Effectiveness of Chlorhexidine-Impregnated Central Venous Catheter Dressing for Preventing Catheter-Related Bloodstream Infections in Pediatric Patients: A Systematic Review and Meta-Analysis Study

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Abstract

Objective The study's objective was to use meta-analysis to assess the effectiveness of a dressing impregnated with chlorhexidine in preventing catheter-related bloodstream infections (CRBSIs) in pediatric patients.

Methods The study was conducted and reported using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses statement. A comprehensive search of 18 databases was conducted up to 5 March 2020 to identify related studies. Following the evaluation of the methodological quality, 8 studies, 1,584 catheters in 1,556 patients were added to the meta-analysis. The odds ratio and Hedge's G effect size value were employed to analyze the data. Either a fixed-effects model or a random-effects model was used to compute the effect size value with 95% confidence intervals (CIs). The heterogeneity of effect sizes was investigated using Cochrane Q statistics, I^2, and Tau^2 tests. To test for publication bias, funnel plot, Orwin's safe *n* number, Begg and Mazumdar rank correlation, Egger test, and Duval and Tweedie's trim and fill procedures were all utilized.

Results The catheter colonization risk was lowered by 50.7% by the chlorhexidine-impregnated (C-I) dressing (odds ratio [OR] = 0.493 [%95 CI: 0.360–0.675]; $p < 0.001$). The use of C-I dressing was associated with a trend toward a decrease in CRBSIs, while this association was not statistically significant (OR = 0.858 [%95 CI: 0.567–1.300]; $p = 0.471$).

Conclusion The use of C-I dressing can effectively reduce the risk of catheter colonization, and it is also a helpful tactic in lowering CRBSIs in pediatric patients with central venous catheters, according to the findings of this meta-analysis.

Keywords
- dressing
- central venous catheter
- catheter-related infections
- chlorhexidine

Introduction

One of the pieces of medical equipment that is widely utilized in clinical settings is the intravenous catheter. Central venous catheters (CVCs) are a vital part of the critical care and management of pediatric patients in intensive care units.[1,2] In neonatal and pediatric intensive care units, these

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catheters are frequently used for intravenous applications and hemodynamic monitoring.[3,4] One of the main issues associated with the use of CVCs is catheter-related bloodstream infection (CRBSI).[3–6] Nearly 90% of bloodstream infections linked to catheters are caused by CVCs.[7] CRBSI is described as the development of bacteremia originating from an intravenous catheter.[2] Despite significant efforts to reduce deleterious effects over the past few decades, CRBSIs are remaining among the most common, dangerous, and expensive health care-associated infections in the pediatric population.[1,3,5,8] However, it is believed that 65 to 70% of CRBSIs might be prevented.[9] One of the most important steps in the prevention of CRBSIs is nursing practices.[3] The care of CVCs falls within the direct and ongoing purview of nurses. They, therefore, have a unique chance to aid in the prevention of CRBSIs. To avoid CRBSIs, it is recommended to perform appropriate catheter maintenance.[10] One of the most frequent entry routes for microorganisms that cause bloodstream infection is the catheter insertion site. The goal of nursing care is to prevent bacterial colonization and maintain a dry insertion site for CVCs. For this reason, choosing the best catheter dressing material is crucial to lowering the occurrence of CRBSIs.[3,11,12] It is recommended to use sterile gauze or a sterile, semipermeable bandage to cover the catheter site. However, in some clinical situations, the use of transparent and semipermeable dressings alone is insufficient to avoid CRBSIs and catheter colonization.[12–14]

Due to its potency as a skin antiseptic, chlorhexidine gluconate (CHG) has attracted a lot of attention lately. Numerous studies have shown how efficient it is at preventing CRBSIs in different ways.[9,15,16] The usefulness of chlorhexidine-impregnated (C-I) dressings as a barrier for bacterial penetration to the CVC insertion site and the efficacy of chlorhexidine in decreasing bioburden within the dressing during usage have been proven by the U.S. Food and Drug Administration.[15] In accordance with recent recommendations, patients who are 18 years of age or older should use C-I dressings to protect the location where CVCs are inserted.[12–14,17–20] C-I dressings are not recommended to cover the site of CVCs for premature infants due to the risk of severe adverse skin reactions.[13,17]

There are many suggestions for using C-I dressings at the catheter insertion site in infants and children to minimize CRBSIs. The Centers for Disease Control and Prevention (CDC) stated in 2017 that the use of dressings containing chlorhexidine in premature infants was not advised due to the possibility of life-threatening adverse skin responses. The same paper claims that there is insufficient information about the effectiveness and safety of C-I dressings in pediatric patients under the age of 18 years from published, high-quality trials.[17] However, some new recommendations for the prevention of infections linked to intravascular catheters advise all patients older than 2 months to utilize C-I dressings for CVC management.[18–21] There is currently no agreement on the best or most efficient dressing material for CRBSI prophylaxis in children and infants. The study's objective was to assess the effectiveness of a dressing impregnated with chlorhexidine in preventing CRBSIs in pediatric patients using systematic review and meta-analysis techniques.

Materials and Methods

Literature Review

There are limited research studies investigating the effect of C-I dressings for CVC care on bloodstream infections caused by catheters in pediatric patients. Therefore, it was intended to include all full-text research studies on the topic that had been published in peer-reviewed publications up until March 2020 using the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analysis Statement) criteria.[22] This study's data collection phase included studies with freely available full texts. The technique of gathering data involved the usage of 18 electronic databases. These databases included “Oxford University Journal,” “Springer Link,” “ProQuest Central,” “ProQuest Electronic Theses,” “ScienceDirect-Ekual,” “Wiley Online Library,” “PubMed,” “Google Scholar,” “Scopus,” “Cochrane,” “ClinicalKey,” “ClinicalTrials,” “EBSCO Host,” “Emerald Ekual,” “Informa Healthcare-Ekual,” “Ovid-Ekual,” and “Taylor & Francis Online.” Two researchers independently reviewed these databases.

Review Strategy

A search was conducted using Turkish and English keywords based on Medical Subject Headings (MeSH). The web search was conducted using the terms “child,” “chlorhexidine,” “dressing,” “central venous catheter,” and “catheter-related infections” as well as their Turkish translations. The PICO (P: population, I: intervention, C: comparison, O: outcomes) approach was used to develop the question for the meta-research analysis. Pediatric patients between the ages of 0 and 18 years were determined as the study's target population. The “intervention” criterion was the use of C-I dressing in CVC dressing and the “comparison” criterion was determined as sterile gauze or a sterile, transparent, semi-permeable dressing covering the catheter site. In terms of outcomes, this criterion encompassed the local skin reactions, dressing changes, catheter colonization, catheter exit site infections, and bloodstream infections related to CVCs.

