

Comparison of 2% Chlorhexidine Gluconate in 70% Alcohol and 10% Povidone-Iodine Used for Port Catheter Dressing Changes in Pediatric Hematology–Oncology Patients: A Prospective Observational Study

Elif Bakır¹, Tufan Aslı Sezer², Hicran Çavuşoğlu¹, Aslınur Özkaya Parlakay³, Orhan Gürsel⁴

¹Department of Pediatric Nursing, Hacettepe University Faculty of Nursing, Ankara, Turkey

²Department of Nursing, Ankara University, Ankara, Turkey

³Department of Pediatric Infectious Disease, Ankara City Hospital, Ankara, Turkey

⁴Department of Pediatric Hematology and Oncology, Gulhane Training and Research Hospital, Ankara, Turkey

What is already known on this topic?

- To prevent catheter-related bloodstream infection (CRBSI), the Centers for Disease Control and Prevention (CDC) and the Infusion Nurses Society recommend using an antiseptic solution of >0.5% chlorhexidine in 70% alcohol when changing the dressings of patients with a central venous catheter (CVC). Chlorhexidine and povidone-iodine are the most commonly used antiseptic agents. However, no studies have compared the effectiveness of 2% chlorhexidine gluconate in 70% alcohol and 10% povidone-iodine solutions in children with port catheters.

What this study adds on this topic?

- In this study, a total of 45 patients and 3984 catheter-days were followed. No differences were found between the effectiveness of 2% chlorhexidine in 70% alcohol and that of 10% povidone-iodine solution, in preventing CRBSI. Therefore, both solutions can be used in dressing changes for port catheters.

Corresponding author:

Elif Bakır

✉elif.bakir@hacettepe.edu.tr

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ABSTRACT

Objective: This study aimed to compare the effectiveness of 2% chlorhexidine gluconate in 70% alcohol with that of 10% povidone-iodine, for dressing changes in pediatric hematology–oncology patients with port catheters, in preventing catheter-related bloodstream infection (CRBSI).

Methods: In this prospective, multicenter, observational, and cross-sectional study, 45 patients (25 patients for chlorhexidine, 20 patients for povidone-iodine) with port catheters were evaluated from January 2018 to May 2019. The sociodemographic, clinical, and port catheter-related variables were evaluated. The mean age of the patients was 6.28 ± 4.58 years, and 60% of patients were female.

Results: Among the patients whose dressings were changed using 2% chlorhexidine gluconate in 70% alcohol, the mean number of dressing changes was 39.52 ± 29.7 and the rates of exit-site infection and CRBSI were 20% (2.37/1000 catheter-days) and 16% (1.90/1000 catheter-days), respectively. Among the patients whose dressings were changed using 10% povidone-iodine, the mean number of dressing changes was 48.0 ± 31.48 and the rates of exit-site infection and CRBSI were 15% (1.59/1000 catheter-days) and 10% (1.06/1000 catheter-days), respectively. None of the patients developed pocket infections. The rates of CRBSI and exit-site infections were not different between the 2 antiseptic solutions.

Conclusion: This study found no differences between the effectiveness of 2% chlorhexidine in 70% alcohol and that of 10% povidone-iodine solution in preventing CRBSI. Therefore, both solutions can be used in dressing changes.

Keywords: Port catheters, catheter-related infections, pediatric hematology, pediatric oncology

INTRODUCTION

A central venous catheter (CVC) is used in hematology and oncology patients receiving long-term treatment, such as intensive chemotherapy, intravenous hydration, blood sampling, and parenteral nutrition.¹ There are 3 types of CVCs, namely tunneled, non-tunneled, and implanted port catheters. The use of implanted port catheters is recommended in pediatric hematology and oncology patients, because they meet the need for continuous venous access during long-term treatments with a low incidence of infections.^{2–5} A meta-analysis comparing the frequency of catheter-related bloodstream infection (CRBSI) between port

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catheter and tunneled catheter showed a nearly 4-fold greater incidence of CRBSI in children (16.3%) than adult patients (4.8%).² This finding underscores the role of patient factor in the development of CRBSI and suggests caution in pediatric patients with port catheters.

