Comparative efficacy of 13 antimicrobial dressings and different securement devices in reducing catheter-related bloodstream infections: A Bayesian network meta-analysis

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Abstract

Purpose: The purpose of our study is to carry out a Bayesian network meta-analysis comparing the efficacy of different antimicrobial dressings for prevention of catheter-related bloodstream infections (CRBSIs) and rank these antimicrobial dressings for practical consideration.

Methods: We searched the PubMed, Cochrane library, Embase, earlier relevant meta-analysis and reference lists of included studies for randomized controlled trials (RCTs) that compared dressings for prevention of CRBSI. Two authors independently extracted data from each included RCT according to a predesigned Excel spreadsheet and assessed the methodological quality of included RCTs using the Cochrane risk of bias tool. Data was analyzed using the WinBUGS (V.1.4.3) and the Stata (V.15.0).

Results: Finally, 35 RCTs involving 8494 patients and evaluating 13 dressings were included. Network meta-analysis showed that transparent dressing may be the best way to prevent CRBSI. Suture and bordered polyurethane dressing might have the lowest risk of CRBSI rate per 1000 catheter-days, and sutureless securement device might lead to the lowest incidence of catheter failure.

Conclusions: This network meta-analysis indicated that transparent dressings may be selected for the prevention of CRBSI in patients with central venous catheters, which is of importance in future research. Although evidence is scant, more attention should be paid to head-to-head comparisons of the most commonly used dressings in this field.

Abbreviations: AD = adherent dressing, BDD = biguanide disc dressing, BPU = bordered polyurethane dressing, CHG = chlorhexidine gluconate, CRl = credible interval, CVC = central venous catheter, HD = hydrocolloid dressing, ICU = intensive care unit, ISD = integrated securement-dressing, NTD = new-generation transparent dressing, OD = occlusive dressings, OR = odds ratio, RCTs = randomized controlled trials, SAD = silver alginete dressing, SPU = standard polyurethane dressing, SSD = sutureless securement device, SUCRA = the surface under the cumulative ranking curve, TA = tissue adhesive, TD = transparent dressing.

Keywords: antimicrobial dressings, catheter-related bloodstream infections, network meta-analysis

1. Introduction

The central venous catheter (CVC) is an essential device for intensive care, patients with cancer, or patients who need parenteral nutrition. However, catheter-related bloodstream infections (CRBSIs), a major complication of CVCs, are associated with significant morbidity, mortality, and additional medical costs. In the United States, CRBSI accounts for an estimated 28,000 deaths and up to $2.3 billion annually in 4 European countries (France, Germany, Italy, and the United Kingdom), it accounts for 14,400 deaths with associated annual costs between €33.9 and €163.9 million. In Australia, a case of CRBSI adds at least AU$14,000 (equivalent to $2010) to the cost of care. In China, the average economic loss per case of CRBSI is about ¥30713. CRBSI remains an important problem associated with patient safety in high-income, middle-income, and low-income countries.

However, most CRBSIs are preventable. Several measures have been implemented to prevent CRBSI, including maximal barrier precautions during catheter insertion, the use of antiseptic agents, catheter impregnation with antiseptic agents or antibiotics, and education and training of health care workers. In recent years, the use of antimicrobial dressings has been demonstrated to significantly reduce the risk of catheter infections. Among them, the chlorhexidine gluconate (CHG)-impregnated dressing is the most commonly used; it is simple to use, breathable, transparent, and has a cost comparable to that of standard film dressing currently used on insertion sites. Other dressings, such as the transparent dressing (TD), bordered polyurethane dressing (BPU), and silver alginete dressing (SAD), are also used to prevent catheter infection. It has been suggested that CVC antibacterial dressings can inhibit the colonization of microorganisms on the surface of the catheter and prevent them from spreading into the bloodstream.
Traditional pairwise meta-analysis only allows for the comparison of 2 interventions for CRBSI, and most previous meta-analyses compared the CHG-impregnated dressing with the traditional dressing. However, many of these treatment strategies have not been directly compared in previous randomized controlled trials (RCTs). Therefore, it is difficult to determine the most effective treatment based on direct evidence. Network meta-analyses of existing datasets make it possible to comparatively assess the efficacies of antimicrobial CVC dressings in reducing CRBSI, summarize and interpret the broader picture of the evidence base, and understand the relative merits of the multiple interventions. In this study, we aimed to perform a systematic review and network meta-analysis in order to compare the effectiveness of 13 antimicrobial CVC dressings and different securement devices in terms of preventing CRBSIs.

