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ORIGINAL ARTICLE

Clinical use of chlorhexidine gluconate antimicrobial dressings for subclavian central venous catheters in patients undergoing hematopoietic stem cell transplantation

Xiao-dong Xu[1], Shu-jia Liu[1], Xiao-lin Liu[1], Dan Li[1], Yu Wang[1], Xia Yan[1]

1 Department of Hematology, Peking University People's Hospital, Peking University Institute of Hematology, National Clinical Research Center for Hematologic Disease, Beijing Key Laboratory of Hematopoietic Stem Cell Transplantation, Beijing, 100044, China

Correspondence to: Xia Yan
Department of Hematology, Peking University People's Hospital, No. 11, Xizhimen South Street, Xicheng District, Beijing 100044, China
TEL.: 010-88324950; E-MAIL: yanxiayxcc@126.com

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Abstract

OBJECTIVE: This study evaluated whether chlorhexidine gluconate (CHG) antimicrobial dressings reduce catheter-related local infection and improve dressing stability in for subclavian central venous catheters (CVCs) in patients undergoing hematopoietic stem cell transplantation (HSCT).

METHODS: A total of 120 patients who underwent HSCT and received subclavian CVC placement in the laminar airflow ward of the Department of Hematology at the study hospital between November 2019 and November 2021 were enrolled. Participants were randomly allocated, using a random number table, to an intervention group or a control group (60 patients each). The intervention group received subclavian CVC fixation and maintenance with CHG antimicrobial dressings, whereas the control group used conventional transparent 3M dressings under the same standardized care protocol. Routine catheter maintenance was performed once weekly in both groups, with continuous intervention over a 5-week period. Outcomes assessed included the incidence of CVC-related local infection (manifested as redness, swelling, and pain at the puncture site), the frequency of dressing changes, and the number of cases of dressing loosening.

RESULTS: The incidence of catheter-related local infection was 46.67% in the control group and 23.33% in the intervention group. The mean number of dressing changes was 6.7 (range, 2–14) in the control group and 5.4 (range, 1–11) in the intervention group. Dressing loosening occurred in 19 control group patients and 9 intervention group patients. All between-group differences were statistically significant ($p < 0.05$), indicating fewer local infections, fewer dressing changes, and less dressing loosening with CHG antimicrobial dressings.

CONCLUSION: In this randomized study, CHG antimicrobial dressings significantly reduced CVC-related local infection, improved dressing fixation, and lowered the frequency of dressing changes in HSCT patients with subclavian CVCs. These findings support the use of CHG dressings to optimize catheter maintenance and may help reduce nursing workload in this high risk population.

Abbreviations:
HSCT - Hematopoietic stem cell transplantation
CVC - central venous catherer
CHG - Chlorhexidine Gluconate
PICC - Peripherally inserted central catheter

INTRODUCTION

Hematopoietic stem cell transplantation (HSCT) is a fundamental therapeutic strategy in which autologous or allogeneic hematopoietic stem cells are infused after high dose chemotherapy and/or radiotherapy to eliminate malignant or abnormally proliferating cells and restore normal hematopoietic and immune function (Wang *et al.* 2022). Currently, HSCT is recognized as an effective curative modality for a wide range of malignant hematologic disorders. During HSCT, patients require sustained infusion of high-dose chemotherapeutic agents, hematopoietic stem cells, blood components, and parenteral nutrition, often during prolonged periods of profound immunosuppression and neutropenia.

Central venous catheters (CVCs) play an essential role during this period by reducing injury to peripheral vessels from irritant medications and preventing local tissue necrosis caused by chemotherapeutic extravasation, thereby ensuring the continuity of treatment and supportive care (Yeral *et al.* 2015). However, catheter related infections frequently develop during CVC indwelling, and local infection at the puncture site is one of the most common early complications. (Lian *et al.* 2013, Linnemann 2014). After exposure to high-dose chemotherapy, patients undergoing HSCT experience a phase of bone marrow suppression characterized by profound immunosuppression and a substantially increased risk of catheter-related infection (Wu *et al.* 2024). The catheter insertion site constitutes a primary portal for microbial entry, underscoring the critical need for effective prevention and control of local infections at the puncture site.

