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Original Article

Which is the safer option for adult patients between peripherally inserted central catheters and midline catheters: a meta-analysis

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Abstract

Background: Peripherally inserted central catheters (PICC) and midline catheters (MC) are widely used for intravenous infusions in oncology and critically ill patients. However, controversy remains regarding which method is superior. This meta-analysis systematically compares the safety differences between these 2 methods of intravenous catheterization.

Methods: Eligible studies comparing PICC and MC were identified through searches in 6 databases. Thrombosis is the primary endpoint, while secondary endpoints include other complications, cost, and satisfaction rate.

Results: Fourteen studies with 20,675 patients were analyzed. Based on patient data, the MC group exhibited higher rates of catheter-related superficial vein thrombosis (SVT) (risk ratio [RR]: 0.42 [0.28, 0.64]), infiltrations (RR: 0.27 [0.12, 0.62]), and leaks (RR: 0.16 [0.05, 0.53]). In contrast, the PICC group had more catheter-related bloodstream infections (RR: 1.95 [1.15, 3.32]). Considering catheter days, the MC group showed increased total complications (RR: 0.51 [0.26, 0.99]), catheter-related thrombosis (deep vein thrombosis [DVT]+SVT) (RR: 0.41 [0.18, 0.95]), and leaks (RR: 0.17 [0.05, 0.64]). In the PICC group, the top 3 complications were catheter occlusions (20 per 1,000 catheter days [CDs]), pain (15 per 1,000 CDs), and phlebitis (11 per 1,000 CDs); for the MC group, they were leaks (33 per 1,000 CDs), premature removals (22 per 1,000 CDs), and catheter-related DVT (22 per 1,000 CDs). Additionally, the PICC group had higher dissatisfaction rates (RR: 4.77 [2.33, 9.77]) and increased costs.

Conclusions: Compared to MC, PICC appears to be a safer intravenous catheterization option for adult patients, exhibiting fewer complications. However, the higher associated costs and lower satisfaction rates of PICC warrant serious attention.

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Introduction

In recent years, the development of intravenous infusion technology has highlighted catheter-related complications. Among commonly used vascular access devices, peripherally inserted central catheters (PICC) and midline catheters (MC) have significant pros and cons that require thorough comparison for clinical decision-making. PICC lines, extending into the superior vena cava, are used for long-term therapies such as chemotherapy and parenteral nutrition.[1] They have a lower risk of infiltration but can lead to complications such as catheter-related bloodstream infections (CRBSIs) and thrombosis.[2,3] MC, inserted into the upper arm and terminating before reaching the central veins, are designed for shorter-term use, typically 1–4 weeks.[4] They offer simpler insertion, lower cost, and reduced risk of central vein injuries.[5] However, MC have a higher incidence of occlusion and phlebitis, limiting their efficacy for long-term treatments.[6,7]

The choice between PICC and MC depends on factors such as therapy duration, medication type, patient vein quality, and complication risks.[8] Although PICC requires meticulous maintenance to prevent infections, MC may offer better patient comfort but necessitates more frequent maintenance.[9,10] This meta-analysis aims to compare the safety and efficacy of PICC and MC. By synthesizing data from recent studies, we evaluate complications (such as thrombosis, CRBSIs, etc.), cost, and patient comfort. Our goal is to provide evidence-based guidance for selecting the most appropriate vascular access device, improving patient outcomes, and minimizing risks associated with intravenous therapy.

Materials and methods

This study followed the PRISMA (Preferred Reporting Items for Systematic reviews and Meta-Analyses) guidelines (Table S1) (PROSPERO ID: CRD42024570503).