CRBSI is a critical complication that can be fatal, especially in patients receiving intensive chemotherapy, due to neutropenia that results from the treatment.⁶ A CRBSI increases the duration of hospital stay and treatment costs.^{7,8} According to the Centers for Disease Control and Prevention (CDC) database, the most commonly reported pathogens that cause CRBSI are coagulase-negative staphylococci, *Staphylococcus aureus*, enterococci, and *Candida*.⁹ In studies of pediatric hematology–oncology patients, the most commonly reported pathogens for CRBSI were coagulase-negative staphylococci, *S. epidermidis*, *Klebsiella pneumoniae*, and *Candida albicans*.^{5,10-13} Skin antisepsis using the preferred skin antiseptic agent of alcohol-based chlorhexidine solution is performed in order to prevent CRBSI. If there is a contraindication for chlorhexidine solution, antiseptic solutions containing povidone-iodine, iodophor, or 70% alcohol are recommended, to minimize the risk of contamination in port catheters.^{9,14-16}

Although numerous studies and systematic reviews have compared the effectiveness of these antiseptic solutions for preventing CRBSI in adults,^{15,17-19} only one study evaluated the preventive effects of chlorhexidine and povidone-iodine on bloodstream infection associated with port catheter in adults.²⁰ However, no studies have compared the effectiveness of 2% chlorhexidine in 70% alcohol and 10% povidone-iodine solutions in children with port catheters. Hence, we need the evidence for evidence-based practice in this field.

The hospitals in Turkey use different antiseptic solutions for changing port catheter dressings. According to a multicenter study from Turkey; it was stated that catheter care was mostly performed by nurses (75%), and generally povidone-iodine (56.7%) or chlorhexidine (23.3%) was used as antiseptic solutions. All centers follow the CDC recommendations, but no common guidelines are followed to prevent catheter-related infection.²¹

The aim of our study is to compare the effectiveness of 2% chlorhexidine in 70% alcohol and 10% povidone-iodine as antiseptic solutions for dressing changes in pediatric hematology–oncology patients with port catheters, in preventing CRBSI, catheter exit-site infection, pocket infection, and catheter colonization.

This study aims to answer the following questions:

1. What is the rate of CRBSI per 1000 catheter-days, based on the antiseptic solution (2% chlorhexidine in 70% alcohol or 10% povidone-iodine) used?
2. What is the rate of catheter exit-site infection per 1000 catheter-days, based on the antiseptic solution (2% chlorhexidine in 70% alcohol or 10% povidone-iodine) used?
3. What is the rate of pocket infection per 1000 catheter-days, based on the antiseptic solution (2% chlorhexidine in 70% alcohol or 10% povidone-iodine) used?

4. Which microorganisms grow per 1000 catheter-days, based on the antiseptic solution (2% chlorhexidine in 70% alcohol or 10% povidone-iodine) used?

METHODS

Study Design and Setting

This study was conducted as a prospective, observational, and cross-sectional study between January 1, 2018 and May 15, 2019 in the Pediatric Hematology and Oncology units of 2 hospitals. In Ankara Children's Hospital Hematology and Oncology Training and Research Hospital, 2% chlorhexidine gluconate in a 70% alcohol solution was used, and in the Gulhane Training and Research Hospital, a 10% povidone-iodine solution was used, respectively, for port catheter dressing changes.

Study Participants

Inclusion Criteria

Children who were pediatric hematology–oncology patients and between the ages of 2 months and 18 years, were receiving inpatient treatment, with a port catheter inserted 72 hours prior, and did not have a CRBSI in the first 72 hours, were included in the study.

Exclusion Criteria

Children who were under 2 months of age and who had an infection in the first 72 hours after insertion of the port catheter were excluded from the study.

In this study, all patients ($N = 45$) who met the inclusion criteria and agreed to participate in the study were included, between January 2018 and May 2019. The patients were enrolled in the study 72 hours after their port catheter was implanted. Their port catheter dressings were changed by a nurse and the researchers observed the changes in the dressing.

Data Collection

The children admitted to the hematology and oncology clinics of both hospitals for chemotherapy between January 2018 and May 2019 were monitored during their period of stayed in the clinic. The patients' port catheter implantation sites were observed and evaluated by the researchers for infection symptoms (redness, sensitivity, pain, leakage, edema, local fever, etc.). Blood for cultures was taken from the peripheral blood and port catheter simultaneously from the patients with symptoms of local infection. The patients' medical records were reviewed for results of the blood culture tests that were performed if the patient was suspected as having an infection.