2. Materials and methods

2.1. Search strategy and selection criteria

This systematic review and meta-analysis was designed based on the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) Statement and Cochrane Collaboration reporting project. We included RCTs that compared antimicrobial dressings and different securement devices for the prevention of CRBSI, the CRBSI rate per 1000 catheter-days, and catheter failure. The RCTs included patients from any inpatient hospital setting with a CVC in place. Studies that evaluated patients with catheters in the vein for ≤48 hours and patients with pacing wires were excluded.

We systematically searched PubMed, the Cochrane Library, and Embase from the date of their inception to June 6, 2018. The search strategy was developed by JHT, who has more than 10 years of experience as an information specialist. We also tracked the references in the included articles and relevant systematic reviews/meta-analyses to identify additional relevant studies. The search strategy was as follows: (CHG-impregnated dressing OR transparent dressing OR sterile dry gauze OR hydrocolloid dressing OR bordered polyurethane dressing OR tissue adhesive OR new-generation transparent dressing OR silver alginate dressing OR standard polyurethane transparent dressing OR adherent dressing OR occlusive dressings OR bionanide disc dressing OR integrated securement-dressing) AND (Catheter-Related Infection* OR Catheter-Related Infection*) AND (random?).

As the present meta-analysis was performed based on previous published studies, no ethical approval and patient consent are required.

2.2. Literature selection and data extraction

Literature search records were imported into EndNoteX8 literature management software (Thomson Reuters, New York, NY). Two researchers (F-PD and J-HT) independently reviewed the title and abstract of the studies and excluded those that clearly did not meet the inclusion criteria. Then the remaining studies were identified by reviewing the full text. Any disagreements were resolved by discussion or through consultation with the third independent examiner. Excluded trials and the reasons for their exclusion were listed and examined by a third reviewer (H-JL). Two authors (F-PD and J-HT) independently extracted data from each included RCT according to a predesigned Excel spreadsheet created in Microsoft Excel 2016 (Microsoft Corp, Redmond, WA). The items extracted contained study’s characteristics (author, year of publication, journal, sample size, type of design, study arms, country where the study was conducted), participant’s characteristics (age, details of intervention, hospital day of catheter insertion, site, sex ratio), characteristics of dressing (number of dressing, dressing change, the day of dressing) and outcomes. FPD performed the data extraction and entry, and J-HT was in charge of examining the data.

2.3. Risk of bias in individual studies

The methodological risk of bias of included RCTs was assessed according to the Cochrane Handbook Version 5.1.0, including the method of random sequence generation (selection bias), allocation concealment, blinding of participants and personnel (performance bias), blinding of outcome assessment (detection bias), incomplete outcome data (attrition bias), selective reporting (reporting bias), and other bias. Those items were evaluated as being high, low, or unclear risk of bias. We resolved any disagreements through discussion and reached a consensus with the third reviewer (H-JL).

2.4. Statistical analysis

The network meta-analysis was performed and presented by the Stata 15.0 using the mvmeta package. The ranking probabilities of all interventions were used to calculate a summary numerical value: the surface under the cumulative ranking curve (SUCRA) which are expressed as percentages. SUCRA value is 100% for the best treatment and 0% for the worst treatment. We assessed the agreement of direct and indirect evidence by an inconsistency plot. The publication bias in the network was assessed by the comparison adjusted funnel plot. Bayesian network meta-analysis was performed in WinBUGS 1.4.3 by using the Markov chain Monte Carlo method. The priors used in 2 different chains were as follows:

