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Comparing the Effects of Chlorhexidine 2% and Iodopovidone-alcohol on Peripheral Venous Catheter Bacterial Colonization in Preterm Neonates

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ABSTRACT

Background: Studies regarding cleansing the area with antiseptic solutions prior to catheterization in premature infants are limited. Therefore, the present study aimed to evaluate and compare the effects of chlorhexidine 2% and iodopovidone-alcohol solutions on bacterial colonization associated with the peripheral venous catheterization in premature infants.

Methods: This quasi-experimental study was conducted in 2016-2017 at a neonatal intensive care unit in Qazvin, Iran. Premature infants (N=106) were assigned to the two groups of "A" treated with chlorhexidine 2% or "B" cleaned with iodopovidone-alcohol 10%. Quantitative culture of the catheters was performed 48 hours after insertion.

Results: Our findings showed that the frequency of positive catheter tips culture was 6.6% among all the samples (N=7). Out of the seven positive cultures, five (43.9%) belonged to the iodopovidone-alcohol group and two (3.7%) were from the chlorhexidine 2% group. Although a number of the positive cultures in the iodopovidone-alcohol group was higher than the chlorhexidine 2% group, this difference was not statistically significant (P=0.21).

Conclusion: Results of this study demonstrated that bacterial colony growth may be decreased when using preparatory chlorhexidine 2%, compared with iodopovidone-alcohol at no added risk to infants. We recommend further study in this regard.

Keywords: Infection, Intensive care, Neonate, Peripheral venous catheter

Introduction

Vascular access is commonly required during treatment of the infants at neonatal intensive care units (NICU) (1, 2). Access to appropriate vasculature can be accomplished using various vessels, including those of the periphery, central, and/or even the umbilical artery (3, 4). Safe and prepared access to the vasculature is critical as intravenous routes are commonly used for fluid therapy, medication infusions, blood and blood product infusions, in addition to feeding and collecting blood samples in some cases (5).

On the other hand, access to peripheral veins in infants admitted to NICUs may be associated with complications, such as catheter-related infections. The incidence of the infections related to applying peripheral catheters in infants is not high. However, when identified in the hospital setting, this type of infection is recognized to be associated with serious side effects (6).

While certain microorganisms can lead to catheter-related infections at any time in the hospital setting, the highest risk occurs as the time of catheter insertion (7). Therefore, different strategies have been proposed for adult patients in attempts to prevent these infections. Recommendations of a guideline involve cleansing of the insertion area with antiseptic solutions

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immediately prior to insertion of the venous catheter (8). Alcohols, povidone-iodine, and chlorhexidine are the most commonly used substances for skin cleaning (9). Iodophormic compounds, such as betadine due to the iodine component are effective on all pathogenic microorganisms, including enteric bacteria, enteric viruses, and fungi (10).

It should be taken into consideration that for achieving complete disinfection of different microorganism types, various amounts of iodine are needed. Given the diverse and non-uniform sensitivity of the microorganisms, as well as the type of the microorganisms, the concentration and duration of iodine activity are different even for one group of organisms. One of the disadvantages of this product is short-time efficacy (11).

The effect of alcohols, such as ethyl alcohol and isopropyl alcohol 70% as an intermediate-level disinfectant is limited because these compounds evaporate quickly and maintain short-term contact. Moreover, these materials do not have the ability to penetrate into organic matters. Substances disinfected with alcohol must be carefully cleaned beforehand and then immersed in alcohol for a sufficient period.

Using the combination of betadine and alcohol results in a wider range of impact for this product, compared to iodine or alcohol alone. In addition, at the same time, the speed of effect will also increase due to the presence of alcohol and the duration of efficacy will augment as well, which can be attributed to iodine (11).

Chlorhexidine is a disinfectant and antiseptic derived from Biguanides with three forms of D-gluconate, acetate, and hydrochloride. Chlorhexidine is bacteriostatic and bactericide at low and high concentrations, respectively. It has low toxicity for mammals and has a high tendency for binding to skin and mucous membranes (12). Chlorhexidine is highly cationic and the chlorhexidine salt is decomposed in physiological pH leading to cation separation.

This substance is released gradually and slowly by binding and sticking to the living surfaces of the cells continuously providing an antimicrobial environment over a period of time. Adhesion of chlorhexidine might be attributed to its cationic property, which connects it to the anionic groups present in the glycoproteins, as well as phosphor-proteins of the mucosal cell surface. The mechanism of effect for chlorhexidine is related to the high tendency for adhesion and strong binding to the bacterial membrane (12). Chlorhexidine is active against both gram-positive and gram-negative organisms, facultative anaerobic and aerobic bacteria, in addition to yeasts (13).

