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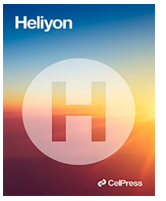

Research article

The ultrasound-guided versus standard technique for peripheral intravenous catheter placement by nurses: A systematic review and meta-analysis

Yishu Tian [a,1], Zixing Zhong [b,1], Djouhayna Dougarem [c], Litao Sun [a,*]

[a] Center for Reproductive Medicine, Department of Ultrasound Medicine, Zhejiang Provincial People's Hospital (Affiliated People's Hospital, Hangzhou Medical College), Hangzhou, Zhejiang, China
[b] Center for Reproductive Medicine, Department of Obstetrics, Zhejiang Provincial People's Hospital (Affiliated People's Hospital, Hangzhou Medical College), Hangzhou, Zhejiang, China
[c] Hospital of Obstetrics and Gynecology, Zhejiang University School of Medicine, Hangzhou, Zhejiang, China

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ABSTRACT

Aim: To comprehensively evaluate the efficacy of Ultrasound-guided technique for peripheral intravenous catheter placement by nurses in their daily practice.
Background: Peripheral intravenous catheter insertion is a common clinical procedure in healthcare settings. Ultrasound-guided peripheral intravenous placement has emerged in recent decades and was recognized as particularly useful in some specific patient groups.
Methods: Studies that had compared the ultrasound-guided and traditional approaches were eligible for inclusion and further analysis. The primary outcome was the success rate on the first intravenous insertion attempt. The secondary outcomes included the time needed for successful insertion, and the average number of attempts to establish the IV access. We systematically assess all studies using Cochrane Collaboration's Risk of Bias tool and the Newcastle-Ottawa Scale. We calculated the odds ratio and standardized mean difference with 95 % confidence intervals for the outcomes. Data were analyzed and visualized on Review Manager 5.3.4 and Stata 16.0.
Results: 23 studies were included (17 randomized controlled trials and six cohort studies) with a population of 2051 patients offered ultrasound-assisted technique and 2479 treated with the conventional approach for comparison. The former approach was associated with a higher success rate on the first attempt in comparison (OR = 2.95, 95 % CI: 1.86, 4.69). This technique also took less time and less acupuncture to patients' skin (SMD = −0.62, 95 % CI: 1.01, −0.23; SMD = −0.55, 95 % CI: 0.92, −0.18). In the sub-group analyses, children were more likely to benefit from ultrasound guided technique. Ultrasound guided technique demonstrated consistent and significant benefits in emergency clinical settings. Hospitals from different geographical locations exhibited similar trends in the three outcomes. Year of publication and study design revealed inconsistent and insignificant outcomes.
Conclusions: Ultrasound-guided technique can be a safer, faster, and more effective alternative to the traditional approach for nurses to establish intravenous access across different clinical settings and age groups.

* Corresponding author.
E-mail addresses: 18211781732@163.com (Y. Tian), zhongzixing@hmc.edu.cn (Z. Zhong), 22165013@zju.edu.cn (D. Dougarem), litaosun1971@sina.com (L. Sun).
[1] The two authors contributed equally to this work.

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1. Introduction

Peripheral intravenous catheter (PIVC) placement is to establish a temporary intravenous (IV) line in the patient's peripheral vein, typically in the arm or hand. It is one of the most common and essential clinical procedures performed in healthcare settings, allowing healthcare professionals to administer fluids, medications, blood products, and other intravenous therapies [1].

Conventionally, this procedure involves inserting a small, hollow plastic catheter called an IV cannula into a vein. The venous access site is often inspected and palpated using anatomical landmarks. However, factors such as cancerous or malnutritional status, obesity, or age may make it more challenging to gain access by observation and palpation [2,3]. This can cause more failed attempts or inaccurate cannulation, leading to unexpected operational complications, e.g., arterial injury, hematoma formation, excessive bleeding, nosocomial infections, etc [4]. Delayed IV access can affect the patients' medical treatment, which can be critical, particularly in emergency clinical settings [5]. Moreover, the unexpected multiple procedures or complications may lengthen patients' hospital stay, and increase healthcare costs by and large [6]. In this context, the ultrasound-guided technique emerged to assist the IV-line placement [7,8]. This technique was first proposed in 1984, and was subsequently applied in emergency and critical settings, such as in the anesthesia department and the intensive care unit (ICU) [9]. The ultrasound probe can visualize the needle or catheter in real-time and guide the direction to ensure safe and accurate placement. It is arguably useful in emergency settings or for patients with difficult access [10,11].