- chain 1: treatment effect: \(d(k) = 0\); SD = 1; \(mu(i) = 0\);
- chain 2: treatment effect: \(d(k) = -1\); SD = 4; \(mu(i) = -3\);

where \(d(k)\) = treatment effect of experimental intervention “k” compared with reference and \(mu(i)\) = treatment effect of the experimental intervention compared with control in the trial “i”. Model fit was determined based on the deviance information criteria for each outcome measure. Two Markov chains were run simultaneously with different arbitrarily chosen initial values. Convergence was found to be adequate when we generated 20,000 simulations for each chain. These simulations were then discarded as “burn-in” and posterior summaries were based on 100,000 subsequent simulations. The model convergence was assessed by trace plots. The results of all outcomes are reported as means of OR with 95% credible interval (CrI).

2.5. Geometry of the network

A network plot was drawn to describe and present the geometry of the treatment network of comparisons across the trials to ensure that a network meta-analysis would be feasible. Trials were excluded if they were not connected by any treatments. In this network plot, nodes represent different interventions, and edges represent the head-to-head comparisons between interventions. The size of the node reflects the sample size of the intervention, and the thickness of the edge reflects the number of included trials.
3. Results

3.1. Study selection

Six hundred fifty-eight records were identified from electronic databases, of which 534 duplicates were excluded using EndNoteX8 software and 52 articles were determined to be irrelevant after the first screening. Six references in 4 systematic reviews were reviewed. Finally, 35 RCTs involving 8494 patients were included. The flow diagram (Fig. 1) shows the search results and selection details.

