# Short-axis versus long-axis approach for ultrasound-guided vascular access: An updated systematic review and meta-analysis of randomised controlled trials

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## ABSTRACT

**Background and Aims:** There are two approaches for ultrasound (US)-guided vessel cannulation: the short axis (SA) approach and the long axis (LA) approach. However, it remains to be seen which approach is better. Therefore, we performed the present updated systematic review and meta-analysis to assess the effectiveness and safety of US-guided vascular cannulation between the SA and LA techniques. **Methods:** We performed a comprehensive electronic database search in PubMed, Embase, Cochrane Library and Web of Science for the relevant studies from inception to June 2022. Randomised controlled trials comparing the SA approach and the LA approach for US-guided vascular access were incorporated in this updated meta-analysis. The first-attempt success rate was the primary outcome. The secondary outcomes were the overall success rate, cannulation time, number of attempts and the incidence of complications. The statistical analysis was conducted using RevMan software (version 5.4; the Nordic Cochrane Centre, the Cochrane Collaboration, Copenhagen, Denmark). The Cochrane risk of bias tool was used to evaluate each study's potential risk for bias. **Results:** In total, 16 studies consisting of 1885 participants were incorporated in this updated meta-analysis. No statistically significant difference was found between the SA and LA vascular access techniques for first-pass success rate (risk ratio = 1.07, 95% confidence interval: 0.94–1.22). The overall cannulation success rate, complication rate, average cannulation time and average number of attempts were not significantly different between the SA and LA groups. **Conclusion:** This updated meta-analysis demonstrated that the SA and LA approaches of US-guided vessel cannulation are similar regarding first-pass success, overall cannulation success rate, total complication rate, cannulation time and the number of attempts.

**Keywords:** Cannulation, internal jugular vein, long axis, peripheral vein, radial artery, short axis, subclavian vein, ultrasound

## INTRODUCTION

Vessel cannulation is a commonly done procedure in the operation room, intensive care unit and emergency setup. Central venous catheter (CVC) insertion is mainly indicated for fluid resuscitation and haemodynamic monitoring.[1,2] Radial arterial cannulation is commonly indicated for beat-to-beat blood pressure monitoring, and peripheral vein cannulation is primarily indicated for fluid resuscitation.[3,4] The common sites where CVC

is placed are the femoral vein, subclavian vein (SCV) and internal jugular vein (IJV). Traditionally, CVC insertions were done using the anatomical landmark method.

Several studies have shown that using ultrasound (US) guidance during CVC insertion and other forms of vascular cannulation leads to enhanced success rates and reduced complication rates compared to the landmark-based approach.[5-9] While US has been shown to reduce complications considerably, it does not fully eliminate them.[10] For US-guided vessel cannulation, there are two approaches: 'short axis (SA)' and 'long axis (LA)'. Each approach has its own set of benefits and drawbacks.[11,12] Although the SA approach allows us to view the artery and vein simultaneously, we cannot see the needle's whole length or tip. In the LA approach, the entire length and the tip of the needle can be seen, but it is technically challenging in part that the needle and US beam should be perfectly aligned. Several studies have recently compared the SA versus LA approach and have reported inconsistent and mixed results.[11-13]

The study conducted by Liu *et al.*[13] provided inadequate evidence to determine the superiority of one approach over another. Moreover, whether the SA approach exhibits advantages over the LA approach for US-guided vascular cannulation remains controversial.[13] Therefore, we carried out this updated systematic review and meta-analysis to examine the clinical efficacy and safety of the SA and LA approaches for US-guided vascular cannulation in adult patients. The primary outcome was the first-attempt success rate, and the secondary outcome included the overall success rate, number of attempts, total time of vessel cannulation and incidence of complications.

## METHODS

This updated systematic review and meta-analysis was performed in accordance with the new Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [supplementary file s-1].[14] This systematic review and meta-analysis protocol was registered at PROSPERO (CRD42022340585).

### Eligibility criteria
The inclusion criteria were as follows: prospective randomised controlled trials (RCTs), studies published in the English language, studies conducted among the management of clinical patients and studies comparing the US-guided SA versus LA approaches of vessel cannulation (IJV, SCV, peripheral veins and radial artery [RA]) in adult patients. The exclusion criteria were as follows: non-RCTs, retrospective studies, case reports, review articles, abstract only, conference papers and protocols, paediatric patients (below 18 years of age), RCTs conducted on phantoms and studies that involved more invasive procedures such as placement of the tunnelled catheter.

### Information sources
We thoroughly searched PubMed, Embase, Cochrane Library and Web of Science electronic databases.

### Search strategy
The electronic search strategy combined terms related to the US, SA, LA, out of plane, in plane, access, cannulation, catheterisation, central line, central vein, IJV, SCV, peripheral vein and RA [supplementary file s-2].

### Study selection
Two authors (AM and MK) independently assessed the databases and performed study selection. Finally, studies that met the specified inclusion criteria were included following a screening of full-text articles. Any discrepancies between the two authors throughout the study selection process were resolved by seeking the opinions of the third author (NK).

### Data extraction
Two authors (AM and MK) independently retrieved data from the included studies utilising a predefined standardised data extraction form from inception to 1 June 2022.

### Data items
Data extracted using the standardised form comprised the following information: the name of the first author, publication year, the nation of origin, age of the patient, body mass index (BMI), gender, number of patients, the experience of operators and the US equipment used.

### Risk of bias assessment and quality assessment
The risk of bias in the included RCTs was assessed by applying the Cochrane risk of bias tool (Cochrane Collaboration).[15] Two independent authors (AM and MK) separately evaluated the methodological quality of all RCTs. Any discrepancies regarding the evaluation of quality were resolved through conversation with the third author (NK). For each domain of bias,

RCTs were assigned a low, high or unclear risk of bias. Studies were evaluated based on many criteria, including random sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessment, inadequate data reporting, selective reporting and other potential biases. The Grading of Recommendation, Assessment, Development and Evaluation (GRADE) approach was implemented to assess the overall quality of evidence about each outcome.[16] The GRADE system classified the evidence into very low, low, moderate and high quality of evidence according to the risk of bias, inconsistency, indirectness, imprecision and publication bias. The assessment of the methodological quality of the included trials was conducted with the modified Jadad score scale.[17] The range of the modified Jadad score is from 0 to 8. Studies with a quality score of 3 or below were classified as low quality, while those with a quality score of 4 or above were classified as high quality.

### Statistical analysis

For continuous variables mean and standard deviation (SD) were extracted for each group to obtain the mean difference (MD) or standardised mean difference (SMD) with a 95% confidence interval (CI) as a pooled result. Dichotomous data were reported as pooled risk ratio (RR) with 95% CI. The statistical analysis was carried out with the help of RevMan software (version 5.4; the Nordic Cochrane Centre, the Cochrane Collaboration, Copenhagen, Denmark). To pool the data, we employed a random effect model. Heterogeneity within the trials was evaluated using the Chi-square test and $I^2$ statistics.[18] Subgroup analyses were performed using various puncture sites to determine the probable causes of heterogeneity among the included studies. A meta-regression analysis was conducted, wherein the quality score of the studies included in the main outcome was used. The Begg test and funnel plot were used to determine if there was any publication bias.[19]

## RESULTS

### Selected studies

The PRISMA flow diagram overviews the phases involved in conducting a database search and including relevant studies. In total, 1282 research articles were identified, and finally, eligibility of a total of 22 full-text articles was assessed. In the final analysis, 16 articles matched the predetermined criteria for inclusion and were subsequently included in the systematic review and meta-analysis [Figure 1].[20-35]

### Study characteristics

A total of 16 RCTs[20-35] comprising 1885 participants were included: 940 participants were allocated to the SA group and 945 in the LA group [Table 1]. The risk of bias assessment for each study indicated that most of the studies included in the analysis exhibited a low risk of bias [Figure 2].