The port catheter dressing changes were followed from the time the catheter was first inserted until the removal of the catheter or the end of the study. The port catheter of each patient was washed with heparin solution and fixed, before the patient was discharged from hospital.

Data Collection Tool

The data collection tool was developed by the researchers. This tool was used to gather data of the patient's name, age, diagnosis, gender, date of hospitalization, date of port catheter placement, date of port needle placement, and signs of

local inflammation or clinical infection (fever, redness, swelling, pain, leakage, and sensitivity).

Diagnostic Procedures

The presence of an infection was determined using the following definitions.

Catheter Exit-site Infection: The signs of inflammation, including redness, swelling, pain, leakage, and sensitivity, at ≤ 2 cm from the catheter placement site, in the absence of a bloodstream infection.²²

Pocket Infection: The presence of a clinical infection or signs of inflammation, including fever, redness, swelling, pain, leakage, and sensitivity in a subcutaneous pocket of an implanted port system, in the absence of a bloodstream infection.²²

CRBSI: A CRBSI is considered in a patient in whom a port catheter that has been implanted for at least 2 days. The diagnostic procedures for detecting CRBSI are initiated when the clinical signs of infection (local infection, fever and/or sepsis, or a combination of these) are present. The diagnostic criteria for CRBSI are the growth of same pathogen in the blood cultures of the peripheral vein and the CVC tip.²²

Recommendations for Dressing Changes: The CDC (2011) and Infusion Nurses Society (INS) (2021) give the following recommendations regarding dressing changes.^{9,14} Hand hygiene procedures should be performed both before and after catheter removal or dressing changes. While changing the dressings on intravascular catheters, clean or sterile gloves should be worn. Skin cleaning should be performed with an antiseptic solution, which should be allowed to dry according to the manufacturer's instructions. Either a gauze dressing or a sterile, transparent, and semi-permeable cloth dressing should be used to cover the CVC region. If the patient is sweating excessively or if there is bleeding or leakage around the CVC, sterile gauze dressings should be used during dressing changes. Gauze dressings should be changed every 2 days, whereas transparent cloth dressings should be changed every week. Any dressing that is loose or visibly dirty should be changed.^{9,14}

Procedures for Dressing Change in the Hospital

In both the hospitals in this study, once the port catheter is implanted, dressing changes are performed by clinical nurses in accordance with own procedures from the CDC (2011) and INS (2021) recommendations. The port needles are changed once a week in both the hospitals. The port catheter dressing procedures followed in the 2 hospitals in this study are described below.

First Hospital (Dressing with 2% Chlorhexidine Gluconate in 70% Alcohol): The dressing procedure using 2% chlorhexidine gluconate in 70% alcohol solution was as follows: after surgical implantation of the port catheter, the catheter site was dressed with 10% povidone-iodine solution and covered with sterile gauze dressing once every 2 days for 15 days until the stitches were removed. After removal of the stitches, dressing was done once a week with 2% chlorhexidine gluconate in 70% alcohol solution, and the port needle was covered with a transparent cloth dressing, in accordance with CDC recommendations. The 2% chlorhexidine gluconate in 70% alcohol solution was

allowed to dry for 2 minutes before covering with the transparent cloth dressing.

Second Hospital (Dressing With 10% Povidone-Iodine): The procedure for dressing with 10% povidone-iodine solution was as follows: after implantation of the port catheter, the catheter site was dressed with 10% povidone-iodine solution once every 2 days, in accordance with the CDC recommendations, and covered with sterile gauze dressing. The 10% povidone-iodine solution was allowed to dry for 2 minutes after application.

Infrastructure in Both the Clinics

The first clinic, which applied 2% chlorhexidine gluconate in 70% alcohol solution for CVC dressing, has 11 double rooms and 3 single rooms. The double rooms are used as single rooms when the patients requires isolation. There are 4 nurses working in the clinic during the day, and dressing changes are made during the day. The number of patients per nurse is 4-5.

The second clinic, which applied 10% povidone solution for catheter dressing, has bed availability for 10 patients, and all rooms are single. There are 4 nurses working in the clinic during the day, and the dressing changes are made during the day. The number of patients per nurse is 2-3.