Figure 1. The flow diagrams.
| No. | Study                        | Country     | Sample | Age        | Number of catheter | Day of catheter insertion | Duration of trial | Country of publication |
|-----|------------------------------|-------------|--------|------------|-------------------|-------------------------|-------------------|------------------------|
| 1   | Nikoletti S 1999            | Australia   | 204/204| 55/56      | 48/44             | 7/3/9                    | 9 ± 10            | Australia              |
| 2   | Chambers S T 2005           | New Zealand | 52/43  | 50/49      | 35/60             | 8/5/4                    | 62.5 ± 7/15       | New Zealand            |
| 3   | Webster J 2017              | Australia   | 51/49  | 56.5 ± 14.9/60.65 ± 15.78 | 51/49             | 7.18/2                   | 9/9 ± 10          | Australia              |
| 4   | GU Feng 2013                | China       | 22/22  | 56/56      | 84/78             | 160/762/160/605/695     | 10/10 ± 10        | China                  |
| 5   | Rickard C M 2016            | Australia   | 56/56  | 69/69/68/73 | 84/28             | 160/762/160/605/695     | 10/10 ± 10        | Australia              |
| 6   | Reynolds H 2015             | Australia   | 30/32/31/30 | 63/63/62/61 | 32/75/60/35/3/64/6   | 10/10 ± 10            | 16 mo              | Australia              |
| 7   | Gangler G O 2017            | Turkey      | 14/13  | 79.0 ± 14.7/67.2 ± 19.4 | 16/11             | 72.5 ± 15/58/85.7 ± 50.8 |                 | Turkey                 |
| 8   | Günther S C 2016            | France      | 316/312| NR         | 1142/1072         | 32.9                     | 7 ± 10            | Germany                |
| 9   | Ruchhiete H 2009            | Germany     | 300/301| 47/47      | 333/268           | 16/12/7/15,76           |                 | Germany                |
| 10  | Le C I 2005                 | Canada      | 29/29  | 74/71      | 27/31             | 58/58/68/32             | 2 ± 7.5/5 ± 2.7   | Canada                 |
| 11  | Pedeleo E 2014              | Brazil      | 43/42  | NR         | 45/27             | 84/28/160/160/605/695   | 10/10 ± 10        | Brazil                 |
| 12  | Bevli L M 2015              | Germany     | 307/306| 56/56      | 361/252           | 10/10 ± 10              | 16 mo              | Germany                |
| 13  | Levy I 2005                 | Israel      | 74/71  | 0 ± 18 y   | 73/72             | 4.67 ± 7 ± 1.9/4.35 ± 2.2 |                 | Israel                 |
| 14  | Garland J S 2001            | America     | 335/370| 47.8 ± 18.5/53.7 ± 19.5 | 4/41              | 47/4/360/350/260/540    | 10/10 ± 10        | America                |
| 15  | Crecen D E 1985             | America     | 316/421| 68/68/65/69 | 459/278          | 1197/724                | 10/10 ± 10        | America                |
| 16  | Khattak A Z 2010            | America     | 25/25  | NR         | 63/68             | 10/10 ± 10              | 10/10 ± 10        | America                |
| 17  | Engul A B 2018              | Turkey      | 63/68  | 70.9 ± 2.1/71.1 ± 2.1 | 63/68             | 10/10 ± 10              | 10/10 ± 10        | Turkey                 |
| 18  | Timaj F J 2012              | France      | 938/465/476 | 47/474 | 63/63/64/64     | 637/301                 | 2108/988          | 10/10 ± 10            | France                 |
| 19  | Righetti M 2016             | Italy       | 3/30   | 1 ± 7/1 y  | 3/4/5             | 20.8 ± 3 ± 2/21 ± 2.9   | 10/10 ± 10        | Italy                  |
| 20  | D'ukuyan S 2016             | Turkey      | 5/50   | 62/63      | 60/40             | 10/10 ± 10              | 10/10 ± 10        | Turkey                 |
| 21  | JF Timaj 2009               | France      | 81/7819| Gestational age | 1052/584        | 1953/825                | 10/10 ± 10        | France                 |
| 22  | Hill M L 2010               | America     | 7/25   | 47         | 60/40             | 10/10 ± 10              | 10/10 ± 10        | America                |
| 23  | Reynolds M & G 1997         | England     | 47/47  | 64/70/1   | 64/60             | 10/10 ± 10              | 10/10 ± 10        | England                |
| 24  | Wolfe J C 1993              | New Zealand | 50/51  | 6/12 ± 21.7/3 ± 10/69 ± 50/73 ± 11 | 51/50             | 5 ± 1/6                 | 48 ± 7 ± 10        | New Zealand            |
| 25  | Cito-Padrón RM 2011         | Spain       | 13/12  | NR         | 54/17             | 51/50                    | 5 ± 1/6                 | Spain                  |
| 26  | Giles Y 2002                | Turkey      | 33/39  | 43/29      | NR                | 48 ± 8 ± 10             | 10/10 ± 10        | Turkey                 |
| 27  | Olsen K 2004                | Canada      | 37/41  | 6/9/77/8 months | 31/37             | 259/270                | 10/10 ± 10        | Canada                 |
| 28  | Kloton T M 2017             | Canada      | 32/31  | 55.3 ± 23/50 ± 7 ± 2.8 | 31/37             | 259/270                | 10/10 ± 10        | Canada                 |
| 29  | Carly J M 1989              | Canada      | 58/57  | 55.1 ± 12.7/51.3 ± 14.8 | 73/42             | 17.9 ± 2 ± 13.5 ± 2.1  | 10/10 ± 10        | Canada                 |
### 3.2. Characteristics of the included studies

The characteristics of the 35 RCTs are summarized in Table 1. The component studies included 8494 participants. Thirteen kinds of antimicrobial dressings were assessed in the prevention of CRBSI. Of the 35 RCTs, 16 (45.7%) compared the TD with sterile dry gauze (SDG) or other antimicrobial dressings; 13 (37.1%) compared the CHG-impregnated dressing with a standard polyurethane dressing or other antimicrobial dressings; and 22 (62.9%) reported the method of randomization. In the sample population, 4197 (49.4%) of 8494 patients were men. Four (11.4%) of 35 studies randomly assigned participants to 3 or more groups. Of the 35 RCTs, 18 RCTs (5502 participants) studied patients in the intensive care unit, and 8 RCTs (960 participants) studied patients on hemodialysis.