The Selection of the Studies

The studies that were retrieved as a consequence of the review were included in this analysis based on the following criteria: the sample age range must be between 0 and 18 years; the study's design must be randomized controlled, case-control, quasiexperimental, cohort, cross-sectional, or a comparable design; it must also provide data for quantitative analysis and have enough statistical detail to calculate the effect size. However, the exclusion criteria included duplication and sampling from a separate group. The studies for the meta-analysis were selected independently by two researchers. A consensus was obtained over the studies that matched the inclusion criteria, and a comparison of the chosen research revealed an agreement rate of 0.978 (98%) overall. The studies were organized for the analysis according to the

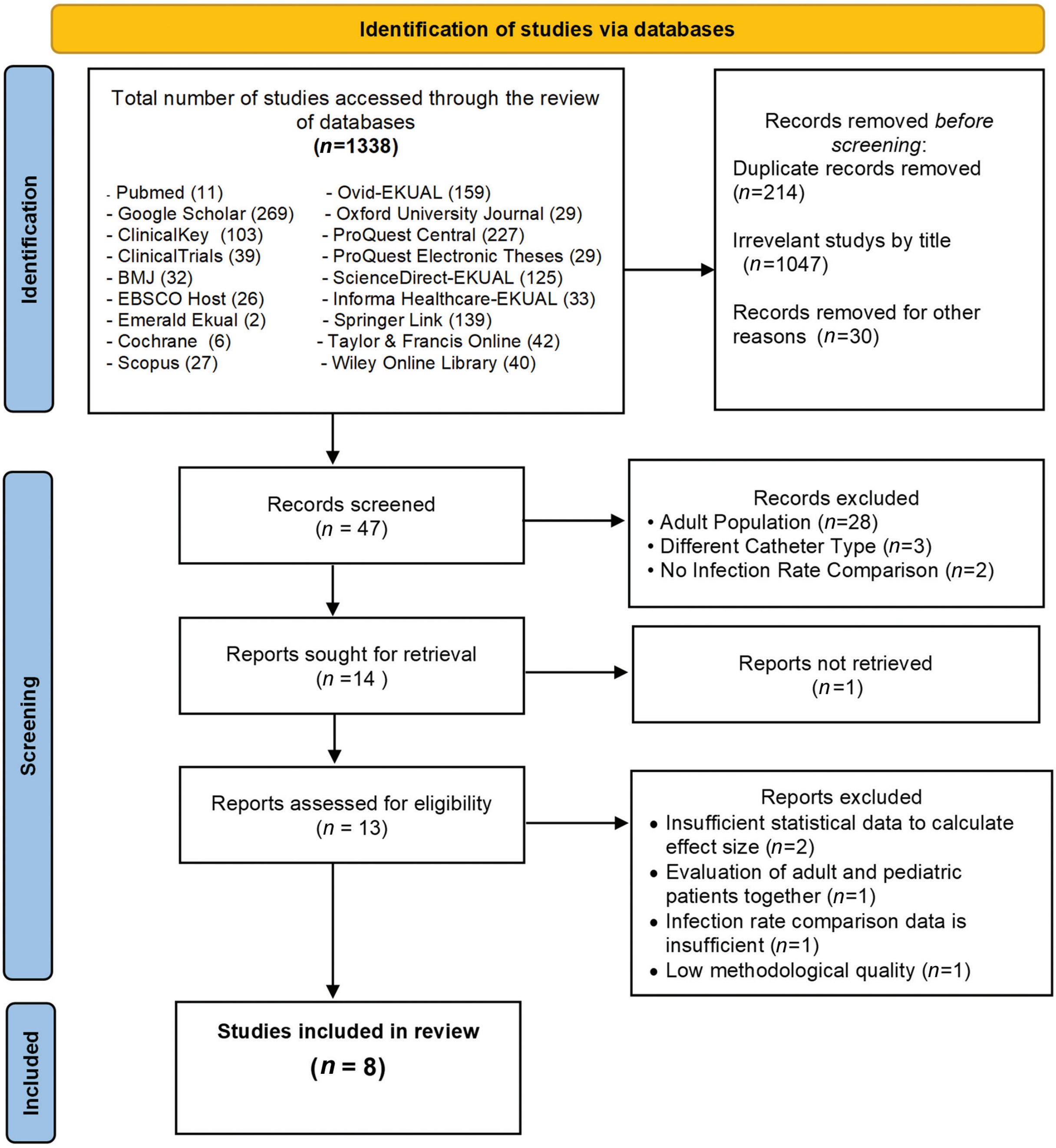

Fig. 1 PRISMA flowchart for study selection.

"PRISMA 2020 Flow Diagram" instructions.[22] The flow diagram in ►**Fig. 1** illustrates how the review only allowed 8 of the 1,338 studies that were accessed to be included in the meta-analysis.

Evaluation of the Studies in Terms of Methodological Quality

The methodological quality of each study was evaluated using the Joanna Briggs Institute Meta-analysis of Statistics Assessment and Review Instrument (JBI-MAStARI critical evaluation instrument), which was translated into Turkish by the researchers.[23,24] The specialized checklists created for the types of studies that JBI advises. The JBI divides quantitative research designs into three categories: experimental/quasiexperimental, observational, and descriptive. Depending on the qualities by the various types of studies, different evaluation criteria are included in each of the three checklists. The items on the checklist were used to assess each of the four types of bias (attrition bias, detection bias, performance bias, and selection bias) that can arise in the research. Each item on the JBI-MAStARI checklists is one point if the answer is "yes," as opposed to zero points if the answer is "no," "not specified," or "not relevant." The methodological quality of the study is indicated by a score that is higher overall. No cutoff point exists for the score.[24] In this meta-analysis, the "Checklist for Experimental and Quasi-Experimental Studies" (score ranges from 0–10) and the "Checklist for Cohort and Case-Control Studies" (score ranges

Table 1 The Methodological Quality Appraisal of the Studies Included in Meta-Analysis

Studies, Year	JBI-MAStARI critical appraisal tool	Total score of critical appraisal tool	Total score of the study
Aslan et al[3] 2020	Checklist for Cohort and Case-Control Studies	9	7
Jitrungruengnij et al[33] 2020	Checklist for Experimental and Quasi-Experimental Studies	10	8
Ergul et al[34] 2018	Checklist for Cohort and Case-Control Studies	9	6
Gerçeker et al[35] 2017	Checklist for Experimental and Quasi-Experimental Studies	10	8
Düzkaya et al[36] 2016	Checklist for Experimental and Quasi-Experimental Studies	10	9
Arpa et al[11] 2013	Checklist for Cohort and Case-Control Studies	9	6
Levy et al[37] 2005	Checklist for Experimental and Quasi-Experimental Studies	10	8
Garland et al[38] 2001	Checklist for Experimental and Quasi-Experimental Studies	10	8

from 0–9) were used to evaluate the studies critically. Studies were scored between 6 and 9, and their research quality was deemed to be of medium to high level, according to the evaluation. The methodological assessment of the caliber of the investigations is summarized in ►**Table 1**. The JBI-MAStARI Critical Tools were used by two researchers independently to assess the quality of the studies, and the researchers' agreement rate was determined to be 0.965 (97%). One article, which caused disagreement among the authors and had insufficient methodological quality, was excluded from the study. Following the evaluation of the methodological quality, 8 studies, 1,584 catheters in 1556 patients were included to the meta-analysis.

