

Chlorhexidine-Impregnated Dressings and Prevention of Catheter-Associated Bloodstream Infections in a Pediatric Intensive Care Unit

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BACKGROUND Bloodstream infections related to use of catheters are associated with increased morbidity and mortality rates, prolonged hospital lengths of stay, and increased medical costs.

OBJECTIVES To compare the effectiveness of chlorhexidine-impregnated dressings with that of standard dressings in preventing catheter-related bloodstream infections.

METHODS A total of 100 children were randomly divided into 2 groups of 50 each: a chlorhexidine group and a standard group. Patient care was provided in accordance with prevention bundles. Patients were followed up for development of catheter-related bloodstream infections.

RESULTS Catheter colonization occurred in 4 patients in the standard group (8%) and in 1 patient in the chlorhexidine group (2%). Catheter-related bloodstream infections occurred in 5 patients in the standard group (10%) and in 1 patient in the chlorhexidine group (2%). Although more patients in the standard group had catheter-related bloodstream infections, the difference in infection rates between the 2 groups was not significant ($P = .07$).

CONCLUSIONS Use of chlorhexidine-impregnated dressings reduced rates of catheter-related bloodstream infections, contamination, colonization, and local catheter infection in a pediatric intensive care unit but was not significantly better than use of standard dressings. (*Critical Care Nurse*. 2016;36[6]:e1-e7)

Central venous catheterization is among the most frequently used procedures in the intensive care unit (ICU).¹ Bloodstream infections or catheter-related bloodstream infections (CRBSIs) are common inherent complications of catheterization.² The Centers for Disease Control and Prevention (CDC) describe CRBSI as a clinical definition that requires specific laboratory testing to more thoroughly identify the catheter as the source of the infection.³

CRBSIs extend the length of hospitalization by adversely affecting morbidity and mortality in pediatric ICUs (PICUs). Increases in the use of drugs, laboratory tests, and other diagnostic methods result in an increased economic burden for health care services.⁴ In the United States, adult and pediatric ICUs combined have approximately 15 million catheter days per year. Proportionate to this number, almost 80 000 CRBSIs are diagnosed.⁵ In addition, catheter-related infections increase mortality by 12% to 25%.³

According to the 2004 report of the International Nosocomial Infection Control Consortium,⁶ the rate of CRBSIs in 54 PICUs was 6.6 per 1000 ventilator days, which is quite high compared with the rate in adult ICUs.

Cleansing the skin with antiseptic solutions before catheter placement helps prevent catheter-related complications. Povidone-iodine is the agent most frequently used for this purpose.¹ The CDC recommends chlorhexidine

Covering catheters with a chlorhexidine-impregnated dressing can reduce catheter colonization and CRBSIs.

and povidone-iodine for catheter care.³ Nursing practice plays a major role in

preventing CRBSIs in the PICU. Examples of preventive practices include avoiding extended catheterization and unnecessary removal of catheters, ensuring that health care providers (including nurses) follow proper hand hygiene when providing catheter care for patients, using proper solutions in catheter care, inserting catheters

under maximal sterile barrier conditions, and using suitable dressings.⁷

Evidence^{3,8} indicates that covering catheters with a chlorhexidine-impregnated dressing can reduce catheter colonization and CRBSIs. However, little research, especially in children, is available on products used to cover central venous catheters and on which materials are effective in preventing CRBSI. The purpose of our research was to compare the efficacy of a chlorhexidine-impregnated dressing with that of a standard dressing in preventing CRBSIs. We hypothesized that covering catheters with a 2% chlorhexidine-impregnated dressing is more effective than using a sterilized pad.

Methods

We performed a randomized, controlled experimental study. The data were gathered between December 2012 and January 2014 in the PICU of a university hospital in Istanbul, Turkey. The 6-bed PICU admits an annual mean of 100 to 150 patients who have acute respiratory failure, sepsis, shock, multiple organ failure, or poisoning or who require postoperative follow-up.

This study was performed in accordance with the Declaration of Helsinki. Approval was granted by the academic board of the pediatrics department and the local ethics board of the university hospital before the research began. The families of the children involved in the study were provided information about the study and gave written consent.