Search strategy

Studies comparing PICC and MC were systematically searched in the Web of Science, EMBASE, Cochrane Library, PubMed,

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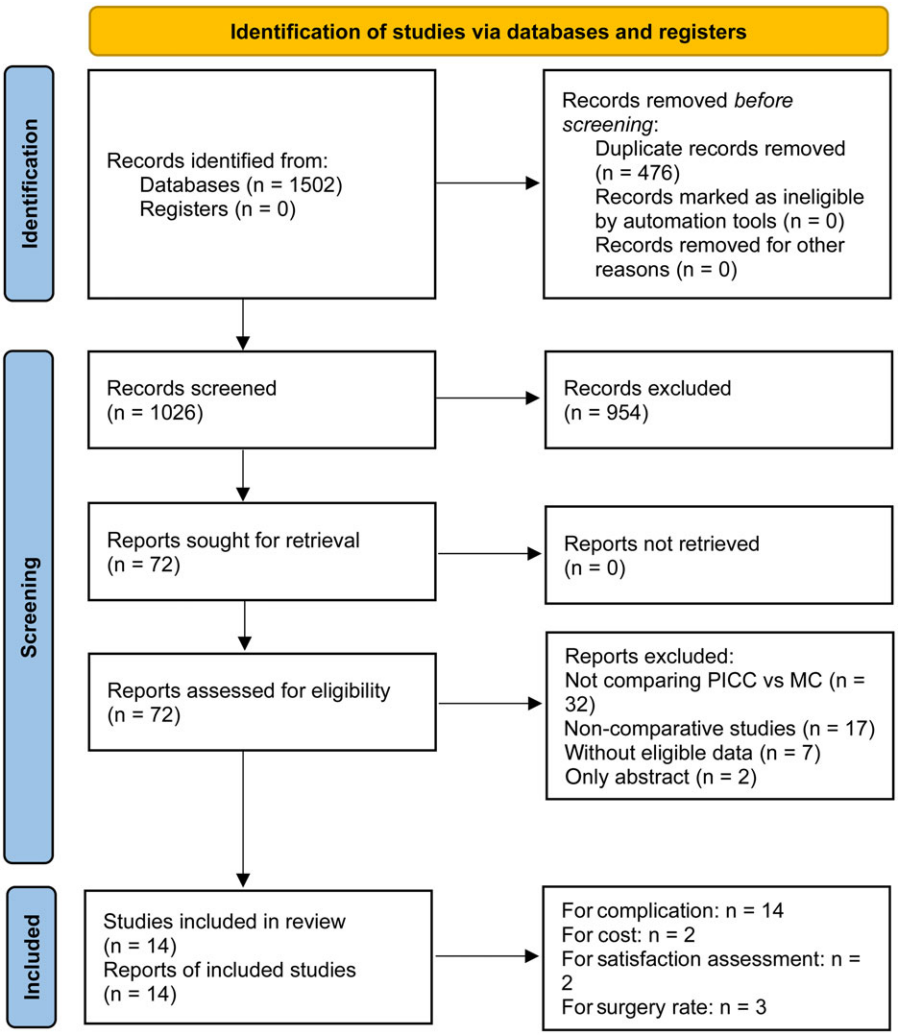

Figure 1. Flow chart of the study selection process.

ScienceDirect, and Scopus databases up to June 15, 2024. The MeSH terms used were "Peripherally inserted central venous catheter" and "Midline catheter." Additionally, eligible articles were further identified through references from retrieved literature. Detailed retrieval strategies are provided in Table S2.

Selection criteria

Inclusion criteria:

1) Population: Adult patients who require the insertion of PICC or MC for intravenous infusion therapy and do not have contraindications for intravenous catheter insertion
2) Intervention and comparison: PICC versus MC.
3) Outcomes: The primary endpoint is thrombosis. Secondary endpoints included other complications, cost, and satisfaction rate.
4) Study design: Randomized controlled trials (RCTs) or cohort studies (CTs).
5) Conference papers, reviews, animal experiments, and articles without original data were excluded.

Data extraction

Two independent investigators extracted the following data: study characteristics (design, period, etc.), participant characteristics (age, sex, etc.), complications (thrombosis, CRBSIs, etc.), cost, and satisfaction (satisfaction rate, dissatisfaction rate, etc.). Disagreements were resolved through re-evaluation.

Outcome assessments

Thrombosis was assessed in different locations: catheter-related, contralateral, contralateral and/or bilateral, and pulmonary embolism (PE). Additionally, thrombosis was also analyzed according to different types: catheter-related superficial thrombosis (SVT) and catheter-related deep vein thrombosis (DVT).