Data Collection Tools

Based on the literature, the researchers developed a data coding form that was used to collect the statistical information required to determine the study parameters (sample, technique, etc.) and effect size from each study. The data of the studies included in the meta-analysis were coded independently by two researchers, and their reliability was tested by comparing these data. An intercoder reliability analysis form was employed to assure intercoder reliability following the coding procedure. Cohen's kappa test was performed using these values, and the reliability was found to be 0.98. The value of 1 was input when the coders agreed and 0 for the codes that did not match. This outcome demonstrates that the coders' degree of agreement is very high.

Statistical Analysis

Cohen's kappa statistics were utilized to assess encoder reliability using the IBM SPSS Statistics V22.0. The analysis of the data in this study was determined using the group difference approach. The odds ratio and the hedge's G impact size value were used in the analysis as effect size statistics.[25,26] The information was examined using the Comprehensive Meta-Analysis program (CMA 3.0). Either a fixed-effects model or a random-effects model was used to compute the effect size value with 95% confidence intervals (CIs). The heterogeneity of effect sizes was investigated using Cochrane Q statistics, I^2 and Tau^2 tests. In meta-analyses, the studies with a small sample size, a small number, or a wide CI, the cutoff p-value of the Cochran Q statistic was accepted to be 0.10.[27,28] Consequently, the study's significance value for heterogeneity tests was set at 0.1; nevertheless, the significance value and confidence range for all other statistical calculations were both set at 0.05 and 95%. Since the odds ratio approach comprised statistical information from two groups and covered the comparison of these groups, it was used in this investigation as an effect size statistic. Hedges's G effect size value, which works better when the sample sizes are below 20, was used to calculate the effect size using averages. I^2 values below 25% are regarded as low heterogeneity, between 25 and 50% as medium heterogeneity, and beyond 50% as high heterogeneity when evaluating heterogeneity. A funnel plot graph, Orwin's fail-safe N, Begg and Mazumdar rank correlations, Egger regression, and Duval and Tweedie's trim and fill methods were used to analyze publication bias.[29–32]

The study (2019/15-27) received permission from the noninterventional research ethics committee of Dokuz Eylul University. This was a meta-analysis; hence, there was no research on children and parents. As a result, neither the children's nor their parents' consent was necessary.

Results

The systematic review comprised nine studies, whereas the meta-analysis included eight trials.[3,11,33–38] The sample was omitted from a study with subpar methodological quality. The meta-analysis comprised a total of eight research from Türkiye, the United States, Israel, and Thailand, among other nations. Infants and children between the ages of 0 and 18 years made up the study's sample. The meta-analysis's execution dates range from 2001 to 2020. The meta-analysis comprised 1,584 catheters in 1,556 patients, including 833 catheters in 821 patients in the comparison group and 751 catheters in 735 patients in the group receiving the C-I dressing. The studies' overall sample sizes ranged from 27 to 705 patients. The features of the studies that were examined in the meta-analysis are listed in ►**Table 2**.

Table 2 The characteristics of the studies included in the meta-analysis

Author/Year/Country	Research design/ sample size	Catheter type and location[a]	Comparison groups	Major findings
Aslan et al (2020) Türkiye	Cross-sectional study $n = 144$	–Temporary CVC – Hemodialysis catheter *Femoral, jugular, and subclavian	C-I dressing and standard dressing	CRBSI rate: No statistically significant difference between the groups ($p = 0.356$) Catheter colonization: There was no significant difference between the two groups ($p = 0.616$).
Jitrungruengnij et al (2020) Thailand	Randomized control study $n = 181$	–Temporary CVC – Peripherally inserted central catheter * Femoral, jugular, subclavian, and brachial	C-I dressing and standard transparent dressing	CRBSI rate: No statistically significant difference between the two groups ($p = 0.62$) Catheter colonization: No statistically significant difference between the two groups (95% CI: 0.10–3.39, $p = 0.59$) Local skin reaction ratio: No statistically significant difference between the two groups ($p = 0.54$)
Ergul et al (2018) Türkiye	Prospective cohort study $n = 131$	–Temporary CVC *Jugular	C-I dressing and standard transparent dressing	CRBSI rate: No statistically significant difference between the two groups ($p > 0.05$) Causative microorganisms: In the CHG-dressing group, CRBSIs caused by Gram-positive microorganisms totaled 0%, but the figure was 8.8% in the control group ($p = 0.028$
Gerçeker et al (2017) Türkiye	Randomized control study $n = 27$	–Hickman catheter – Port-a-cat	C-I dressing and standard transparent dressing	CRBSI rate: No statistically significant difference between the two groups ($p > 0.05$) Catheter colonization: No statistically significant difference between the two groups ($p = 0.259$) Catheter exit site infection rate: No statistically significant difference between the two groups ($p = 0.222$)
Düzkaya et al. (2016) Türkiye	Randomized control study $n = 100$	–Temporary CVC *Femoral, jugular, and subclavian	C-I dressing and standard gauze dressing	CRBSI rate: No statistically significant difference between the two groups ($p > 0.05$) Catheter colonization: No statistically significant difference between the two groups ($p > 0.05$) Catheter exit site infection rate: No statistically significant difference between the two groups ($p > 0.05$)
Arpa et al. (2013) Türkiye	Cohort study $n = 123$	–Temporary CVC *femoral, jugular, and subclavian	C-I dressing and standard transparent dressing	CRBSI rate: There was no statistically significant difference between the two groups ($p = 0.292$) Catheter colonization: 6.3% in the C-I dressing group, 21.7% in the transparent dressing group . The difference between the two groups was statistically significant ($p = 0.028$). Catheter exit site infection rate: No significant difference between the two groups ($p = 0.488$)

Table 2 (*Continued*)

Author/Year/Country	Research design/ sample size	Catheter type and location[a]	Comparison groups	Major findings
				Local skin reaction: No statistically significant difference between the two groups ($p > 0.05$)
Levy et al (2005) Israel	Randomized control study $n = 145$	–Temporary CVC *jugular	C-I disk dressing and standard transparent dressing	CRBSI rate: No significant difference between the two groups ($p = 1.00$). Catheter Colonization: There is a significant difference between the two groups ($p = 0.0446$; RR, 0.6166; 95% CI: 0.3716–1.023) Local skin reaction: C-I disc dressing group 5.4% transparent dressing group 1.4%.
Garland et al. (2001) United States of America	Randomized control study $n = 705$	–Temporary CVC – Broviac catheters	C-I disk dressing and standard transparent dressing	CRBSI rate No significant difference between the two groups ($p = 0.60$). Catheter Colonization: C-I disc dressing group 15% transparent dressing group 24%. There is a significant difference between the two groups ($p = 0.004$; RR: 0.6. 95% CI: 0.5–0.9).