### Primary outcome

Thirteen studies[20-24,26-30,32,34,35] reported on first-attempt success rate. A random effect model was used, and significant heterogeneity was observed ($I^2$ = 80%). Seven studies[20,21,24,26,27,29,32] were on IJV, four studies[28,30,34,35] were on RA and two studies[22,23] were from other groups (one on SCV and one on left axillary vein). According to the forest plot of the first-pass success rate, the meta-analysis found no statistically significant differences between the SA and LA groups. (RR = 1.07, 95% CI: 0.94–1.22, $P$ = 0.30, $I^2$ = 80%) [Figure 3a]. Subgroup analysis was done based on the cannulation site (IJV, SCV, RA and left axillary vein). There was no significant difference when subgroup analysis was performed according to the cannulation site for IJV, RA and peripheral vein ($P$ = 0.11, $I^2$ = 55.3%) [Figure 3a]. The use of the SA technique resulted in a significant increase in the first-pass success rate compared to the LA technique within the SCV subgroup[22] and left axillary vein subgroup.[23]

### Secondary outcome

Ten studies[21-26,30,31,33,35] reported about the overall success rate. A random effect model was used, and significant heterogeneity was observed ($I^2$ = 53%). The results of the meta-analysis indicated that there was no statistically significant difference between the SA and LA groups (RR = 1.03, 95% CI: 0.98–1.07, $P$ = 0.24, $I^2$ = 53%)[Figure 3b].

Thirteen studies[20-23,26-29,31-35] reported on complication rate. A random effect model was used, and significant heterogeneity was observed ($I^2$ = 72%). The meta-analysis found no significant difference between the SA and LA groups (RR = 1.12; 95% CI: 0.63–1.99, $P$ = 0.69, $I^2$ = 72%) [Figure 3c].

Twelve studies[20-22,26-30,32-35] reported an average cannulation time. A random effect model was used, and significant heterogeneity was observed
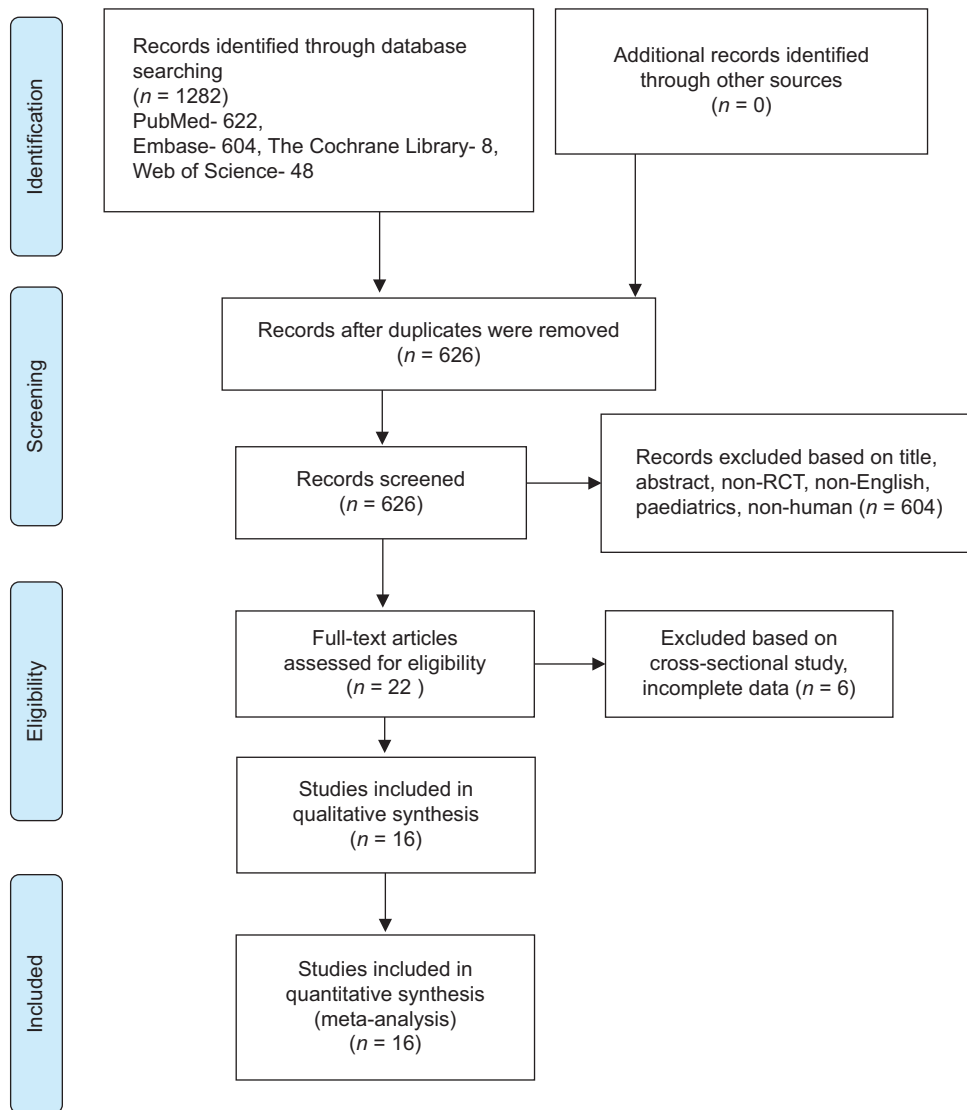
**Figure 1:** Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram. RCT = randomised controlled trial, n: number
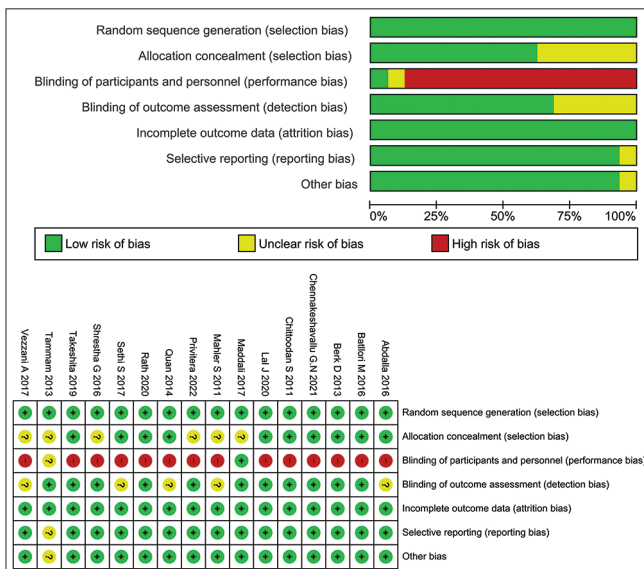


**Figure 2:** Risk of bias summary

($I^2 = 72\%$). The meta-analysis found no statistically significant difference between the SA and LA groups (MD = −6.06, 95% CI: −12.68–0.56, $P$ = 0.07, $I^2 = 94\%$) [Figure 3d].

Further, subgroup analysis was done based on cannulation sites (IJV, SCV, RA and others) according to the forest plot of cannulation time. There was no significant difference when subgroup analysis was performed according to the cannulation site ($P$ = 0.21, $I^2 = 36.7\%$) [Figure 3d].

Eight studies[20,23,26,28,29,33-35] reported the average number of attempts. A random effect model was used, and significant heterogeneity was observed ($I^2 = 68\%$). The meta-analysis found no statistically significant difference between the SA and LA groups (MD = −0.12, 95% CI: −0.26–0.01, $P$ = 0.07, $I^2 = 68\%$) [Figure 3e].

