Original Article

Finding the Sources of Septicemia at a Neonatal Intensive Care Unit: Newborns and Infants Can Be Contaminated While Being Fed

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SUMMARY: This study was conducted to determine whether the hospital devices and materials used for the examination and treatment of patients play a role in the outbreaks of infection in hospitals. Environmental sampling was performed to find the possible sources of septicemia at the neonatal intensive care unit (NICU). Environmental sampling results and blood culture records from the outbreak areas were compared to determine if they had any relationship with each other. Semisolid and solid samples were compared with liquid samples for positive cultures using a chi-square test. Statistical significance was accepted at \( P < 0.05 \). The results showed that liquid sources were more frequent media for infectious agents (OR, 8.75; chi-square, 0.0278). The most common cultured microorganisms were coagulase negative \textit{Staphylococcus} and \textit{Klebsiella pneumoniae}, which were responsible for septicemias at NICU. There were strong relationships between environmental culture results and the agents responsible for the outbreak of septicemia at the NICU. The formula heater at the pediatric clinic also revealed the same microorganisms with the blood cultures of 3 patients in the same clinic. Although there are matches between the environmental sampling and blood culture records in our study, there is a need for further studies. We conclude that moist areas and liquid environments must be regularly checked for pathogen microorganisms. Instead of using heated water to sterilize infant formula, dry air sterilization should be used. Liquid media like oxygen reservoir solution and antiseptic solutions must be checked for contamination and should be changed periodically.

INTRODUCTION

During septicemia outbreaks, finding the sources of infection is very important in order to take preventive measures, eradicate the detected sources, and keep healthy individuals away from the sepsis. Adult, neonatal, and surgical intensive care units (ICUs), as well as burn units are especially common sites of septicemia outbreaks. Septicemia in either ICUs or neonatal intensive care units (NICUs) is a big problem worldwide. Here, the authors report a study that was designed to identify potential sources of infection during a septicemia outbreak involving \textit{Klebsiella pneumoniae} and coagulase negative \textit{Staphylococcus} (CNS) at an NICU.

MATERIALS AND METHODS

The approval of the local ethical committee was received, and informed consent was obtained from the patients and families when necessary. The study was conducted in Süleyman Demirel University Medical School Hospital, Isparta, Turkey. The hospital has an infection control committee with an active infection control policy covering 400 patient beds including two ICUs and seven operating rooms. During the outbreaks of \textit{K. pneumoniae} and CNS septicemia at the NICU, in order to identify potential sources of infection, we obtained cultures from all potential sources in almost all clinics and ICUs in our hospital. A total of 71 environmental sampling cultures were collected from the departments of obstetrics and gynecology, pediatrics, plastic surgery, emergency, internal medicine, urology, ear-nose-throat, pediatric surgery, ICU, and NICU. The cultures were taken from the special devices and materials that are commonly used in clinics for the examination and treatment of the patients. These potential sources of infection in the hospital can be divided into three groups: liquid, solid, and semisolid materials. The moistened swab technique was used to take cultures from examination devices such as stethoscopes, otoscopes, and other metal devices used for wound care like scissors and clamps. The swab technique was also used to take cultures from semisolid materials such as antibiotic ointments and other ointments including panthenole, vaseline, and lidocaine hydrochloride (HCl). Cultures from liquid sources such as alcohol, 10% benzalkonium chloride, oxygen reservoir solution, prilocaine HCl, floor cleaning solution, distilled water, acid borique, ethacridinlactat, formula-heater water, and formula were taken directly by swab. In our hospital, all liquid media were changed periodically; alcohol, benzalkonium chloride, prilocaine HCl, ethacridinlactat, and acid borique were changed every week; distilled water, floor cleaning solution, formula-heater water, and oxygen reservoir solution were changed every other day. All collected cultures were placed in transport media and inoculated onto trypticase soy agar with 5% sheep blood and eosin methylene blue agar, incubated at 37°C for 48 h and examined for colony growth at 24 h and 48 h. Blood culture records were retrospectively collected for a 14-day period that included the 7 days before and after outbreaks of \textit{K. pneumoniae} and CNS in the NICU, ICU, and pediatrics clinics. The culture records of the pediatrics clinic and ICU were included because the ICU was
located near the NICU, and the pediatrics clinic had very close patient relations with the NICU. Cultures from the outbreak areas and related areas were compared with the collected cultures from the potential sources around the hospital. CNS was defined as a Gram-positive catalase-positive and coagulase-negative coccus. An oxidation-fermentation test was performed for Micrococcus-Staphylococcus differentiation. Colonies that grow in both oxidation and fermentation media were accepted as Staphylococcus. K. pneumoniae colonies were identified by Api 32E (BioMerieux Inc., Marcy l’Etoile, France). Inactive Escherichia coli was identified by Api 32E, and by motility and triple sugar iron tests. Statistical significance was determined with the chi-square test for the qualitative assessment of the reservoir of the infections between liquid and semisolid-solid materials. Statistical significance was accepted at $P < 0.05$.

