



## RESEARCH ARTICLE

# Risk of catheter-related bloodstream infection associated with midline catheters compared with peripherally inserted central catheters: A meta-analysis

Huapeng Lu<sup>1</sup>  | Yeru Hou<sup>2</sup> | Jiejie Chen<sup>2</sup> | Yan Guo<sup>3</sup> | Lan Lang<sup>1</sup> | Xuemei Zheng<sup>4</sup> | Xia Xin<sup>4</sup> | Yi Lv<sup>1</sup> | Qinling Yang<sup>1</sup> 

<sup>1</sup>Department of Hepatobiliary and Pancreas Surgery, The First Affiliated Hospital, Xi'an Jiaotong University, Xi'an, Shaanxi, P. R. China

<sup>2</sup>School of Nursing, Health Science Center, Yan'an University, Shaanxi, P. R. China

<sup>3</sup>School of Nursing, Health Science Center, Xi'an Jiaotong University, Xi'an, Shaanxi, P. R. China

<sup>4</sup>Department of Nursing, The First Affiliated Hospital, Xi'an Jiaotong University, Xi'an, Shaanxi, P. R. China

## Correspondence

Qinling Yang, Department of Hepatobiliary and Pancreas Surgery, The First Affiliated Hospital, Xi'an Jiaotong University, Xi'an, Shaanxi, P. R. China.  
Email: 13519133867@163.com

## Funding information

Xi'an Jiao Tong University, Grant/Award Number: 2017HL-04

## Abstract

**Background:** Both midline catheters (MCs) and peripherally inserted central catheters (PICCs) can cause catheter-related bloodstream infection (CRBSI), but the prevalence associated with each is not clear.

**Objective:** To compare the risk of CRBSI between MCs and PICCs with a meta-analysis.

**Methods:** The Web of Science Core Collection, PubMed, Scopus, Embase, The Cochrane Library and ProQuest were searched. All studies comparing the risk of CRBSI between MCs and PICCs were included. Selected studies were assessed for methodological quality using the Downs and Black checklist. Two authors independently assessed the literature and extracted the data. A fixed effects model was used to generate estimates of CRBSI risk in patients with MCs versus PICCs. Publication bias was evaluated, and meta-analyses were conducted with RevMan 5.3.

**Results:** A total of 167 studies were identified. Ten studies were collected, involving 33,322 patients. The prevalence of CRBSI with MCs and PICCs was 0.58% (40/6,900) and 0.48% (127/26,422), respectively. Meta-analysis showed that the prevalence of CRBSI was not significantly different between MCs and PICCs (RR = 0.77, 95% CI: 0.50–1.17,  $p = .22$ ). While the result showed that the prevalence of CRBSI with MCs was lower than that with PICCs (RR = 0.55, 95% CI: 0.33–0.92,  $p = .02$ ) after poor-quality studies were removed. The sensitivity analysis shows that the results from this meta-analysis are fair in overall studies and non-poor-quality studies. All studies have no significant publication bias.

**Conclusions:** This study provides the first systematic assessment of the risk of CRBSI between MCs and PICCs and provides evidence for the selection of appropriate vascular access devices for intravenous infusion therapy in nursing. The prevalence of CRBSI was not significantly different between them.

## KEYWORDS

catheter-related bloodstream infection, complication, intravenous infusion therapy, meta-analysis, midline catheter, peripherally inserted central catheter

This is an open access article under the terms of the Creative Commons Attribution-NonCommercial-NoDerivs License, which permits use and distribution in any medium, provided the original work is properly cited, the use is non-commercial and no modifications or adaptations are made.

© 2020 The Authors. *Nursing Open* published by John Wiley & Sons Ltd.

## 1 | INTRODUCTION

Intravenous infusion therapy is the most widely used therapy in the field of nursing. Catheter-related bloodstream infection (CRBSI) is a serious complication from a catheter. CRBSI, also called catheter-related sepsis, is defined as the presence of bacteraemia originating from an intravenous catheter (Gahlot et al., 2014). It is one of the most frequent, lethal and costly complications of central venous catheterization. It is also the most common cause of nosocomial bacteraemia (Fletcher, 2005; Reigadas et al., 2013). CRBSI may cause a series of potential morbidity, prolonged hospitalizations and increased expense. The attributable cost for CRBSI was \$32,000–\$69,332 (Goudie et al., 2014; Kaye et al., 2014; Stevens et al., 2014; Wilson et al., 2014; Zimlichman et al., 2013).

A midline catheter (MC) is approximately a 3–8-inches long, thin, soft tube that is inserted through a needle placed into a vein in your arm, and the tip of this catheter is at or below the axillary vein. The prevalence of CRBSI with MCs has been reported in many studies to be 0%–0.9% (Chopra et al., 2019; Cummings et al., 2011; Maki et al., 2006; Mushtaq et al., 2018; Rotta et al., 2015). A peripherally inserted central catheter (PICC) is a form of intravenous access that is inserted in a peripheral vein such as an upper arm vein and the tip reaches the superior vena or right atrium and thus becomes a central catheter. PICCs are used to obtain central venous access. The prevalence of CRBSI 0.13%–7.3% with PICCs (Bhargava et al., 2018; Bouzad et al., 2016; Kagan et al., 2019; Liu et al., 2019; Poletti et al., 2018; Puspos, 2016).

Many studies have shown that the prevalence of CRBSI in MCs and PICCs is controversial. To provide evidence for the selection of appropriate vascular access devices (VAD) for intravenous infusion therapy in the field of nursing, this study provides the first systematic assessment of the risk of CRBSI between them.