**Table 1: Characteristics of included RCTs**

| Author name | Country | Years | Number of patients SA/LA | Total | Vein | Clinical Setting | BMI SA/LA | Mean age SA/LA | Number of Patients (F/M) SA/LA | Operator (Dr experience) |
|---|---|---|---|---|---|---|---|---|---|---|
| Lal J[20] | India | 2020 | 36/36 | 108 | IJV | ICU | NM/NM | SA- 48.72±14.26 LA- 49.14±17.52 | SA- 12/24 LA- 19/17 | NM |
| Rath A[21] | India | 2020 | 50/50 | 100 | IJV | ICU | SA- 23.5±4.2 LA- 22.8±5.1 | SA- 57.11±5.4 LA- 56.2±17.7 | SA- 20/30 LA- 20/30 | 3-years of experience in US-guided central venous cannulation |
| Vezzani A[22] | Italy | 2017 | 95/95 | 190 | SCV | ICU | SA- 26±4 LA- 27±5 | SA- 70±12 LA- 71±12 | SA- 21/74 LA- 27/68 | 3 years' experience of US-guided central vein cannulation |
| Maddali MM[23] | Oman | 2017 | 43/43 | 86 | left axillary vein | NM | SA- 27.4±5.1 LA- 26±4.3 | SA- 59.7±13 LA- 61.8±13.7 | NM/NM | NM |
| Takeshita J[24] | Japan | 2019 | 40/40 | 120 | Right IJV | OR | SA- 21.4 LA- 22.4 | NM/NM | SA- 9/31 LA- 11/29 | NM |
| Privitera D[25] | Italy | 2021 | 141/142 | 283 | RA | OR | NM/NM | SA- 66.80±17.00 LA- 68.94±16.25 | SA- 57 (M) LA- 63 (M) | NM |
| Batllori M[26] | Spain | 2016 | 73/75 | 148 | IJV | OR | SA- 27.7±4.8 LA- 27.3±4.1 | SA- 64.9±63 LA- 64.0±64 | SA- 28/45 LA- 26/49 | NM |
| Chittoodan S[27] | Ireland | 2011 | 49/50 | 99 | IJV | OR | NM/NM | SA- 62.9±13.2 LA- 62.9±13.1 | SA- 12/37 LA- 13/37 | Experience of more than 50 US-guided internal jugular cannulations. |
| Berk D[28] | Turkey | 2013 | 54/54 | 108 | RA | NM | NM/NM | SA- 56±1 LA- 54±2 | SA- 31/23 LA- 24/30 | Research had placed more than 50 arterial lines by using either in-plane or out-of-plane approaches. |
| Chennakeshavallu GN[29] | India | 2021 | 70/70 | 140 | IJV | OR | SA- 25.29±4.24 LA- 25.26±3.71 | SA- 54.21±14.08 LA- 55.83±14.39 | SA- 18/52 LA- 23/47 | Fifty ultrasound-guided IJV procedures using these three approaches |
| Sethi S[30] | India | 2016 | 75/75 | 150 | RA | OR | SA- 62.8±11.6 LA- 64.6±12.2 | SA- 59.5±8.2 LA- 57.7±7.6 | SA- 46/29 LA- 41/34 | NM |
| Mahler SA[31] | USA | 2011 | 20/20 | 40 | Peripheral | OR | NM/NM | SA- 48±15 LA- 47±14 | SA- 14/6 LA- 11/9 | NM |
| Shrestha GS[32] | Nepal | 2016 | 41/41 | 82 | IJV | ICU | NM/NM | SA- 59.68±22.01 LA- 49.59±18.58 | SA- 18/23 LA- 11/30 | 3 years of experience in cannulation of central veins. |
| Tammam TF[33] | Egypt | 2013 | 30/30 | 90 | IJV | NM | SA- 27.41±7.17 LA- 64.6±12.2 | SA- 56.03±14.52 LA- 51.33±15.29 | SA- 17/13 LA- 14/16 | 10 years in IJV catheter placement |
| Abdalla UEM[34] | Egypt | 2016 | 42/42 | 126 | RA | ICU | SA- 31.2 LA- 30.12 | SA- 55±11 LA- 59±9 | NM/NM | NM |
| Quan Z[35] | China | 2014 | 81/82 | 163 | RA | OR | NM/NM | SA- 49.2±08.1 LA- 46.1±07.9 | SA- 22/59 LA- 18/64 | NM |

*Contd...*

**Table 1: Contd...**

| Ultrasound equipment | First-pass success rate SA/LA | Overall success rate SA/LA | Number of attempts (average with CI) SA/LA | Cannulation time SA/LA | Complication total SA/LA | Jadad score |
|---|---|---|---|---|---|---|
| M- Turbo Sonosite, Japan | SA- 32 (88.9%) <br> LA- 28 (77.8%) | SA- 0 <br> LA- 0 | SA- 32/4/0/0 <br> LA- 28/7/1/0 | SA- 96.5±15.29 <br> LA- 106.72±22.42 | SA- 7 (19.4%), <br> LA- 7 (18.15%) | 6 |
| Arrow Gard Blue®, Teleflex Medical IDA, Business and Technology Park, Athlone, Ireland | SA- 40 (80%) <br> LA- 48 (96%) | SA- 44 <br> LA- 48 | SA- 0 <br> LA- 0 | SA- 74.2±110.1 <br> LA- 70.3±105.2 | SA- 13 (26%) <br> LA- 4 (8%) | 7 |
| A Philips CX50 system (Philips Healthcare, Eindhoven, The Netherlands) | SA- 82 (86%) <br> LA- 64 (67%) | SA- 91 (96%) <br> LA- 74 | SA- 0 <br> LA- 0 | SA- 69±74 <br> LA- 98±103 | SA- 3 <br> LA- 13 | 7 |
| Logiq E ultrasound machine (GE Healthcare, Wauwatosa, WI) | SA- 34 <br> LA- 20 | SA- 42 <br> LA- 39 | SA- 1.4±0.7 <br> LA- 1.8±0.9 | SA- 0 <br> LA- 0 | SA- 3 (7%) <br> LA- 7 (16.3%) | 7 |
| S-Nerve Ultrasound System (Fujifilm Medical Co., Ltd., Tokyo, Japan) | SA- 28 (70%) <br> LA- 38 (95%) | 0/0 | SA- 1 [1–3] <br> LA- 1 [1–2] | SA- 31.7 (24.4–40.6) <br> LA- 24.3 (20.8–32.1) | SA- 0 <br> LA- 0 | 6 |
| MyLab Alpha, Esaote Spa, Florence, Italy | 0/0 | SA- 136 (96.45%) <br> LA- 131 (92.25%) | SA- 0, <br> LA- 0 | SA- 0 <br> LA- 0 | SA- 0 <br> LA- 0 | 6 |
| SonoSite, Bothell, WA, USA | SA- 51 (69.9%) <br> LA- 39 (52%) | SA- 71 (97.3) <br> LA- 73 (97.3) | SA- 1.51±0.97 <br> LA- 1.92±1.36 | SA- 35.0 (23.4) <br> LA- 46.1 (36.3) | SA- 22 <br> LA- 10 | 6 |
| SonoSite®, Micromaxx, Bothell, WA, USA | SA- 48 (98%) <br> LA- 39 (78%) | SA- 0 <br> LA- 0 | SA- 0 <br> LA- 0 | SA- 39.6 (18.4) <br> LA- 46.9 (42.4) | SA- 0 <br> LA- 0 | 6 |
| Esaote My Lab 30, US Machine, Florance, Italy | SA- 28 (51%) <br> LA- 41 (76%) | SA- 0 <br> LA- 0 | SA- 1.5±0.5 <br> LA- 1.27±0.4 | SA- 46.8±34 <br> LA- 23.7±17 | SA- 63 <br> LA- 13 | 6 |
| MyLabTMOne/Touch ultrasound system with the probe frequency of 6–13 MHz | SA- 62 (88.5) <br> LA- 58 (82.8%) | SA- 0 <br> LA- 0 | SA- 62/8/0 <br> LA- 58/8/4 | SA- 11.07±2.93 <br> LA- 17.62±5.97 | SA- 0 <br> LA- 0 | 6 |
| Sonosite® MicroMaxx® Ultrasound System, Sonosite INC, Bothell, WA, USA | SA- 60/75 <br> LA- 62/75 | SA- 0 <br> LA- 0 | SA- 0 <br> LA- 0 | SA- 28.4±8.2 <br> LA- 27.6±7.6 | SA- 0 <br> LA- 0 | 6 |
| Sonosite Micromax, Sonosite, Inc, Bothell, WA, USA | 0/0 | SA- 19 (95) <br> LA- 17 (85) | SA- 0 <br> LA- 0 | SA- 0 <br> LA- 0 | SA- 3 (15%) <br> LA- 3 (15%) | 5 |
| a 6–10 L38 MHz linear transducer SonoSite turbo unit (SonoSite®, Micromaxx, Bothwell, WA, USA). | SA- 21 (51.2%) <br> LA- 27 (67.9%) | SA- 0 <br> LA- 0 | SA- 0 <br> LA- 0 | SA- 40.39 (22.83) <br> LA- 45.24 (26.74) | SA- 1 (2.4) <br> LA- 1 (2.4) | 5 |
| GE LogiqBook XP Portable | 0/0 | SA- 30 (100%) <br> LA- 30 (100%) | SA- 1.13 (0.35) <br> LA- 1.17 (0.38) | SA- 52.30 (11.91) <br> LA- 52.70 (11.74) | SA- 2 <br> LA- 0 | 5 |
| Toshiba Xario, Japan | SA- 21 (50%) <br> LA- 11 (27%) | SA- 25 (60%) <br> LA- 29 (70%) | SA- 1.6±0.8 <br> LA- 1.8±0.7 | SA- 28±19 <br> LA- 66±5 | SA- 11 (27%) <br> LA- 11 (26%) | 6 |
| Terason2000+, Terason, sBurlington, MA, USA | SA- 72 (88.9) <br> LA- 60 (73.2) | SA- 78 <br> LA- 78 | SA- 72/6/3 <br> LA- 60/18/2/1/1 | SA- 29.7 (17.20) <br> LA- 26.2 (9.8) | SA- 12 (14.8) <br> LA- 15 (18.3) | 6 |