**RESULTS**

Out of a total of 71 environmental cultures taken from the potential sources of infection in the clinics, only 8 cultures were positive; 7 positive cultures came from liquid samples (7/35) and 1 positive culture came from solid or semisolid samples (1/36). (OR, 8.75; chi-square, 0.0278) (Table 1). The positive cultures showed that CNS was isolated from water obtained from the two formula heaters in the NICU and the pediatrics clinic, and K. pneumoniae was cultured directly from the formula-heater water. The only nonliquid environment positive culture was lidocaine HCl, in which colonization of inactive E. coli was detected. The microbiological records of a total of 33 positive blood cultures from 23 patients in the ICU, NICU and pediatrics clinics were retrospectively checked in order to compare them with the positive culture results of the potential sources of hospital infections (Table 2). The cultures from 12 patients at the NICU revealed that CNS and K. pneumoniae (n = 8 for either) were the most frequent isolates, followed by Streptococcus viridans (n = 2), Enterobacter cloacae (n = 1) and Enterococcus spp. (n = 1). From 8 patients at the ICU, 4 Acinetobacter baumannii, 4 Streptococcus pneumoniae, 1 CNS, and 1 K. pneumoniae were grown in blood cultures. One K. pneumoniae and 2 CNS isolates were found in the cultures from 3 patients in the pediatrics clinic (Table 2).

**DISCUSSION**

Finding the correct source of septicemias in clinics is very important. Outbreaks of septicemia in ICUs or NICUs are an especially big concern throughout the world. Those nosocomial infections may be due to fomites or transient colonization of the skin of health personnel working in both ICU and NICUs. Therefore, we must prevent the introduction of epidemic microorganisms from colonized patients or heath personnel by restricting the admission of colonized patients from other ICUs and by means of strict disinfection/antiseptic procedures for all potential sources of pathogen microorganisms (1).

In our study, we studied the colonization of ICU devices like formula heaters and liquid media like formula and oxygen reservoir solution (distilled water) by microorganisms prevalent in the NICU outbreak. K. pneumoniae and CNS were responsible for the NICU outbreak. The bacteria responsible for this outbreak were also identified in the formula and formula-heater water in the NICU and in the formula-heater water in the pediatrics clinic. Four-fifths of all microorganisms found in the positive blood cultures from the NICU (a total of 20 positive blood cultures; CNS, 8; K. pneumoniae, 8) matched the microorganisms in the cultures collected from the NICU (formula-heater water; K. pneumoniae, CNS). Also, in the pediatrics clinic, the colonization of formula-heater water by CNS and K. pneumoniae matched the positive cultures from the patients at the pediatrics clinics (the cultures from 3 patients in the pediatrics clinic revealed 1 K. pneumoniae and 2 CNS isolates).

The septicemia might be caused by microorganisms present in formula and in formula-heater water. To determine whether formula and formula-heater water are responsible for septi-cemia in the NICU, genetic analysis is needed as well as an extensive environmental survey in a case control study (2). However, according to the culture results, the potential risk of formula-heater water and formula contamination is evident; consequently, the need for clear-cut measures to prevent patient infection from these liquid media is also evident.