Chlorhexidine gluconate (CHG) antimicrobial dressings are composite devices comprising a transparent adhesive dressing integrated with a gel pad containing 2% chlorhexidine gluconate. Previous investigations have provided preliminary evidence that CHG antimicrobial dressings reduce local infection associated with peripherally inserted central catheters and other central venous devices in non-HSCT populations. However, these studies enrolled relatively small samples and did not focus on hematopoietic stem cell transplantation. To date, randomized evidence on the use of CHG dressings to prevent subclavian CVC-related local infection in adult HSCT patients cared for in laminar airflow wards is limited.

Against this background, the present randomized study compares the clinical performance of CHG antimicrobial dressings with that of conventional transparent 3M dressings in the maintenance of subclavian

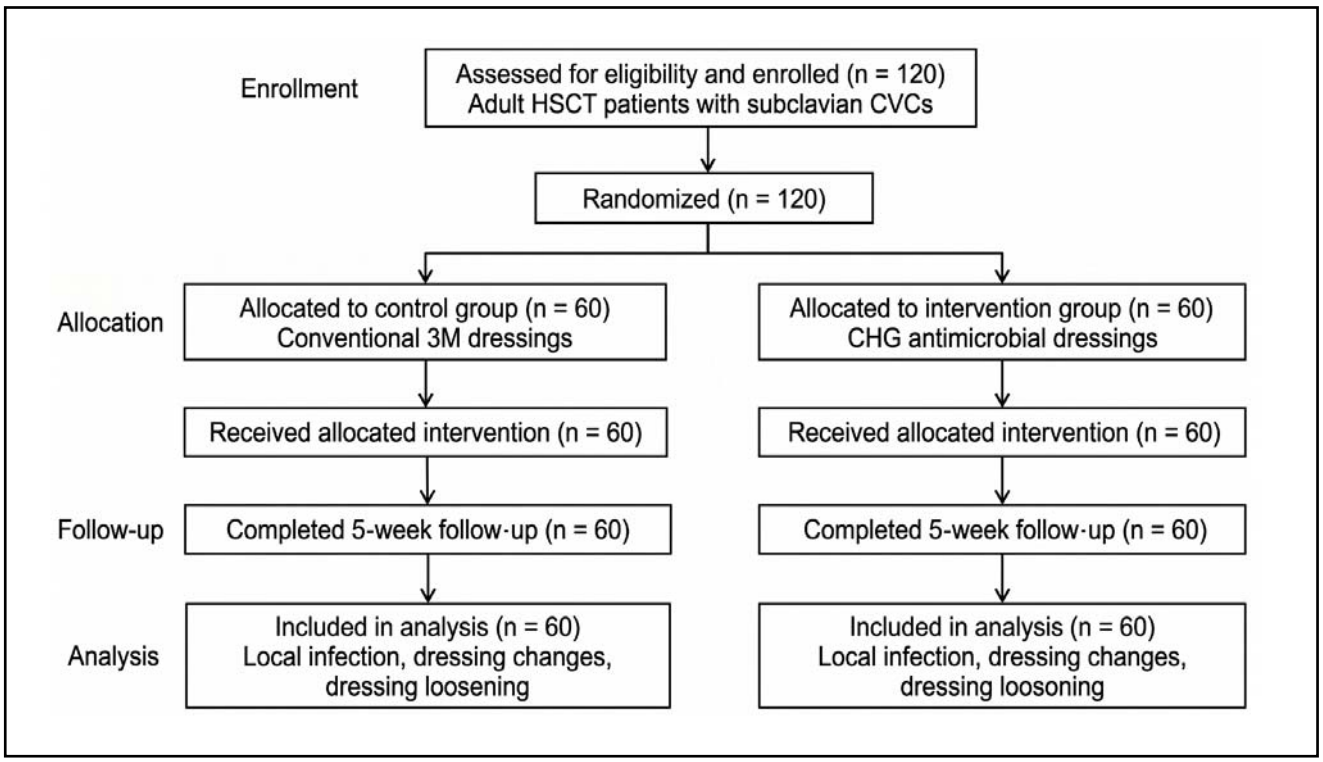

Fig. 1. Flow of participants through the randomized trial.
Flow of participants through the randomized trial. The diagram shows the number of patients screened for eligibility, excluded (with main reasons), enrolled and randomized to the intervention group (chlorhexidine gluconate antimicrobial dressings) or control group (conventional transparent dressings), followed during the 5 week observation period, and included in the final analysis.