Sample

The sample consisted of patients admitted to the PICU. We used NASS and PASS statistical software (NCSS, LLC) to perform a power analysis and determine the number of patients required. We found that a minimal sample size of 61 patients would have 80% power to detect a difference of 19% between development and no development of CRBSIs, as reported previously,^{3,4,9-11} at $\alpha = .05$. All patients who met the inclusion criteria were randomized and evenly distributed into chlorhexidine ($n = 50$) and standard ($n = 50$) groups (see Figure); the randomization was maintained by using a web-based program (<http://www1.assumption.edu/users/avadum/applets/RandAssign/GroupGen.html>). In order to avoid selection bias, the person who performed the randomization was not involved in recruiting participants or in obtaining informed consent for the study. The laboratory

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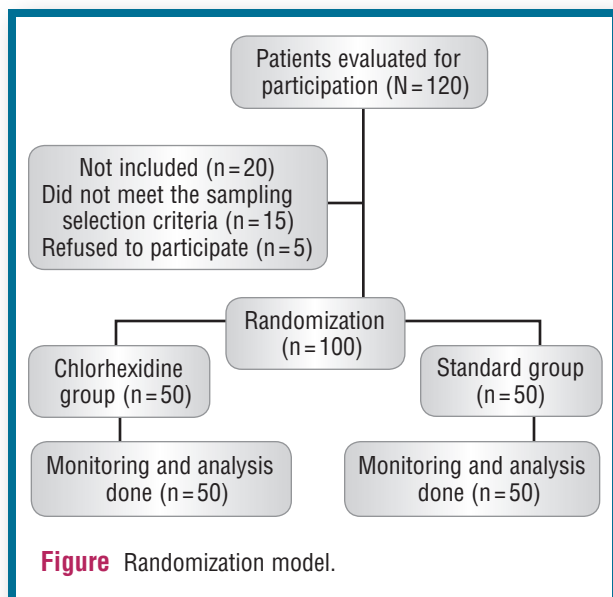
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personnel who interpreted the microbiological results also had no knowledge of the study.

Patients were included in the study if they were 1 month to 18 years old, had no CRBSIs at the time of admission to the hospital, had had a central venous catheter in place for more than 72 hours, were not receiving any neuromuscular blockers, and had given written consent to be part of the study.

Procedure

Catheters were covered with a sterilized pad in the standard group and with a 2% chlorhexidine-impregnated dressing in the chlorhexidine group. A patient diagnosis form was prepared and completed for each patient.

Catheter care in both groups was carried out as directed in the daily CRBSIs prevention bundle, which had been previously prepared and introduced to the PICU. For both groups, maximum barrier and aseptic precautions were taken during placement of catheters and during catheter care (hand washing, sterile gown with long sleeves, mask, large sterile drapes, and gloves). During placement of catheters, 10% povidone-iodine was used for dermal antisepsis, and the cleansing was maintained for 3 minutes. For catheter care, 10% povidone-iodine was used for dermal antisepsis, and cleansing was maintained for 3 minutes. Then the site was wiped with sterilized physiological saline and, after 30 to 60 seconds to allow for drying, was covered with a sterilized pad (standard group) or a 2% chlorhexidine-impregnated dressing (chlorhexidine group). For both groups, utmost

care was taken to avoid getting the catheter wet when the patient's body was being washed.

In the chlorhexidine group, the 2% chlorhexidine-impregnated dressing remained in situ for 7 days, unless it became wet. The CDC suggests that dressings used on the insertion sites of short-term central venous catheters should be replaced every 2 days for gauze dressings. However, we changed the gauze dressings daily because children's skin is more sensitive than adults' skin and frequent exposure of the catheter insertion site allowed earlier recognition of redness or changes. No guidewire exchange was needed because we use 3-lumen silicone catheters in our unit.

A patient diagnosis form with 4 sections was prepared in conformity with the relevant literature.^{1,3,4,6} The form consisted of 35 open-ended and closed questions related to patient characteristics, clinical details, physiological parameters, and factors associated with the catheter.

Culture Assessment

When a catheter was to be removed, 2 samples of blood were obtained for microbial culture, 1 from the central venous catheter and 1 from the peripheral blood. In addition, the skin was cleansed with 10% povidone-iodine to prevent contamination of the catheter's end by microorganisms on the skin, and then the 2- to 3-cm catheter end (tip) was removed and sent to the laboratory along with the blood samples. Catheters were removed when they were no longer required or they leaked, when the patient had a fever (with no other recognized focus of infection and redness at the catheter site), or when the patient died.

A catheter was considered sterile if both cultures of the catheter end and cultures of the 2 blood samples showed no growth of microorganisms or if cultures of both blood samples showed growth of the same organisms.

