Systematic Review and Meta-Analysis

Efficacy and safety of supraclavicular versus infraclavicular approach for subclavian vein catheterisation: An updated systematic review and meta-analysis of randomised controlled trials

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ABSTRACT

Background and Aims: Subclavian vein catheterisation (SVC) is more effective than internal jugular or femoral catheterisation and is linked to a lesser incidence of infection and patient discomfort. Whether the supraclavicular (SC) or infraclavicular (IC) approach is more effective for SVC is unclear in the previous systematic review. This updated review is designed to search the efficacy and safety of both approaches adopting the Grading of Recommendations Assessment, Development and Evaluation approach. **Methods:** In May 2022, we explored the databases of Embase, MEDLINE, CENTRAL, ClinicalTrials.gov and WHO-ICTRP for randomised controlled trials to compare the two approaches. **Results:** Seventeen trials (2482 cases) were included. In the primary outcomes, the SC approach likely reduces the failure proportion (relative risk [RR], 0.63; 95% confidence interval [CI], 0.47–0.86; I^2 = 5%) and the incidence of malposition (RR, 0.23; 95% CI, 0.13–0.39; I^2 = 0%) with moderate evidence and may slightly reduce the incidence of arterial puncture and pneumothorax (RR, 0.59; 95% CI, 0.29–1.22; I^2 = 0%) with low evidence. In the secondary outcomes, the SC approach may decrease the access time and may increase the first-attempt success proportion. **Conclusion:** The SC approach for SVC should be selected after considering the clinician's expertise.

Key words: Catheterisation, subclavian vein, supraclavicular approach, infraclavicular approach

INTRODUCTION

Central venous catheterisation (CVC) is a standard invasive procedure performed for continuous drug administration or central venous pressure measurement. Approximately 5 million CVC procedures are performed in the United States annually.[1] Subclavian vein catheterisation (SVC) is known to result in fewer instances of infection, thrombosis and patient discomfort than internal jugular (IJ) or femoral catheterisation.[2] However, SVC may be avoided owing to concerns of pneumothorax, malposition and subclavian arterial puncture.[3,4]

The use of either the supraclavicular (SC) or infraclavicular (IC) approaches is generally used for SVC.[2] The SC approach has some anatomical benefits over the IC approach, including the

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presence of a well-known point for insertion (the clavi-sternomastoid angle), a short distance between the body surface and the vein, a larger target vein domain, a less angular path to the vein and farther distance from the lung.[5] The IC approach has been the traditional and routinely practised technique since 1952, whereas the SC approach has been used since 1965.[6,7]

The previous systematic review comparing the SC and IC approaches included a non-randomised controlled trial (RCT), which lowered the level of evidence and made it difficult to assess the true effectiveness of these two approaches.[2,8] Additionally, the review was not evaluated by the Grading of Recommendations Assessment, Development and Evaluation (GRADE) approach; hence, the conclusion did not consider the quality of the evidence.[9]

Therefore, a comprehensive systematic review using the GRADE criteria was required to definitively establish the superiority of either approach. Herein, we conducted an updated review aiming at exploring the efficacy and safety of the SC and IC approaches using the GRADE approach.

METHODS

Registration and protocol

This study protocol has been made public under the Open Science Framework (OSF) (accessible online: https://osf.io/zx82j/[accessed on 31 May 2022]). This review was conducted in compliance with the Preferred Reporting Items for Systematic Reviews and Meta-analysis statement (PRISMA).[10]

Eligibility criteria

Individual RCTs that evaluated the SC versus IC approach for SVC were included. All papers were considered, including printed and unprinted articles, meeting abstracts and letters. In addition, no restrictions were imposed on the language or country of origin. We also did not eliminate studies according to the duration of observation or publication year. We excluded crossover trials, cluster randomised trials and quasi-experimental studies.

Participants

Patients who underwent SVC of all ages, genders and races were included. Patients who were allergic to local anaesthetic formulations or were contraindicated for SVC were excluded.

Interventions and comparators

Subclavian venous catheter placement was performed via the SC approach by either a physician, nurse or other healthcare provider. All cannula sizes, both landmark- and ultrasound-guided punctures and both emergency (including cardiopulmonary resuscitation) and elective (before and after anaesthesia) settings, were included. However, studies that involved catheter replacement, placement of additional devices (e.g. pacemaker placement) or involved procedures more invasive than a typical percutaneous central catheter placement (e.g. tunnelled catheter or extracorporeal membrane oxygenation cannula placement) were excluded.