Quality assessment for included studies

The quality of CTs was evaluated using the Newcastle-Ottawa Scale (NOS), including 3 items: selection, comparability, and outcome. A score of 6 or more points signifies medium to high quality.[11] The RCTs' quality was assessed with the Jadad scale, which allocates up to 5 points for randomization, blinding, and participant inclusion, with scores of 3 or higher indicating high quality.[12] The results' quality was assessed using the GRADE approach.[13]

Statistical analysis

Pooling data were analyzed using RevMan 5.3 and STATA 12.0. Continuous variables were analyzed using mean difference (MD),

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Table 1. Baseline characteristics of the included studies

Study	Country	Period (year)	Design	Groups	Number of patients	Sex (M/F)	Age (mean, year)	Catheter days	Selection of patients	Quality
Bahl 2019[15]	USA	2016.07–2017.08	CT	PICC	1483	778/705	66	–	Adult patients	7
				MC	1094	695/399	65	–		
Bing 2022[16]	USA	2014.01–2016.05	CT	PICC	1636	800/836	57	–	Adult patients	9
				MC	1772	820/952	57	–		
Caparas 2014[17]	USA	–	RCT	PICC	25	13/12	69	176	Patients receiving IV vancomycin	4
				MC	29	9/20	72	174		
Lescinskas 2020[18]	USA	2015.08–2017.05	CT	PICC	63	46/14	45.5	–	Adult patients	7
				MC	50	19/31	49.1	–		
Lisova 2015[19]	Czech	2013.01–2013.12	CT	PICC	167	–	–	15,197	Adult patients	7
				MC	162	–	–	2,268		
Marsh 2023[20]	Australia	2020.09–2021.01	RCT	PICC	12	6/6	59	141	Adult patients	4
				MC	12	5/7	62	88		
Seo 2020[5]	USA	2017.11–2018.07	CT	PICC	50	20/30	61	1,424	Adult patients	8
				MC	50	25/25	66	707		
Sharp 2014[7]	Australia	2004.01–2010.12	CT	PICC	97	59/38	29	1,358	Adult patients with cystic fibrosis	7
				MC	231	130/101	29	5,082		
Swaminathan 2022[6]	USA	2017.12–2020.01	CT	PICC	5758	2986/2772	64.9	80,612	Adult patients	8
				MC	5105	2136/2969	64.8	30,630		
Tao 2019[21]	China	2016.08–2018.09	CT	PICC	208	131/77	58.6	1,304	Adult patients with gastrointestinal tumors	8
				MC	279	178/101	59.2	1,161		
Thomsen 2024[22]	Denmark	2018.10–2020.02	RCT	PICC	152	79/73	64.8	2,564	Adult patients	3
				MC	152	95/57	64.4	1,942		
Tso 2017[23]	USA	2008.02–2014.10	CT	PICC	205	–	38	–	Adult patients receiving IV dihydroergotamine	7
				MC	110	–	38	–		
Xu 2016[24]	USA	2015.01–2015.05	CT	PICC	185	114/71	60	–	Adult patients	7
				MC	172	78/94	62.5	–		
Zerla 2015[25]	Italy	2010.03–2013.12	CT	PICC	793	–	–	118,707	Adult patients with tumors	8
				MC	623	–	–	17,071		

Note. CT, cohort study; M/F, male/female; MC, midline catheters; PICC, peripherally inserted central catheters; RCT, randomized clinical trial.

while dichotomous variables were assessed with pooled risk ratios (RR). Heterogeneity was assessed with the I^2 statistic and χ^2 test. Significant heterogeneity ($I^2 > 50\%$ or $P < .1$) warranted a random-effects model; otherwise, a fixed-effects model was utilized. Funnel plots were used to assess publication bias.[14] Statistical significance was indicated by $P < .05$.