### 3.3. Methodological quality of the included studies

Table 2 shows the quality assessment of the studies in this network meta-analysis; the studies with high risk of bias, low risk of bias, and unclear risk of bias are marked in red, green, and yellow, respectively. Twenty-two studies used random sequence generation, and 12 studies used allocation concealment. In 6 studies, the participants, personnel, and outcome assessors were blinded. In 2 trials, the investigators were not blinded, but the outcome assessors were blinded. More than 10% of patients were lost to follow-up, causing high attrition bias. The quality evaluation showed that potential bias was caused by the inadequate random sequence generation and allocation concealment, as well as a lack of blinding of participants and personnel.

### 3.4. Results of the network meta-analysis

Figure 3 shows the network structure of the comparisons among the different interventions for the outcomes. The lines between the intervention nodes indicate the direct comparisons made within randomized trials. The width of the lines is proportional to the number of trials comparing each pair of interventions. The size of each node is proportional to the number of randomly assigned participants (e.g., the sample size). A star geometry is formed between all of these network plots. The missing links between active interventions reflect the lack of direct comparisons.

### 3.5. Primary outcome: CRBSI

The results of the network meta-analysis comparing 10 antimicrobial dressings are shown in Fig. 3A. Twenty-five RCTs\(^{19,20,22,23,31–34,41,44–47,53,54–58}\) (7090 patients) reported the incidence of CRBSI and included all 10 dressings (CHG, BDD, AD, TD, SPU, SDG, SAD, OD, NTD, and HD). The result indicated that TD (odds ratio [OR] 0.35, 95% CI 0.14, 0.89) was statistically significantly more effective than the other dressings in preventing CRBSI. The indirect comparison of reported interventions for CRBSI according to WinBUGS 1.4.3 is presented in Table 3.

### 3.6. Secondary outcome: CRBSI rate per 1000 catheter-days

Ten RCTs\(^{19,20,31,39–41,43,49,54,51}\) (1497 participants) reported the CRBSI rate per 1000 catheter-days. Suture + BPU (OR 0.34, 95% CI 0.27, 0.43) was statistically significantly more effective than dressings alone in reducing the CRBSI rate per 1000 catheter-days.
catheter-days. Moreover, BDD can also obviously reduce the CRBSI rate per 1000 catheter-days when compared with CHG (OR 0.64, 95% CI 0.43, 0.93). Eight RCTs\(^\text{20-22,42,48,61,52,59}\) reported catheter failure. The result indicated that SSD (OR 0.35, 95% CI 0.14, 0.89) was statistically significantly more effective than other dressings in reducing catheter failure.

### 3.7. Rank probability

Rank probability analysis (Table 4, Fig. 4) indicated that TD had the highest probability of reduction of incidences of CRBSI (SUCRA = 92.5%), followed by HD (SUCRA = 69.8%) and SAD (SUCRA = 67.4%). Suture + BPU (SUCRA = 62.0%) had the largest probability of being the best treatment in the reduction of...
the CRBSI rate per 1000 days, followed by BDD (SUCRA = 61.6%) (Table 5, Fig. 5). SSD had the highest probability of being the best treatment in terms of catheter failure (SUCRA = 81.5%), followed by TD (SUCRA = 77.4%). The results of rank probability analysis are presented in Table 6.

### 3.8. Publication bias

We drew comparison-adjusted funnel plots for all outcomes (Fig. 6). Different colors correspond to different comparisons.

### Table 3

The indirect comparison in CRBSI.