## 2 | METHODS

### 2.1 | Literature search

We followed the preferred reporting item for systematic reviews and meta-analyses (PRISMA) guidelines in conducting this meta-analysis (Moher et al., 2009). We performed a serial literature search for English and non-English papers during December 2019. The Web of Science Core Collection (Science Citation Index Expanded: 1900–present; Social Sciences Citation Index: 1900–present; Arts & Humanities Citation Index: 1975–present, Conference Proceedings Citation Index- Science: 1996–present; Conference Proceedings Citation Index- Social Science & Humanities: 1996–present; Emerging Sources Citation Index: 2015–present), PubMed (inception– present), Scopus (inception– present), Embase (inception– present), The Cochrane Library (inception– present) and ProQuest (inception– present) were searched. We used Boolean logic with search terms including “midline catheter”, “midline venous catheter”, “midline peripheral

### BOX 1 Search strategy in the PubMed

#1 (((midline catheter\* [Title/Abstract]) OR midline venous catheter\* [Title/Abstract]) OR midline peripheral catheter\* [Title/Abstract]) OR medium-term intravenous access\* [Title/Abstract]

#2 (((((peripherally inserted central catheter\* [MeSH Terms]) OR peripherally inserted central catheter\* [Title/Abstract]) OR peripherally inserted central venous catheter\* [Title/Abstract]) OR percutaneous indwelling central catheter\* [Title/Abstract]) OR PICC line\* [Title/Abstract]) OR PICC [Title/Abstract]

#3 ((((((bacteremia) OR bacteremia) OR bacteriemia) OR bloodstream infection) OR septicemia) OR sepsis) OR sepsis]

#4 #1 AND #2 AND #3

catheter”, “medium-term intravenous access”, “peripherally inserted central catheter”, “percutaneous indwelling central catheter” “peripherally inserted central venous catheter”, “PICC line”, “PICC”, “bacteremia”, “bacteriemia”, “septicemia”, “sepsis”, “bloodstream infection”. To search for all terms that begin with a word, enter the word followed by an asterisk. Text box 1 provides a detailed search strategy in PubMed.

### 2.2 | Study eligibility and selection criteria

Two authors independently determined study eligibility. Any differences in opinion about eligibility were resolved through another author as third-party consensus. Studies were included if they compared the complication of CRBSI between PICCs and MCs. Studies were excluded if they (a) were case reports, reviews, commentaries, or studies that did not report the prevalence of CRBSI; (b) were non-human studies; (c) were secondary research; (d) included several participants <10; (e) were a duplicate report; and (f) reported incomplete data and the relevant data were not available.

### 2.3 | Definition of variables and outcome

PICCs was defined as catheters inserted in the basilic, cephalic or brachial veins of the upper extremities with tips that terminated in the superior vena or right atrium. MCs were defined as a typical 8–20-cm long catheter and placed peripherally into the antecubital fossa or upper arm, with the tip located at or below the axillary vein. The primary outcome was the occurrence of CRBSI after MCs or PICCs placement. CRBSI was defined as the presence of bacteremia attributed to MCs or PICCs catheter, positive blood culture with no other explanation.

## 2.4 | Data abstraction and validity assessment

Data were collected independently from all included studies on a template adopted from the Cochrane collaboration (Li et al., 2019). For all studies, we extracted author, publication year, study design, study location, study period, population, study indicator, number of PICCs and MC, and number of CRBSIs.

## 2.5 | Assessment of risk bias

The risk bias of the included studies was independently assessed by two authors. Because retrospective cohort studies, randomized controlled trials met the inclusion criteria, the risk of bias was assessed according to the checklist for measuring study quality developed by Downs and Black (1998). This tool included five sections that included reporting (10 questions, total score of 11), external validity (3 questions, total score of 3), internal validity or bias (7 questions, total score of 7), internal validity or confounding (6 questions, total score of 6) and power (1 question, total score of 5). Quality assessment of the studies was determined by the following cut-off points: excellent ( $\geq 26$ ), good (20–25), fair (15–19) and poor ( $\leq 14$ ) (Ray-Barruel et al., 2019). An overall quality score was assigned to individual studies.

## 2.6 | Statistical analysis

The meta-analyses were conducted using Review Manager software, version 5.3 (<https://community.cochrane.org/help/tools-and-software/revman-5>). Dichotomous outcomes eligible in each study are demonstrated as a risk ratio (RR) with an estimated 95% confidence interval (CI). Continuous outcomes are shown as the weighted mean difference (WMD) with the 95% CI, which were calculated from the mean, standard deviation (SD), *p*-value and sample size in each study. Heterogeneity was assessed using Higgins  $I^2$ , which evaluates the percentage of total variation across studies that were due to heterogeneity rather than by chance:  $0\% \leq I^2 < 25\%$ ,  $25\% \leq I^2 < 50\%$ ,  $50\% \leq I^2 < 75\%$  and  $75\% \leq I^2$  indicated no heterogeneity, low heterogeneity, moderate heterogeneity and severe heterogeneity, respectively. Thus, if  $I^2 > 50\%$ , which was considered to reflect substantial heterogeneity, a random effects model was used. If  $I^2 \leq 50\%$ , which was considered to reflect no heterogeneity, a fixed effects model was employed. The chi-square tests were also used to evaluate the heterogeneity:  $p < .1$  means heterogeneity, while  $p > .1$  indicates no heterogeneity. A  $p < .05$  was considered statistically significant. The publication biases were judged by funnel plots.

## 2.7 | IRB approval

This meta-analysis study was approved by the institutional review board of the Department of Hepatobiliary and Pancreas Surgery, The First Affiliated Hospital, Xi'an Jiaotong University.

## 3 | RESULTS

### 3.1 | Eligible studies

A total of 167 studies were identified and 25 duplicated studies were excluded. 103 studies, including no CRBSI endpoint ( $N = 46$ ), reviews ( $N = 31$ ), case series ( $N = 6$ ), duplicate reports ( $N = 5$ ) and other forms of publication ( $N = 15$ ), were excluded after screening the title and abstract. After full-text articles for eligibility were assessed, an additional 29 studies were excluded due to the following criteria: no CRBSI endpoint ( $N = 13$ ), reviews ( $N = 8$ ), infection data only ( $N = 4$ ) and commentaries ( $N = 4$ ). Finally, a total of 10 studies were selected for data extraction. The flow diagram of the study selection is summarized in Figure 1.

### 3.2 | Study characteristic

A total of 10 studies were selected for inclusion in this meta-analysis (Barr et al., 2012; Benali et al., 2013; Caparas & Hu, 2014; Lisova et al., 2015; Moureau et al., 2002; Sargent & Nixon, 1997; Seo et al., 2020; Sharp et al., 2014; Snooks et al., 2019; Xu et al., 2016), with four studies from the United States (Caparas & Hu, 2014; Moureau et al., 2002; Seo et al., 2020; Xu et al., 2016), accounting for 40%, three studies from UK (Barr et al., 2012; Sargent & Nixon, 1997; Snooks et al., 2019) and one study each from Australia (Sharp et al., 2014), Canada (Benali et al., 2013), and the Czech Republic (Lisova et al., 2015). One study was abstracts of meetings (Benali et al., 2013). Overall, 33,322 participants were included: 6,900 (20.71%) were included in the MCs group and 26,422 (79.29%) were included in the PICCs group. A summary of the included studies is presented in Table 1.