A catheter was considered contaminated if a culture of the catheter end had fewer than 15 colony-forming units (cfus) and no growth occurred in cultures of the blood samples or if cultures of the 2 blood samples showed growth of the same microorganisms but the microorganisms differed from the microbes in the culture of the catheter end. Colonization was defined as growth of 15 cfus or more in the catheter-end culture in the absence of local or systemic signs of infection and no growth in the cultures of the 2 blood samples or if cultures of the 2 blood samples showed growth of the

Table 1 Comparison of demographics and clinical status (n = 100)

Characteristic	Chlorhexidine group (n = 50)	Standard group (n = 50)	χ^2 (P) ^a
Sex			0.0 (.58)
Female	20	20	
Male	30	30	
Age			2.1 (.11)
1 month to 1 year	35	28	
>1 year	15	22	
Diagnosis			11.1 (.05)
Respiratory diseases	18	15	
Neurological diseases	14	6	
Infectious diseases	5	15	
Postoperative follow-up	6	5	
Cardiological diseases	2	6	
Other diseases	5	3	
Additional diseases			0.2 (.60)
Yes	9	9	
No	41	41	
Nutrition status			4.3 (.10)
Enteral	10	3	
Parenteral	8	9	
Enteral and parenteral	32	38	
Catheter vein			1.4 (.49)
Femoral	22	22	
Jugular	10	6	
Subclavian	18	22	
Blood products			0.4 ^b (.34)
Used	32	35	
Not used	18	15	
Immunosuppressive medication			0.1 ^b (.50)
Used	5	6	
Not used	45	44	
Reason for catheter removal			3.3 (.35)
No further requirement	46	42	
Fever and redness at catheter insertion site	4	5	

^a χ^2 values from Pearson χ^2 test.^b Fisher exact test.

same microorganisms but the microorganisms differed from the microbes in the culture of the catheter end.

Local catheter infection was defined as growth of 15 cfus or more in the culture of the catheter end and findings of inflammation at the catheter insertion site in the absence of blood-borne infection. CRBSIs were defined as growth of 15 cfus or more in the catheter-end culture and microorganisms in the 2 blood samples that have the same antibiotic resistance pattern as the microbes in the catheter end.

Data Analysis

We used SPSS, version 17.0 for Windows (IBM SPSS), for analysis of the data. We calculated means, medians,

number of patients, and percentages. A *t* test was used to determine if the means of χ^2 analyses differed from each other and to investigate whether dependence existed between the variables measured by using a 2 or more ordinal (serial) or nominal (categorical) scale.

Results

Among the 100 patients, 63% were 1 month to 1 year old, 60% were male; 33% had respiratory system diseases; and 18% had additional diseases (Table 1). Catheters were in place in the 100 patients in the study group for a mean of 14.01 days (SD, 6.98 days), and the patients' mean length of stay in the PICU was 15.35 days (SD, 10.10 days).

Table 2 Comparison of culture results

Characteristic	No. (%) of patients		χ^2 (P)
	Chlorhexidine group (n = 50)	Standard group (n = 50)	
Sterile	46 (92)	35 (70)	8.1 (.07)
Contamination	1 (2)	4 (8)	
Catheter colonization	1 (2)	4 (8)	
Local catheter infection	1 (2)	2 (4)	
Catheter-related bloodstream infection	1 (2)	5 (10)	

The standard group and the chlorhexidine groups were similar to each other in sex, age, diagnosis, existence of additional disease, nutritional status, and the vein used for catheterization (Table 1).

The results of the comparison of groups for the characteristics of the sterile catheter, colonization, contamination, local catheter infection, and CRBSI are shown in Table 2. Colonization, contamination, local catheter infection, and CRBSI did not differ significantly between the 2 groups (all $P > .05$).

Compared with the standard group, the chlorhexidine group had a shorter PICU length of stay, shorter duration of mechanical ventilation, and shorter duration of catheterization (Table 3). However, the differences between the 2 groups were not significant (all $P > .05$).

Vancomycin-resistant enterococci were isolated from 1 patient in the chlorhexidine group who had a CRBSI and from 2 patients in the standard group who had a CRBSI (Table 4). Among patients in the standard group who had a CRBSI, *Pseudomonas aeruginosa* was isolated from 1 patient, methicillin-resistant *Staphylococcus aureus* from 1 patient, and *Acinetobacter* from 1 patient. The pathogens isolated from the standard group did not differ from the pathogens isolated from the chlorhexidine group ($P = .20$).