Nonetheless, clinical concerns remain regarding the effectiveness, safety, and duration of the ultrasound-guided procedure in the general patient population [12–14]. In this study, we collected and synthesized all available evidence to assess the efficacy of the ultrasound-guide approach compared with the traditional approach from different aspects.

2. Methods

2.1. Protocol and registration

We conducted this systematic review and meta-analysis according to the Preferred Reporting Item for Systematic Reviews and Meta-analysis (PRISMA) Statement [15,16]. It was registered on The International Prospective Register of Systematic Reviews (PROSPERO) with an identifier: CRD42023426521.https://www.crd.york.ac.uk/prospero/display_record.php?RecordID=426521.

2.2. Study identification and selection

Three electronic databases, PubMed, Web of Science (WOS), and Embase, were searched from the inception to September 30, 2023. Two independent investigators (YST and ZXZ) combined Medical Subject Headings (MeSH) terms and free text words, e.g., 'ultrasonography' and 'peripheral catheterization' and 'nurses'. The inclusion criteria were: 1) prospective or retrospective studies comparing ultrasound-guided peripheral intravenous catheter insertions and traditional approaches; 2) the subjects were limited to humans regardless of age and gender. We then excluded conference abstracts, case reports, editorials, letters, and reviews. There were no restrictions on language or places of study. To supplement the search, they reviewed each reference from the papers that were included. The detailed search strategies can be accessed in the supplementary file: Search Strategy. The two researchers (YST and ZXZ) independently searched the database and LTS was to resolve the disagreement between the two as the third independent reviewer.

2.3. Data extraction and quality evaluation

The two operators (YST and ZXZ) extracted data from each original article: the title of the studies, name of the authors of the studies, year of publication, study types, the nation of the studies conducted, the number of participants and the average ages of them, the number of insertions per subject, the duration of the successful process, and the success rate of first-time catheter insertion were extracted from each study. LTS made the final decision when there were disagreements regarding data extraction.

Randomized studies were evaluated using the Cochrane Collaboration's Risk of Bias tool based on seven domains (random sequence generation, allocation concealment, blinding of participants, blinding of outcome assessment, incomplete outcome data, selective outcome reporting, and other biases (Fig. 2). Cohort studies were assessed according to the Newcastle-Ottawa Scale (NOS). It is a nine-star rating system to evaluate the quality of each cohort study. The quality is good if rated between seven and nine. A score between four and six was considered moderate. Poor quality was defined if the score was three or less(Supplementary Table 1).

2.4. Sub-group analysis

We also performed the sub-group analysis to assess 1) whether there were differences across sub-groups in various aspects; 2) where the source of heterogeneity between studies came from. All studies were firstly divided into two sub-groups according to the participants' age across studies: the young age group included all studies with participants aged eighteen or less, while the adult group only included grown-ups whose ages were older than eighteen. Then, all studies were subsequently divided according to their geographical locations, i.e., USA, Brazil, and Europe (comprised of records from France, Spain, and Turkey). The third sub-group analyses were made on the year of publication; studies published before 2015 were compared with those after 2015. The year 2015 was chosen as this was the median year among all included studies. The fourth divided the studies according to their designs,

randomized controlled trials (RCTs) and non-RCTs were compared. Lastly, the studies were compared in terms of clinical settings, emergency Vs non-emergency.

2.5. Statistical analysis

Review Manager 5.3.4 and Stata 16.0 were used to analyze and visualize the data extracted from the included studies. The primary outcome of this study was the success rate on the first attempt. They were pooled by odds ratio (OR) with 95 % confidence intervals (CIs). The I^2 was used to test the heterogeneity ($I^2 \geq 50$ % indicates significant heterogeneity) [17]. The forest plot was used to visualize the overall results, with the Mantel-Haenszel being adopted as the statistical method. The secondary outcomes include the duration of successful IV-line placement, and the number of attempts. The unit of the time for successful IV insertion is the second (s). It was pooled by standardized mean difference (SMD) with 95 % CIs. A sensitivity analysis was performed with the removal of each study once to assess whether any single study could affect the whole outcome. Publication bias was visualized via funnel plot [17].