Outcome of interest

The primary outcomes that were measured included (1) failure proportion, (2) incidence of malposition and (3) incidence of arterial puncture and pneumothorax. The secondary outcomes included: (1) access time, (2) first-attempt success proportion and (3) all adverse events. The definition of failure was the need for more than three attempts at catheterisation, a change in the operator, a change of the puncture site during catheterisation or the definition by the original authors. The ratio of patients with failed procedures to total number of patients who underwent the procedures was used to calculate failure proportion. Malposition was defined as misplacement of the catheter in vein other than the intended. The ratio of patients with malposition to the total number of patients was used to calculate the incidence of malposition. Furthermore, arterial and pulmonary puncture were considered puncture-related complications of CVC. Arterial puncture was defined as puncture of an artery, insertion of a guidewire into an artery or insertion of the catheter into an artery as detected using a blood gas analysis, ultrasound or chest radiogram. Pneumothorax was defined as pneumothorax during or after catheter placement detected using ultrasound or chest radiogram. The ratio of patients with arterial puncture and pneumothorax to the total number of patients was used to calculate the incidence of those events. The definition of access time was the time in seconds from the first skin penetration to the completion of the string suturing around the catheter. First-attempt success was defined when the needle, guiding wire, dilator and catheter were entirely right positioned with no removal for reinsertion or redirection. The ratio of the patients with first-attempt success to the total number of patients was used to calculate the first-attempt success proportion. The original authors' definitions were also acceptable for the definition of access time, successful first attempt at

catheterisation and the incidence of puncture-related complications. All adverse episodes were included as defined by the respective original authors.

Information sources and selection

We searched MEDLINE via PubMed from 1946, Embase via ProQuest from 1974, and CENTRAL, ClinicalTrials.gov, and World Health Organization-International Clinical Trials Registry Platform (WHO-ICTRP) databases from their inception through March 2022, using specific keywords (Supplementary Digital Content File 1). Moreover, we personally searched all studies reference lists, including relevant clinical guidelines.[11,12] We contacted the authors of the initial studies for any unreported or supplementary data. Two reviewers (EI and HO) separately performed title and abstract screening of all papers found in the search. The articles selected from abstract screening were involved in the full-text assessment and judged for suitability. Furthermore, we contacted the original authors regarding missing data in the content of nine trials. Wherever necessary, any differences of opinion were settled through conversation or consultation with a third reviewer (JW).

Data collection

Data were retrieved from the involved trials by two reviewers (EI and HO) independently using a form for data collecting created in Microsoft Excel 2019 version 16.73 (Microsoft Corp, Redmond, Washington). The extracted data in a data collection form included information regarding the author, year, study design, study setting, number of participants, gender, age, inclusion/exclusion criteria, funding sources, catheter type, catheter size, landmark-/ultrasound-guided technique, operator and outcome measurement from each included study. In addition, information that was lacking was acquired from the authors if needed, and studies wherein such information could not be retrieved were excluded.

Risk of bias evaluation

Separate reviewers (EI and HO) evaluated the risk of bias independently utilising the Cochrane tool version 2 (RoB 2).[13] The consensus was used to settle disagreements between the two reviewers, and when this failed, a third reviewer (JW) intervened. Risk of bias plots was generated using a web application known as robvis.[14]

Reporting bias assessment

We performed an extensive literature search on clinical trial registries (ICTRP and ClinicalTrials.gov) for unpublished trials. Outcomes listed in the study protocol and those reported in relevant papers were assessed for outcome reporting bias. In addition, visual evaluation of the funnel plots and the Eggers tests were used to determine publication bias. A significance threshold of $P < 0.10$ was established.

Measurement of treatment effects

For dichotomous variables, including failure proportion; the incidence of malposition, puncture-related complications; and first-attempt success proportion, we used random-effect models to evaluate the relative risk (RR) with 95% confidence interval (CI). The models were also used to evaluate the mean difference (MD) with 95% CI for continuous variables such as access time. We used the same definitions for adverse events as the original authors and summarised them accordingly. However, adverse events were eliminated from the meta-analysis.

SYNTHESIS OF RESULT

The pooled summary estimates and forest plots were generated for each analysis using RevMan 5.4.2 (the Cochrane Collaboration, Copenhagen, Denmark).