Abbreviations: CHG, chlorhexidine gluconate; C-I, chlorhexidine-impregnated; CI, confidence interval; CRBSI, catheter-related bloodstream; CVC, central venous catheters; RR, relative risk.

Catheter-Related Bloodstream Infections

The impact of the use of C-I dressings on CRBSI was examined by a meta-analysis, sensitivity analysis, and subgroup analysis of eight trials. The Q-value and *p*-value from the heterogeneity test used to determine the overall effect were found to be 5.226 and 0.632, respectively. The Q-value is 12.017 in the X^2 critical value range table for 7 degrees of freedom (df) and 0.10 significance level. The study was deemed to be homogeneous because the Q-value is lower than the Q-value in the X^2 table. The homogeneity of the study is also demonstrated by the I^2 value, which is 0, and the Tau^2 value, which is 0.000. For this reason, the fixed effect model was used as the analysis model. The results of the meta-analysis of eight trials are shown in ►**Fig. 2**. The odds ratio at the 95% confidence level was used to calculate the effect size for each study. The graph's squares reflect the impact size of the relevant study, and the lines on each side of the squares show the upper and lower bounds of the effect sizes within the 95% CI. The area of each square represents the contribution of the corresponding study to the total impact size. The overall effect size of the research is displayed by the diamond-shaped rhombus. According to the fixed effect model, the overall effect size in the meta-analysis was 0.858 odds. The odds ratio's lowest and greatest values inside the 95% CI were 0.567 and 1.3, respectively. The overall effect's *p*-value was 0.471. When the statistical significance was calculated with the *Z* test, it was found to be $Z = -0.721$. It was discovered that patients wearing C-I dressings experienced a 14.2% lower incidence of CRBSI (odds ratio [OR] = 0.858 [95% CI: 0.567–1.300]) than patients in the comparison group. The impact rate in this group, however, was not statistically significant ($Z = -0.721$; $p = 0.471$).

The study tested for publication bias using the funnel plot, Duval and Tweedie, Egger regression, Begg and Mazumdar's rank correlations, and Orwin's fail-safe N. The meta-analysis of eight studies comparing the incidence of CRBSI in patients with C-I dressings and in patients in the comparison group revealed that 171 additional studies are needed to raise the odds ratio over 1.05. It was established that publication bias did not affect the meta-analysis because this number is not a practical and accessible number. Duval and Tweedie's clipping and filling analysis revealed that there are no missing studies. Begg, Mazumdar, and Egger regression analysis revealed no publication bias ($p > 0.05$). The probability of publication bias was also investigated using the funnel plot, as seen in ►**Fig. 3**. It is accepted that there is no publication bias if the graph of the standard error against the effect value derived from individual studies in the meta-analysis is funnel shaped. The effect sizes can be conceptualized as having a symmetrical structure, as seen in ►**Fig. 4**. This shows a negligible amount of publication bias and suggests that the meta-analysis may not have been affected by publication bias.

Colonization of Catheters

Colonization of the CVC is defined as growth of 15 colony-forming units or more in the catheter-end culture in the absence of local or systemic signs of infection and no growth

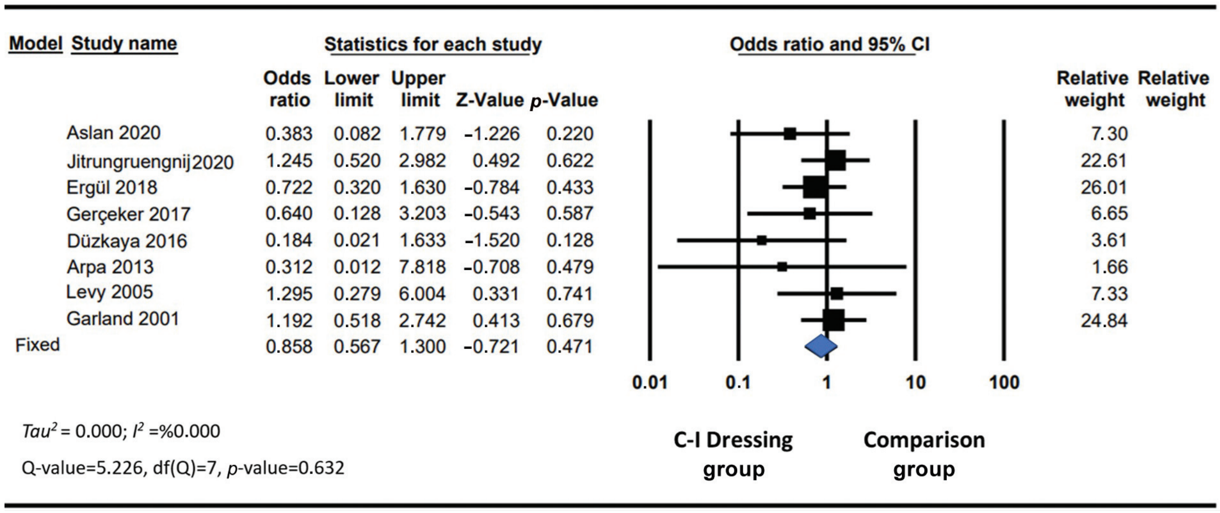

Fig. 2 The effect size value of the studies investigating the effect of chlorhexidine impregnated CVC dressing on CRBSI in pediatric patients.

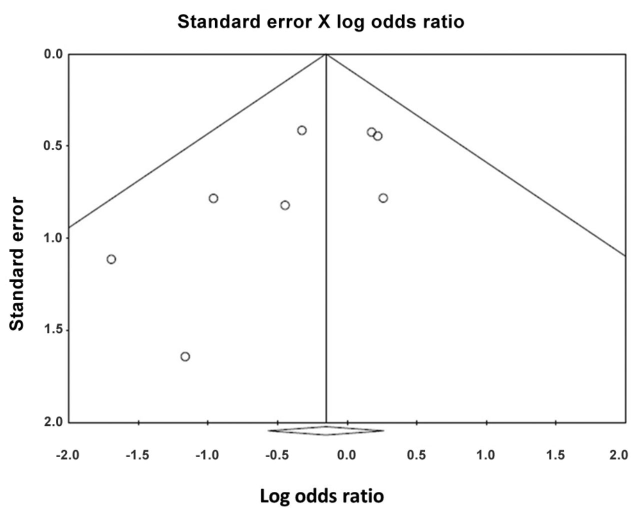

Fig. 3 Funnel plot of studies analyzing the effect of chlorhexidine impregnated CVC dressing on CRBSI.

in the cultures of the two blood samples.[11,36,37] The impact of using C-I dressing in CVC care on catheter colonization was examined in seven trials.[3,11,33,35–38] These studies were subjected to a sensitivity analysis, subgroup analysis, and meta-analysis. The Q-value and p-value from the heterogeneity test used to determine the overall effect were found to be 2.337 and 0.886, respectively. The Q-value is 10.645 in the X^2 critical value range table for 6 degrees of freedom (df) and 0.10 significance level. The study is deemed to be homogeneous because the Q-value is lower than the Q-value in the X^2 table. According to the fixed effect model, the overall effect size in the meta-analysis is 0.493 odds. The odds ratio's lowest and greatest values inside the 95% CI were 0.360 and 0.675, respectively. The meta-analysis showed that patients with C-I dressings had a 50.7% lower incidence of catheter colonization (OR = 0.493 [95% CI: 0.360–0.675]) than patients without C-I dressings. This effect was statistically significant ($Z = -4.399$; $p < 0{,}001$).