3. Result

3.1. Study selection

We searched three databases (PubMed, WOS, Embase) and collected a total of 1178 articles. Six additional studies were identified after we had checked all the references from full-text articles. Of the 1184 studies, 127 were removed as duplicates. 1057 records were further screened and 1007 of them were after checking their title and abstract. There were 50 studies investigated for full-text assessment. 27 of them were excluded for reasons. Finally, 23 studies were included for systematical evaluation and meta-analysis [18–40]. See Fig. 1.

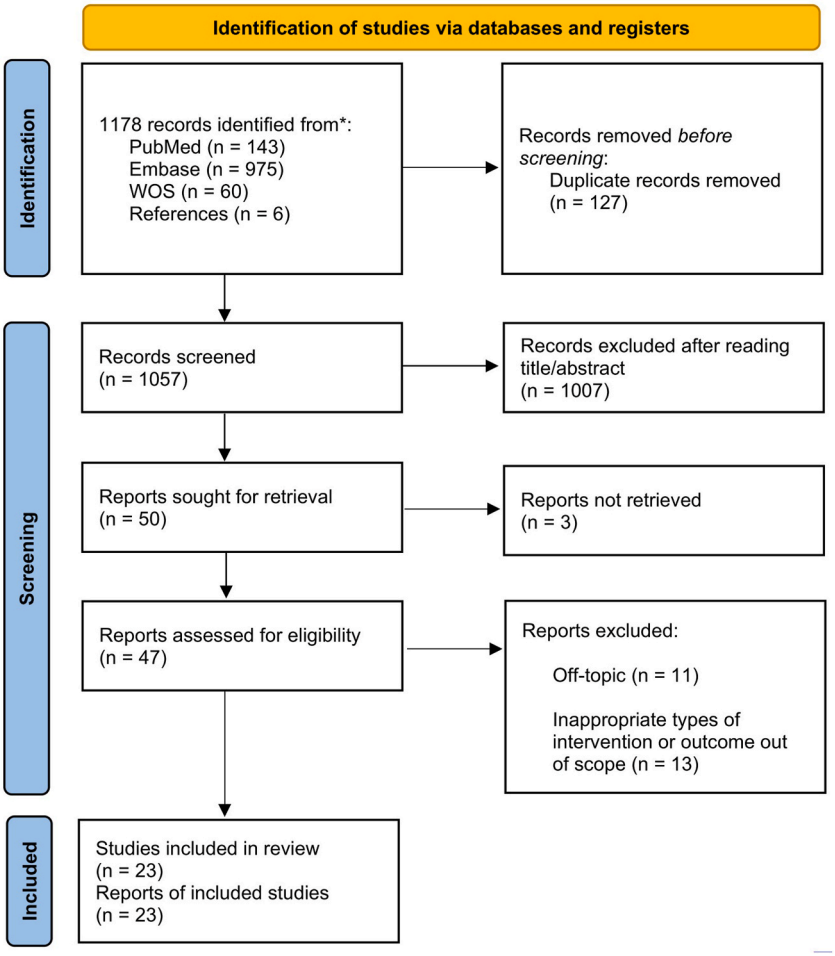

Fig. 1. Flowing diagram of included studies selection process.

3.2. Basic characteristics of included studies

The 23 reports originated from six countries: Brazil, France, Spain, Turkey, and the USA. Participants ranged from 19 to 605 in the study group, and 16 to 584 in the control group [18,36]. In 17 studies reporting gender ratio, we identified that 44 % (1608/3641) of the participants were female, with 46 % (847/1848) in the study group and 42 % (761/1793) in the control group. More detailed information can be seen in Table 1. Given each study's different aims and focuses, not every article in our systematic review and meta-analysis reported the data on participants' ages, the success rate on the first attempt, the duration to complete the successful insertion, and the average number of acupunctures per patient.

3.3. Results of the systematic review

Our systematic review and meta-analysis comprised 17 randomized clinical trials, and six cohort studies. The randomized trials were further assessed via Cochrane Collaboration's Risk of Bias tool that was built-in on RevMan 5.3.4. See Fig. 2 (right column). Cohort studies were evaluated through the Newcastle-Ottawa Scale (NOS) for quality check, and all were rated as high quality (Supplementary Table 1).