CVCs in adult HSCT recipients, with the objective of generating HSCT-specific evidence to inform and refine catheter care practices in laminar airflow wards.

MATERIALS AND METHODS

General data

A total of 120 patients who underwent HSCT and had indwelling subclavian CVCs in place in the laminar airflow ward of the Department of Hematology at the study hospital between November 2019 and November 2021 were enrolled. Inclusion criteria were: (1) scheduled HSCT requiring subclavian CVC placement; (2) age ≥ 18 years; and (3) written informed consent provided by the patient or a legal representative.

Exclusion criteria were: (1) known allergy to CHG antimicrobial dressings or conventional 3M dressings; (2) allergy to 2% chlorhexidine gluconate alcohol solution; (3) active infection at enrollment, including fever, phlebitis, local infection, or bloodstream infection; and (4) pneumothorax after subclavian CVC placement, persistent bleeding or oozing within 24 hours of catheterization, or catheter removal within 5 weeks of treatment in the laminar airflow ward.

A total of 120 patients were enrolled and randomized to the intervention or control group (Figure 1). Eligible patients were randomly allocated to the intervention or control group using a random number table, with 60 patients assigned to each group. The study protocol was reviewed and approved by the Medical Ethics Committee of the study hospital (Ethics Approval No. 2017PHB086).

Study methods

In both groups, subclavian CVC insertion was performed by appropriately qualified physicians in accordance with standardized catheterization procedures. Catheter maintenance was carried out by nurses who had received specialized training, following standardized maintenance protocols (Hong & Peng 2019).

During each dressing change, the existing dressing was gently removed at a 0-degree angle. After sterile gloves were applied, the puncture site was designated as the center, and the surrounding skin was disinfected using sterile cotton balls saturated with 2% chlorhexidine gluconate alcohol solution. Disinfection was carried out in an alternating "clockwise–counterclockwise–clockwise" pattern for a total of six passes. During the initial pass, the cotton ball was held at the puncture site for 15 seconds with moderate rotational pressure to ensure adequate antiseptic contact. Following completion of skin disinfection, the area was allowed to air-dry naturally, after which the dressing was applied using a tension-free application technique.

Patients in the intervention group received CHG antimicrobial dressings, whereas those in the control group were managed with conventional 3M dressings. Routine dressing changes were performed once weekly in both groups, and catheter maintenance was continued for a total duration of 5 weeks. All procedures were implemented in strict compliance with aseptic principles.

Unscheduled dressing changes were indicated under specific circumstances. In both groups, dressings were replaced immediately if edge curling, loosening, or suspected contamination was observed. In the control group, the presence of bleeding or exudation at the puncture site prompted immediate dressing replacement, with alginate dressings applied to facilitate the absorption of blood or exudate.

In the intervention group, immediate replacement was not required when bleeding or exudation remained within the gel pad coverage area of the CHG antimicrobial dressing, and the standard dressing change schedule was maintained. When bleeding or exudation extended beyond the gel pad coverage, the dressing was replaced without delay, and a CHG antimicrobial dressing was reapplied without additional use of alginate dressings. Throughout the study period, nurses conducted targeted assessments of the puncture site during each shift, evaluating skin conditions such as redness, swelling, pain, bleeding, and exudation, and documented all findings accordingly.

Outcome measures

1) **CVC-related local infection:** The occurrence of local infection at the catheter puncture site was assessed in both groups based on predefined clinical manifestations: redness, swelling, or pain. For each patient, the presence of at least one of these signs was recorded, and the incidence of local infection was calculated; time to symptom resolution was also documented when available.
2) **Catheter maintenance–related indicators:** The total number of dressing changes was documented for each group. In addition, the proportional distribution of reasons for dressing changes was analyzed, including routine scheduled changes, unscheduled changes resulting from dressing loosening, and unscheduled changes due to local inflammatory reactions.
3) **Dressing fixation effectiveness:** Instances of dressing loosening occurring during the intervention period were recorded and compared between the two groups.

Statistical analysis

All data were analyzed using SPSS, version 22.0. Continuous variables were expressed as mean ± standard deviation ($x \pm s$) and compared between groups using the independent-samples t-test. Categorical variables were expressed as frequencies and percentages and analyzed using the chi-squared (χ^2) test. A p-value < 0.05 was considered statistically significant.