In the study, publication bias was tested using the funnel plot, Orwin's fail-safe N, Duval and Tweedie, Begg and

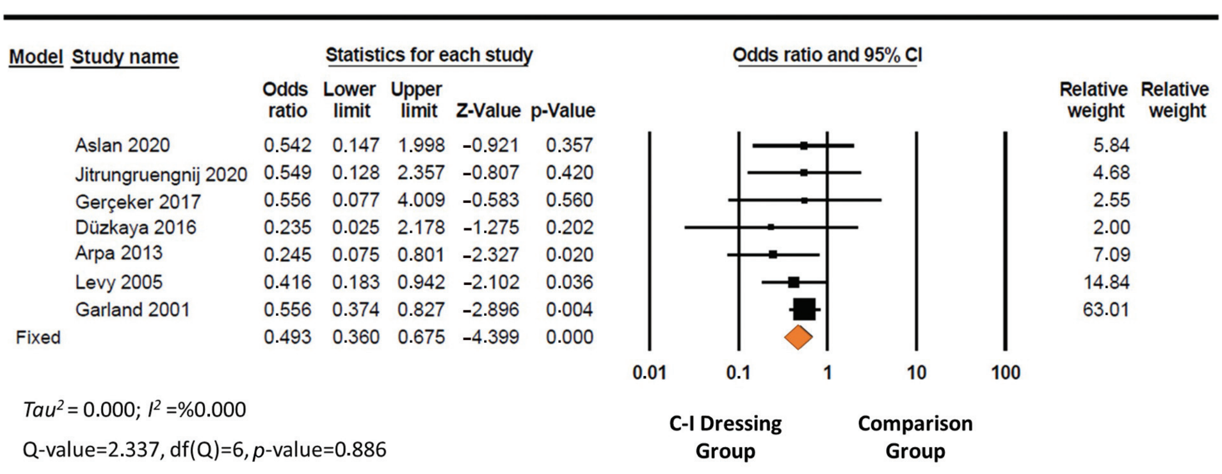

Fig. 4 The effect size value of the studies investigating the effect of chlorhexidine impregnated CVC dressing on catheter colonization in pediatric patients.

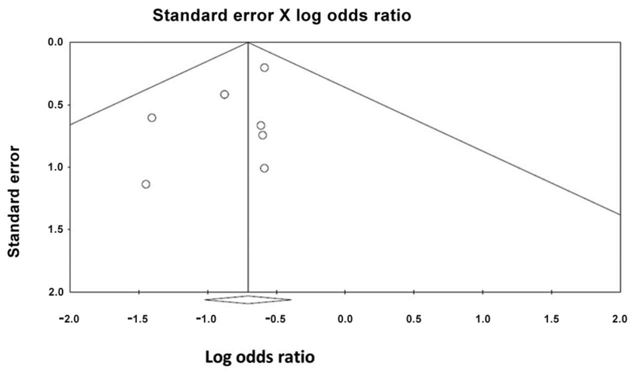

Fig. 5 Funnel plot of studies analyzing the effect of chlorhexidine impregnated CVC dressing on catheter colonization.

Mazumdar's rank correlations, and Egger regression. The meta-analysis of seven studies comparing the incidence of CRBSI in patients with C-I dressings and in patients in the comparator group revealed that 559 additional studies are needed to raise the odds ratio over 1.05. It was shown that publication bias had no impact on the meta-analysis study. Duval and Tweedie's clipping and filling analysis revealed that there are no missing studies. Begg, Mazumdar, and Egger regression analysis revealed no publication bias ($p > 0.05$). As seen by the Funnel Plot in ►**Fig. 5**, it can also be claimed that the effect sizes have a symmetrical structure. This analysis suggests that the study may not have had much publication bias.

Exit Site Infection

Exit site infection was defined as erythema, induration, and tenderness around the catheter exit site, with or without BSI.[37] A meta-analysis of three trials looking at the impact of C-I dressing on catheter exit site infection was performed.[11,35,36] Patients using CVC-impregnated drapes for CVC dressings were shown to have a 68.2% lower incidence of catheter exit site infection (OR = 0.318 [95% CI: 0.061–1.658]) compared with the reference group. However, $Z = -1.359$; $p = 0.174$ indicated that this effect was not statistically significant (►**Fig. 6**).

Local Skin Reactions

Four studies that looked at the impact of C-I dressing on the occurrence of local skin reactions in CVC patients were included in a meta-analysis.[11,33,37,38] In children, including premature neonates, who received C-I dressing, it was discovered that, although not statistically significant, the likelihood of a local skin reaction increased 4.7 times when compared with the control group (OR = 4.696 [95% CI: 0.979–22.534], $Z = -1.933$, $p = 0.053$). With the exception of one study, which included premature neonates, a meta-analysis of three studies involving nonpremature neonates and kids was performed.[38] Children who utilized C-I dressings for CVC care had a likelihood of a local skin reaction that was 1.9 times higher than that of the comparison group, despite this finding not being statistically significant (OR = 1.892 [95% CI: 0.745–4.801, $Z = -1.341$; $p = 0.180$]).

Dressing Change Frequency

The frequency of dressing changes was examined in a meta-analysis of two trials looking at the impact of utilizing C-I dressing for catheter care.[11,33] The analysis revealed that, compared with the comparison group, the use of C-I dressing in CVC care reduced the frequency of dressing changes, but the impact size was small (−0.240) and not statistically significant ($Z = -0.804$; $p = 0.422$).