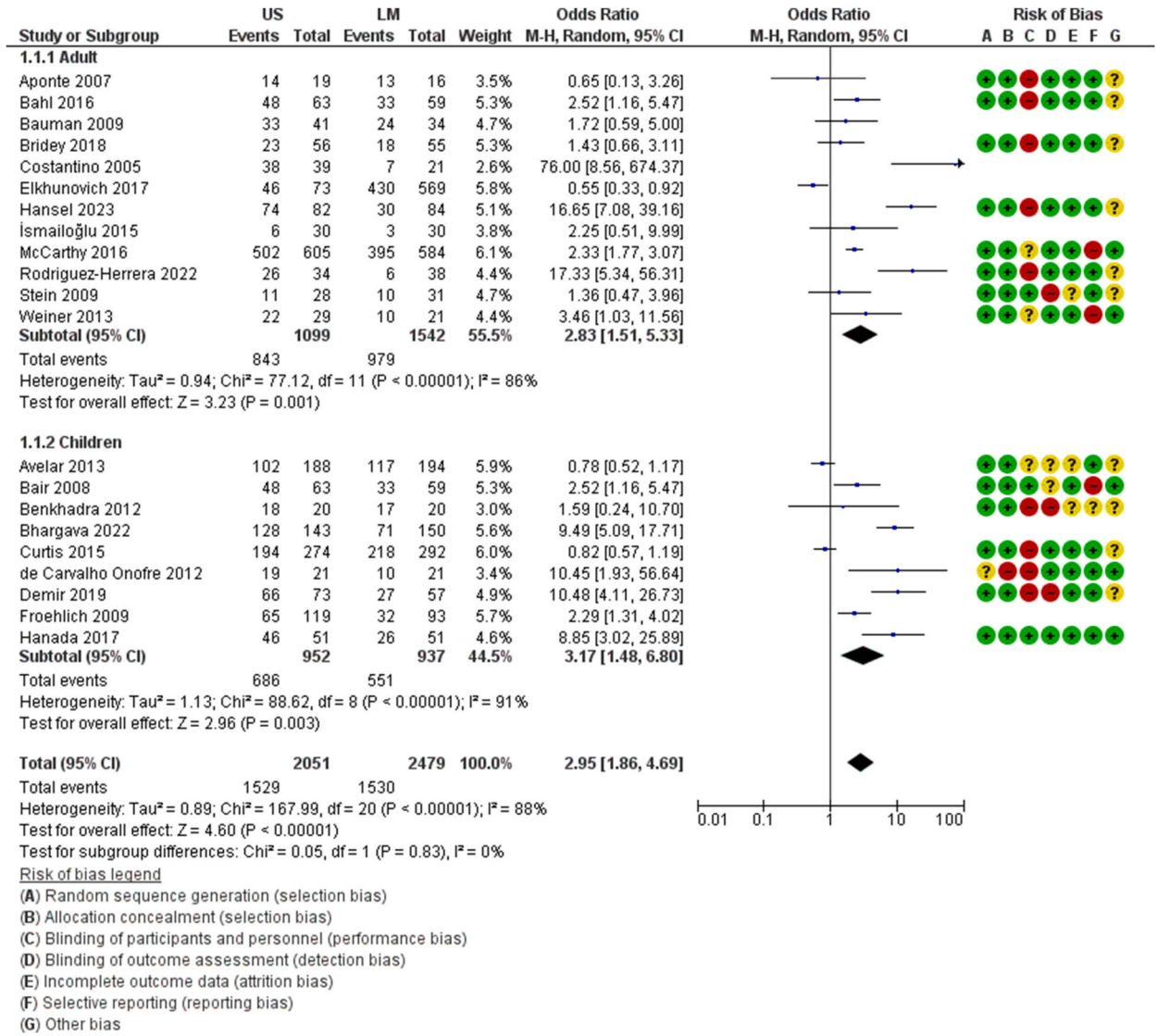

Fig. 2. Forest plot and Risk of Bias. The forest plot shows odds ratio between adults and children on ultrasound-guided peripheral intravenous catheter and conventional approach. Risk of Bias Summary for the Randomized controlled trials. Green color indicates low risk, yellow indicates unknown risk and red color indicates high risk. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

Table 1
Description of the 23 studies included in the meta-analysis.