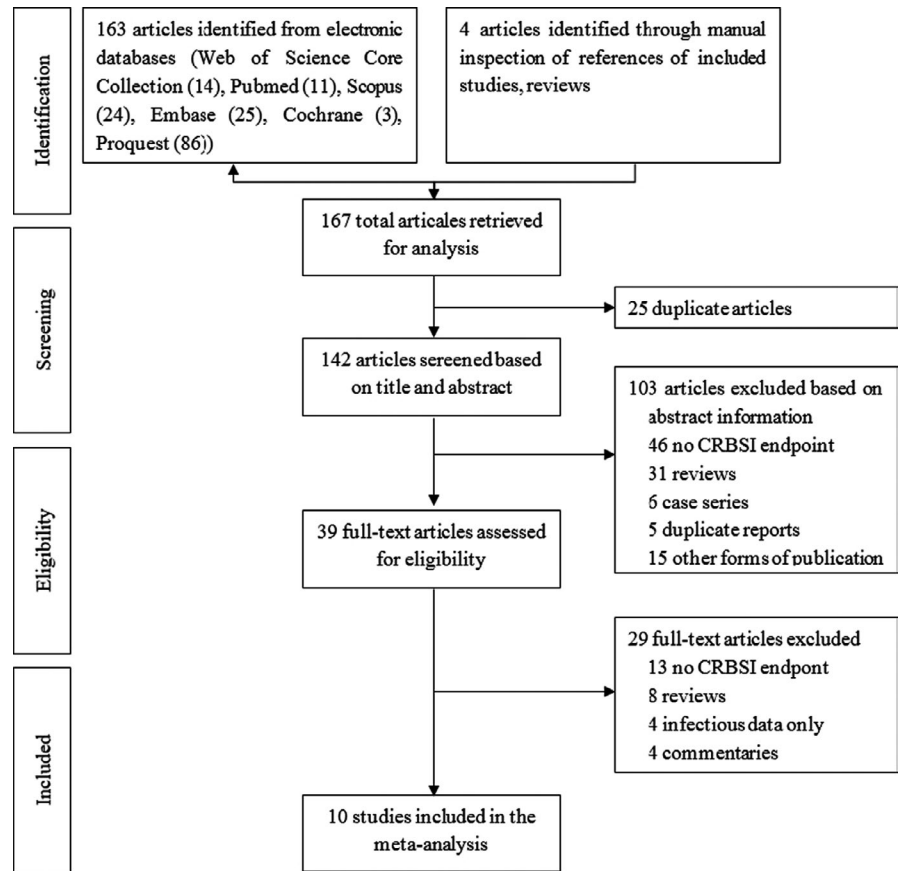
### 3.3 | Study quality

The study quality of 10 studies with meet selected inclusion and two studies with incomplete data reported were evaluated independently and shown in Table 1; four studies were good (Caparas & Hu, 2014; Seo et al., 2020; Sharp et al., 2014; Xu et al., 2016), two studies were fair (Barr et al., 2012; Moureau et al., 2002) and four studies were poor (Benali et al., 2013; Lisova et al., 2015; Sargent & Nixon, 1997; Snooks et al., 2019).

### 3.4 | Meta-analysis results

A total of 10 studies were analysed that involved 33,322 participants. The prevalence of CRBSI with MCs and PICCs was 0.58% (40/6,900) and 0.48% (127/26422), respectively. Heterogeneity among the studies was low ( $I^2 = 40\%$ ,  $p = .11$ ). Thus, a fixed effects model was used. Meta-analysis showed that the prevalence of CRBSI was not significantly different between MCs and PICCs (RR = 0.77, 95% CI: 0.50–1.17,  $p = .22$ ) (Figure 2).

**FIGURE 1** The flow diagram of the study selection



Subgroup analyses were performed among the US, UK, and the other nations; the other nations subgroup included studies in Australia (Sharp et al., 2014), Canada (Benali et al., 2013) and the Czech Republic (Lisova et al., 2015). In the US subgroup, heterogeneity among the studies was low ( $I^2 = 0\%$ ,  $p = .83$ ). Meta-analysis showed that the prevalence of CRBSI with MCs was lower than that with PICCs (RR = 0.53, 95% CI: 0.31–0.89,  $p = .02$ ). In the UK subgroup, heterogeneity among the studies was low ( $I^2 = 0\%$ ,  $p = .74$ ). Meta-analysis showed that the prevalence of CRBSI with MCs was higher than that with PICCs (RR = 3.67, 95% CI: 1.18–11.37,  $p = .02$ ). In the other nations subgroup, the prevalence of CRBSI has not been analysed (Figure 2).

Subgroup analyses also were performed in adults and the others; the others subgroup included studies in children (Benali et al., 2013), adults and children (Moureau et al., 2002), and no reporting age of the participants (Caparas & Hu, 2014; Sargent & Nixon, 1997; Snooks et al., 2019). In the adult subgroup, heterogeneity among the studies was low ( $I^2 = 0\%$ ,  $p = .52$ ). Meta-analysis showed that the prevalence of CRBSI was not significantly different between MCs and PICCs (RR = 0.82, 95% CI: 0.31–2.14,  $p = .69$ ). In the others subgroup, heterogeneity among the studies was low ( $I^2 = 68\%$ ,  $p = .02$ ). Meta-analysis showed that the prevalence of CRBSI was not significantly different between MCs and PICCs (RR = 0.76, 95% CI: 0.47–1.21,  $p = .25$ ) (Figure 3).

If the four poor-quality studies were removed (Benali et al., 2013; Lisova et al., 2015; Sargent & Nixon, 1997; Snooks et al., 2019),

heterogeneity among the studies was low ( $I^2 = 0\%$ ,  $p = .82$ ). Thus, a fixed effects model was used. Meta-analysis showed that the prevalence of CRBSI with MCs was lower than that with PICCs (RR = 0.55, 95% CI: 0.33–0.92,  $p = .02$ ).