Discussion

There is no agreement on the best or most efficient dressing material for BSI prophylaxis in young children and infants. Adult patient meta-analyses have provided evidence for the effectiveness of C-I dressings in lowering CRBSI rates. However, these studies' conclusions are broad and not focused on particular CVC types or patient demographics.[39] Our study is the first meta-analysis to look at studies just including kids and to investigate the effectiveness of C-I catheter dressing in preventing CRBSI in pediatric patients. The effectiveness of C-I dressing in avoiding catheter exit site infections as well as its impact on how frequently catheter dressings are changed were also examined in this meta-analysis. Our meta-analysis study revealed that patients wearing C-I dressings had a 14.2% lower incidence of CRBSI than those in the comparator group. Although not statistically significant, the effect rate in this group still exists. In the studies that made up the meta-analysis, it was shown that the rates of CRBSI varied between 1.7 and 38.5% in the comparator groups but ranged from 0 to 28.6% in the groups utilizing C-I dressing. These

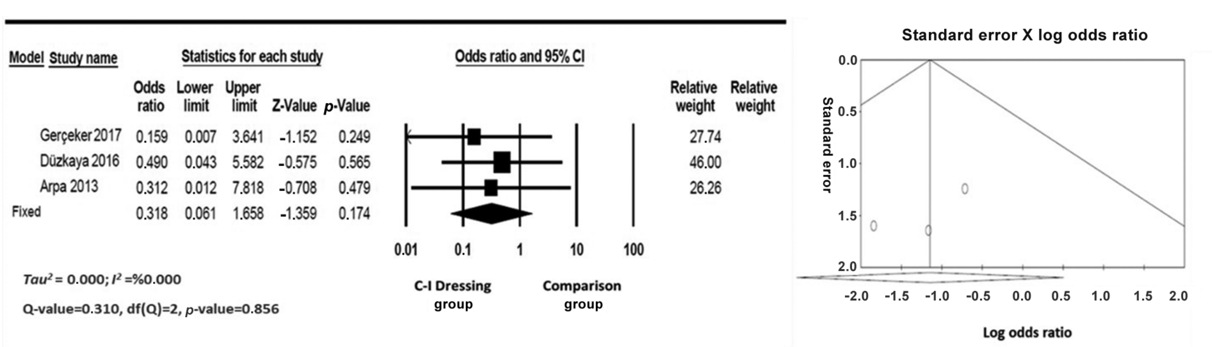

Fig. 6 The effect size value and funnel plot of studies analyzing the effect of chlorhexidine impregnated CVC dressing on exit site infection.

discrepancies in CRBSI ratios are believed to be the result of variations in practice between the study units. The importance of CVC placement, care, and precautionary packages in the prevention of CRBSI was stressed in the studies included in the meta-analysis but little information was provided regarding the implementation of a precautionary package or the interventions included in the precautionary. Although the "CVC Infections Prevention Package" based on current guidelines was reportedly implemented to all patients in only two research studies, the catheter dressing approach was extensively detailed in all the studies included in the meta-analysis.[3,35] Only one of these investigations included a detailed breakdown of the cautionary package's contents.[35] These findings diverge from those of the meta-analysis, which also included trials including adult patients. In a meta-analysis of nine randomized controlled trials comprising 6,067 patients and 11,214 catheterizations, Safdar et al found that the use of C-I dressings reduced the relative risk for CRBSI by 45% (relative risk [RR] = 0.60; %95 CI: 0.41–0.88, $p = 0.009$).[40] Three of the twelve RCTs included in the meta-analysis by Wei et al. were performed on young patients. The study's findings revealed that C-I dressings are a successful anti-infection tactic and are helpful in lowering the incidence of CRBSI (OR = 0.60; 95% CI: 0.42–0.85; $p = 0.001$).[16] A meta-analysis by Wang et al used a total of 13 RCTs, of which four were performed on young patients. C-I dressing was demonstrated to significantly lower the incidence of CRBSIs in the study (RR = 0.55, 95% CI: 0.39–0.77, $p = 0.001$).[41] The use of C-I dressing in CVC care has been found to decrease the risk of CRBSI in our investigation; however, this impact was not statistically significant. The existence of CRBSI precautionary packages, the interventions contained in the packages, the rates of compliance with the precautionary package, and the variations in nursing practices in the pediatric units where the trials were done were deemed to be responsible for this outcome.

Colonization is assumed to be the cause of CRBSIs.[42] The most significant cause of catheter infections is skin flora, which plays a significant role in catheter colonization and infection.[12] For catheter colonization and CRBSI prevention, catheter care and the dressing material selected for care are crucial.[3] Data on the impact of employing C-I dressing in CVC care on catheter colonization were available from seven of the studies that were included in the meta-analysis. While the rate of catheter colonization in the trials' C-I dressing group was between 2 and 15%, it ranged from 5 to 29.6% in the comparator group. The risk of catheter colonization was found to be 50.7% lower in the group using C-I dressing compared with the comparison group (OR = 0.493 [95% CI: 0.360–0.675], $Z = -4.399$; $p < 0.001$). This effect was statistically significant and comparable to those shown in meta-analyses of research done on adult patient populations.[16,40,41] The meta-analysis conducted by Safdar et al revealed that the prevalence of catheter colonization significantly reduced when CHG-impregnated dressing was used to dress CVC catheters as opposed to conventional dressing techniques (RR = 0.52; 95% CI: 0.43–0.64; $p = 0.001$).[40] Similar to this, Wang et al meta-analysis's from 2019 found that the application of dressing impregnated with chlorhexidine significantly decreased the incidence of catheter colonization (RR = 0.52, 95% CI: 0.40–0.67, $p = 0.001$).[41] The use of C-I dressing in CVC care is an effective method in lowering the probability of catheter colonization, according to the findings of our meta-analysis study.

One of the key entry locations for microorganisms that cause bloodstream infection is the catheter skin entry site. One goal of catheter dressing is to prevent bacterial colonization and infection at the catheter exit site by keeping the skin entry area dry.[3,11,12] The meta-analysis revealed that although there was no statistically significant difference, patients who used C-I dressing had a 68.2% lower risk of catheter exit site infection than those in the control group (OR = 0.318 [%95 CI: 0.061–1.658], $Z = -1.359$; $p = 0.174$). Our meta-analysis study revealed that using C-I dressing is an effective method for lowering catheter exit site infections.

The negative consequences of repeated topical exposure to chlorhexidine must be taken into account. It is advised to carefully monitor signs and symptoms for hypersensitivity responses while using dressings and antiseptic solutions that contain chlorhexidine.[5,13,20,43,44] Our meta-four analysis's published clinical studies that specifically addressed skin responses. Local skin reactions were more common in the C-I dressing group in studies, where they occurred between 5.4 and 8.7% of the time and between 0 and 6.7% of the time in the comparison group. There were no reports of severe dermatitis.

Premature babies made up the sample in one of these investigations. As a result of this study performed by Garland et al (2001), local contact dermatitis was reported local reactions at the site of the chlorhexidine dressing occurred in 5.7% of the antiseptic dressing-treated neonates and most reactions occurred in neonates ≤28 weeks gestational age and ≤1,000 g. In the same study, local contact dermatitis was reported with a rate of 1.5% in neonates weighing more than 1,000 g.[38] In the other three studies included in the meta-analysis, nonpremature neonates and children were included in the study.[11,33,37] Levy et al reported that four patients (5.4%) in the study group had mild contact dermatitis of the CVC insertion site, all four of these patients were neonates and the did not require a change in the dressing or removal of the CVC.[37] Arpa et al reported that local allergic reaction developed on the skin in four patients in the C-I dressing group, the ages of the patients were between 4 months and 9 years old.[11] In the study by Jitrungruengnij et al, local skin reactions were detected in 6.8% of the participants but this was not significantly different between both groups; eight participants from the C-I dressing group (7.5%) and eight participants from the standard transparent dressings group (6%) had local skin reactions ($p = 0.54$), whereas 1.0% moderate dermatitis was reported of the participants (one participant from the C-I dressing group and one participant from the standard transparent dressings group).[33]

The meta-analysis that included the premature neonates trial revealed that, although it was not statistically significant, the likelihood of a local skin reaction increased by 4.7 times when compared with the reference group. On the contrary, this increase was shown to be 1.9 times and not statistically significant in the meta-analysis of trials involving nonpremature infants and children. Our findings indicates that C-I dressings can be used safely in all children except neonates. However, while using C-I dressings, nurses and doctors should pay close attention to any signs and symptoms of hypersensitivity reactions and keep an eye out for erythema and dermatitis in the skin area covered by the dressing.