The knowledge is limited considering the efficacy of cleansing the area with antiseptic solutions prior to catheterization in premature infants admitted to NICUs. According to different antiseptic characteristics of chlorhexidine 2% and iodopovidone-alcohol mentioned above, our hypotheses were that chlorhexidine 2% and iodopovidone-alcohol have different impacts on bacterial colonization associated with peripheral venous catheterization (PVC) in premature infants. Consequently, the present study was designed and conducted to compare the influence of chlorhexidine 2% and iodopovidone-alcohol on bacterial colonization related to PVC in premature infants.

Methods

This quasi-experimental study was conducted in 2016-2017 at a specialized neonatal hospital in Qazvin, Iran. All the aspects of this study were approved by the Ethics Committee of Qazvin University of Medical Sciences. Parents of the infants were provided with voluntary written informed consents prior to starting the study. The research was also registered in Iranian Registry of Clinical Trials with the code of IRCT2017062034653N1.

The inclusion criteria for the infants entailed being less than 37 weeks gestational age, not having inflammation in the vascular catheter insertion site, not having septicemia symptoms confirmed by body temperature > 38.5°C, leukocytosis, tachycardia, and/or respiratory rate > 60 per min (presence of two of these four signs indicates septicemia), not having proven bacteremia approved by positive primary C-reactive protein and positive blood culture.

Using a sample size formula, the sample size in this study was determined as 106 subjects that were divided into two groups. The neonates were assigned to the two groups of “A” treated by chlorhexidine 2% or “B” treated by iodopovidone-alcohol 10% using a permuted block randomization method in four-member blocks. Randomized participants stratification was performed by one of the nurses working in the NICU who was not involved in any parts of this study.

Study Procedure

In the first step, two nurses, other than the researcher, with at least 5 years of neonatal work

experience and established skill in placing peripheral catheters in premature infants were selected to complete the study. Before the study, we used alcohol alone in our NICU for cleaning the catheter insertion site.

Catheter insertion was carried out using standard sterile techniques. First, hands were washed with the sterile method and sterile gloves were worn.

In group "A", following selecting the appropriate place to reach the peripheral blood vessels, the site was disinfected with sterilized cotton impregnated with iodopovidone 10% and was allowed to dry. Afterwards, the remaining iodopovidone was removed from the area by alcohol 70%. Finally, catheterization was performed when the skin became dry.

For group "B", after selecting the appropriate place to reach the peripheral blood vessels, the insertion site was sprayed with chlorhexidine 2% (1-2 cc chlorhexidine). Next, 30 second elapse was passed followed by cleansing the area with sterile cotton and was left to get dried then Immediately after air drying, catheterization was performed

Quantitative culture of the catheters' tip was carried out 48 hours after insertion. The 1-cm end of the catheter was placed into a sterile tube containing 0.5 ml normal saline solution following removal. Afterwards, the solution was shaken, cultured on blood agar culture medium, and placed in an incubator at 37°C for 72 hours. In a double-blinded manner, growth mediums were checked daily for bacterial growth. Colony counts more than five were considered as positive.

All the data were analyzed using SPSS software version 16. The Kolmogorov-Smirnov test was used to check the assumption of data normality. Due to lack of data normality, the Mann-Whitney test was used for comparing the mean number of colonies between the two groups. Spearman correlation co-efficient was applied to investigate the relationships between the number of colonies and catheter insertion site for both the control and intervention groups, as well as for the culture results in both control and test groups. Two-tailed significance was examined utilizing an alpha level of 0.05.

Results

A total of 106 premature neonates were included in this study as 53 in each of the "A" and "B" groups. The demographic data of the subjects are summarized in Table 1. Positive culture frequency associated with catheter tips among all samples was 6.6% (N=7). Out of the positive results, five (43.9%) were from the iodopovidone-alcohol group, four of which were coagulase-negative Staphylococci and one case was gram-positive bacteria. In addition, two (3.7%) of the seven positive cases were from the chlorhexidine 2% group, both of which were coagulase-negative Staphylococci. Although a number of the positive cultures in the iodopovidone-alcohol group was higher than the chlorhexidine 2% group, this difference was not significant (P=0.21).

Regarding the results of cultures from the catheter tips after removal, statistical analysis of the data showed that six (7.08%) out of the total 77 catheters inserted in the upper limb and one (3.45%) out of the total 29 catheters inserted in the lower limb had positive cultures. Moreover, we observed that the highest colony numbers were 5-20, which with four (57.1%) catheters was more prevalent among catheters inserted in the upper limbs. Furthermore, three catheters were demonstrated to have more than 20 colonies. Two of these cases (28.5%) were associated with upper limbs and the other case (14.3%) was from the lower limb (P=0.22).

Table 1. Participants demographic characteristics

Items		Chlorhexidine 2%	Iodopovidone-alcohol	P-value
Gestational age		30.1±2.5	29.6±2.7	0.3
Weight		1531.98±588.94	1459.39±625.29	0.54
Gender	Girl	29 (54.7%)	27 (50.9%)	069
	Boy	24 (47.2%)	26 (49.1%)	
Catheter site	Upper limb	36 (67.9%)	41 (77.3%)	0.27
	Lower limb	17 (32.1%)	12 (22.7%)	

Discussion

This study aimed to compare the effects of iodopovidone-alcohol versus chlorhexidine 2% on the number of colonies grown with the culture of catheter tips that had been inserted into peripheral veins of premature neonates admitted to NICUs. This study demonstrated for the first

time that bacterial colony growth may be lessened further when using preparatory chlorhexidine 2% compared to iodopovidone-alcohol at no added risk for the neonates.