### 3.5 | Sensitivity analyses

Sensitivity analyses were conducted. If Moureau et al. (2002) was rejected, heterogeneity ( $I^2 = 0\%$ ,  $p = .98$ ) and meta-analysis showed the prevalence of CRBSI was not significantly different between MCs and PICCs (RR = 0.23, 95% CI: 0.04–1.41,  $p = .11$ ) among the US subgroup. Heterogeneity and meta-analysis results have no significant changed in the UK subgroup, the other nations subgroup, the adult subgroup, the others subgroup and all studies.

If Sargent and Nixon (1997) was rejected, heterogeneity ( $I^2 = 0\%$ ,  $p = .70$ ) and meta-analysis showed that the prevalence of CRBSI with MCs was lower than that with PICCs (RR = 0.63, 95% CI: 0.40–1.00,  $p = .05$ ) in all subjects. Heterogeneity ( $I^2 = 0\%$ ,  $p = .84$ ) and meta-analysis showed the prevalence of CRBSI was not significantly different between MCs and PICCs (RR = 2.07, 95% CI: 0.27–15.90,  $p = .48$ ) among the UK subgroup. Heterogeneity ( $I^2 = 0\%$ ,  $p = .57$ ) and meta-analysis showed the prevalence of CRBSI was lower than that with PICCs (RR = 0.59, 95% CI: 0.35–1.00,  $p = .05$ ) among the others subgroup. Heterogeneity and meta-analysis results have no significant changed in the US subgroup, the other nations subgroup

TABLE 1 Characteristics and quality of included studies with a comparison group

Study	Study design	Study location	Study period	Population	Study indicator	Midline		PICC		Study quality
						BSI	Total	BSI	Total	
Seo et al. (2020)	RC	New York, US	Nov. 2017 to Jul. 2018	≥18 years	Demographics, catheter-related adverse events (local events, dislodgment, infiltration, occlusion, Venous thromboembolism (VTE), extravasation, infection), risk factors for complications, data on catheter gauge, use of ultrasound during placement, service placing the line, anticoagulation and/or antiplatelet therapy, situ time of midline, site of placement, total number of medications infused, medication type, duration of therapy, vesicant properties.	0	82	1	50	Good (21)
Snooks et al. (2019)	RC	Southampton, UK	Jun. 2017 to Dec. 2018	NR	Complications (infection, VTE)	2	43	0	22	Poor (11)
Xu et al. (2016)	RC	Pennsylvania, US	Jan-May 2015	19-98 years	Demographics, comorbidity score, length of stay, insertion location, line duration, complications	0	200	2	206	Good (23)
Lisova et al. (2015)	RC	Prague, Czech Republic	During 2013	23-90 years	Complications (infection, VTE, occlusion, displacement)	5	162	4	167	Poor (14)
Caparas and Hu (2014)	RCT	New York, US	NR	≥1 dose and ≥6 days vancomycin	Demographics, administration of other antibiotics, average number of days on vancomycin, dwell time, complications	0	30	1	28	Good (23)
Sharp et al. (2014)	RC	Adelaide, Australia	2004 to 2010	18-47 years	Demographics, comorbidity, inpatients/outpatients, severity of exacerbation, lung function, adverse events (CRBSI, DVT, occlusion, pain, infiltration, bleeding, phlebitis, leakage, dislodgement), and whether VAD was removed unexpectedly	0	231	0	97	Good (22)
Benali et al. (2013)	RCT	Montreal, Canada	NR	≤18 years and weighed ≥3 kg	Demographics, dwell time, complications (DVT, infection)	0	69	0	84	Poor (14)
Barr et al. (2012)	RC	Glasgow, UK	Jan 1, 2001 to May 31, 2011	adults	Demographics, Infection, phlebitis, external leakage, extravasation, occlusion, length of IV course (duration line use), type of line, experience, comorbidity	12	648	0	43	Fair (19)
Moureau et al. (2002)	RC	US	Apr. 1999 to Sep. 2000	1-101 years	Demographics, type of VAD, principal diagnosis, complications by event and device type, underlying causes and outcomes of DVT dysfunction	14	5,423	117	25,707	Fair (19)
Sargent and Nixon (1997)	RC	London, UK	late 1995 to early 1996	AIDS patients	Patient information, practitioners, catheter insertion, catheter use, catheter removal	7	12	2	18	Poor (14)

Abbreviations: RC, retrospective cohort study; RCT, randomized controlled trial; NR, not reported.