Results

Search results

Initially, 1,502 studies were identified, and 14 studies (PICC group: 10,834 patients; MC group: 9,841 patients) were analyzed (Figure 1).[6–11,18–21] Table 1 presents the baseline characteristics. Eight studies were conducted in the United States, 4 in Europe, 2 in Australia, and 1 in China. The average catheter time for the PICC group was 30.49 days, whereas for the MC group, it was 18.24 days. All studies were rated as medium to high quality based on the NOS and Jadad scale (Tables S3 and S4). All outcomes were rated as low to very low quality by the GRADE system (Table S5).

Thrombosis

According to patients, the rate of catheter-related SVT (RR: 0.42 [0.28, 0.64]) was higher in the MC group. Catheter-related DVT, contralateral thrombosis (DVT+SVT, DVT and SVT), contralateral and/or bilateral thrombosis (DVT+SVT, DVT and SVT), and PE were similar between the 2 groups (Table 2, Figure 2).

According to catheter days, the rate of catheter-related thrombosis (DVT+SVT) (RR: 0.41 [0.18, 0.95]) was higher in the MC group. Catheter-related DVT and PE were similar between the 2 groups (Table 3).

Complications assessment according to patients

More infiltrations (RR: 0.27 [0.12, 0.62]) and leaks (RR: 0.16 [0.05, 0.53]) were found in the MC group. Meanwhile, more CRBSIs (RR:

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Table 2. Comparison of PICC versus MC on thrombosis events according to patients

	PICC		MC			
Thrombosis events	Event/total	%	Event/total	%	Risk ratio [95% CI]	*P*
Catheter-related thrombosis						
DVT+SVT	349/10834	3.22%	313/9841	3.18%	1.06 [0.69, 1.61]	0.8
DVT	290/9783	2.96%	239/8889	2.69%	1.09 [0.71, 1.68]	0.69
SVT	34/1713	1.98%	58/1233	4.70%	0.42 [0.28, 0.64]	<.0001
Contralateral thrombosis						
DVT+SVT	33/1483	2.23%	29/1094	2.65%	0.84 [0.51, 1.37]	0.49
DVT	15/1483	1.01%	13/1094	1.19%	0.85 [0.41, 1.78]	0.67
SVT	18/1483	1.21%	16/1094	1.46%	0.83 [0.43, 1.62]	0.58
Contralateral and/or bilateral thrombosis						
DVT+SVT	62/1483	4.18%	60/1094	5.48%	0.76 [0.54, 1.08]	0.12
DVT	25/1483	1.69%	25/1094	2.29%	0.74 [0.43, 1.28]	0.28
SVT	42/1483	2.83%	44/1094	4.02%	0.70 [0.46, 1.07]	0.1
Pulmonary embolism	40/7446	0.54%	27/6309	0.43%	1.15 [0.71, 1.86]	0.58

Note. CI, confidence interval; DVT, deep vein thrombosis; MC, midline catheters; PICC, peripherally inserted central catheters; RR, risk ratio; SVT, superficial vein thrombosis.

1.95 [1.15, 3.32]) were found in the PICC group (Figure 3). The rates of total complications, catheter occlusions, premature removals (all causes), catheter displacements, phlebitis, and pain were similar between the 2 groups (Table 4, Figures S1 and S2).

Complications assessment according to catheter days

According to catheter days, more total complications (RR: 0.51 [0.26, 0.99]) and leaks (RR: 0.17 [0.05, 0.64]) were found in the MC group. The rates of catheter occlusions, pain, phlebitis, catheter displacements, infiltrations, CRBSIs, and premature removals were similar between the 2 groups (Table 3).

Cost and satisfaction assessment

In the assessment of satisfaction, a higher rate of dissatisfaction (RR: 4.77 [2.33, 9.77]) was reported in the PICC group. The rate of satisfaction and needing improvements was similar between the 2 groups (Figure S3). Meanwhile, the costs (MD: 63.00 [61.59, 64.41] dollars) were also higher in the PICC group (Figure S4).

Sensitivity analysis

Sensitivity analyses for total complications, catheter-related thrombosis (DVT+SVT), and catheter-related DVT were performed, demonstrating that excluding any individual study did not affect the results' reliability (Figure S5).