We requested the original authors for data not presented in the published manuscripts. All dichotomous variables underwent an intention-to-treat analysis, and it was assumed that all absent participants before event occurrence did not experience them. Missing data were not substituted for continuous data according to the recommendations in the Cochrane Handbook.[15] However, when the original authors reported only the median and interquartile range (IQR), we changed the median to the mean and standard deviation obtained by the IQR/1.35 based on the methodology in Cochrane Handbook.[15] The information available from the original studies was subjected to a meta-analysis.

Visual evaluation of the forest plots and calculation of the I^2 statistic were used to determine the statistical heterogeneity (I^2 value: 0–40%, may not be important; 30–60%, may exhibit moderate; 50–90%, may exhibit substantial; 75–100%, demonstrates considerable).[15] The I^2 statistic was calculated using the Cochrane Chi-squared test (Q-test), and P values below 0.10 were regarded as statistically significant. When substantial heterogeneity occurred (I^2 >50%), we conducted subgroup analyses of the primary outcomes within age groups, cannulation methods

(landmark- or ultrasound guided), and whether the vein cannulation was performed by experts, as described in the protocol. Although subgroup analyses were not anticipated in the protocol for outcomes with low heterogeneity, subgroup analyses were eventually conducted for this comparison since many studies compared landmark- versus ultrasound-guided techniques. The results have been added to the Supplementary Digital Content File accordingly.

Sensitivity analysis

We conducted sensitivity analyses to assess potential heterogeneity. We pre-planned the protocol below for sensitivity analyses about the main outcomes: (1) studies using imputed statistics are excluded, (2) analysis limited to those participants who concluded the study with all available data and (3) use of only our definitions for primary outcomes.

Certainty of evidence

The results of the primary and secondary outcomes outlined by the Cochrane handbook were summarised.[15] For imprecision, we evaluated the number of participants or events and the CIs. For inconsistency, we evaluated the overlapping of CIs, the analogy of point estimates and statistical testing or measures such as I^2, Chi-square and Tau. For indirectness, we evaluated data on population, intervention, comparator, direct comparison and outcome.[15] Then, we determined the certainty of evidence using GRADEpro tool (McMaster University, Hamilton, ON, Canada) with the assessment of the risk of bias, imprecision, inconsistency, indirectness and publication bias. We listed the evidence presented in the included studies and evaluated the degree of the evidence for outcomes explained in the protocol following the GRADE approach.[9]

Differences between the protocols and reviews

Subgroup analyses of the primary outcomes other than the classification of the cannulation method were designed but not performed owing to low heterogeneity ($I^2 < 50\%$).

RESULTS

Selected studies

Following the screening of 1028 records published until May 2022, 28 studies were retained for full-text review [Figure 1]. These consist of 4 studies, including NCT02478749 and,[16-18] 3 studies including NCT04265703, TCTR20210728003, NCT03879954, 1 study including NCT05140668, and 1 study including (Supplementary Digital Content File 2).[19] Combining these 4 papers with the 5 studies that were not published as papers, there were a total of 9 exclusions. We also identified four studies from the guidelines and citations. By contacting the original authors, we obtained unpublished data for two studies (NCT04637347).[5] Finally, 17 studies (2568 cases to 2482 cases) from 23 reports were included in this review [Table 1] (NCT04637347).[3,5-7,20-31]