BMI=body mass index, CI=confidence interval, F=female, ICU=intensive care unit, IJV=internal jugular vein, LA=long axis, M=male, NM=not mentioned, OR=operating room, RA=radial artery, RCTs=randomised controlled trials, SA=short axis, SCV=subclavian vein, US=ultrasound
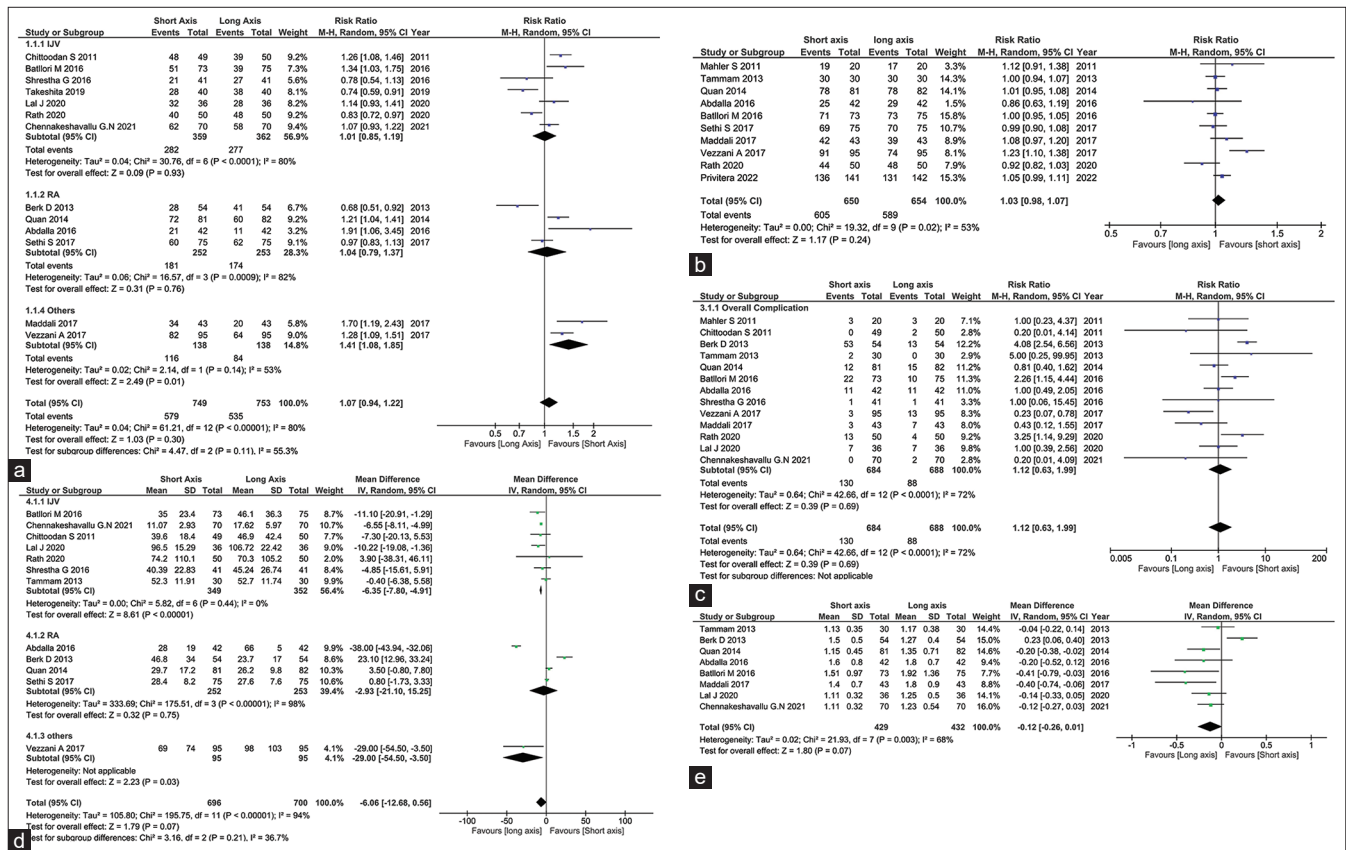
**Figure 3:** (a) Forest plot of first-pass success rate. (b) Forest plot of overall success rate (c) Forest plot of complication rate (d) Forest plot of cannulation time (e) Forest Plot of number of attempts. SD- Standard deviation, CI- Confidence interval, df- degrees of freedom, IJV- Internal jugular vein, M-H- Mantel-Haenszel, RA- Radial artery, SCV- Subclavian vein
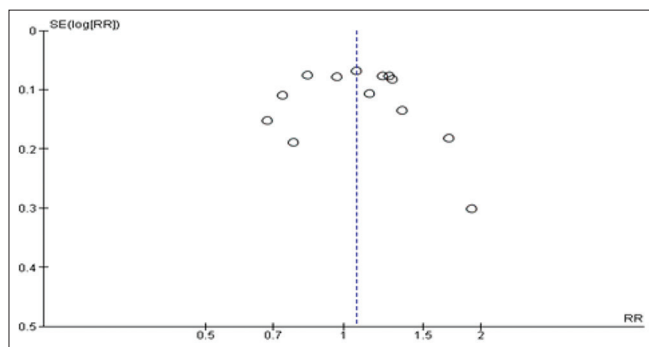


**Figure 4:** Funnel plot for assessment of publication bias. RR = Risk ratio, SE = Standard error

## Publication bias

The Begg test for publication bias indicated no probable publication bias among the included studies ($P = 0.62$) [Figure 4].

## Summary of findings (GRADE)

The certainty of evidence (CoE) for the first-pass success rate was deemed moderate [Supplement file s-3]. CoE for the overall success rate was moderate. CoE for the complication rate was low. CoE for cannulation time was low. CoE of a number of attempts was moderate.

## Modified Jadad score

The quality of 16[20-35] included studies was evaluated with a modified Jadad score, and all included studies were of high quality (Jadad score >4) [Supplementary file s-4].

## Meta-regression

We performed a meta-regression analysis using the modified Jadad score to investigate the extent of heterogeneity in our meta-analysis. It was found that there was no significant association between the modified Jadad score and the overall effect size in the main outcome measure in the meta-analysis [Supplementary file s-5].

## DISCUSSION

This updated meta-analysis demonstrated that during US-guided vessel cannulation, the SA approach did not improve the first-pass success rate, overall success rate, cannulation time, number of attempts and complication rate compared to the LA approach in adult patients. In the primary outcome, significant heterogeneity was observed ($I^2 = 80\%$). To overcome this, a subgroup analysis was done based on different

puncture sites, which showed that the results were consistent with IJV and RA subgroups. Using the SA method significantly improved the first-pass success rate compared to the LA approach within the subgroup consisting of SCV and the left axillary vein.

Few meta-analyses have recently been reported comparing the SA and LA approaches to vascular access using US guidance. For US-guided vascular access, Gao *et al.*[6] reviewed five RCTs involving 470 patients and found inadequate evidence to support using either the SA or the LA plane. The study by Liu *et al.*[13] comprised 11 studies involving 1210 participants. The findings of this study indicate that there is inadequate evidence to determine the superiority of one approach over another approach. Zhang *et al.*[36] conducted a study comprising SA and LA US-guided IJV cannulation (including 10 RCTs and 1141 patients) and showed insufficient evidence to demonstrate any difference between the two approaches. Yunyang *et al.*[37] included seven RCTs consisting of 729 patients, which indicated that the first-attempt success rate was significantly higher and the frequency of arterial puncture was lesser in the SA group compared to the LA group for US-guided central venous cannulation. The meta-analysis by Wang *et al.*[38] of six studies and 725 patients found that the SA approach does not increase the first-attempt or total success rate of RA catheterisation compared to the LA approach. There are some noticeable differences between our meta-analysis and the previous meta-analysis. First, by including five additional RCTs, this is an updated analysis, representing a more accurate and latest comprehensive study.[20,21,24,25,29] Second, the strength of our study is that we have compared the two approaches for cannulating all kinds of vessels, that is, IJV, SCV, RA and peripheral vein.