Discussion

Catheter care with an appropriate antiseptic solution and suitable dressings is efficient in preventing CRBSIs. In a meta-analysis of the solutions used in catheter care, Chaiyakunapruk et al¹ found that use of chlorhexidine rather than povidone-iodine for catheter cleansing reduced the rate of CRBSIs by 50% in patients whose catheter was in place for a short time. Conversely, Humar et al² compared use of chlorhexidine with use of povidone-iodine

Table 3 Comparison of groups' duration of mechanical ventilation, hospital stay, and catheterization

Characteristic	Chlorhexidine group (n = 50)	Standard group (n = 50)	t (P)
Days of mechanical ventilation, mean (SD)	8.78 (8.84)	10.46 (8.66)	0.01 (.34)
Days in pediatric intensive care unit, mean (SD)	14.22 (9.05)	16.48 (11.02)	0.96 (.27)
Days of catheterization, mean (SD)	13.78 (6.95)	14.24 (7.07)	0.29 (.74)

Table 4 Comparison of microorganisms

Isolated pathogen	No. (%) of patients								χ^2 (P)
	Chlorhexidine group (n = 50)				Standard group (n = 50)				
	CT	CL	LCI	CRBSIs	CT	CL	LCI	CRBSIs	
Vancomycin-resistant enterococci	1 (2)			1 (2)	1 (2)	2 (4)		2 (4)	5.4 (.20)
<i>Acinetobacter</i>								1 (2)	
<i>Pseudomonas aeruginosa</i>			1 (2)		2 (4)	1 (2)		1 (2)	
Methicillin-resistant <i>Staphylococcus aureus</i>						1 (2)		1 (2)	
<i>Escherichia coli</i>		1 (2)			2 (4)	1 (2)			

Abbreviations: CL, colonization; CRBSIs, catheter-related bloodstream infections; CT, contamination; LCI, local catheter infection.

for antisepsis during insertion of a central venous catheter and found no differences between the 2 products in the rate of CRBSIs.

The CDC recommends use of either chlorhexidine or povidone-iodine for catheter care. We used povidone-iodine for both groups in our study. Both the dressing used to cover the catheter and the solution used for antisepsis during catheter care have an impact on the rate of infection.³ Levy et al¹⁰ found that a dressing impregnated with chlorhexidine remarkably reduced colonization of central venous catheters. In a randomized, controlled study with 1636 patients, Timsit et al⁸ found that compared with a standard dressing, use of a chlorhexidine-impregnated dressing reduced the rate of CRBSIs. In a study in infants, Garland et al¹¹ compared skin cleansing with povidone-iodine with use of a chlorhexidine-impregnated dressing at the insertion site of central venous catheters. Colonization was remarkably reduced in the chlorhexidine group, but the 2 groups did not

Use of 2% chlorhexidine-impregnated sterile in the PICU reduced the rate of CRBSIs, contaminations, and colonization.

that silver-impregnated catheters and chlorhexidine-impregnated sponges with standard multilumen central venous catheters did not reduce colonization or infection rates. Similarly, we found no significant difference between the 2 groups in our study in colonization, contamination, local catheter infection, and CRBSIs.

However, we think that even though the lower values in the chlorhexidine group were not statistically significant, they are clinically important. A meta-analysis and systematic review by Rivas Ruiz et al⁹ indicated that dressings made with chlorhexidine gluconate pads were effective in reducing CRBSIs in infants and children and rarely were associated with serious adverse effects.

CRBSIs extend the length of hospital stay.^{13,14} In our study, although the differences between the standard group and the chlorhexidine group were not statistically significant, the chlorhexidine group had a shorter ICU length of stay, shorter duration of mechanical ventilation, and shorter duration of catheterization. Moreover, significantly fewer colonies were found in the microbial cultures of the catheter ends in the chlorhexidine group.

Limitations

During the study, the PICU in which the research took place was relocated to a smaller area because not enough units were available for care of patients with chronic neurological illnesses. Thus, patients stayed in the PICU longer than was necessary, a situation that limited the number of new patients admitted. The nurses and physicians responsible for care of our patients could not be blinded to the allocation of dressings because of the physical appearance of the chlorhexidine-impregnated dressings. This situation could be a source of possible bias.

Conclusions

Use of 2% chlorhexidine-impregnated sterilized dressings in the PICU reduced the rate of CRBSIs, contaminations, and colonization. In addition, compared with the standard group, the chlorhexidine group had a shorter ICU length of stay, shorter duration of mechanical ventilation, and shorter duration of catheterization. Although the group with chlorhexidine-impregnated dressings had reduced rates of CRBSIs, contamination, colonization, and local catheter infection, the differences between the 2 groups were not statistically significant. Our results might have clinical usefulness and may merit further evaluation. We recommend the use of 2% chlorhexidine-impregnated sterile dressings in catheter care in PICUs to prevent CRBSIs or reduce the rate of the infections. **CCN**

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None reported.

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