Publication bias

The analysis of total complications, catheter-related thrombosis (DVT+SVT), CRBSIs, and catheter displacement revealed no evidence of publication bias (Figure S6).

Discussion

The debate over the optimal choice between PICC and MC for intravenous therapy in oncology and critical care is ongoing. Both catheter types play essential roles in patient management, yet their associated complications and overall effectiveness require detailed evaluation to inform clinical decision-making. This study aims to address the controversy by systematically comparing the safety profiles of PICC and MC, focusing on complications, cost, and patient satisfaction. Our findings suggest that PICC generally have fewer complications (catheter-related thrombosis [DVT+SVT], catheter-related SVT, infiltrations, and leaks) but are associated with higher costs and greater patient dissatisfaction compared to MC.

Thrombosis is a primary concern with the use of vascular access devices. Our study showed that the rate of catheter-related thrombosis (DVT+SVT) was higher in the MC group, especially when evaluated per catheter days. These results are consistent with previous studies that reported a higher risk of thrombosis with MC, likely due to their shorter length and positioning in peripheral veins, which may predispose patients to venous irritation and subsequent clot formation.[26] In contrast, PICCs extend into larger central veins, potentially providing better hemodilution of infused substances and a reduced risk of thrombosis.[27] The longer duration of PICC placement, averaging 30.49 days compared to 18.24 days for midlines, may also contribute to the higher rate of thrombosis observed in the PICC group. The prolonged catheter placement may cause mechanical irritation to the vessel wall, leading to endothelial damage and promoting thrombus formation.[28] Additionally, the extended exposure time allows for a greater accumulation of fibrin and other clotting factors around the catheter, which could increase the likelihood of developing DVT.[29] Moreover, the presence of the catheter over a longer period increases the risk of CRBSIs, which are known to contribute to a hypercoagulable state and further elevate the risk of thrombosis.[30] However, it is important to note that PICCs are not without thrombotic complications, necessitating vigilant monitoring and management to mitigate these risks.[31]

Beyond thrombosis, other complications associated with these catheters are also critical. Our analysis revealed that MC had higher incidences of infiltrations and leaks, complications that can significantly affect patient comfort and safety.[7] Conversely, PICCs were more frequently associated with CRBSIs, severe complications that require prompt medical intervention.[32] This discrepancy