In their meta-analysis, Liu *et al.* observed that the SA method yielded similar results to the LA method in terms of first-pass success rate.[13] The findings of the updated meta-analysis are consistent with the results of a meta-analysis done by Zhang *et al.*,[36] who reported that the aggregate RR was 1.08 (95% CI: 0.95–1.22). In the present meta-analysis, we found that the first-pass success rate was similar in both groups, contrary to the results of the meta-analysis conducted by Yunyang *et al.*[37] Our result differs from the meta-analysis conducted by Yunyang *et al.*,[37] probably because new RCTs have been published after their publication. Recently, besides the SA and LA approaches, another oblique approach has also

been suggested, having the advantages of both the SA and LA techniques.[39,40] Tampo suggested a three-step procedure of US-guided IJV catheterisation to prevent the associated complications.[41] The procedure involves the following steps. First, the needle is advanced in SA; next, the anterior wall is punctured in LA; and last, the guidewire is confirmed in SA from IJV to the brachiocephalic vein.

Taking into account both the SA and LA methods, Takeshita *et al.* showed a significant improvement in the success rate of IJV cannulation by novices in a manikin model.[42] Dynamic needle tip positioning (DNTP) is a modified form of the SA approach that was introduced by Clemmesen *et al.* for peripheral venous cannulation.[43] In this technique, the needle and probe are shifted alternatively to visualise the needle tip continuously. Very few studies have shown the advantage of a DNTP over palpation technique for US-guided vascular access.[44,45]

There are some strengths associated with the present systematic review and meta-analysis. First, since we have included five new recently published RCTs, this is an updated version of a previously published meta-analysis on this topic.[20,21,24,25,29] We have also conducted a subgroup analysis to explore the heterogeneity among the included studies.

There are several limitations in our meta-analysis. A substantial amount of heterogeneity was observed between the included studies, which limits the generalisability of the results. Heterogeneity may be due to vessel type, operator experience, equipment used and definition of outcomes mentioned in the different trials. We have not searched for studies other than English language and unpublished studies through a manual search of conference proceedings, correspondence with experts and a search of clinical trial registries, and this may result in publication bias.

## CONCLUSION

The available data does not support the superiority of the SA technique over the LA technique in terms of first-pass success, overall cannulation success rate, total complication rate, cannulation time and the number of attempts for US-guided vascular access. In the subgroup of patients with SCV and left axillary veins, the SA method had a greater first-pass success rate than the LA approach. However, further rigorously conducted RCTs are required to validate the results.

## Conflicts of interest

There are no conflicts of interest.

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## REFERENCES

1. Troianos CA, Hartman GS, Glas KE, Skubas NJ, Eberhardt RT, Walker JD, *et al.* Guidelines for performing ultrasound guided vascular cannulation: Recommendations of the American Society of Echocardiography and the Society of Cardiovascular Anesthesiologists. J Am Soc Echocardiogr 2011;24:1291–318.
2. Nakayama Y, Takeshita J, Nakajima Y, Shime N. Ultrasound-guided peripheral vascular catheterization in pediatric patients: A narrative review. Crit Care 2020;24:592.
3. Osuda M, Edanaga M, Matsumoto T, Yamamoto A, Ihara S, Tanaka S, *et al.* Comparison of Mill Suss™-guided radial artery catheterization with the long-axis in-plane ultrasound-guided method under general anesthesia: A randomized controlled trial. J Anesth 2020;34:464–7.
4. Bardin-Spencer AJ, Spencer TR. Arterial insertion method: A new method for systematic evaluation of ultrasound-guided radial arterial catheterization. J Vasc Access 2021;22:733–8.
5. Hind D, Calvert N, Mcwilliams R, Davidson A, Paisley S, Beverley C, *et al.* Ultrasonic locating devices for central venous cannulation: Meta-analysis. BMJ 2003;327:361.
6. Gao YB, Yan JH, Gao FQ, Pan L, Wang XZ, Lv CJ. Effects of ultrasound-guided radial artery catheterization: An updated meta-analysis. Am J Emerg Med 2015;33:50–5.
7. Lalu MM, Fayad A, Ahmed O, Bryson GL, Fergusson DA, Barron CC, *et al.* Ultrasound-guided subclavian vein catheterization: A systematic review and meta-analysis. Crit Care Med 2015;43:1498–507.
8. Stolz LA, Stolz U, Howe C, Farrell IJ, Adhikari S. Ultrasound-guided peripheral venous access: A meta-analysis and systematic review. J Vasc Access 2015;16:321–6.
9. Gu WJ, Tie HT, Liu JC, Zeng XT. Efficacy of ultrasound-guided radial artery catheterization: A systematic review and meta-analysis of randomized controlled trials. Crit Care 2014;18:R93.
10. Parienti JJ, Mongardon N, Mégarbane B, Mira JP, Kalfon P, Gros A, *et al.* Intravascular complications of central venous catheterization by insertion site. N Engl J Med 2015;373:1220–9.
11. Erickson CS, Liao MM, Haukoos JS, Douglass E, DiGeronimo M, Christensen E, *et al.* Ultrasound-guided small vessel cannulation: Long-axis approach is equivalent to short-axis in novice sonographers experienced with landmark-based cannulation. West J Emerg Med 2014;15:824–30.
12. Vogel JA, Haukoos JS, Erickson CL, Liao MM, Theoret J, Sanz GE, *et al.* Is long-axis view superior to short-axis view in ultrasound-guided central venous catheterization? Crit Care Med 2015;43:832–9.
13. Liu C, Mao Z, Kang H, Hu X, Jiang S, Hu P, *et al.* Comparison between the long-axis/in-plane and short-axis/out-of-plane approaches for ultrasound-guided vascular catheterization: An updated meta-analysis and trial sequential analysis. Ther Clin Risk Manag 2018;14:331–40.
14. Moher D, Liberati A, Tetzlaff J, Altman DG, PRISMA Group. Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. Int J Surg 2010;8:336–41.
15. Higgins JPT, Altman DG, Gotzsche PC, Juni P, Moher D, Oxman AD, *et al.* The Cochrane Collaboration's tool for assessing risk of bias in randomised trials. BMJ 2011;343:d5928.
16. Guyatt GH, Oxman AD, Santesso N, Helfand M, Vist G, Kunz R, *et al.* GRADE guidelines: 12. Preparing summary of findings tables-binary outcomes. J Clin Epidemiol 2013;66:158–72.
17. Jadad AR, Moore RA, Carroll D, Jenkinson C, Reynolds DJ, Gavaghan DJ, *et al.* Assessing the quality of reports of randomized clinical trials: Is blinding necessary? Control Clin Trials 1996;17:1–12.
18. Higgins JPT, Thompson SG, Deeks JJ, Altman DG. Measuring inconsistency in meta-analyses. BMJ 2003;327:557–60.
19. Begg CB, Mazumdar M. Operating characteristics of a rank correlation test for publication bias. Biometrics 1994;50:1088–101.
20. Lal J, Bhardwaj M, Verma M, Aggrawal T. A prospective, randomised, comparative study to evaluate long axis, short axis and medial oblique axis approach for ultrasound-guided internal jugular vein cannulation. Indian J Anaesth 2020;64:193.
21. Rath A, Mishra SB, Pati B, Dhar SK, Ipsita S, Samal S, *et al.* Short versus long axis ultrasound guided approach for internal jugular vein cannulations: A prospective randomized controlled trial. Am J Emerg Med 2020;38:731–4.
22. Vezzani A, Manca T, Brusasco C, Santori G, Cantadori L, Ramelli A, *et al.* A randomized clinical trial of ultrasound-guided infra-clavicular cannulation of the subclavian vein in cardiac surgical patients: Short-axis versus long-axis approach. Intensive Care Med 2017;43:1594–601.
23. Maddali MM, Arora NR, Chatterjee N. Ultrasound guided out-of-plane versus in-plane transpectoral left axillary vein cannulation. J Cardiothorac Vasc Anesth 2017;31:1707–12.
24. Takeshita J, Nishiyama K, Fukumoto A, Shime N. Combined approach versus 2 conventional approaches in ultrasound-guided central venous catheterization: A randomized controlled trial. J Cardiothorac Vasc Anesth 2019;33:2979–84.
25. Privitera D, Mazzone A, Pierotti F, Airoldi C, Galazzi A, Geraneo A, *et al.* Ultrasound-guided peripheral intravenous catheters insertion in patient with difficult vascular access: Short axis/out-of-plane versus long axis/in-plane, a randomized controlled trial. J Vasc Access 2022;23:589–97.
26. Batllori M, Urra M, Uriarte E, Romero C, Pueyo J, López-Olaondo L, *et al.* Randomized comparison of three transducer orientation approaches for ultrasound guided internal jugular venous cannulation. Br J Anaesth 2016;116:370–6.
27. Chittoodan S, Breen D, O'Donnell BD, Iohom G. Long versus short axis ultrasound guided approach for internal jugular vein cannulation: A prospective randomised controlled trial. Med Ultrason 2011;13:21–5.
28. Berk D, Gurkan Y, Kus A, Ulugol H, Solak M, Toker K. Ultrasound-guided radial arterial cannulation: Long axis/in-plane versus short axis/out-of-plane approaches? J Clin Monit Comput 2013;27:319–24.
29. Chennakeshavallu GN, Gadhinglajkar S, Sreedhar R, Babu S, Sankar S, Dash P. Comparison of three ultrasound views for internal jugular venous cannulation in patients undergoing cardiac surgery: A randomized trial. J Med Ultrasound 2021;29:176-80.