Study/ Year	Study design	Age of the participants[a] (yr)						No. of attempts[a]		Duration[a] (s)		Clinical setting
		Study	N	Female (N, %)	Control	N	Female (N, %)	Study	Control	Study	Control	
1 [18].	RCT	55.5 (15.7)	19	15 (79)	57.3 (18.9)	16	12 (75)	1.3 (0.9)	1.4 (0.7)	304 (295)	172 (222)	POU
2 [19].	RCT	8.2	188	NG	7.2	194	NG	NG	NG	NG	NG	POU
3 [20].	RCT	61.0	63	47 (75)	62	59	43 (73)	1.5 (2.2)	1.7 (2.2)	948 (3034)	1242 (1099)	ED
4 [21].	RCT	1.3 (1.1)	23	NG	0.7 (0.5)	21	NG	NG	NG	NG	NG	ED
5 [22].	Prospective	48.2 (12.6)	41	32 (78)	45.9 (13.5)	34	22 (65)	1.6 (0.7)	3.6 (2.2)	2144 (1188)	4488 (4560)	ED
6 [23].	RCT	1.3 (0.9)	20	8 (40)	1.2 (0.9)	20	5 (25)	1(0)	2.9 (1.5)	74 (28)	438 (155)	PPOU
7 [24].	Self-control	9.8 (6.8)	143	64 (45)	9.2 (6.9)	150	70 (47)	1.2 (0.6)	1.1 (0.4)	NG	NG	PICU
8 [25].	RCT	64.4 (18.1)	57	22 (39)	61.5 (17.5)	57	22 (39)	NG	NG	NG	NG	ICU
9 [26].	Prospective	NG		NG	NG	NG	NG	1.7 (0.7)	3.7 (2.0)	240 (336)	900 (708)	ED
10 [27].	RCT	7.8 (5.7)	137	73 (46)	7.2 (5.8)	146	61 (42)	1.4 (0.2)	1.4 (0.4)	498 (954)	390 (618)	PED
11 [28].	RCT	4.0 (6.7)	21	6 (29)	4.5 (5.5)	21	10 (48)	NG	NG	1416 (477)	2784 (1431)	PW
12 [29].	RCT	8.5 (4.4)	72	32 (44)	9.3 (4.5)	57	27 (47)	1.1 (0.3)	2.2 (1.6)	2234 (1242)	10359 (9193)	PW
13 [30].	RCT	2.9 (2.5)	25	15 (60)	1.8 (2.1)	25	10 (40)	1.5 (1.2)	3.0 (1.6)	378 (342)	864 (576)	PED
14 [31].	Retrospective	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	PW
15 [32].	Retrospective	5.7 (8.0)	119	NG	4.8 (7.8)	93	NG	NG	NG	224 (269)	422 (623)	PICU
16 [33].	RCT	1.1 (1.4)	51	16 (31)	1.3 (1.5)	51	24 (47)	1.2	2.0	238 (92)	171(102)	PW
17 [34].	RCT	59.0 (16.0)	82	51 (62)	59.7 (17.0)	84	53 (63)	NG	NG	321 (136)	885 (973)	AW
18 [35].	Prospective	NG		19 (63)	NG		16 (53)	2.1 (0.6)	2.1 (0.6)	NG	NG	ED
19 [37].	RCT	68.2 (16.7)	34	22 (65)	68.9 (18.8)	38	22 (53)	NG	NG	126 (101)	618 (387)	ED
20 [36].	RCT	49.9	605	384 (63)	46.9	584	334 (58)	NG	NG	189.6	102	ED
21 [38].	RCT	58.1 (15.6)	28	20 (71)	54.8 (17.8)	31	18 (58)	2.1 (0.5)	2.4 (0.8)	3612 (1608)	2892 (1722)	ED
22 [39].	RCT	NG	61	NG	NG	61	NG	1.27	1.87	NG	NG	ED
23 [40].	RCT	46.2 (14.6)	29	21 (72)	53.0 (14.2)	21	12 (57)	2.0 (1.2)	2.1 (1.1)	1656 (1821)	1584 (1265)	ED

The unit for time for successful acupuncture is the second (s); AW: adult ward; ED: emergency department; ICU: intensive care unit; NG: not given from the original studies; PED: pediatric emergency department; PICU: pediatric intensive care unit; POU: pre-operative unit; PPOU: pediatric pre-operative unit; PW: pediatric ward; RCT: randomized control trial.

[a] Mean (SD).