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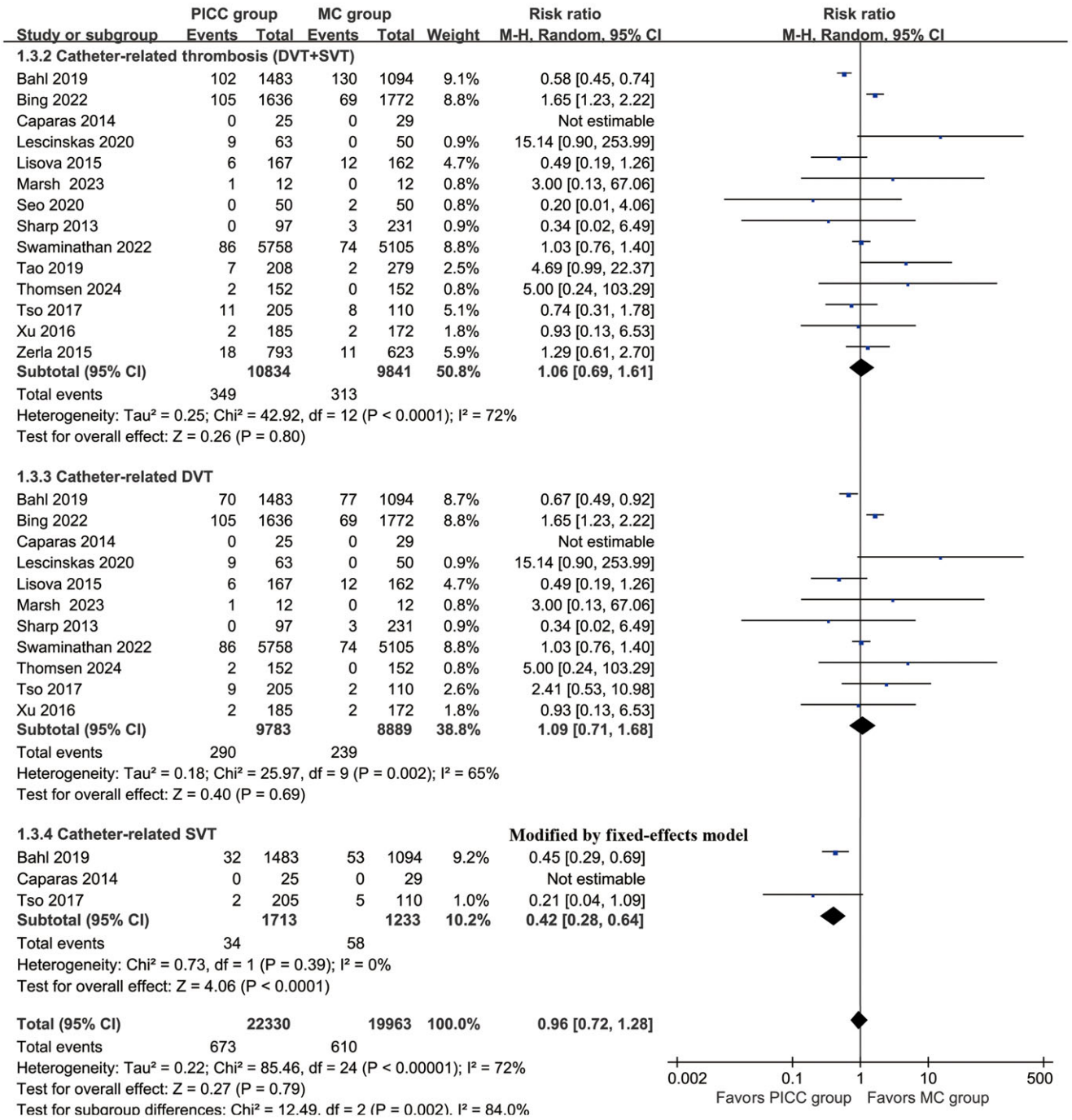

Figure 2. Forest plots of catheter-related thrombosis (DVT+SVT), catheter-related DVT, and catheter-related SVT associated with PICC versus MC. DVT, deep vein thrombosis; SVT, superficial vein thrombosis; PICC, peripherally inserted central catheters; MC, midline catheters.

suggests that although MC may be preferable in scenarios where reducing the risk of CRBSIs is paramount, PICCs might be more suitable for longer-term use where infiltration and leakage are primary concerns.[5] Notably, the lower rates of catheter occlusion and phlebitis in PICCs suggest a more favorable profile for long-term use in stable patients.[33]

Cost and patient satisfaction are crucial factors influencing the choice of vascular access devices. Our study found that PICCs incur higher costs due to their more complex insertion and maintenance protocols, contributing to higher dissatisfaction rates reported among patients.[34] The dissatisfaction associated with PICCs may be attributed to the frequent need for maintenance and the discomfort linked to long-term central venous access. On the other hand, MCs, despite their lower costs, often lead to higher complication rates, potentially increasing overall healthcare costs due to the additional treatments required to manage these complications.[35] Balancing these factors is vital to optimizing patient outcomes and healthcare resource utilization. Additionally, the patient satisfaction aspect sheds light on the holistic patient care approach. The higher dissatisfaction rates in PICC users could be a result of the invasive nature of the procedure and the associated discomfort

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Table 3. Complications assessment according to catheter days