30. Sethi S, Maitra S, Saini V, Samra T, Malhotra SK. Comparison of short-axis out-of-plane versus long-axis in-plane ultrasound-guided radial arterial cannulation in adult patients: A randomized controlled trial. J Anesth 2017;31:89–94.
31. Mahler SA, Wang H, Lester C, Skinner J, Arnold TC, Conrad SA. Short- vs long-axis approach to ultrasound-guided peripheral intravenous access: A prospective randomized study. Am J Emerg Med 2011;29:1194–7.
32. Shrestha GS, Gurung A, Koirala S. Comparison between long- and short-axis techniques for ultrasound-guided cannulation of internal jugular vein. Ann Card Anaesth 2016;19:288-92.
33. Tammam TF, El-Shafey EM, Tammam HF. Ultrasound-guided internal jugular vein access: Comparison between short axis and long axis techniques. Saudi J Kidney Dis Transpl 2013;24:707–13.
34. Abdalla UEM, Elmaadawey A, Kandeel AR. Oblique approach for ultrasound-guided radial artery catheterization vs transverse and longitudinal approaches, a randomized trial. J Clin Anesth 2017;36:98–101.
35. Quan Z, Tian M, Chi P, Cao Y, Li X, Peng K. Modified short-axis out-of-plane ultrasound versus conventional long-axis in-plane ultrasound to guide radial artery cannulation: A randomized controlled trial. Anesth Analg 2014;119:163–9.
36. Zhang J, Wang X, Miao S, Shi M, Wang G, Tu Q. Comparison of short and long axis ultrasound-guided approaches to internal jugular vein puncture: A meta-analysis. J Int Med Res 2019;47:4069–82.
37. Yunyang H, Zaisheng Q, Nengxian S, Jin HE, Zhenhua Z. Short-axis versus long-axis approach in ultrasound-guided central venous cannulation: An updated systematic review and meta-analysis. Nan Fang Yi Ke Da Xue Xue Bao 2020;40:308–15.
38. Wang HH, Wang JJ, Chen WT. Ultrasound-guided short-axis out-of-plane vs. long-axis in-plane technique for radial artery catheterization: An updated meta-analysis of randomized controlled trials. Eur Rev Med Pharmacol Sci 2022;26:1914–22.
39. Dilisio R, Mittnacht AJC. The "medial-oblique" approach to ultrasound-guided central venous cannulation--maximize the view, minimize the risk. J Cardiothorac Vasc Anesth 2012;26:982–4.
40. Baidya DK, Chandralekha, Darlong V, Pandey R, Goswami D, Maitra S. Comparative sonoanatomy of classic "Short Axis" probe position with a novel "Medial-oblique" probe position for ultrasound-guided internal jugular vein cannulation: A crossover study. J Emerg Med 2015;48:590–6.
41. Tampo A. Three-step procedure for safe internal jugular vein catheterization under ultrasound guidance. J Med Ultrason 2018;45:671–3.
42. Takeshita J, Nishiyama K, Beppu S, Sasahashi N, Shime N. Combined short- and long-axis ultrasound-guided central venous catheterization is superior to conventional techniques: A cross-over randomized controlled manikin trial. PLoS One 2017;12:e0189258.
43. Clemmesen L, Knudsen L, Sloth E, Bendtsen T. Dynamic needle tip positioning - ultrasound guidance for peripheral vascular access. A randomized, controlled and blinded study in phantoms performed by ultrasound novices. Ultraschall Med 2012;33:E321–5.
44. Kiberenge RK, Ueda K, Rosauer B. Ultrasound-guided dynamic needle tip positioning technique versus palpation technique for radial arterial cannulation in adult surgical patients: A randomized controlled trial. Anesth Analg 2018;126:120–6.
45. Hansen MA, Juhl-Olsen P, Thorn S, Frederiksen CA, Sloth E. Ultrasonography-guided radial artery catheterization is superior compared with the traditional palpation technique: A prospective, randomized, blinded, crossover study. Acta Anaesthesiol Scand 2014;58:446–52.

# SUPPLEMENTARY MATERIAL [FOR ONLINE]

| s-1: PRISMA checklist | | | |
|---|---|---|---|
| **Section/topic** | **#** | **Checklist item** | **Reported on page #** |
| **TITLE** | | | |
| Title | 1 | Identify the report as a systematic review, meta-analysis, or both. | 1 |
| **ABSTRACT** | | | |
| Structured summary | 2 | Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number. | 1 |
| **INTRODUCTION** | | | |
| Rationale | 3 | Describe the rationale for the review in the context of what is already known. | 1-2 |
| Objectives | 4 | Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS). | 1-2 |
| **METHODS** | | | |
| Protocol and registration | 5 | Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number. | 2 |
| Eligibility criteria | 6 | Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale. | 2 |
| Information sources | 7 | Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched. | 2 |
| Search | 8 | Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated. | 2 |
| Study selection | 9 | State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis). | 2 |
| Data collection process | 10 | Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators. | 2 |
| Data items | 11 | List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made. | 2 |
| Risk of bias in individual studies | 12 | Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis. | 2-3 |
| Summary measures | 13 | State the principal summary measures (e.g., risk ratio, difference in means). | 3 |
| Synthesis of results | 14 | Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I2) for each meta-analysis. | 3 |
| Risk of bias across studies | 15 | Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies). | 3 |
| Additional analyses | 16 | Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified. | 3 |
| **RESULTS** | | | |
| Study selection | 17 | Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram. | 3 |

| s-1: Contd... | | | |
|---|---|---|---|
| **Section/topic** | **#** | **Checklist item** | **Reported on page #** |
| Study characteristics | 18 | For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations. | 3 |
| Risk of bias within studies | 19 | Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12). | 3 |
| Results of individual studies | 20 | For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot. | 3-4 |
| Synthesis of results | 21 | Present results of each meta-analysis done, including confidence intervals and measures of consistency. | 3-4 |
| Risk of bias across studies | 22 | Present results of any assessment of risk of bias across studies (see Item 15). | 4 |
| Additional analysis | 23 | Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]). | 6 |
| **DISCUSSION** | | | |
| Summary of evidence | 24 | Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers). | 6-8 |
| Limitations | 25 | Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias). | 8 |
| Conclusions | 26 | Provide a general interpretation of the results in the context of other evidence, and implications for future research. | 8 |
| **FUNDING** | | | |
| Funding | 27 | Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review. | 8 |