Statistical Analysis

Statistical Package for the Social Sciences (SPSS) version 21.0 (IBM SPSS Corp.; Armonk, NY, USA) was used for the data analysis. Percentages and arithmetic means were used to evaluate the numerical values. The Shapiro-Wilk test was used to assess the distribution of the data. The Mann-Whitney *U*-test was used to assess the differences between variables with non-normally distributed data between the 2 hospitals, and the independent samples *t*-test was used to assess the differences between variables with normally distributed data between the 2 hospitals. Pearson's chi-square test, Fisher's exact test, and phi coefficient analysis were used to compare the nominal variables. **Total Catheter-Days and Incidence of Infection:** The number of days from catheter implantation until the end of the study corresponded to the total catheter-days. The incidence of infection was calculated as follows: number of CRBSI/total catheter-days \times 1000.

RESULTS

Patient Characteristics and Port Catheter-Related Variables

A total of 45 patients from both hospitals were included in the study. The mean age of the patients was 6.28 ± 4.58 years, and 60% of the patients were female. Most of the patients had been diagnosed with leukemia (64.4%) (Table 1). The remaining patients had been diagnosed with solid tumor (neuroblastoma (11.1%), non-Hodgkin lymphoma (6.7%), testicular cancer (4.5%), astrocytoma (4.5%), pelvic mass (2.2%), anaplastic ependymoma (2.2%), osteosarcoma (2.2%), and Wilms' tumor (2.2%). The mean total catheter-days of the patients included in the study was 88.53 ± 58.83 (Table 1).

Catheter Infection Characteristics

Table 2 shows the catheter-related bloodstream and exit-site infection rates. While the CRBSI rate in the chlorhexidine group was 1.90 per 1000 catheter-days, it was 1.06 in the

Table 1. Patient Characteristics and Port Catheter-Related Variables

Variables	2% Chlorhexidine Gluconate in 70% Alcohol	10% Povidone-Iodine	Total	Statistical Value (P)
Age (Mean ± SD)	5.4 ± 3.09	7.4 ± 5.84	6.28 ± 4.58	U: 221.00 P ^a : .506
Gender (n (%))				
Male	15 (60)	12 (60)	27 (60)	χ ² : 0.000
Female	10 (40)	8 (40)	18 (40)	P ^b : .621
Diagnosis (n (%))				
Leukemia	25 (100)	4 (20)	29 (64.4)	P ^c : .000
Solid tumor	-	16 (80)	16 (35.6)	
Total catheter-days	2105	1879	3984	
Mean ± SD	84.20 ± 57.71	93.95 ± 61.26	88.53 ± 58.83	T: 0.548
Min-Max	29-245	12-256	12-256	P ^d : .587
Number of days the patients stayed in the hospital				
Mean ± SD	88.8 ± 57.84	101.45 ± 65.60	94.46 ± 61.02	U: 221.00
Min-Max	30-252	18-272	18-272	P ^a : .508
Number of days the port needle was attached				
Mean ± SD	84.20 ± 57.71	93.95 ± 61.26	88.53 ± 58.83	T: 0.548
Min-Max	29-245	12-256	12-256	P ^d : .587
Number of dressings				
Mean ± SD	39.52 ± 29.77	48.0 ± 31.48	43.28 ± 30.49	U: 196.00
Min-Max	12-124	6-132	6-132	P ^a : .217
Number of cultures				
(Mean ± SD)	0.76 ± 1.42	0.65 ± 1.89	0.71 ± 1.63	U: 221.00
Min-Max	0-5	0-8	0-8	P ^a : .362

^aMann-Whitney U-test; ^bPearson's chi-square test; ^cFisher's exact test; ^dIndependent samples t-test.

Table 2. Catheter Infection Characteristics

Type of Infection	2% Chlorhexidine Gluconate in 70% Alcohol (N = 25), n (%)	10% Povidone-Iodine (N = 20), n (%)	Statistical Value (P)
CRBSI	4 (16)	2 (10)	
Rate per 1000 catheter-days	1.90	1.06	.678
ESI	5 (20)	3 (15)	
Rate per 1000 catheter-days	2.37	1.59	.716

*Fisher's exact test. CRBSI, catheter-related bloodstream infection; ESI, exit-site infection.

povidone-iodine group. The rate of exit-site infection was 2.37 per 1000 catheter-days in the chlorhexidine group and 1.59 in the povidone-iodine group. The rates of CRBSI and exit-site infections were not significantly different between the 2 antiseptic solutions used. None of the patients developed pocket infections. The relationship between 2 categorical variables (the rate of CRBSI and diseases) was assessed using the phi

coefficient analysis (φ: 0.155; P > .05). Accordingly, no significant relationship was found between the diseases (leukemia and solid tumors) and the type of catheter infection.