The use of C-I dressing in CVC care has been demonstrated to be a cost-effective procedure in studies on adult patients. The National Health Service (NHS) in England has the potential to save between £4.2 million and £10.8 million annually if this approach becomes normal practice, with the cost savings of using a dressing containing CHG gel instead of a regular dressing projected to be £73 per patient.[45] However, C-I dressings have been demonstrated as an option that can be utilized in certain patients, such as those who have frequent SCI-BSI or simply require CVC care, in recent years due to the price of C-I dressing materials and the budgetary restraints of the hospitals.[46] It was noted that no research was done on the impact of the use of C-I dressing on the frequency of dressing changes in the meta-analyses that included adult patients. It was attempted to obtain comparable data on the usage of CHG-impregnated dressing's effects on cost, nursing workload, and frequency of dressing changes in the studies included in the meta-analysis. Only two research had data on how frequently people changed their clothes. The use of C-I dressing in the CVC care lowered the frequency of dressing changes compared with the reference group, although the impact size was small and not statistically significant ($p = 0.422$), according to the meta-analysis of two trials. The meta-analysis that was conducted using only two papers, however, was unable to run publication bias tests, and this should be taken into account when extrapolating the findings.

The study only included theses and papers in Turkish and English. One of the study's drawbacks is that the studies included in the meta-analysis used small sample sizes, and another is that the frequency of dressing changes and the skin antiseptic used during CVC maintenance vary depending on the study.

Conclusion

The study's findings support the notion that using C-I dressing can help prevent catheter colonization and catheter exit site infections. The inclusion of transparent dressing containing CHG-impregnated gel pads in the "Central Venous Catheter Infections Precautions Package" for all children except neonates, a CHG allergy check prior to the use of C-I dressing, caution regarding the signs and symptoms of local skin reactions, and monitoring is advised during dressing use are all suggested in light of the study's findings. Implementation as a component of a suite of metrics determines the efficacy of C-I dressing use in CVC care in the prevention of CRBSI. C-I dressings shouldn't be considered a substitute for established best practices for central venous catheterization procedures and CVC care, but rather as an addition to the collection of strategies that have been shown to reduce CRBSIs. The conclusions of this meta-analysis study highlight the importance of carefully planned randomized controlled trials for future research. Additionally, it clarifies the factors that must be managed and investigated in research that assess the impact of various dressing materials. The efficiency of employing C-I dressing in CVC care should be investigated comparatively in different patient groups, different catheter types, and different C-I dressing materials to identify the patient subgroups most likely to benefit. This is especially important in centers with high CRBSI rates. Examining the effects of C-I dressing use on dressing change frequency, nursing effort and treatment cost are another of our recommendations.

Conflict of Interest
None declared.

References

1 Rabelo BS, de Alvarenga KAF, Miranda JWFB, et al. Risk factors for catheter-related infection in children with cancer: a systematic review and meta-analysis. Am J Infect Control 2023;51(01):99–106
2 Kochanowicz JF, Nowicka A, Al-Saad SR, Karbowski LM, Gadzinowski J, Szpecht D. Catheter-related bloodstream infections in infants hospitalized in neonatal intensive care units: a single center study. Sci Rep 2022;12(01):13679
3 Aslan N, Yıldızdaş D, Menemencioğlu A, et al. Comparison of standard dressing and chlorhexidine gluconate-impregnated dressing for the prevention of catheter-related bloodstream infection in our pediatric intensive care unit. J Pediatr Emerg Intensive Care Med 2020;7:24–29
4 Bierlaire S, Danhaive O, Carkeek K, Piersigilli F. How to minimize central line-associated bloodstream infections in a neonatal intensive care unit: a quality improvement intervention based on a retrospective analysis and the adoption of an evidence-based bundle. Eur J Pediatr 2021;180(02):449–460
5 Lai NM, Taylor JE, Tan K, Choo YM, Ahmad Kamar A, Muhamad NA. Antimicrobial dressings for the prevention of catheter-related infections in newborn infants with central venous catheters. Cochrane Database Syst Rev 2016;3(03):CD011082
6 İşgüder R, Devrim İ, Ceylan G, Kara A, Gülfidan G, Ağın H. Risk factors for recurrent central line-associated bloodstream infections in a pediatric intensive care unit. Turk J Med Sci 2017;47(04):1128–1136
7 Myatra SN. Improving hand hygiene practices to reduce CLABSI rates: nurses education integral for success. Indian J Crit Care Med 2019;23(07):291–293
8 Whalen A, Mack EH. Prevention of central line-associated bloodstream infections in children: current challenges and opportunities. Curr Treat Options Pediatr 2020;6(03):203–213
9 Martinez T, Baugnon T, Vergnaud E, et al. Central-line-associated bloodstream infections in a surgical paediatric intensive care unit: risk factors and prevention with chlorhexidine bathing. J Paediatr Child Health 2020;56(06):936–942
10 Benligül EM, Bektaş M, Arslan G. Current approach to prevention of central venous catheter-related bloodstream infections in children. J Pediatr Emerg Intensive Care Med 2021;8:67–76
11 Arpa Y, Aygün H, Yalçınbaş Y, San D. Comparison of catheter related infection rates in pediatric cardiovascular surgery patients with use of transparent cover and transparent cover saturated with chlorhexidine gluconate in central catheter care. Journal of Research and Development in Nursing 2013;15(02):57–67