3.4. Results of the meta-analysis and sub-group analysis

In this systematic review and meta-analysis, 4530 participants were included. 2051 patients underwent ultrasound-guided peripheral intravenous catheterization (USGPIVC), while 2479 patients underwent traditional blind IV insertions. The primary outcome is the success rate on the first attempt of IV insertion. The pooled odds ratio (OR) of the success rate is 2.95 (95 % CI: 1.86, 4.69; see Fig. 2). The overall I^2 was 88 % and the between-study variance Tau^2 was 0.89. The funnel plot demonstrated no obvious asymmetry, indicating insignificant publication bias, as seen in Fig. 3. The leave-one-out sensitivity analysis revealed that Curtis et al. [27] was the major contributor to the pooled result, but leaving this study did not cause directional change to the pooled results (Supplementary Fig. 1).

We further conducted five sub-group analyses to investigate whether patients' age, geographical location, year of publication, study design, and clinical setting had impacted the outcomes. Firstly, the overall results from sub-group analysis between young and adult patients suggested that age disparity was not associated with a difference in the success rate of the first attempt of USGPIVC. The OR was 2.83 (95 % CI: 1.51, 5.33) in adults and 3.17 (95 % CI: 1.48, 6.80) in children, respectively. Although the overall time spent was in favor of ultrasound-guided catheter placement (SMD = −0.62, 95 % CI: 1.01, −0.23), the duration was even less in children group (SMD = −0.83, 95 % CI: 1.49, −0.23). For the adult patients, the general direction favored ultrasound assisted procedure, but

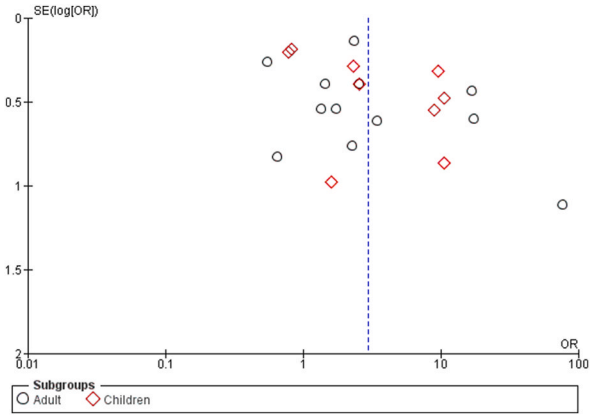

Fig. 3. The funnel plot to assess publication bias.

the results did not reach statistical difference (SMD = −0.47, 95 % CI: 0.95, 0.02). In contrast, the average number of attempts was comparable between the two age groups, with the adult group just reaching statistical significance (SMD = −0.49; 95 % CI: 0.94, −0.05). Both groups were consistent with the pooled results (SMD = −0.55, 95 % CI: 0.92, −0.18). See Supplementary Figs. 2–3.

Given the divergence in clinical practices across different nations, we also conducted sub-group analyses based on geographical locations. Among the 23 studies, 15 were conducted in the USA, five were from Europe (two from France, two from Turkey, and one from Spain), and three from Brazil. Regarding the primary outcome, European hospitals exhibited a notably high odds ratio in first-attempt success with ultrasound-guided catheter placement (OR = 4.25, 95 % CI: 1.35, 13.44). Similar but less pronounced result can be seen in the United States (OR = 2.24, 95 % CI: 1.31, 3.84). The synthesized result was more remarkable but heterogeneous in Brazil (OR = 4.89, 95 % CI: 0.45, 52.62). The three sub-groups were not significantly different in individual comparisons (Supplementary Fig. 4).

The results were highly varied in secondary outcomes. Regarding the time for completing a successful insertion, the results of average ranged from 74 to 3612 s in USGPIVC group and from 170 to 10359 s in landmark group, respectively. European nurses outperformed their North and South American peers in applying the ultrasound-assisted intravenous catheter (IVC) placement (SMD = −1.95, 95 % CI: 2.81, −1.09). This was also the case in an average number of acupunctures to skin, with European nurses showing a negative SMD, favoring USGPIVC (SMD = −0.89, 95 % CI: 1.77, −0.01). By contrast, the average number of attempts before achieving successful cannulation was inconsistent across the United States (SMD = −0.35, 95 % CI: 0.89, 0.18), with Costantino et al. (SMD = −1.51, 95 % CI: 2.11, −0.91) and Curtis et al. (SMD = 0.97, 95 % CI: 0.73, 1.22) at two ends. (Supplementary Figs. 5–6).