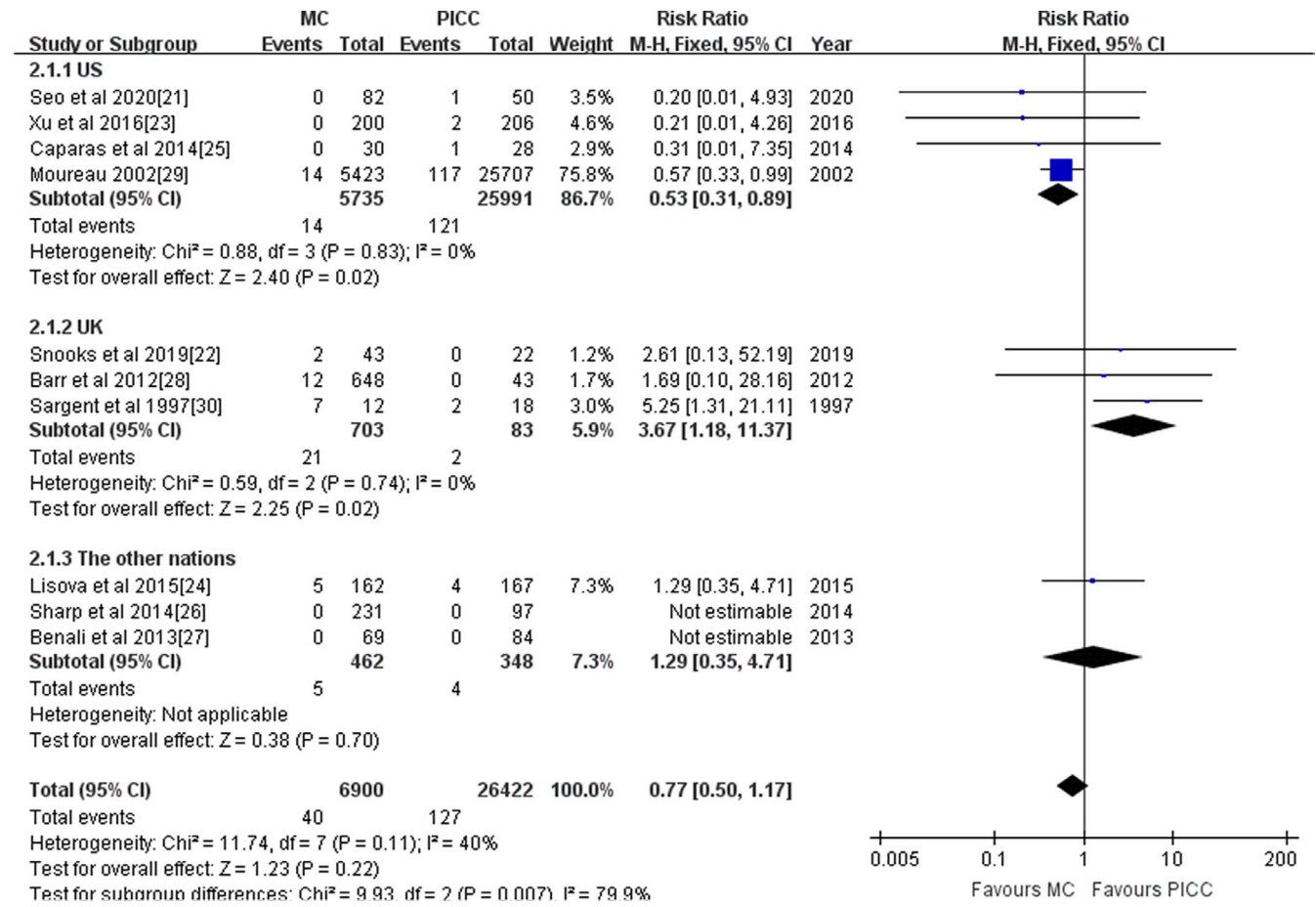


FIGURE 2 Subgroup analyses by nation for CRBSI between MCs and PICCs

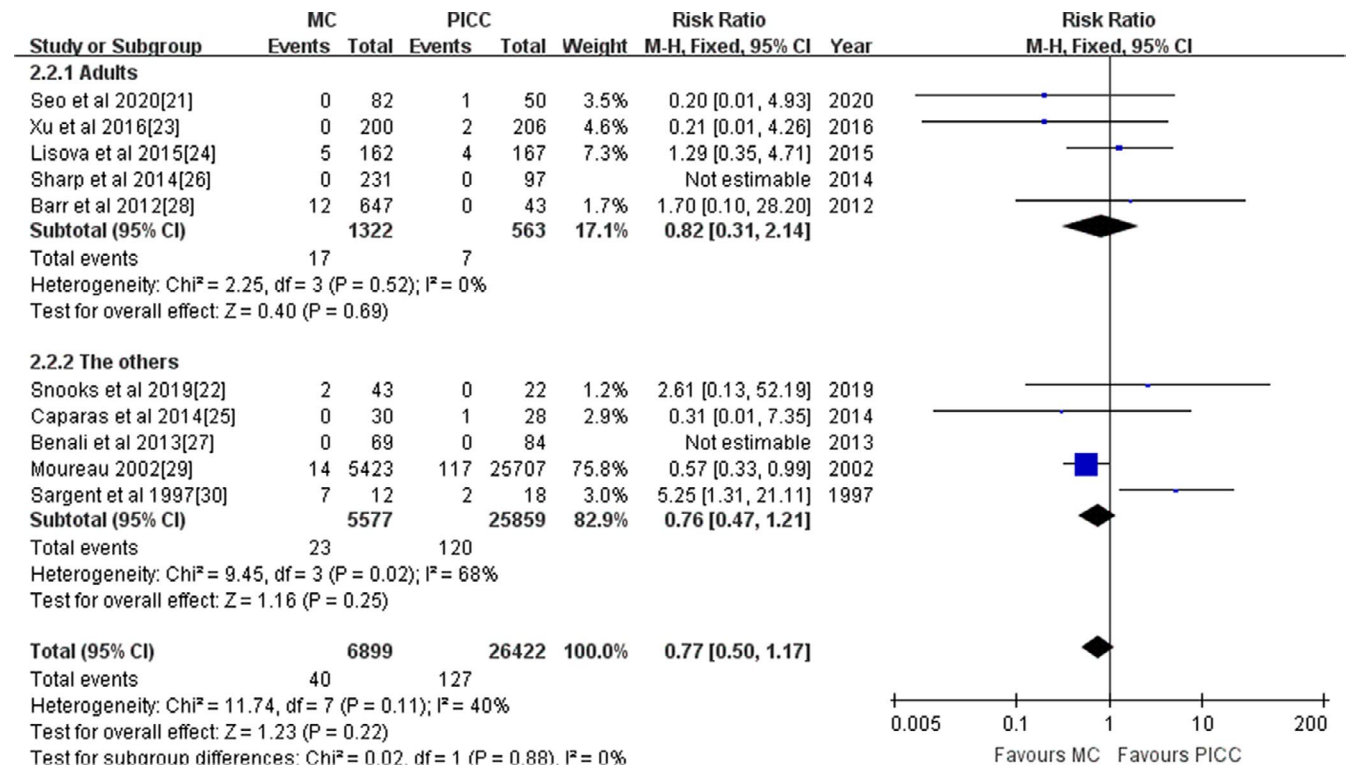


FIGURE 3 Subgroup analyses by age for CRBSI between MCs and PICCs

and the adult subgroup. There was no significant change in the heterogeneity and meta-analysis results after other studies were rejected one by one.

### 3.6 | Publication bias analyses

Funnel plots of publication bias for studies examining CRBSI were assessed (Figure 4). The symmetric funnel plots indicated no publication bias. However, partial studies at the bottom of the funnel are poor quality.

## 4 | DISCUSSION

CRBSI is a serious complication in intravenous infusion therapy. CRBSI can increase the length of hospitalizations, costs and mortality (Bessis et al., 2020; Velissaris et al., 2019). The prevalence of CRBSI was different with different VADs. PICCs is long-term use of central venous access, which causes high CRBSI is an important problem (Lee et al., 2020; Silva et al., 2020). MCs is a new type of VAD, which has been widely used. Both MCs and PICCs can cause CRBSI in intravenous therapy. Many studies have shown that the risk of CRBSI in MCs and PICCs is different. In this study, the risk of CRBSI between MCs and PICCs was compared with a systematic review and meta-analysis, to provide evidence for the selection of appropriate VADs for intravenous therapy. This is the first systematic assessment of the risk of CRBSI between MCs and PICCs.