12 Turkish Association of Hospital Infections and Control. National Vascular Access Management Guide 2019. J Hosp Infect 2019;23 (Suppl 1):1–54
13 Gorski LA, Hadaway L, Hagle ME, et al. Infusion Therapy Standards of Practice, 8th Edition. J Infus Nurs 2021;44(1S, Suppl 1):S1–S224
14 O'Grady NP, Alexander M, Burns LA, et al; Healthcare Infection Control Practices Advisory Committee (HICPAC) Guidelines for the prevention of intravascular catheter-related infections. Clin Infect Dis 2011;52(09):e162–e193
15 Beekman K, Steward D. Chlorhexidine gluconate utilization for infection prevention in the NICU: a survey of current practice. Adv Neonatal Care 2020;20(01):38–47
16 Wei L, Li Y, Li X, Bian L, Wen Z, Li M. Chlorhexidine-impregnated dressing for the prophylaxis of central venous catheter-related complications: a systematic review and meta-analysis. BMC Infect Dis 2019;19(01):429
17 Centers for Disease Control and Prevention. 2017 Recommendations on use of chlorhexidine-impregnated dressings for prevention of intravascular catheter-related infections: An update to the 2011 guidelines for the prevention of intravascular catheter-related infections from the Centers for Disease Control and Prevention. Centers for Disease Control and Prevention, National Center for Emerging and Zoonotic Infectious Diseases, Division of Healthcare Quality and Promotion. Accessed August 30, 2022 at: https://www.cdc.gov/infectioncontrol/pdf/guidelines/c-i-dressings-H.pdf
18 Apfelbaum JL, Rupp SM, Tung Aet al. Practice guidelines for central venous access 2020: an updated report by the American Society of Anesthesiologists Task Force on Central Venous Access. Anesthesiology 2020;132(01):8–43
19 Ling ML, Apisarnthanarak A, Jaggi N, et al. APSIC guide for prevention of Central Line Associated Bloodstream Infections (CLABSI). Antimicrob Resist Infect Control 2016;5(01):16
20 Marschall J, Mermel LA, Fakih M, et al; Society for Healthcare Epidemiology of America. Strategies to prevent central line-associated bloodstream infections in acute care hospitals: 2014 update. Infect Control Hosp Epidemiol 2014;35(07):753–771
21 Huang EY, Chen C, Abdullah F, et al; 2011 American Pediatric Surgical Association Outcomes and Clinical Trials Committee. Strategies for the prevention of central venous catheter infections: an American Pediatric Surgical Association Outcomes and Clinical Trials Committee systematic review. J Pediatr Surg 2011; 46(10):2000–2011
22 Page MJ, McKenzie JE, Bossuyt PM, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372(71):n71
23 The Joanna Briggs Institute Critical Appraisal tools. Accessed 06 March 2022 at: https://jbi.global/critical-appraisal-tools
24 Nahcivan N, Seçginli S. How are the methodological quality of quantitative studies included in systematic review? Turkiye Klinikleri J Public Health Nurs-Special Topics 2017;3(01):10–19
25 Dinçer S. Applied meta-analysis in educational sciences. First edition,. Ankara: Pegem Akademi; 2014
26 Akoğlu H. Odds oranı, rölatif risk, NNT ve NNH. Accessed September 27, 2020 at; https://www.aciltipakademisi.org/odds-orani-rolatif-risk-nnt-ve-nnh/
27 Kılıçkap M. [How to interpret meta-analyses: a recipe for interpretation of the methodology used in the meta-analyses conducted on cardiovascular risk factors in Türkiye]. Turk Kardiyol Dern Ars 2018;46(07):624–635
28 Çarkungöz E, Ediz B. Meta analysis. Uludag Univ. J. Fac. Vet. Med. 2009;28(01):33–37
29 Şen S, Akbaş N A study on multilevel meta-analysis methods. J Measure Evaluat Educ Psychol 2016;7(01):1–17
30 Gedik A, Üstüner M. The relationship between organizational commitment and job satisfaction in educational organizations: a meta-analysis study. E-Int J Educat Res 2017;8(02):41–57
31 Bakioğlu A, Göktaş E A method of determining an education policy: meta-analysis. J Civil Educat Res 2018;1(02):35–54
32 Kansızoğlu HB, Sulak SE. The effect of student-centered grammar teaching practices on student achievement: a meta-analysis study. J Hacettepe Univ Faculty Educat 2019;34(04):958–980
33 Jitrungruengnij N, Anugulruengkitt S, Rattananupong T, et al. Efficacy of chlorhexidine patches on central line-associated bloodstream infections in children. Pediatr Int 2020;62(07): 789–796
34 Ergul AB, Gokcek I, Ozcan A, Cetin S, Gultekin N, Torun YA. Use of a chlorhexidine-impregnated dressing reduced catheter-related bloodstream infections caused by Gram-positive microorganisms. Pak J Med Sci 2018;34(02):347–351
35 Gerçeker GÖ, Yardımcı F, Aydınok Y. Randomized controlled trial of care bundles with chlorhexidine dressing and advanced dressings to prevent catheter-related bloodstream infections in pediatric hematology-oncology patients. Eur J Oncol Nurs 2017; 28:14–20
36 Düzkaya DS, Şahiner NC, Uysal G, Yakut T, Çitak A. Chlorhexidine-impregnated dressings and prevention of catheter-associated bloodstream infections in a pediatric intensive care unit. Crit Care Nurse 2016;36(06):e1–e7
37 Levy I, Katz J, Solter E, et al. Chlorhexidine-impregnated dressing for prevention of colonization of central venous catheters in infants and children: a randomized controlled study. Pediatr Infect Dis J 2005;24(08):676–679
38 Garland JS, Alex CP, Mueller CD, et al. A randomized trial comparing povidone-iodine to a chlorhexidine gluconate-impregnated dressing for prevention of central venous catheter infections in neonates. Pediatrics 2001;107(06):1431–1436
39 Margatho AS, Ciol MA, Hoffman JM, et al. Chlorhexidine-impregnated gel dressing compared with transparent polyurethane dressing in the prevention of catheter-related infections in critically ill adult patients: a pilot randomised controlled trial. Aust Crit Care 2019;32(06):471–478
40 Safdar N, O'Horo JC, Ghufran A, et al. Chlorhexidine-impregnated dressing for prevention of catheter-related bloodstream infection: a meta-analysis. Crit Care Med 2014;42(07):1703–1713
41 Wang HX, Xie SY, Wang H, Chu HK. The effects of chlorhexidine dressing on health care-associated infection in hospitalized patients: a meta-analysis. Iran J Public Health 2019;48(05): 796–807
42 Koeppen M, Weinert F, Oehlschlaeger S, Koerner A, Rosenberger P, Haeberle HA. Needle-free connectors catheter-related bloodstream infections: a prospective randomized controlled trial. Intensive Care Med Exp 2019;7(01):63
43 Loveday HP, Wilson JA, Pratt RJ, et al; UK Department of Health. epic3: national evidence-based guidelines for preventing healthcare-associated infections in NHS hospitals in England. J Hosp Infect 2014;86(Suppl 1):S1–S70
44 Devinck A, Bauters T, Lapeere H, Willems L. Anaphylaxis related to disinfection with chlorhexidine in a teenager treated for cancer. J Oncol Pharm Pract 2021;27(01):227–231
45 Jenks M, Craig J, Green W, Hewitt N, Arber M, Sims A. Tegaderm CHG IV securement dressing for central venous and arterial catheter insertion sites: a NICE Medical Technology Guidance. Appl Health Econ Health Policy 2016;14(02):135–149
46 Kikuchi M, Sato T, Okada S, Abe N, Sato A, Suzuki Y. Maintenance antisepsis in reducing the rate of late-onset central venous catheter-related bloodstream infection: a comparison of 0.05% and 1% chlorhexidine. J Infect Chemother 2020;26(02):188–193