The sources of septicemias can be in different locations and different devices, intravascular catheters, implants such as prosthetic valves, drugs, and other therapeutics such as polygeline (a plasma expander), patients, and even doctors (2-4). Infections diagnosed in children at a pediatric ICU might also be due to microorganisms present in the patients’ admission flora (5). In the literature, it is also stated that catheter-related sepsis is one of the most common causes of bacteremia in ICU and NICU patients (6,7). CNS was one of

| Table 1. Positive cultures from the environmental sampling with the comparison of liquid, solid and semisolid sources of the pathogen microorganisms |
|---------------------------------|-----------------|-----------------|
| Liquid                          | Semisolidsolid  |
| Positive culture                | 7               | 1               |
| Negative culture                | 28              | 35              |
| Total                           | 35              | 36              |

OR, 8.75; chi-square, 0.0278. $P < 0.05$.

| Table 2. Blood culture records of the patients at NICU, ICU and pediatrics clinic before and after 7 days of outbreaks of K. pneumoniae and CNS at the NICU |
|---------------------------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| Acinetobacter baumannii         | Streptococcus pneumoniae | Streptococcus viridans |
| NICU                            | 8                | 8               | 1               | 1               | 4               | 4               |
| ICU                             | 1                | 1               |                 |                 |                 |                 |
| Pediatrics clinic               | 1                | 2               |                 |                 |                 |                 |

NICU, neonatal intensive care unit; CNS, coagulase negative Staphylococcus.
the common cultured microorganisms in our environmental sampling and in blood cultures of the patients in our series. CNS is a commonly found pathogen that causes infections of the bloodstream, the lower respiratory tract, and the urinary tract, although the presence of CNS in blood cultures is usually thought to be a contamination (8,9). As shown in our study, environmental sources can be contaminated with potentially dangerous bacteria and may pose a risk of nosocomial infection. Moisturized media and liquid materials are especially important sources of pathogen microorganisms. Liquid media like formula-heater water, oxygen reservoir solution, and 10% benzalkonium chloride contained many pathogen microorganisms that matched the bacteria that were responsible for the outbreaks in the NICU and that also matched the blood cultures of the patients at the pediatrics clinic. However, the environmental sampling of solid and semisolid materials revealed only one microorganism. In the literature, solid environments have also proven to be responsible for nosocomial infections in pediatric patients. The equipment (e.g., stethoscopes and otoscopes) and staff members, and particularly the hands of staff members, might be responsible for hospital infections (10). It has also been reported that bacterial colonization of toys in the NICU and a nosocomial toys-associated outbreak by *Pseudomonas aeruginosa* might also be responsible for outbreaks of septicemias and hospital infections (11-14). Different objects such as utensils, toys, and clothes can serve as vectors, especially for *Shigella* spp. and for other microorganisms (15).

In conclusion, medical devices used in a hospital can be contaminated with potentially dangerous bacteria and may pose a great risk of nosocomial infection. Effective measures must be implemented to prevent the spread of infections via medical devices. Hospital infections are generally due to highly antibiotic-resistant microorganisms that can be easily transmitted among patients in ICUs. In all patients with long-time ICU and NICU stays, strict epidemiological surveillance should be made after routine cultures of the patients are taken. We should also record the antibiotic therapy, instrumentation, and resistance to antibiotics. Because the microorganisms that cause epidemics may be found everywhere in hospitals, infection control procedures must be increased by committees such as infection control committees. Although there is a match between the blood cultures from the patients and the environmental sampling cultures at the NICU and pediatrics clinic, further research is needed to evaluate the potential role of formula and formula-heater water as fomites in hospital infections and as reservoirs for potentially pathogenic microorganisms that can influence the bacterial flora in hospitals.

Our study showed that dry air sterilization of formula should be used rather than water heater sterilization. Liquid media like oxygen reservoir solution, floor cleaning solution, and 10% benzalkonium chloride must be regularly checked for pathogen microorganisms and must be changed very often and also sterilized with their containers. The modest medical costs incurred through the procedures for the isolation and identification of the bacteria obtained from environmental cultures are far lower than the cost of treating septicemic patients in an outbreak.

REFERENCES