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Tab. 1. Baseline characteristics of patients in the two study groups

Variable	Group	Control group	Intervention group	*p* value
Age (years)	-	34.3±18.62	35.1±15.57	0.697
Sex	Male	32	35	0.581
	Female	28	25	
Primary Diagnosis	Acute lymphoblastic leukemia (ALL)	24	22	0.914
	Acute myeloid leukemia (AML)	30	31	
	Other hematologic diseases	6	7	

RESULTS

Comparison of general characteristics between the two groups

In the control group, 60 patients were included, comprising 32 male and 28 female patients, with a mean age of 34.3 ± 18.62 years. The underlying diagnoses consisted of acute myeloid leukemia in 30 cases, acute lymphoblastic leukemia in 24 cases, and other hematologic conditions in 6 cases. The intervention group also included 60 patients, of whom 35 were male and 25 were female, with a mean age of 35.1 ± 15.57 years. Disease distribution in this group included acute myeloid leukemia in 31 cases, acute lymphoblastic leukemia in 22 cases, and other hematologic conditions in 7 cases.

No statistically significant differences were observed between the two groups in sex, age, or disease type ($p > 0.05$), indicating baseline comparability. Detailed characteristics are presented in Table 1.

Comparison of CVC-related local infection, dressing change frequency, and dressing loosening between groups

Compared with the control group, the intervention group had a lower incidence of CVC related local infection, fewer dressing changes overall, and fewer cases of dressing loosening during the 5 week observation period; all differences were statistically significant ($p < 0.05$) (Table 2).

DISCUSSION

As the primary form of vascular access during HSCT, the safe and sustained indwelling of a CVC throughout periods of profound neutropenia and immunosuppression is closely linked to treatment continuity and overall therapeutic safety. While CVCs effectively minimize the risk of peripheral vessel injury, infections related to catheter indwelling continue to represent a major clinical concern, particularly in HSCT recipients with markedly diminished resistance to microbial invasion. After high dose chemotherapy, patients undergoing HSCT enter a phase of bone marrow suppression characterized by profound immunosuppression and markedly diminished resistance to microbial invasion.

When a CVC-related local infection develops and is not adequately controlled in a timely manner, progression to catheter colonization or catheter-related bloodstream infection may occur. These complications increase the physical burden, extend hospitalization, elevate healthcare costs, and in some cases necessitate catheter removal, thereby disrupting the HSCT treatment course (Lian *et al.* 2013). Consequently, the refinement of catheter maintenance practices and the effective reduction of local infection risk are critical components in improving clinical outcomes for patients receiving HSCT.

Within strategies aimed at preventing and managing CVC-related local infections in HSCT units, standardized catheter maintenance procedures and appropriate dressing selection constitute two fundamental elements (Liu & Su 2012). CHG antimicrobial dressings, as a newer type of composite dressing, provide combined physical barrier protection and chemical antimicrobial activity. The gel pad containing 2% chlorhexidine gluconate allows sustained release of the antiseptic, effectively inhibiting the growth and proliferation of commonly encountered pathogenic microorganisms. This antimicrobial activity can be maintained for up to seven days, which may help reduce bacterial colonization of the

Tab. 2. Comparison of CVC-related local infection and catheter maintenance-related outcomes between the two groups

Variable	Control group	Intervention group	*p* value
CVC-related local infection, n (%)	28 (46.67%)	14 (23.33%)	0.007
Number of dressing changes (times)	6.7 (2~14)	5.4 (1~11)	0.003
Dressing loosening (cases)	19	9	0.031

Note: CVC-related local infection was defined as the presence of at least one of the following clinical manifestations at the catheter puncture site: redness, swelling, or pain.

skin at the puncture site and limit microbial invasion at its source (Bashir *et al.* 2012, Safdar *et al.* 2014a, Timsit *et al.* 2012, Wei *et al.* 2019).

In addition, the dressing incorporates a highly breathable, semipermeable polyurethane film together with a soft nonwoven fabric border and a controlled-force relief groove design. These features enhance adherence to the skin and resistance to traction, effectively reducing the likelihood of edge curling and loosening. At the same time, improved local breathability, reduced adhesive residue, and enhanced comfort are achieved, supporting sustained use during catheter indwelling.