**s-2 search keyword with Boolean operators**

**PubMed search strategy**

| Search number | Query | Sort by | Filters | Search details | Results | Time |
|---|---|---|---|---|---|---|
| 5 | ultrasound guided, short axis OR out of plane, long axis OR in plane, internal jugular vein, subclavian vein, radial artery, peripheral vein, cannulation, catheterization | | | (("diagnostic imaging"[MeSH Subheading] OR ("diagnostic"[All Fields] AND "imaging"[All Fields]) OR "diagnostic imaging"[All Fields] OR "ultrasound"[All Fields] OR "ultrasonography"[MeSH Terms] OR "ultrasonography"[All Fields] OR "ultrasonics"[MeSH Terms] OR "ultrasonics"[All Fields] OR "ultrasounds"[All Fields] OR "ultrasound s"[All Fields]) AND ("guide"[All Fields] OR "guided"[All Fields] OR "guides"[All Fields] OR "guiding"[All Fields]) AND ("short"[All Fields] OR "shorts"[All Fields]) AND ("axis, cervical vertebra"[MeSH Terms] OR ("axis"[All Fields] AND "cervical"[All Fields] AND "vertebra"[All Fields]) OR "cervical vertebra axis"[All Fields] OR "axis"[All Fields])) OR ("out"[All Fields] AND ("aircraft"[MeSH Terms] OR "aircraft"[All Fields] OR "plane"[All Fields] OR "planes"[All Fields]) AND "long"[All Fields] AND ("axis, cervical vertebra"[MeSH Terms] OR ("axis"[All Fields] AND "cervical"[All Fields] AND "vertebra"[All Fields]) OR "cervical vertebra axis"[All Fields] OR "axis"[All Fields])) OR (("aircraft"[MeSH Terms] OR "aircraft"[All Fields] OR "plane"[All Fields] OR "planes"[All Fields]) AND ("internal"[All Fields] OR "internally"[All Fields] OR "internals"[All Fields]) AND ("jugular veins"[MeSH Terms] OR ("jugular"[All Fields] AND "veins"[All Fields]) OR "jugular veins"[All Fields] OR ("jugular"[All Fields] AND "vein"[All Fields]) OR "jugular vein"[All Fields]) AND ("subclavian vein"[MeSH Terms] OR ("subclavian"[All Fields] AND "vein"[All Fields]) OR "subclavian vein"[All Fields]) AND ("radial artery"[MeSH Terms] OR ("radial"[All Fields] AND "artery"[All Fields]) OR "radial artery"[All Fields]) AND ("peripheral"[All Fields] OR "peripherally"[All Fields] OR "peripherals"[All Fields] OR "periphereal"[All Fields] OR "peripheric"[All Fields] OR "peripherically"[All Fields]) AND ("veins"[MeSH Terms] OR "veins"[All Fields] OR "vein"[All Fields]) AND ("cannulate"[All Fields] OR "cannulated"[All Fields] OR "cannulating"[All Fields] OR "cannulator"[All Fields] OR "cannulators"[All Fields] OR "cannulisation"[All Fields] OR "cannulization"[All Fields] OR "cannulized"[All Fields] OR "catheterization"[MeSH Terms] OR "catheterization"[All Fields] OR "cannulation"[All Fields] OR "cannulations"[All Fields]) AND ("catheterisation"[All Fields] OR "catheterization"[MeSH Terms] OR "catheterization"[All Fields] OR "catheterisations"[All Fields] OR "catheterising"[All Fields] OR "catheterism"[All Fields] OR "catheterisms"[All Fields] OR "catheterise"[All Fields] OR "catheterised"[All Fields] OR "catheterizations"[All Fields] OR "catheterize"[All Fields] OR "catheterized"[All Fields] OR "catheterizing"[All Fields])) | 622 | 8:28:52 |

**Cochrane search strategy**

Search Name:  ultrasound guided, long axis OR In-plane, short axis OR out-plane, internal jugular vein OR IJV, Subclavian vein, Radial artery, Peripheral vein, cannulation, Catheterization, Randomized control trial in Keyword (Word variations have been searched)

Last Saved:      27/07/2022 17:52:07

ID       Search

#1       ultrasound guided, long axis OR In-plane, short axis OR out-plane, internal jugular vein OR IJV, Subclavian vein, Radial artery, Peripheral vein, cannulation, Catheterization, Randomized control trial:kw (Word variations have been searched)

## Embase search strategy

| No. | Query | Results | Date |
|---|---|---|---|
| #1 | ultrasound guided, long axis' OR (('ultrasound'/exp OR ultrasound) AND guided, AND long AND ('axis'/exp OR axis)) OR 'in-plane, short axis' OR ('in plane,' AND short AND ('axis'/exp OR axis)) OR 'out-plane, internal jugular vein' OR ('out plane,' AND internal AND jugular AND ('vein'/exp OR vein)) OR 'ijv, subclavian vein, radial artery, peripheral vein, cannulation, catheterization' OR (ijv, AND subclavian AND radial AND ('artery,'/exp OR artery,) AND peripheral AND ('vein,'/exp OR vein,) AND ('cannulation,'/exp OR cannulation,) AND ('catheterization,'/exp OR catheterization,) AND randomized AND ('control'/exp OR control) AND ('trial'/exp OR trial)) | 604 | 27-Jul-2022 |

## Web of Science search strategy

| | |
|---|---|
| ultrasound guided, long axis OR In-plane, short axis OR out-plane, internal jugular vein OR IJV, Subclavian vein, Radial artery, Peripheral vein, cannulation, Catheterization, Randomized control trial (Title) | |
| Timespan: 1956-2022 | |
| Results found | 48 |

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**s-3 Summary of findings: Grading of Recommendations, Assessment, Development And Evaluation (Grade)**

Is the short-axis approach better than the long-axis approach for ultrasound-guided vascular access in first-pass success rate?

Patient or population: Adult population

Setting: Hospital

Intervention: Short-axis approach

Comparison: Long-axis approach

| Outcomes | Anticipated absolute effects* (95% CI) | | Relative effect (95% CI) | No. of participants (studies) | Certainty of the evidence (Grade) | Comments |
|---|---|---|---|---|---|---|
| | Risk with long-axis approach | Risk with short-axis approach | | | | |
| First-pass success rate | 710 per 1000 | 760 per 1000 (668–867) | RR 1.07 (0.94–1.22) | 1502 (13 RCTs) | ⊕⊕⊕◯ Moderate[a] | |
| First-pass success rate- IJV | 765 per 1000 | 773 per 1000 (650–911) | RR 1.01 (0.85–1.19) | 721 (seven RCTs) | ⊕⊕⊕◯ Moderate[a] | |
| First-pass success rate- RA | 688 per 1000 | 715 per 1000 (543–942) | RR 1.04 (0.79–1.37) | 505 (four RCTs) | ⊕⊕◯◯ Low[a,b] | |
| First-pass success rate- Others | 609 per 1000 | 858 per 1000 (657–1000) | RR 1.41 (1.08–1.85) | 276 (two RCTs) | ⊕◯◯◯ Very low[a,c,d] | |

*The risk in the intervention group (and its 95% confidence interval) is based on the assumed risk in the comparison group and the relative effect of the intervention (and its 95% CI). CI=confidence interval, RR=risk ratio, No.=number. GRADE Working Group grades of evidence. High certainty: we are very confident that the true effect lies close to that of the estimate of the effect. Moderate certainty: we are moderately confident in the effect estimate: the true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different. Low certainty: our confidence in the effect estimate is limited: the true effect may be substantially different from the estimate of the effect. Very low certainty: we have very little confidence in the effect estimate: the true effect is likely to be substantially different from the estimate of effect. [a]Downgrade quality of evidence -1 due to serious inconsistency ($I^2$ value is >50%). [b]Downgrade quality of evidence -1 due to serious imprecision (wide 95% CIs). [c]Downgraded quality of evidence -1 due to serious limitation in study design (unclear allocation concealment). [d]Downgrade quality of evidence -2 due to very serious imprecision (wide 95% CIs and small number of events)

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**Summary of findings:**

Is the short-axis approach better than the long-axis approach for ultrasound-guided vascular access in overall success rate?