Additionally, we investigated the possibility that heterogeneity may have its origin in the year of publication. We chose the year 2015 as it was the median year of all records. The pooled result from ten studies published before 2015 showed an OR of 2.51 (95 % CI: 1.26, 5.01), while the collective OR of the sub-group of publications after 2015 was 3.62 (95 % CI: 1.83, 7.15). The overall trend favored USGPIVC: SMD = −0.72, 95 % CI: 1.25, −0.19 for the studies conducted before 2015 Vs SMD = −0.50, 95 % CI: 1.01, −0.23 for those after 2015. Contrasting comparisons can be seen in terms of an average number of attempts before successful IV insertion: SMD = −0.88, 95 % CI: 1.36, −0.40 Before 2015 Vs SMD = 0.02, 95 % CI: 0.62, 0.66 After 2015, P = 0.03 (Supplementary Figs. 7–9).

Since most of the included studies were randomized trials, we decided to determine if the research designs influenced the pooled data or contributed to heterogeneity. There were 17 RCTs and six cohort studies. The primary outcomes were comparable: OR = 2.80, 95 % CI: 1.64, 4.77 in RCTs sug-group and OR = 3.25, 95 % CI: 1.02, 10.29, P = 0.82. Secondary outcomes revealed that non-RCTs studies showed more prominent SMD favoring USGPIVC despite relatively smaller sample size: SMD = −0.59, 95 % CI: 1.08, −0.10 in RCTs sub-group and SMD = −0.77, 95 % CI: 1.25, −0.29 in pooled results of non-RCTs. Opposite trend was observed in average number of attempts before achieving successful cannulation: SMD = −0.52, 95 % CI: 0.95, −0.09 in RCTs sub-group and SMD = −0.62, 95 % CI: 1.49, 0.24 in non-RCTs (Supplementary Figs. 10–12).

Lastly, we assessed if clinical settings could have an impact on the overall results or whether they could be responsible for heterogeneous results. 12 studies were conducted in the Emergency department, with ten's data that could be extractable. 11 studies were conducted in non-emergency room, e.g., pre-operative unit or general ward. Regarding the primary outcome, the OR were similar in the two sub-groups: OR = 2.54, 95 % CI: 1.42, 4.53; Vs OR = 3.08, 95 % CI: 1.37, 6.91; P = 0.70 (Supplementary Fig. 13). In terms of secondary outcomes, there were insignificant differences between different clinical settings. See Supplementary Figs. 14–15 in detail.

4. Discussion

This systematic review and meta-analysis primarily focused on comparing the efficacy between ultrasound-guided PIVC insertion and conventional IV access placement. The overall results favored USGPIVC comprehensively. Regarding the primary outcome of the first-attempt success rate, the pooled results demonstrated the advantage of ultrasound assistance. Although it is not statistically significant, the tendency is more prominent among children and patients with difficult IV access. The duration of a successful IV cannulation was shorter with ultrasound assistance, particularly in young patients. However, the heterogeneity was notable between

studies. This may reflect highly varied clinical proficiency, different clinical settings, various types of ultrasound devices, or the accuracy in duration estimation. The average number of attempts was also less with ultrasound guidance. The geographical analysis may imply that nurses from European countries may have a higher odds ratio to insert a peripheral intravenous catheter with ultrasound guidance in their first attempt when compared to their peers outside Europe. However, the year of publication sub-group analysis demonstrated unanticipated but inconsistent results across different outcomes. This may indicate that the ultrasound technique has been used widely and routinely in clinical practice. Study design and clinical setting were also considered as sources of heterogeneity, but they were almost comparable in primary and secondary results.