The findings of this study demonstrated that patients in the intervention group who received CHG antimicrobial dressings had a substantially lower incidence of CVC-related local infection (23.33%) than those in the control group (46.67%). These findings are consistent with the chemical antimicrobial properties of CHG dressings and with observations reported in previous studies (Buetti *et al.* 2020, Safdar *et al.* 2014b).

With respect to dressing fixation, fewer instances of dressing loosening were recorded in the intervention group (9 cases) than in the control group (19 cases), which is consistent with the structural design of the CHG dressing aimed at improved fixation stability. In addition, the mean number of dressing changes was lower in the intervention group (5.4) than in the control group (6.7). This reduction was associated with the capacity of CHG antimicrobial dressings to absorb limited amounts of blood or exudate, so that leakage often remained within the gel pad coverage area and immediate dressing replacement was unnecessary, thereby reducing unscheduled dressing changes.

Compared with conventional 3M dressings, CHG antimicrobial dressings provide the additional benefit of enhanced visualization. Alginate dressings, which are commonly used in clinical practice to manage blood and exudate, are opaque and may obscure the puncture site, limiting timely assessment of local skin conditions by healthcare personnel. By contrast, the gel pad of CHG antimicrobial dressings remains transparent even after absorption of exudate, enabling ongoing visual inspection of the insertion site and potentially facilitating earlier identification of signs suggestive of infection, thereby supporting timely and targeted intervention. Furthermore, the reduced need for dressing replacement observed in this study may alleviate nursing workload and, over time, lessen the overall care burden for patients and institutions, although formal economic evaluation was not performed.

Strengths and limitations of the study

A key strength of this study is its systematic evaluation of CHG antimicrobial dressings for CVC maintenance in patients undergoing HSCT, a population characterized by profound immunosuppression. The findings provide clinically relevant evidence for catheter care in this high-risk group. From a methodological perspective, the inclusion of multiple pragmatic outcome measures—such as the incidence of CVC-related local infection, dressing fixation stability, and the frequency of dressing changes—allows for a comprehensive assessment of the clinical utility of CHG dressings and offers multidimensional support for clinical decision-making.

Several limitations should also be acknowledged. The moderate sample size and single-center design may restrict the external validity of the results, particularly for other HSCT settings and catheter types, and should be considered when extrapolating these findings. In addition, long-term follow-up was not performed, and comparisons of more severe outcomes, such as catheter-related bloodstream infection, were not included. Although CHG antimicrobial dressings are associated with a higher per-use cost than conventional dressings, the potential reduction in infection-related expenditures with prolonged use was not examined in detail and warrants further health economic evaluation. Future investigations could address these limitations by extending follow-up periods, enrolling larger and more diverse populations, and comparing different types of antimicrobial dressings, such as iodine-containing alternatives, to identify more effective and cost-efficient catheter maintenance strategies for this patient population.

CONCLUSION

Overall, CHG antimicrobial dressings demonstrated significant advantages in the maintenance of subclavian CVCs among adult HSCT recipients cared for in a laminar airflow ward. Their use is associated with a reduced incidence of CVC-related local infection, enhanced dressing fixation stability, and a lower frequency of dressing changes. By offering improved local infection control and more stable dressing fixation in this high risk group, CHG antimicrobial dressings may represent a valuable option for wider use in catheter maintenance protocols.

DECLARATIONS

Ethics approval and consent to participate

This study was conducted in accordance with the Declaration of Helsinki and was approved by the Ethics Committee of Peking University People's Hospital (No.2017PHB086). A written informed consent was obtained from all participants.

Consent for publication

Not applicable

Availability of data and materials

The datasets used and/or analysed during the current study available from the corresponding author on reasonable request.

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Competing interests

All authors have contributed significantly to the manuscript and declare that the work is original and has not been submitted or published elsewhere. None of the authors have any financial disclosure or conflict of interest.

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Authors' contributions

Conception and design of the research:
Xiao-dong Xu, Xia Yan
Acquisition of data: Xiao-lin Liu, Dan Li, Yu Wang
Analysis and interpretation of the data:
Shu-jia Liu, Dan Li
Statistical analysis: Shu-jia Liu, Xiao-lin Liu
Obtaining financing: Xiao-dong Xu
Writing of the manuscript: Xiao-dong Xu, Yu Wang
Critical revision of the manuscript for intellectual content: Xiao-dong Xu, Shu-jia Liu, Xia Yan
All authors read and approved the final draft.

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