Complications	Studies involved	PICC		MC		Risk ratio [95% CI]	*P*
		Event/total	%	Event/total	%		
Total	9	749/221483	0.34%	394/59123	0.67%	0.51 [0.26, 0.99]	0.05
Catheter occlusion	7	436/221166	0.20%	128/58861	0.22%	0.58 [0.23, 1.44]	0.24
Pain	3	6/4063	0.15%	12/7112	0.17%	0.65 [0.08, 5.42]	0.69
Phlebitis	4	6/5402	0.11%	4/8359	0.05%	1.82 [0.50, 6.56]	0.36
Catheter-related DVT	6	95/100048	0.09%	89/40184	0.22%	0.40 [0.11, 1.41]	0.15
Catheter displacement	6	15/22023	0.07%	22/11334	0.19%	0.52 [0.14, 1.89]	0.32
Catheter-related thrombosis (DVT+SVT)	9	120/221483	0.05%	104/59123	0.18%	0.41 [0.18, 0.95]	0.04
Infiltration	5	3/5663	0.05%	15/7993	0.19%	0.29 [0.05, 1.81]	0.18
Bloodstream infection	7	113/219984	0.05%	29/53953	0.05%	0.89 [0.35, 2.31]	0.82
Premature removal (all cause)	4	62/124053	0.05%	55/24802	0.22%	0.30 [0.21, 0.45]	0.23
Leak	4	2/5522	0.04%	26/7905	0.33%	0.17 [0.05, 0.64]	0.009
Pulmonary embolism	1	14/80612	0.02%	8/30630	0.03%	0.66 [0.28, 1.58]	0.36

Note. CI, confidence interval; DVT, deep vein thrombosis; MC, midline catheters; PICC, peripherally inserted central catheters; RR, risk ratio; SVT, superficial vein thrombosis.

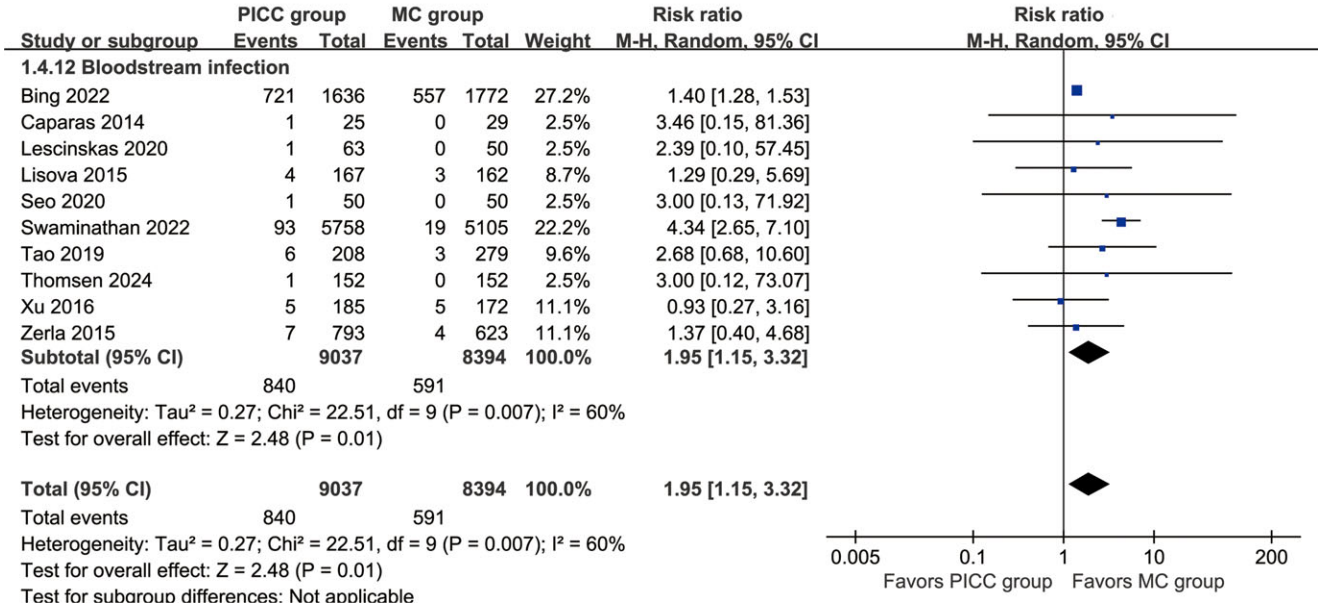

Figure 3. Forest plots of catheter-related bloodstream infection associated with PICC versus MC. PICC, peripherally inserted central catheters; MC, midline catheters.

over extended periods.[36] In contrast, MCs, being less invasive, tend to offer better patient comfort despite their higher complication rates. This dichotomy suggests a nuanced approach to catheter selection where patient preferences and clinical indications must be harmonized.