A few systematic reviews focused on similar topics [4,41–46]. In terms of outcome, our research was generally consistent with them. Reviews conducted a decade ago were more likely to focus on specific patient populations. Egan et al. [41], Liu et al. [44], and Stolz et al. [45] primarily focused on difficult patients, but their definitions for difficulty were different. Their studies suggested that first-attempt success rates were higher with ultrasound guidance in patients with difficult IV access. At the same time, the duration and numbers of IV insertions were comparable between USGPIVC and traditional techniques. Decades ago, hospitals had limited medical resources, which could account for the focus on a particular patient population. The shortage of ultrasound and qualified nurses precludes the wide use of ultrasound-guided techniques for IVC placement to non-difficult patients. In our research, this conclusion was extrapolated to the general population by newly collected evidence. The overall first-attempt success rate was higher while the duration was shorter for the USGPIVC procedure, regardless of participants' age and region. This may be owing to the advancement in portable ultrasound devices and the training of more experienced professionals over decades. As a result, recent researchers paid closer attention to specific clinical problems. For example, Tran et al. [46] focused on the USGPIVC versus landmark technique in emergency settings. Kleidon et al. [43] focused only on children and drew a conclusion contrasting to most other reviews. In their selected young age population, the ultrasound guidance seemed not to improve the success rate of the first attempt, nor the overall success. They also stated that various inclusion criteria might be the source of any potential bias in selection. By contrast, with more included articles, we concluded that the USGPIVC is more likely to gain first-attempt success in adults and children. In addition, the duration of the process of IV insertion is shorter with ultrasound guidance in children and the number of attempts is less, although not statistically significant. Xiong et al. [4] were concerned about the safety of central venous cannulation, while Fetzer et al. [42] focused on pain management during PIVC insertion. Despite limited studies included, these can be the potential trend in future clinical research topics. Overall, as the most recent review, we were able to include the most records, with five studies conducted in the last five years [24,25,29,34,37]. This not only allowed us to synthesize the most updated evidence for clinical reference, but also to find additional information from sub-group analysis: European hospitals seemed to outperform rest hospitals in using ultrasound-assisted IVC technique, while the ultrasound technique has been stably used for nearly two decades.

To our knowledge, we were the first to thoroughly synthesis the data for patients needing peripheral IV insertion across various clinical contexts, taking into account all age groups. We were also the first to compare differences across regions in IV insertion using ultrasound guidance versus the conventional approach. Additionally, we compared years of publication to see whether the efficacy of USGPIVC improved over time. Our systematic review and meta-analysis give rise to some potential research perspectives in this clinical field: whether handheld ultrasound can provide the same accuracy in assisting IV insertion; and whether there will be a role for artificial intelligence (AI) in assisting PIVC placement.

However, there were some limitations to our study. Firstly, although we imposed no restriction in language during the search, we could only retrieve a handful of non-English articles. This is a shared problem in the abovementioned reviews [4,41–46]. Secondly, some unextractable data preclude further analysis of the efficacy and safety of USGPIVC in several reports [19,25,35,37]. For example, the fact that USGPIVC placement is less time-consuming may be contradictory to some clinician's experience, and this may be owing to some significantly delayed cases of traditional approach in difficult patients. Thirdly, we did not compare the patients' satisfaction rate between the two methods. This was limited because only two records incorporated patients' satisfaction as part of their results [25,26]. This may become an important topic in future studies as we are heading toward a patient-oriented healthcare system. Lastly, there are confounders such as the biased gender ratio (56: 44), clinical settings (mostly done in emergency settings) precluding extrapolation to further clinical practice, which also caused significant heterogeneity between studies. Other factors, such as various definitions used in the clinical trials, and the place of research (general practitioners' clinic Vs. tertiary hospital) could also explain the heterogeneity. Future well-designed homogenous randomized clinical trials may alleviate the heterogeneity.

5. Conclusion

In this systematic review and meta-analysis, we concluded that the USGPIVC is more effective and less time-consuming and is associated with a higher success rate on the first attempt regardless of patients' age, geographical locations, and year of publication of studies. Therefore, we should promote more educational programs of ultrasound-guidance PIVCs to help more nurses and healthcare providers gain confidence and proficiency in delivering better healthcare services to all in need.

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Data availability statement

Data associated with this current study has been publicly available and was included in article/supplementary material/referenced in article.

CRediT authorship contribution statement

Yishu Tian: Writing – original draft, Software, Resources, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Zixing Zhong:** Writing – review & editing, Writing – original draft, Resources, Methodology, Investigation, Funding acquisition, Data curation. **Djouhayna Dougarem:** Writing – review & editing, Software, Methodology, Investigation, Formal analysis, Data curation. **Litao Sun:** Writing – review & editing, Validation, Supervision, Resources, Project administration, Funding acquisition, Formal analysis.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Litao Sun reports financial support was provided by National Natural Science Foundation of China. Zixing Zhong reports financial support was provided by Zhejiang Provincial Project for Education. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.heliyon.2024.e30582.

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