In this study, we found that the prevalence of CRBSI was not significantly different between MCs and PICCs (RR = 0.77, 95% CI: 0.50–1.17,  $p = .22$ ) in all subjects. If the four poor-quality studies were removed, the result showed that the prevalence of CRBSI with MCs was lower than that with PICCs (RR = 0.55, 95% CI: 0.33–0.92,  $p = .02$ ), while the meta-analysis was sensitive when some good or fair-quality studies were removed.

The studies from the US show that the prevalence of CRBSI with MCs was lower than with PICCs (RR = 0.53, 95% CI: 0.31–0.89,

$p = .02$ ). The finding is consistent with Park, Eklund, Riesenber, & White (2019), Banton and Leahy-Gross (1998), and DeVries et al. (2019), while the meta-analysis of research from the US is contrary to that from the United Kingdom. This result may be explained by the fact that the results of meta-analysis were still sensitive. If Moureau et al. (2002) or Sargent and Nixon (1997) were rejected, the results in subgroup and all subjects will change. As the principal investigator of the Moureau study, this was primarily a home care patient outcomes report which may provide reasoning for the sensitivity rejection. The distinction between hospital and home may be wide in terms of infection prevalence and should be concerned. This limitation indicated that study findings need to be interpreted cautiously. So, more high-quality contrastive studies of CRBSI between MCs and PICCs in adults still need in the future.

### 4.1 | Limitations

Some study limitations are listed: a. Ten studies were included; one studies were abstracts presented at meetings and four studies are poor quality; b. only published literature is included; unpublished results are not included. Maybe some studies were not retrieved; and c. most of the subjects were adults, but few of them were children. This limitation means that study findings need to be interpreted cautiously.

### 4.2 | Conclusions

The purpose of the current study was to determine the risk of CRBSI associated with MCs compared with PICCs with a meta-analysis. The findings indicate that the prevalence of CRBSI was not significantly different between MCs and PICCs (RR = 0.77, 95% CI: 0.50–1.17,  $p = .22$ ). This study provides the first systematic assessment of the risk of CRBSI between MCs and PICCs and provides evidence for the selection of appropriate vascular access devices (VAD) for intravenous infusion therapy in nursing. The prevalence of CRBSI was not significantly different between them. The limitation means that study findings need to be interpreted cautiously. More contrastive studies of CRBSI between MCs and PICCs are still needed in the future.

### ETHICS STATEMENT

This meta-analysis study was approved by the institutional review board of the Department of Hepatobiliary and Pancreas Surgery, The First Affiliated Hospital, Xi'an Jiaotong University.

## 6 | IRB APPROVAL

This meta-analysis study was approved by the institutional review board of the Department of Hepatobiliary and Pancreas Surgery, The First Affiliated Hospital, Xi'an Jiaotong University.

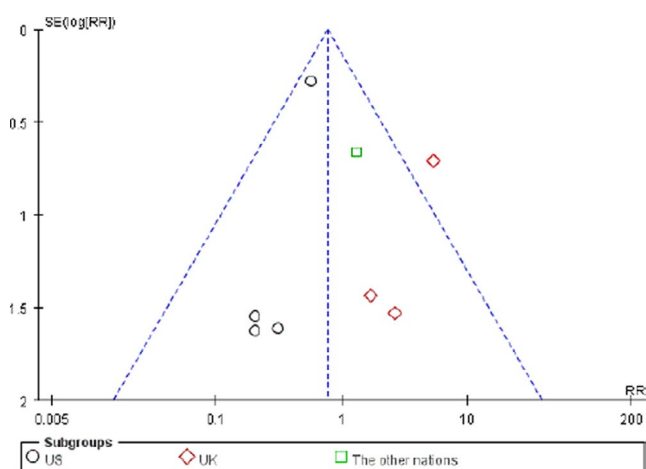


FIGURE 4 Funnel plots of publication bias for CRBSI

## ADDENDUM ON AUTHOR CONTRIBUTION

HL contributed to the design, acquisition, analysis, interpretation of data and drafting of the manuscript. YL, JC, YG and LL contributed to the design, acquisition, analysis, interpretation of data and critical revision of the manuscript. XZ, XX, LY contributed to the interpretation of data and critical revision of the manuscript. LH and YQ had full access to all the study and take responsibility for the integrity of the data accuracy of the data analysis.

## ACKNOWLEDGMENTS

This research was supported by grants from the fundamental research funds of the First Affiliated Hospital of Xi'an Jiao Tong University for funding this study (2017HL-04).

## CONFLICT OF INTEREST

None of the authors have any financial and personal relationships with other people or organizations that could inappropriately influence their work.

## FUNDING INFORMATION

The Fundamental Research Funds of the First Affiliated Hospital of Xi'an Jiao Tong University (2017HI-04) for funding this study. None of the authors have any financial and personal relationships with other people or organizations that could inappropriately influence their work.

## DATA AVAILABILITY STATEMENT

All data generated or analysed during this study are included in this article.