| Comparisons | OR (95% CrI) |
|-------------|-------------|
| HD (Reference) | |
| SPU | 0.53 (0.1, 0.3) |
| BDD | 0.67 (0.16, 0.26) |
| CHG | 0.32 (0.06, 0.16) |
| TD | 0.53 (0.12, 0.22) |
| OD | 0.59 (0.02, 0.03) |
| NTD | 0.02 (0.08, 0.11) |
| SDG | 0.67 (0.14, 0.36) |
| SAD | 0.41 (0.12, 0.19) |
| AD | 0.69 (0.21, 0.17) |
| SPU (reference) | |
| HD | 16.96 (3.26, 4.80) |
| SPU | 4.35 (0.1, 1.42) |
| BDD | 0.56 (0.02, 0.51) |
| CHG | 0.90 (0.04, 0.87) |
| TD | 0.14 (0.02, 0.17) |
| OD | 0.54 (0.03, 0.43) |
| NTD | 1.17 (0.06, 1.05) |
| SDG | 0.70 (0.07, 0.50) |
| SAD | 1.16 (0.13, 0.81) |
| CHG (reference) | |
| HD | 43.98 (3.74, 30.84) |
| SPU | 3.19 (0.49, 1.23) |
| BDD | — |
| CHG | 1.54 (0.24, 0.65) |
| TD | 2.43 (0.39, 0.93) |
| OD | 0.43 (0.08, 0.09) |
| NTD | 1.56 (0.31, 0.49) |
| SDG | 3.17 (0.43, 1.42) |
| SAD | 2.07 (0.52, 0.53) |
| AD | 2.95 (0.56, 0.84) |
| AD (reference) | |
| HD | 38.24 (6.29, 11.13) |
| SPU | 2.09 (0.08, 1.93) |
| BDD | 9.18 (1.55, 3.22) |
| CHG | — |
| TD | 1.66 (0.05, 0.13) |
| OD | 0.28 (0.04, 0.13) |
| NTD | 0.99 (0.05, 0.07) |
| SDG | 2.16 (0.06, 1.33) |
| SAD | 1.25 (0.10, 0.90) |
| AD | 2.13 (0.21, 1.45) |
| TD (reference) | |
| HD | 21.66 (4.66, 6.36) |
| SPU | 1.34 (0.06, 1.15) |
| BDD | 4.72 (0.17, 1.47) |
| CHG | 0.66 (0.02, 0.62) |
| TD | — |
| OD | 0.17 (0.02, 0.62) |
| NTD | 0.60 (0.03, 0.52) |
| SDG | 1.40 (0.06, 1.25) |
| SAD | 0.73 (0.04, 0.58) |
| AD | 1.22 (0.08, 0.97) |
| OD (reference) | |
| HD | 1019 (49.7, 472.6) |
| SPU | 103.2 (53.31, 73.11) |
| BDD | 457.1 (11.12, 321) |
| CHG | 74.43 (7.77, 60.4) |
| TD | 94.56 (17.75, 72.86) |
| OD | — |
| NTD | 54.36 (6.36, 40.58) |
| SDG | 132.8 (15.37, 100.1) |
| SAD | 64.99 (6.26, 47.37) |

Data of entries in bold type means significant results.

AD = adherent dressing, BDD = biguanide disc dressing, BPU = bordered polyurethane dressing, CHG = chlorhexidine gluconate, CrI = credible interval, HD = hydrocolloid dressing, ISD = integrated securement-dressing, NTD = new-generation transparent dressing, OD = occlusive dressings, SAD = silver alginate dressing, SDG = sterile dry gauze, SPU = standard polyurethane dressing, SSD = sutureless securement device, TA = tissue adhesive, TD = transparent dressing, CRBSI = catheter-related blood infections.
The results showed that the probability of publication bias was very small for the included studies.

4. Discussion

Our network meta-analysis collected the currently available RCTs to assess the effectiveness of 13 antimicrobial CVC dressings and different securement devices for the prevention of CRBSI. According to the results of the rank probability analysis, TD appeared to be the most effective in reducing CRBSI among the 13 antimicrobial CVC dressings. In this network meta-analysis, no significant difference in the intervention effect was detected with respect to the CRBSI rate per 1000 days or catheter failure for all included dressings. Based on the results of the rank probability analysis, suture + BPU was associated with the lowest CRBSI rate per 1000 days, and SSD was associated with the lowest catheter failure. When the differences in the effect size of different treatments are small, the clinical decision about the choice of treatments can be recommended based on the results of probability ranking.[60]

In this network meta-analysis, 35 RCTs were included and involved 8494 patients, and 13 antimicrobial dressings were assessed for the prevention of CRBSI. In the treatment of CRBSI, the result of the indirect comparison indicated that HD was better than SPU, BDD, CHG, TD, OD, NTD, SDG, SAD, and AD. SPU was better than CHG, TD, OD, NTD, SAD, and AD. BDD was better than CHG, TD, OD, and NTD. CHG was better than TD, OD, NTD, and SAD. TD was better than CHG, OD, NTD, SAD, and AD. NTD was better than OD, and SDG was better than SPU, CHG, TD, OD, SAD, and AD. SAD has advantages over OD and NTD, whereas AD has advantages over CHG, OD, and SAD. These differences were statistically significant.