Causative Organisms in CRBSI and Removal of the Catheter

The bacteria that caused the CRBSIs are listed in Table 3, along with the number of catheters that were removed due

Table 3. Causative Organisms in CRBSI and Removal of Catheter

Colonizing Bacteria and Removal of Catheter	2% Chlorhexidine Gluconate in 70% Alcohol, n (%)	10% Povidone-Iodine, n (%)	Statistical Value (P)
No colonizing bacteria	21 (84)	18 (90)	.218
<i>Candida albicans</i>	3 (12)	-	
<i>Klebsiella pneumoniae</i>	1 (4)	2 (10)	
Catheter Removal Due to CRBSI			.362
Yes	4 (16)	1 (5)	
No	21 (84)	19 (95)	

*Fisher's exact test.

to a CRBSI. *Candida* ($n = 3$) and *K. pneumoniae* ($n = 1$) were seen in the blood culture of the chlorhexidine group, whereas only *K. pneumoniae* ($n = 2$) was seen in the blood culture of the povidone-iodine group. There were no significant differences between the antiseptic solutions used and the types of microorganisms present, or the number of catheters that were removed due to CRBSI.

DISCUSSION

In this study, we compared the effectiveness of 2% chlorhexidine gluconate in 70% alcohol and that of 10% povidone-iodine antiseptic solutions in the prevention of CRBSI in pediatric hematology-oncology patients with port catheters. We found no statistically significant differences in the incidence of CRBSI, exit-site infections, or the number of catheters that needed to be removed, between the 2 groups using the 2 different antiseptic solutions, respectively.

In other studies, there were no differences in the effectiveness of these 2 antiseptic solutions in preventing CRBSI. In a study conducted by Kieran et al.,²³ no significant differences were found between the effectiveness of 2% chlorhexidine gluconate in 70% alcohol and 10% povidone-iodine, in preventing CRBSI in preterm infants with an umbilical venous catheter and a peripheral central catheter. A retrospective study evaluated the differences in the incidence of CRBSI in children receiving hemodialysis, when either 0.5% chlorhexidine in alcohol or 5% povidone-iodine solution was used to disinfect the CVC during dressing changes.²⁴ It was found that the infection rate was lower in the chlorhexidine group, and the difference was not significant. The frequency of dressing changes was not reported in that study.

Similar results have been found in adult oncology patients. A study of 239 adult patients, who had a tunneled CVC for chemotherapy, compared the effectiveness of 0.05% chlorhexidine to 10% povidone-iodine, and no difference was found.¹⁸ Similarly, Kao et al.²⁰ found no difference in the effectiveness of 2% chlorhexidine in 70% alcohol compared to 10% povidone-iodine in preventing CRBSI in adult cancer patients with a port catheter.

Conversely, some studies have found chlorhexidine to be more effective in preventing CRBSI than povidone-iodine.^{6,19,25}

The differences in the results of these previous studies may be related to the different protocols being followed for CVC dressing changes. It should be noted that the drying time for the antiseptic solution and the frequency of dressing changes were either different, or not reported in all studies. Hence, it is difficult to compare the results. Additionally, as highlighted in the CDC (2011) and INS (2021) guidelines, factors including training of the catheter care team and the use of standard protocols and checklists for CVC dressing changes and follow-up are also important for the prevention of CRBSI.^{9,14} Differences in these factors may have influenced the infection rates in the aforementioned studies.

In our study, we investigated which pathogens were implicated when the patients developed CRBSI. We determined that for most patients whose dressing changes were performed with

2% chlorhexidine gluconate in 70% alcohol solution, *C. albicans* was the microorganism that caused the infection. Alternatively, *K. pneumoniae*, a Gram-negative bacteria, was found in patients whose dressing changes were performed with 10% povidone-iodine. The results of the other studies vary. In a study that examined CVC-related complications in pediatric oncology patients (54.1% of whom had an implanted port), Gram-positive bacteria were detected in most patients whose dressing changes were performed using 0.5% chlorhexidine in 70% alcohol.¹³ On the other hand, Chen et al.²⁰ retrospectively evaluated the clinical characteristics of pediatric oncology patients with CVCs (Hickman and port), and they found that Gram-positive and Gram-negative bacteria were present in an equal proportion of infections (36.3%). In their study, fungi were observed in 22.7% of infections in patients whose dressing changes were performed with povidone-iodine.