Catheter-related infections in preterm infants admitted to NICUs can provoke several complications. Regarding increased infection risk due to central catheter use, previous studies in adults have focused on central catheter infections. On the other hand, peripheral catheter usage and infection rate in neonates have not received sufficient attention.

Accordingly, for the first time, this study demonstrated that disinfecting the catheter insertion site with chlorhexidine 2% and/or iodopovidone-alcohol solutions may lead to a decline in the number of positive bacterial cultures. However, these data as a preliminary finding suggest that chlorhexidine 2% solution may be more effective for this purpose, compared to iodopovidone-alcohol solution.

Although less positive bacterial culture does not directly indicate a reduction in infection rate, it is likely that the risk of infection will decrease as the number of positive cultures diminish. Garland et al. had previously compared the effects of chlorhexidine and iodopovidone solutions on reducing the number of positive bacterial cultures and infections caused by peripheral catheters in infants admitted to NICUs. Similar to the current study, they reported that both solutions were influential for diminishing the number of the positive bacterial cultures (9.3% positive culture in the iodopovidone group and 4.7% in the chlorhexidine group). However, the latter authors concluded that chlorhexidine was more effective than iodopovidone (14).

Moreover, Van Esch examined the effects of dressing at the central venous catheter site on bacterial colonization at catheter tips in comparison with the impacts of iodopovidone 10% solution in infants (N=705) admitted to the NICU. They demonstrated that using impregnated chlorhexidine dressing at the central catheter insertion site resulted in a significant cutback in bacterial colonization at catheter tips. Nevertheless, these authors reported that 15% of the infants in the chlorhexidine group represented skin complications at the dressing site (15).

Consistent with the aforementioned studies, the effects of different concentrations of chlorhexidine 2% and iodopovidone 10% during catheterization in infants admitted to NICUs have been studied. Observations from that studies suggested that the use of these two solutions pose similar effects on reducing the number of positive cultures (16, 17). Nuntnarumit and Sangsuksawang (2013) compared application of iodopovidone 10% and chlorhexidine 1% for disinfecting the blood culture collection site and the amount of contamination in the blood cultures. The results of the latter study showed that chlorhexidine could be more effective than the iodopovidone 10% solution (17).

Characteristics of an appropriate antiseptic solution used to cleanse skin prior to venous catheterization include having the ability to affect a wide range of bacteria, initiating a quick and long-lasting effect, not being allergenic for the consumer, and availability, as well as affordability and non-toxicity. According to the results of this study and the other studies, chlorhexidine gluconate possesses all these features. Therefore, chlorhexidine gluconate is a widely used disinfectant solution that can be influential in infants (18).

It should be noted that the previous studies have reported side effects, such as allergic reactions of skin, ulcers, and superficial burns when using chlorhexidine in NICUs (19, 20). However, these complications are more likely to occur when large areas of skin are in contact with this solution over an extended period of time (e.g., when the entire infant body is washed with a solution or when dressings containing the solution are placed on the catheters). Furthermore, it does not seem that the use of chlorhexidine gluconate solution for cleansing a catheter insertion site has complications in premature infants.

In addition, the method used in the present study can be used to diminish the possibility of chlorhexidine 2% skin absorption in premature infants, which is in line with the reports in the previous studies (16). Finally, avoiding chlorhexidine-impregnated dressings at the site of catheter insertion can also reduce the risk of chlorhexidine 2% skin absorption.

Limitations

The limitation of our study may be related to that we did not able to follow and record the side effects of chlorhexidine and iodopovidone in details. In addition, colonization of the catheter as an endpoint might be regarded as another limitation. We assume that a clinical endpoint, such as infection may be better. Moreover, lack of a control group is another limitation that should be taken into consideration.

Conclusion

According to the findings of the present study, both solutions can be used to reduce the number of positive bacterial cultures in the catheter region. Moreover, we suggest that chlorhexidine 2% solution has more favorable effects in terms of reducing the number of positive cultures, compared to iodopovidone-alcohol. It was observed in this study that the techniques used to disinfect catheter insertion areas and concentrations of the disinfectants should be considered in infants admitted to the NICU.

Subsequently, we recommend future research on the effects of chlorhexidine 2% and iodopovidone solutions on bacterial growth associated with catheter tips in other procedures such as chest tube insertion in preterm neonates. Furthermore, we may suggest further studies in terms of the impacts of chlorhexidine and iodopovidone solutions with different concentrations as used in this study.

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Conflicts of interests

The authors of the current study declare no conflict of interest for this study.

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