## ORCID

Huapeng Lu  <https://orcid.org/0000-0003-2649-8903>

Qinling Yang  <https://orcid.org/0000-0003-4880-6735>

## REFERENCES

- Banton, J., & Leahy-Gross, K. (1998). Assessing catheter performance: Four years of tracking patient outcomes of midline, midclavicular and PICC line program. *Journal of Vascular Access Devices*, 3, 19–25. <https://doi.org/10.2309/108300898775992923>
- Barr, D. A., Semple, L., & Seaton, R. A. (2012). Self-administration of outpatient parenteral antibiotic therapy and risk of catheter-related adverse events: A retrospective cohort study. *European Journal of Clinical Microbiology and Infectious Diseases*, 31(10), 2611–2619. <https://doi.org/10.1007/s10096-012-1604-z>
- Benali, S., Rypens, F., Lacroix, J., Dubois, J., & Garel, L. (2013). Midline catheters versus peripherally inserted central catheters (PICC) in children: A randomized clinical trial. *Pediatric Radiology*, 43(S3), S541.
- Bessis, S., Cassir, N., Meddeb, L., Remacle, A. B., Soussan, J., Vidal, V., Fournier, P.-E., Fenollar, F., Raoult, D., & Brouqui, P. (2020). Early mortality attributable to PICC-lines in 4 public hospitals of Marseille from 2010 to 2016 (Revised V3). [Journal Article; Multicenter Study; Observational Study]. *Medicine (Baltimore)*, 99(1), e18494. <https://doi.org/10.1097/MD.00000000000018494>
- Bhargava, V., George, L., Malloy, M., & Fonseca, R. (2018). The Role of a Single Dose of Vancomycin in Reducing Clinical Sepsis in Premature Infants Prior to Removal of Peripherally Inserted Central Catheter: A Retrospective Study. *American Journal of Perinatology*, 35(10), 990–993. <https://doi.org/10.1055/s-0038-1632391>
- Bouzad, C., Duron, S., Bousquet, A., Arnaud, F.-X., Valbousquet, L., Weber-Donat, G., Teriitehau, C., Baccialone, J., & Potet, J. (2016). Peripherally Inserted Central Catheter-Related Infections in a Cohort of Hospitalized Adult Patients. *Cardiovascular and Interventional Radiology*, 39(3), 385–393. <https://doi.org/10.1007/s00270-015-1182-4>
- Caparas, J. V., & Hu, J. P. (2014). Safe administration of vancomycin through a novel midline catheter: A randomized, prospective clinical trial. *The Journal of Vascular Access*, 15(4), 251–256. <https://doi.org/10.5301/jva.5000220>
- Chopra, V., Kaatz, S., Swaminathan, L., Boldenow, T., Snyder, A., Burris, R., Bernstein, S. J., & Flanders, S. (2019). Variation in use and outcomes related to midline catheters: Results from a multicentre pilot study. *BMJ Quality & Safety*, 28(9), 714–720. <https://doi.org/10.1136/bmjqs-2018-008554>
- Cummings, M., Hearse, N., McCutcheon, H., & Deuter, K. (2011). Improving antibiotic treatment outcomes through the implementation of a midline: Piloting a change in practice for cystic fibrosis patients. *Journal of Vascular Nursing*, 29(1), 11–15. <https://doi.org/10.1016/j.jvn.2010.11.005>
- DeVries, M., Lee, J., & Hoffman, L. (2019). Infection free midline catheter implementation at a community hospital (2 years). *American Journal of Infection Control*, 47(9), 1118–1121. <https://doi.org/10.1016/j.ajic.2019.03.001>
- Downs, S. H., & Black, N. (1998). The feasibility of creating a checklist for the assessment of the methodological quality both of randomised and non-randomised studies of health care interventions. *Journal of Epidemiology and Community Health*, 52(6), 377–384. <https://doi.org/10.1136/jech.52.6.377>
- Fletcher, S. (2005). Catheter-related bloodstream infection. *Continuing Education in Anaesthesia Critical Care & Pain*, 5(2), 49–51. <https://doi.org/10.1093/bjaceaccp/mki011>
- Gahlot, R., Nigam, C., Kumar, V., Yadav, G., & Anupurba, S. (2014). Catheter-related bloodstream infections. *International Journal of Critical Illness and Injury Science*, 4(2), 162–167. <https://doi.org/10.4103/2229-5151.134184>
- Goudie, A., Dynan, L., Brady, P. W., & Rettiganti, M. (2014). Attributable cost and length of stay for central line-associated bloodstream infections. [Journal Article; Research Support, N.I.H., Extramural; Research Support, Non-U.S. Gov't]. *Pediatrics*, 133(6), e1525–e1532. <https://doi.org/10.1542/peds.2013-3795>
- Kagan, E., Salgado, C. D., Banks, A. L., Marculescu, C. E., & Cantey, J. R. (2019). Peripherally inserted central catheter-associated bloodstream infection: Risk factors and the role of antibiotic-impregnated catheters for prevention. *American Journal of Infection Control*, 47(2), 191–195. <https://doi.org/10.1016/j.ajic.2018.07.006>
- Kaye, K. S., Marchaim, D., Chen, T.-Y., Baures, T., Anderson, D. J., Choi, Y., Sloane, R., & Schmader, K. E. (2014). Effect of nosocomial bloodstream infections on mortality, length of stay, and hospital costs in older adults. [Journal Article; Multicenter Study]. *Journal of the American Geriatrics Society*, 62(2), 306–311. <https://doi.org/10.1111/jgs.12634>
- Lee, J. H., Kim, M. U., Kim, E. T., Shim, D. J., Kim, I. J., Byeon, J. H., & Kim, H. B. (2020). Prevalence and predictors of peripherally inserted central venous catheter associated bloodstream infections in cancer patients: A multicentre cohort study. *Medicine (Baltimore)*, 99(6), e19056. <https://doi.org/10.1097/MD.00000000000019056>
- Li, T., Higgins, J. P., & Deeks, J. J. (2019). Cochrane Handbook for Systematic Reviews of Interventions Version 6 2019-12-30, 2019. <https://training.cochrane.org/handbook/current>
- Lisova, K., Paulinova, V., Zemanova, K., & Hromadkova, J. (2015). Experiences of the first PICC team in the Czech Republic. *British*



