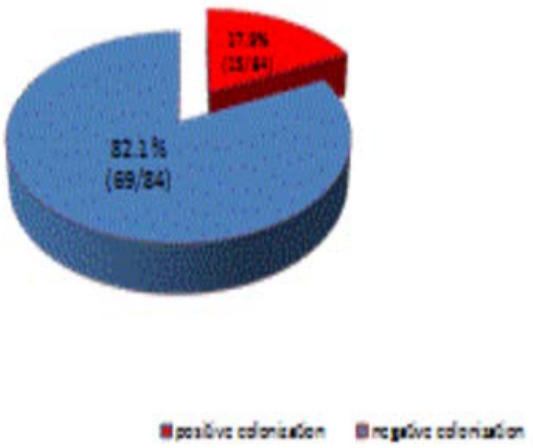

Figure 1: Microbial colonization of intravascular catheters.

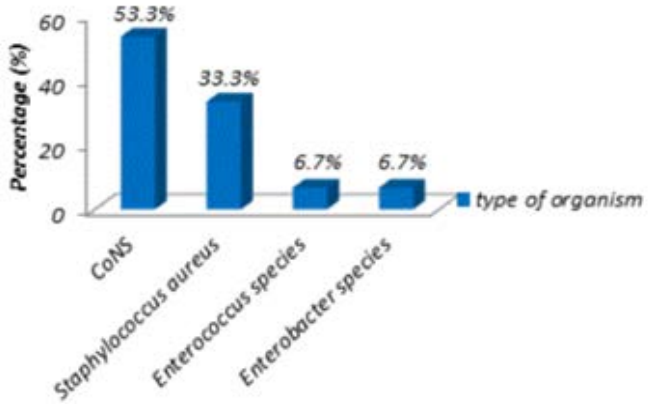

Figure 2: Microorganisms isolated from intravascular catheters.

Results

Out of the 84 catheter tips analyzed, intravascular catheter colonization occurred in 15 catheters, representing a prevalence of 17.9%. It is noteworthy that all instances of colonization were observed in short-term intravascular catheters, and no cases were identified in central venous catheters (CVCs) during the study period.

For the 35 newborns with clinical sepsis, as determined by pediatricians, both blood samples and intravascular catheter tips were collected to detect catheter-related bloodstream infection (CRBSI). Among the 35 blood samples analyzed, microorganisms were isolated from 4 samples. However, there was no growth observed in the intravascular catheter tip samples. Consequently, CRBSI was not detected during the study period.

The occurrence of microbial colonization of intravascular catheters varied across different newborn categories. Preterm newborns exhibited a higher occurrence at 30%, whereas term babies had an occurrence of 11.1%. Very low birth weight newborns showed the highest microbial colonization at 60%, followed by low birth weight (25%), normal birth weight (8.7%), and extremely low birth weight newborns showed no occurrence.

Among the 15 cases of intravascular catheter colonization, four types of microorganisms were isolated: Coagulase-negative staphylococci (CoNS), Staphylococcus aureus, Enterococcus species, and Enterobacter species. CoNS was the most prevalent, accounting for 53.3% (8 out of 15), followed by Staphylococcus aureus at 33.3% (5 out of 15), Enterococcus species at 6.7% (1 out of 15), and Enterobacter species at 6.7% (1 out of 15).

Discussion

Antimicrobial susceptibility testing for gram-positive cocci revealed that Coagulase-negative staphylococci were 100% sensitive to amoxicillin/clavulanic acid and vancomycin. Sensitivity to ampicillin, cloxacillin, oxacillin, and amoxicillin/flucloxacillin ranged from 75% to 87.5%. Staphylococcus aureus showed 100% sensitivity to amoxicillin/clavulanic acid and vancomycin but 100% resistance to ampicillin. Sensitivity to cloxacillin, oxacillin, and amoxicillin/flucloxacillin ranged from 20% to 40%. Enterococcus species were totally sensitive to ampicillin, amoxicillin/flucloxacillin, amoxicillin/clavulanic acid, and vancomycin, while resistant to cloxacillin and oxacillin. In this study, 80% of MRSA (methicillin-resistant Staphylococcus aureus) was isolated, showing simultaneous resistance to ampicillin and cloxacillin.

Antimicrobial susceptibility testing for gram-negative bacilli indicated that Enterobacter species were sensitive to imipenem, amikacin, ceftazidime/sulbactam/cefoperazone but resistant to gentamicin and cefotaxime.

In this study, 84 intravascular catheters were collected from newborns with day one onwards, with or without clinical sepsis. The occurrence of microbial colonization of intravascular catheters was noted in 15 out of 84 catheters, accounting for 17.9%. This result is comparable to findings in other studies, such as Ohnmar Kyaw-Myint [9], who reported a colonization rate of 11.7% in an ICU setting.

Compared with a variety of studies, the present study's findings align closely with some, like Hnin-Phyu [10], who reported a 29.5% colonization rate in blood dyscrasia patients. However, other studies indicated higher rates, ranging from 37% in an NICU ward in Iran to 61.8% in adult patients at YGH in 2005.

Several factors could contribute to the lower culture positivity observed in the present study. The inclusion of sample catheters from day one onwards, insertion under strict aseptic conditions, and routine replacement by experienced healthcare staff might have influenced these results. Additionally, the focus on

peripheral venous intravascular catheters, excluding central venous catheters, and the use of Teflon catheters, known for lower vulnerability to microbial colonization, could be contributing factors.

The study did not identify any cases of catheter-related bloodstream infection (CRBSI) in patients with peripheral venous intravascular catheters. The absence of central venous catheters during the study period and routine replacement or removal by experienced healthcare staff likely contributed to this lack of CRBSI detection [11-15].

The study population included both term and preterm neonates, with preterm neonates showing a higher risk of infection due to their immature immune systems. The occurrence of microbial colonization of intravascular catheters did not show correlation with sex, but 60% of colonization cases occurred in very low birth weight infants.

Staphylococci, known for their ability to form biofilms on indwelling polymeric devices, were identified as a major cause of catheter colonization. Fungi, common in very low birth weight infants, were not isolated, possibly due to antifungal prophylaxis. Coagulase-negative staphylococci (CoNS) frequency was high, likely due to migration of skin flora, the commonest route of contamination for short-term intravascular catheters.

The sensitivity pattern revealed that vancomycin and amoxicillin/clavulanic acid were the most effective drugs against CoNS and Staphylococcus aureus. All methicillin-resistant Staphylococcus aureus (MRSA) isolates were susceptible to vancomycin. Challenges in evaluating the antimicrobial susceptibility pattern of Enterococcus species and Enterobacter species were noted due to the small sample size.

Conclusion

In conclusion, this study conducted in the Special Care Baby Unit (SCBU) of the 550-bedded Children's Hospital in Mandalay revealed a microbial colonization rate of 17.9% in intravascular catheters, despite adherence to good insertion practices. The occurrence of microbial colonization was directly related to gestational age and birth weight. Preterm, low birth-weight infants were identified as more susceptible to microbial colonization compared to term and normal birth-weight infants.

The study emphasizes the critical role of proper hand hygiene and aseptic techniques during the insertion and care of intravascular catheters as essential preventive measures against colonization and subsequent bloodstream infection.

Based on the antibiograms obtained from this study, the recommended drugs for gram-positive cocci were vancomycin and amoxicillin/clavulanic acid, while for gram-negative bacilli, imipenem, amikacin, ceftazidime, and sulbactam/cefoperazone were indicated.

Conflict of Interest

The authors declare no conflicts of interest in conducting this study.

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