Patient or population: Adult patients

Setting: Hospitals

Intervention: Short-axis approach

Comparison: Long-axis approach

| Outcomes | Anticipated absolute effects* (95% CI) | | Relative effect (95% CI) | No. of participants (studies) | Certainty of the evidence (Grade) | Comments |
|---|---|---|---|---|---|---|
| | Risk with long-axis approach | Risk with short-axis approach | | | | |
| Overall success rate | 901 per 1000 | 928 per 1000 (883–964) | RR 1.03 (0.98–1.07) | 1304 (10 RCTs) | ⊕⊕⊕◯ Moderate[a] | |

*The risk in the intervention group (and its 95% confidence interval) is based on the assumed risk in the comparison group and the relative effect of the intervention (and its 95% CI). CI=confidence interval, RR=risk ratio, No.=number. GRADE Working Group grades of evidence. High certainty: we are very confident that the true effect lies close to that of the estimate of the effect. Moderate certainty: we are moderately confident in the effect estimate: the true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different. Low certainty: our confidence in the effect estimate is limited: the true effect may be substantially different from the estimate of the effect. Very low certainty: we have very little confidence in the effect estimate: the true effect is likely to be substantially different from the estimate of effect. [a]Downgrade quality of evidence -1 due to serious inconsistency ($I^2$ value is >50%)

**Summary of findings:**

Is the short-axis approach better than the long-axis approach for ultrasound-guided vascular access in complications?

Patient or population: Adult population

Setting: Hospitals

Intervention: Short-axis approach

Comparison: Long-axis approach

| Outcomes | Anticipated absolute effects* (95% CI) | | Relative effect (95% CI) | No. of participants (studies) | Certainty of the evidence (Grade) | Comments |
|---|---|---|---|---|---|---|
| | Risk with long axis approach | Risk with Short axis approach | | | | |
| Overall complication | 128 per 1000 | 143 per 1000 (81–255) | RR 1.12 (0.63–1.99) | 1372 (13 RCTs) | ⊕⊕○○ Low[a,b] | |

*The risk in the intervention group (and its 95% confidence interval) is based on the assumed risk in the comparison group and the relative effect of the intervention (and its 95% CI). CI=confidence interval, RR=risk ratio, No.=number. GRADE Working Group grades of evidence High certainty: we are very confident that the true effect lies close to that of the estimate of the effect. Moderate certainty: we are moderately confident in the effect estimate: the true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different. Low certainty: our confidence in the effect estimate is limited: the true effect may be substantially different from the estimate of the effect. Very low certainty: we have very little confidence in the effect estimate: the true effect is likely to be substantially different from the estimate of effect. [a]Downgrade quality of evidence -1 due to serious inconsistency ($I^2$ value is >50%). [b]Downgrade quality of evidence -1 due to serious imprecision (wide 95% CIs)

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**Summary of findings:**

Is the short-axis approach better than the long-axis approach for ultrasound-guided vascular access in cannulation time?

Patient or population: Adult population

Setting: Hospitals

Intervention: Short-axis approach

Comparison: Long-axis approach

| Outcomes | Anticipated absolute effects* (95% CI) | | Relative effect (95% CI) | No. of participants (studies) | Certainty of the evidence (Grade) | Comments |
|---|---|---|---|---|---|---|
| | Risk with long-axis approach | Risk with short-axis approach | | | | |
| Cannulation time | The mean cannulation time was 0 | MD 6.06 lower (12.68 lower to 0.56 higher) | - | 1396 (12 RCTs) | ⊕⊕○○ Low[a,b] | |
| Cannulation time- IJV | The mean cannulation time- IJV was 0 | MD 6.35 lower (7.8 lower to 4.91 lower) | - | 701 (seven RCTs) | ⊕⊕⊕○ Moderate[b] | |
| Cannulation time- RA | The mean cannulation time- RA was 0 | MD 2.93 lower (21.1 lower to 15.25 higher) | - | 505 (four RCTs) | ⊕⊕○○ Low[a,b] | |
| Cannulation time- others | The mean cannulation time- others was 0 | MD 29 lower (54.5 lower to 3.5 lower) | - | 190 (one RCT) | ⊕⊕○○ Low[c] | |

*The risk in the intervention group (and its 95% confidence interval) is based on the assumed risk in the comparison group and the relative effect of the intervention (and its 95% CI). CI=confidence interval, MD=mean difference, RCTs=randomised controlled trials, No.=number. GRADE Working Group grades of evidence. High certainty: we are very confident that the true effect lies close to that of the estimate of the effect. Moderate certainty: we are moderately confident in the effect estimate: the true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different. Low certainty: our confidence in the effect estimate is limited: the true effect may be substantially different from the estimate of the effect. Very low certainty: we have very little confidence in the effect estimate: the true effect is likely to be substantially different from the estimate of effect. [a]Downgrade quality of evidence -1 due to serious inconsistency ($I^2$ value is >50%). [b]Downgrade quality of evidence -1 due to serious imprecision (wide 95% CIs). [c]Downgrade quality of evidence -2 due to very serious imprecision (wide 95% CIs and small number of patients)

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**Summary of findings:**

Is the short-axis approach better than the long-axis approach for ultrasound-guided vascular access in the number of attempts?

Patient or population: Adult patients

Setting: Hospitals

Intervention: Short axis approach

Comparison: long axis approach

| Outcomes | Anticipated absolute effects* (95% CI) | | Relative effect (95% CI) | No. of participants (studies) | Certainty of the evidence (Grade) | Comments |
|---|---|---|---|---|---|---|
| | Risk with long-axis approach | Risk with short-axis approach | | | | |
| No. of attempts | The mean no. of attempts was 0 | MD 0.12 lower (0.26 lower to 0.01 higher) | - | 861 (eight RCTs) | ⊕⊕⊕○ Moderate[a] | |

*The risk in the intervention group (and its 95% confidence interval) is based on the assumed risk in the comparison group and the relative effect of the intervention (and its 95% CI). CI=confidence interval; MD=mean difference, No.=number. GRADE Working Group grades of evidence. High certainty: we are very confident that the true effect lies close to that of the estimate of the effect. Moderate certainty: we are moderately confident in the effect estimate: the true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different. Low certainty: our confidence in the effect estimate is limited: the true effect may be substantially different from the estimate of the effect. Very low certainty: we have very little confidence in the effect estimate: the true effect is likely to be substantially different from the estimate of effect. [a]Downgrade quality of evidence -1 due to serious inconsistency ($I^2$ value is >50%)

## s-4 Modified Jadad score

| Corresponding author | Was the research described as randomised? | Was the approach of randomisation appropriate? | Was the research described as blinding? | Was the approach of blinding appropriate? | Was there a presentation of withdrawals and dropouts? | Was there a presentation of the inclusion /exclusion criteria? | Was the approach used to assess adverse effects described? | Was the approach of statistical analysis described? | Total |
|---|---|---|---|---|---|---|---|---|---|
| Jatin Lal | +1 | +1 | 0 | +1 | 0 | +1 | +1 | +1 | 6 |
| Arun Rath | +1 | +1 | 0 | +1 | +1 | +1 | +1 | +1 | 7 |
| Antonella Vezzani | +1 | +1 | 0 | +1 | +1 | +1 | +1 | +1 | 7 |
| Madan Mohan Maddali | +1 | +1 | 0 | +1 | +1 | +1 | +1 | +1 | 7 |
| Jun Takeshita | +1 | +1 | 0 | 0 | +1 | +1 | +1 | +1 | 6 |
| Danilele Privitera | +1 | +1 | 0 | 0 | +1 | +1 | +1 | +1 | 6 |
| M. Batllori | +1 | +1 | 0 | 0 | +1 | +1 | +1 | +1 | 6 |
| Suresh Chittoodan | +1 | +1 | 0 | +1 | 0 | +1 | +1 | +1 | 6 |
| Derya Berk | +1 | +1 | 0 | 0 | +1 | +1 | +1 | +1 | 6 |
| G. N. Chennakeshavallu | +1 | +1 | 0 | 0 | +1 | +1 | +1 | +1 | 6 |
| Sameer Sethi | +1 | +1 | 0 | 0 | +1 | +1 | +1 | +1 | 6 |
| Mahler Simon | +1 | +1 | 0 | 0 | 0 | +1 | +1 | +1 | 5 |
| Gentle Sunder Shrestha | 0 | +1 | 0 | +1 | 0 | +1 | +1 | +1 | 5 |
| Tammam | 0 | +1 | 0 | +1 | 0 | +1 | +1 | +1 | 5 |
| Abdalla | +1 | +1 | 0 | 0 | +1 | +1 | +1 | +1 | 6 |
| Quan | +1 | 0 | 0 | +1 | +1 | +1 | +1 | +1 | 6 |

## s-5 Meta-regression