Table 4

| Treatment | SUCRA | PrBest | MeanRank |
|-----------|-------|--------|----------|
| TD        | 92.5  | 71.5   | 1.7      |
| HD        | 69.8  | 2.9    | 3.7      |
| SAD       | 67.4  | 9.7    | 3.9      |
| NTD       | 65.9  | 1.2    | 4.1      |
| OD        | 60.3  | 0.3    | 4.6      |
| SDG       | 44.3  | 12.3   | 6.0      |
| CHG       | 35.3  | 1.4    | 6.8      |
| SPU       | 33.9  | 0      | 6.9      |
| AD        | 23.3  | 0.4    | 7.9      |
| BDD       | 7.3   | 0.3    | 9.3      |

AD = adherent dressing, BDD = biguanide disc dressing, CHG = chlorhexidine gluconate-impregnated dressing, HD = hydrocolloid dressing, NTD = new-generation transparent dressing, OD = occlusive dressings, SAD = silver alginate dressing, SDG = sterile dry gauze, SPU = standard polyurethane dressing, TD = transparent dressing, CRBSI = catheter-related blood infections.
As a commonly used antiseptic agent, CHG has been used in intensive care units (ICU) for routine daily care, and its use has been shown to decrease the incidence of CRBSI. Some studies have shown that CHG-impregnated dressings reduce the incidence of CRBSI. The study by Karpanen suggested that CHG-impregnated dressings have detectable antimicrobial activity for up to 7 days, and the sustained release of CHG from the dressing increases with time, which may reduce the microbial load at the catheter insertion site, thereby reducing the risk of CRBSI. However, these studies only compared 2 dressings. Based on the largest evidence and network meta-analysis of antimicrobial CVC dressings, our findings indicated that TD is the most effective in preventing CRBSI, which may also be of benefit with arterial catheters.

Recently, Chong et al performed a network meta-analysis to assess the comparative efficacy of antimicrobial CVC impregnations in reducing CRBSI in adults, and they included 60 studies with 17,255 catheters. Their study suggested that the minocycline-rifampicin-impregnated CVC is most effective for preventing CRBSI. In addition, the placement of dressings is important. In our network meta-analysis, we found that suture combined with bordered polyurethane dressing (similar to SPU dressings but with a tough, adhesive fabric border) had the largest probability of being the best treatment in the CRBSI rate per 1000 catheter-days than dressings alone. Therefore, combining 2 or more dressings and securement devices might be considered a more rational and optimal approach to reducing the CRBSI rate per 1000 catheter-days.

One study confirmed that catheter failure is an ongoing, significant problem, and that antimicrobial dressings and securement devices are priority areas for improvement. Recently, in the study by Roethlisberger et al, the dressing was stapled to the skin along its edges with a surgical stapler to minimize the risk of detachment and dislocation.

The trial by Chan et al compared standard care with 3 innovative dressing and securement methods in 121 adult patients receiving acute care. Their findings also showed that securement devices combined with dressings are superior to standard care alone in terms of CRBSI, the catheter failure rate, product costs, and patient and staff satisfaction. Those results are similar to our study’s findings. Our network meta-analysis showed that SSD might lead to the lowest incidence of catheter failure, followed by TD, SPU, and SSD + SPU. However, a 4-arm randomized controlled trial with 123 patients in the operating