- Journal of Nursing*, 24(Suppl 2), S4–S10. <https://doi.org/10.12968/bjon.2015.24.Sup2.S4>
- Liu, Z., Chen, J., Zan, L., Yi, H., Ding, S., & Yan, C. (2019). Exploring the Risk Factors of Thrombosis and Bloodstream Infections in Peripherally Inserted Central Catheter (PICC) Patients. *Journal of Biomaterials and Tissue Engineering*, 9(7), 929–934. <https://doi.org/10.1166/jbt.2019.2095>
- Maki, D. G., Kluger, D. M., & Crnich, C. J. (2006). The risk of bloodstream infection in adults with different intravascular devices: A systematic review of 200 published prospective studies. *Mayo Clinic Proceedings*, 81(9), 1159–1171. <https://doi.org/10.4065/81.9.1159>
- Moher, D., Liberati, A., Tetzlaff, J., & Altman, D. G. (2009). Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. *PLoS Med*, 6(7), e1000097. <https://doi.org/10.1371/journal.pmed.1000097>
- Moureau, N., Poole, S., Murdock, M. A., Gray, S. M., & Semba, C. P. (2002). Central venous catheters in home infusion care: Outcomes analysis in 50,470 patients. *Journal of Vascular and Interventional Radiology*, 13(10), 1009–1016. [https://doi.org/10.1016/s1051-0443\(07\)61865-x](https://doi.org/10.1016/s1051-0443(07)61865-x)
- Mushtaq, A., Navalkele, B., Kaur, M., Krishna, A., Saleem, A., Rana, N., Gera, S., Chandramohan, S., Surapaneni, M., & Chopra, T. (2018). Comparison of complications in midlines versus central venous catheters: Are midlines safer than central venous lines? *American Journal of Infection Control*, 51(3), 252–2458. <https://doi.org/10.1016/j.ajic.2018.01.006>
- Park, T., Eklund, J., Riesenber, J., & White, S. (2019). Does implementation of an effective midline catheter program for vascular access in a large academic hospital decrease rates of bloodstream infections? *Journal of Vascular and Interventional Radiology*, 30(3), S159. <https://doi.org/10.1016/j.jvir.2018.12.433>
- Poletti, F., Coccino, C., Monolo, D., Crespi, P., Ciccio, G., Cordio, G., Seveso, G., & De Servi, S. (2018). Efficacy and safety of peripherally inserted central venous catheters in acute cardiac care management. *The Journal of Vascular Access*, 19(5), 455–460. <https://doi.org/10.1177/1129729818758984>
- Puspos, J. (2016). Tri-bundles for PICC insertion: Prevention of PICC related complications. *Journal of the Association for Vascular Access*, 21(4), 261. <https://doi.org/10.1016/j.java.2016.10.061>
- Ray-Barruel, G., Xu, H., Marsh, N., Cooke, M., & Rickard, C. M. (2019). Effectiveness of insertion and maintenance bundles in preventing peripheral intravenous catheter-related complications and bloodstream infection in hospital patients: A systematic review. *Infection, Disease & Health*, 24(3), 152–168. <https://doi.org/10.1016/j.idh.2019.03.001>
- Reigadas, E., Rodríguez-Creixems, M., Guembe, M., Sanchez-Carrillo, C., Martín-Rabadán, P., & Bouza, E. (2013). Catheter-related bloodstream infection caused by *Enterococcus* spp. [Journal Article]. *Clinical Microbiology & Infection*, 19(5), 457–461. <https://doi.org/10.1111/j.1469-0691.2012.03897.x>
- Rotta, S. A., Laird, J., Crombie, R. E., Connolly, K., Possenti, P., & Savetamal, A. (2015). Use of midline catheters in burn patients decreases central line use and CLABSI rates. *Journal of Burn Care & Research*, 36, S122. <https://doi.org/10.1097/BCR.0000000000000251>
- Sargent, J., & Nixon, E. (1997). I.v. access options for AIDS patients with cytomegalovirus disease. [Comparative Study; Journal Article]. *British Journal of Nursing*, 6(10), 543–553. <https://doi.org/10.12968/bjon.1997.6.10.543>
- Seo, H., Altshuler, D., Dubrovskaya, Y., Nunnally, M. E., Nunn, C., Ello, N., Papadopoulos, J., & Chen, X. J. (2020). The Safety of Midline Catheters for Intravenous Therapy at a Large Academic Medical Center. *Annals of Pharmacotherapy*, 54(3), 232–238. <https://doi.org/10.1177/1060028019878794>
- Sharp, R., Esterman, A., McCutcheon, H., Hearse, N., & Cummings, M. (2014). The safety and efficacy of midlines compared to peripherally inserted central catheters for adult cystic fibrosis patients: A retrospective, observational study. *International Journal of Nursing Studies*, 51(5), 694–702. <https://doi.org/10.1016/j.ijnurstu.2013.09.002>
- Silva, J. T., Lagares-Velasco, A., Fernández-Ruiz, M., González-Monterrubio, G., Pérez-Cárdenas, M. D., Aguado, J. M., & López-Medrano, F. (2020). Peripherally inserted central venous catheter placed and maintained by a dedicated nursing team for the administration of antimicrobial therapy vs. another type of catheter: a retrospective case-control study. *Enfermedades Infecciosas Y Microbiología Clínica*, 38(9), 425–430. <https://doi.org/10.1016/j.eimc.2020.01.005>
- Snooks, R., Catton, T., Harris, M., & Galea, M. (2019). Central venous, peripherally inserted central and midline catheters on neurointensive care: A retrospective audit. *Journal of Neurosurgical Anesthesiology*, 31(1), 92–93. <https://doi.org/10.1097/ANA.0000000000000562>
- Stevens, V., Geiger, K., Concannon, C., Nelson, R. E., Brown, J., & Dumyati, G. (2014). Inpatient costs, mortality and 30-day re-admission in patients with central-line-associated bloodstream infections. *Clinical Microbiology & Infection*, 20(5), O318–O324. <https://doi.org/10.1111/1469-0691.12407>
- Velissaris, D., Karamouzou, V., Lagadinou, M., Pierrakos, C., & Marangos, M. (2019). Peripheral Inserted Central Catheter Use and Related Infections in Clinical Practice: A Literature Update. [Journal Article; Review]. *Journal of Clinical Medicine Research*, 11(4), 237–246. <https://doi.org/10.14740/jocmr3757>
- Wilson, M. Z., Rafferty, C., Deeter, D., Comito, M. A., & Hollenbeak, C. S. (2014). Attributable costs of central line-associated bloodstream infections in a pediatric hematology/oncology population. [Journal Article]. *American Journal of Infection Control*, 42(11), 1157–1160. <https://doi.org/10.1016/j.ajic.2014.07.025>
- Xu, T., Kingsley, L., DiNucci, S., Messer, G., Jeong, J.-H., Morgan, B., Shutt, K., & Yassin, M. H. (2016). Safety and utilization of peripherally inserted central catheters versus midline catheters at a large academic medical center. *American Journal of Infection Control*, 44(12), 1458–1461. <https://doi.org/10.1016/j.ajic.2016.09.010>
- Zimlichman, E., Henderson, D., Tamir, O., Franz, C., Song, P., Yamin, C. K., Keohane, C., Denham, C. R., & Bates, D. W. (2013). Health care-associated infections: A meta-analysis of costs and financial impact on the US health care system. *JAMA Internal Medicine*, 173(22), 2039–2046. <https://doi.org/10.1001/jamainternmed.2013.9763>

**How to cite this article:** Lu H, Hou Y, Chen J, et al. Risk of catheter-related bloodstream infection associated with midline catheters compared with peripherally inserted central catheters: A meta-analysis. *Nurs Open*. 2021;8:1292–1300. <https://doi.org/10.1002/nop2.746>