The limitations of this meta-analysis should be considered when interpreting the results. First, the included studies vary in design, population characteristics, and clinical settings, introducing heterogeneity into the analysis. Second, the quality of evidence, as assessed by the GRADE approach, was generally low to very low, reflecting potential biases and limitations in the primary studies. Thirdly, none of the included studies specified whether thrombosis and other adverse events occurred during or after catheter placement, making it challenging to analyze the causes of these complications. Additionally, the reliance on published data may result in publication bias, as studies with negative results are less often published. Future research should include high-quality RCTs with standardized outcome measures to provide more robust evidence. Despite these limitations, our findings contribute valuable insights into the comparative safety profiles of PICC and MC. The higher thrombosis rates observed with MC highlight the need for careful consideration of patient-specific factors when selecting a vascular access device. For instance, patients with a higher risk of thrombotic events may benefit more from PICC, despite their higher costs and maintenance requirements. Conversely, in settings where the risk of infection is a primary concern, and short-term access is sufficient, MC might be the preferred choice.

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Table 4. Complications assessment according to patients

		PICC		MC			
Complications	Studies involved	Event/total	%	Event/total	%	Risk ratio [95% CI]	*P*
Total	14	1753/10834	16.18%	1221/9841	12.41%	1.00 [0.70, 1.41]	0.99
Bloodstream infection	10	840/9037	9.30%	591/8394	7.04%	1.95 [1.15, 3.32]	0.01
Catheter occlusion	7	436/7225	6.03%	128/6602	1.94%	1.69 [0.81, 3.53]	0.16
Premature removal (all cause)	5	66/1155	5.71%	58/1106	5.24%	0.81 [0.40, 1.62]	0.54
Catheter-related thrombosis (DVT+SVT)	14	349/10834	3.22%	313/9841	3.18%	1.06 [0.69, 1.61]	0.8
Catheter-related DVT	11	290/9783	2.96%	239/8889	2.69%	1.09 [0.71, 1.68]	0.69
Catheter displacement	6	15/699	2.15%	22/903	2.44%	0.84 [0.45, 1.58]	0.6
Catheter-related SVT	3	34/1713	1.98%	58/1233	4.70%	0.42 [0.28, 0.64]	<.0001
Phlebitis	5	9/667	1.35%	9/863	1.04%	1.22 [0.51, 2.92]	0.66
Pain	4	6/446	1.35%	15/567	2.65%	0.77 [0.35, 1.68]	0.51
Infiltration	6	3/521	0.58%	24/646	3.72%	0.27 [0.12, 0.62]	0.002
Leak	5	2/509	0.39%	28/634	4.42%	0.16 [0.05, 0.53]	0.003

Note. CI, confidence interval; DVT, deep vein thrombosis; MC, midline catheters; PICC, peripherally inserted central catheters; RR, risk ratio; SVT, superficial vein thrombosis.

Conclusion

PICC appears to be a safer method of intravenous catheterization for adult patients, with fewer complications compared to MC. However, the higher cost and patient dissatisfaction associated with PICC require careful consideration. Clinicians should tailor catheter selection to individual patient needs, balancing the risk of complications with cost and patient comfort to optimize care outcomes. Future research should focus on high-quality RCTs to further clarify the comparative safety and efficacy of these vascular access devices.

Supplementary material. The supplementary material for this article can be found at https://doi.org/10.1017/ice.2024.190.

Data availability statement. Data is provided within the manuscript or supplementary information files.

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Author contribution. Juan Qiu had full access to all the data in the manuscript and took responsibility for the integrity of the data and the accuracy of the data analysis. All authors read and approved the final manuscript.

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Ethics standard. This article does not contain any studies with human participants or animals performed by any of the authors.

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