| Table 5 | Rank probability of CRBSI rate per 1000 days (SUCRA/%). |
|---------|-----------------------------------------------------|
| Treatment | SUCRA | PrBest | MeanRank |
| Suture + BPU | 62.0 | 3.7 | 5.2 |
| BDD | 61.6 | 43.1 | 5.2 |
| TD | 59.0 | 15.2 | 5.5 |
| SDG | 57.4 | 18.2 | 5.7 |
| NTD | 54.9 | 0.6 | 6.6 |
| CHG | 54.3 | 3.6 | 6.0 |
| AD | 49.0 | 2.3 | 6.6 |
| SAD | 44.9 | 1.8 | 7.1 |
| TA + SPU | 43.3 | 2.9 | 7.2 |
| SPU | 41.9 | 1.9 | 7.4 |
| Suture + AD | 38.9 | 6.7 | 7.7 |
| SSD + SPU | 32.9 | 0 | 6.9 |

AD = adherent dressing, BDD = biguanide disc dressing, CHG = chlorhexidine gluconate-impregnated dressing, NTD = new-generation transparent dressing, SAD = silver alginate dressing, SDG = sterile dry gauze, SPU = standard polyurethane dressing, SSD + SPU = sutureless securement device + standard polyurethane dressing, Suture + AD = suture + adherent dressing, Suture + BPU = suture + biguanide disc dressing, TA + SPU = tissue adhesive + standard polyurethane dressing, TD = transparent dressing, CRBSI = catheter-related blood infections.
Theater and intensive care found that the application of SSD was harder than other interventions. SSD requires a multistep procedure to apply, which likely led to a longer application time compared with the other interventions, and lower satisfaction ratings. Therefore, improving the application of SSD in the future is very important.

The methodological quality of the included RCTs was moderate to high. The sample sizes of the included RCTs ranged from 25 to 1879 patients. One study indicated that small to moderately sized trials have stronger effect estimates than larger trials. Therefore, we used a comparison-adjusted funnel plot to assess the bias of small-study effects. The results showed that the probability of bias of the included studies was low.

There were some limitations in our study. First, a number of the meta-analyses published focused on the efficacy and safety of different dressings for CRBSI. However, it has been difficult to directly compare the clinical efficacy among dressings in RCTs and traditional meta-analysis.

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Table 6

| Treatment     | SUCRA | PrBest | MeanRank |
|---------------|-------|--------|----------|
| SSD           | 81.5  | 26.9   | 3.2      |
| TD            | 77.4  | 10.8   | 3.7      |
| SPU           | 62.5  | 0.7    | 5.5      |
| SPU+SPU       | 57.7  | 9.0    | 6.1      |
| CHG           | 54.4  | 26.8   | 6.5      |
| Suture+AD     | 49.1  | 13.2   | 7.1      |
| TA+SPU        | 48.0  | 10.6   | 7.2      |
| BPU           | 47.4  | 0.2    | 7.3      |
| SPU+BPU       | 44.4  | 0.5    | 7.7      |
| TA            | 39.9  | 0.3    | 8.2      |
| Suture+BPU    | 35.8  | 0.4    | 8.7      |
| ISD           | 31.2  | 0.6    | 9.3      |
| SDG           | 20.7  | 0      | 10.5     |

-from 25 to 1879 patients. One study indicated that small to moderately sized trials have stronger effect estimates than larger trials. Therefore, we used a comparison-adjusted funnel plot to assess the bias of small-study effects. The results showed that the probability of bias of the included studies was low.

5. Conclusion

We compared 13 antimicrobial dressings for preventing CRBSIs through a Bayesian network meta-analysis. The use of this method has enabled us to provide new information on the relative effectiveness of antimicrobial dressings for the management of CRBSIs and catheter failure. Based on the results of the network
meta-analysis and probability ranking analysis, TD may be the best way to prevent CRBSIs, a sutureless securement device might lead to the lowest incidence of catheter failure, and suture and bordered polyurethane dressing might have the lowest CRBSI rate per 1000 catheter-days. Therefore, this network meta-analysis is important for future research, and it highlights the need for properly designed RCTs and more head-to-head comparisons of the most commonly used dressings in this field. Currently, there is scant evidence, mainly indirect, and mostly from small trials with a risk of unclear bias.

Author contributions
Data curation: Fangping Dang.
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Writing – review & editing: Fangping Dang.

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