In a retrospective study in which CVC-related complications in pediatric hematology patients with tunneled (55.2%) and implanted (44.8%) port catheters were examined, *S. epidermidis* was the most commonly detected pathogen in patients whose dressing changes were performed with 10% povidone-iodine solution.⁵

In our study, 3 port catheters were removed due to *C. albicans* detection in patients receiving catheter care with 2% chlorhexidine gluconate in 70% alcohol. Among the patients receiving catheter care with 10% povidone-iodine solution, 3 were administered antibiotic treatment due to *K. pneumoniae* development. The infection continued in spite of treatment in 2 patients, and their port catheters had to be removed. When the solutions were compared, the catheter removal rate was higher in the chlorhexidine group than in the povidone-iodine group. However, the difference was not significant.

It has been observed that removal of the CVC in patients who developed port catheter infections differed in terms of the microorganism that caused the infection.^{4,12,26} The guidelines for the prevention of CRBSI recommend the removal of a port catheter if *S. aureus* or *Candida* spp. are present.^{9,27,28} Our study centers have a similar treatment approach in cases of CVC-related infections. The primary reason for the higher rate of catheter removal in the patients whose dressings were changed using 2% chlorhexidine gluconate in 70% alcohol was that the organism that caused the infections was *C. albicans*.

In our study, only 20% of the patients in whom povidone-iodine was used for catheter dressing changes had been diagnosed with leukemia, whereas all the patients in the group in which chlorhexidine was used had been diagnosed with leukemia. Moreover, 4 of the 6 patients who developed CRBSI were patients with leukemia. These findings are consistent with other studies which show that infections are more common in this group of patients.^{1,5,29} It is known that the chemotherapy protocol of leukemia patients is longer and more intense than that for solid tumors, which may be the underlying cause. This situation results in more frequent use of port catheters, and hence the risk of infection is increased.

A high patient-to-nurse ratio was reported to be effective in increased CRBSI rate in the literature.^{27,30} In our study, a single

nurse was responsible for the care of 4-to-5 patients in the clinic using chlorhexidine. On the other hand, a single nurse was responsible for 2-to-3 patients in the clinic using povidone-iodine. Catheter-related infections indicate the quality of nursing care. Appropriate catheter care by nurses prevents CRBSI and other catheter-related complications.³¹ A higher patient-to-nurse ratio in the clinic using chlorhexidine might have affected catheter care, due to the nurses' higher work load. Besides, when the physical conditions of the clinics were compared, in the povidone-iodine group, the rooms were all single-bed rooms, which provides an advantage over the chlorhexidine group in terms of infection control.

This study is the first to compare the effectiveness of 2% chlorhexidine gluconate in 70% alcohol and 10% povidone-iodine solutions in preventing CRBSI in pediatric hematology-oncology patients with a port catheter. In conclusion, we found no differences between the effectiveness of 2% chlorhexidine gluconate in 70% alcohol and 10% povidone-iodine solutions in preventing CRBSI.

LIMITATIONS

In this study, because only a small number of patients could be reached, we could not randomize the sample selection for the study. Therefore, the results cannot be generalized. This study was conducted in 2 centers. There were differences in the physical characteristics of the clinics, the number of patients per nurse, the underlying disorders (leukemia or solid tumor), and also the immune status of the patients (leukocyte, neutrophil counts, type of chemotherapy, etc.). These conditions might be factors in increasing the risk of CRBSI.

CONCLUSION

Preventing port catheter-related infections has an important role in the therapy of pediatric hematology and oncology patients, because it reduces antibiotic use and hospitalization, decreases the need for catheter replacement, and may decrease mortality. As optimal port catheter management is the keystone of infection control, it is of crucial importance to determine the most effective care protocol. Our study contributes to literature on the importance and effectivity of antiseptics used in port catheter dressing. We recommend that future prospective studies examining the effectiveness of antiseptic solutions in pediatric patients include a larger sample size.

Ethical Committee Approval: Ethical committee approval was received from the Hacettepe University Clinical Researches Ethics Boards (dated 12/22/2017 and numbered 16033).

Informed Consent: Written informed consent was obtained from all participants who participated in this study.

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