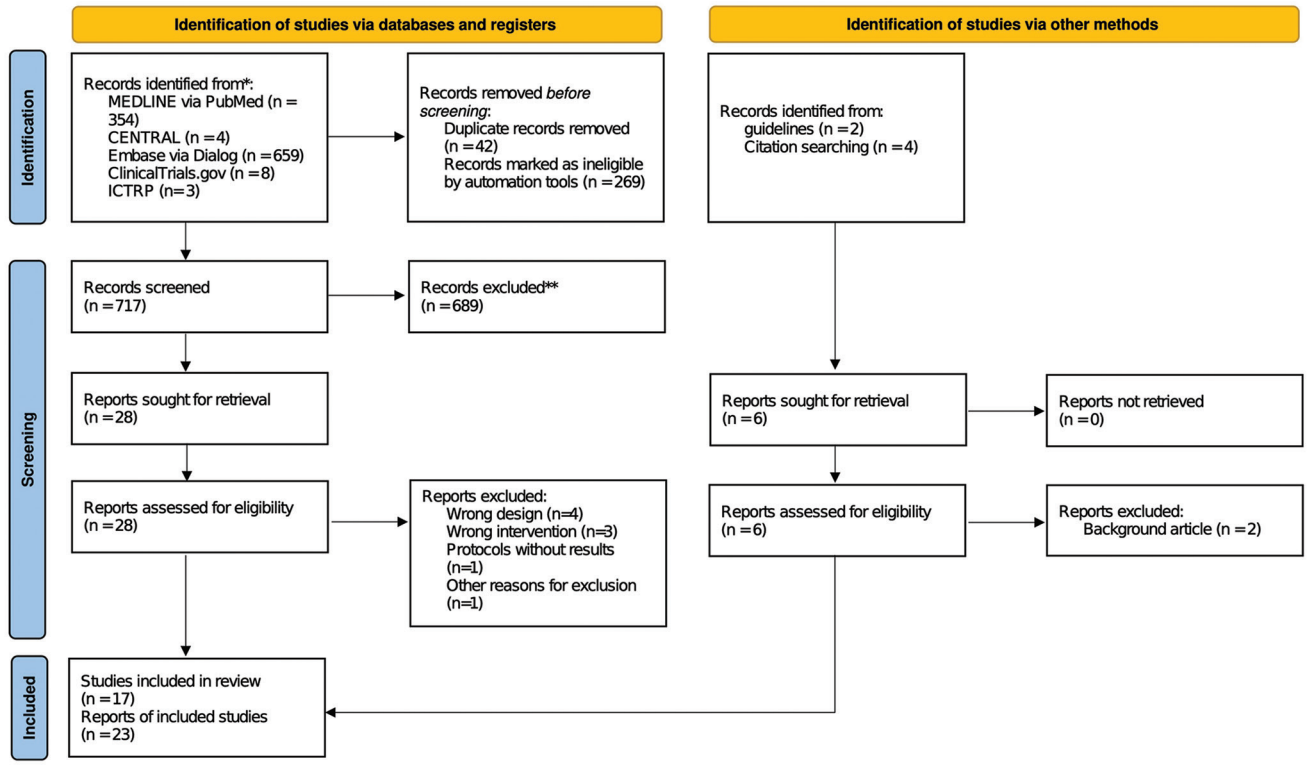
Primary outcomes

Failure proportion

In our meta-analysis, data from 17 trials comprising 2482 participants in whom the failure proportion was measured were pooled [Table 2, Figures 2 and 3a] (NCT04637347).[3,5-7,20-31] The comprehensive results revealed that the SC approach likely reduced the failure proportion compared with the IC approach (RR, 0.63; 95% CI, 0.47–0.86; I^2 = 5%; moderate quality) [Table 2, Figure 3a]. In addition, eight trials that met our definition of failure proportion were subjected to sensitivity analysis (Supplementary Digital Content File 3). The sensitivity analysis and main analysis results were comparable. Subgroup analyses were performed based on the cannulation method (landmark- or ultrasound-guided), although the results were comparable with those of the primary analysis (Supplementary Digital Content File 4). The risk of bias in the quantitative synthesis is illustrated [Figure 2].

Incidence of malposition

In our meta-analysis, data from 14 trials comprising 2214 participants in whom the incidence of malposition was measured were pooled [Table 2, Figure 3b and Supplementary Digital Content File 5] (NCT05140668, NCT04637347).[3,5,20,22-30] The comprehensive results showed that the SC approach likely reduced the incidence of malposition compared with the IC approach (RR, 0.23; 95% CI, 0.13–0.39; I^2 = 0%; moderate quality) [Table 2, Figure 3b]. Subsequently, six trials that met our definition of malposition were subjected to sensitivity analysis [Supplementary Digital Content File 6]. The results of the sensitivity and main analyses were comparable. Subgroup analyses were performed based on the cannulation method (landmark- or ultrasound-guided), although the results were comparable with those of the primary analysis [Supplementary Digital Content File 7].



*Consider, if feasible to do so, reporting the number of records identified from each database or register searched (rather than the total number across all databases/registers).
**If automation tools were used, indicate how many records were excluded by a human and how many were excluded by automation tools.

From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi: 10.1136/bmj.n71. For more information, visit: http://www.prisma-statement.org/

Figure 1: Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 flow diagram. CENTRAL = Cochrane Central Register of Controlled Trials; ICTRP = International Clinical Trials Registry Platform; RCTs = randomised controlled trials

Table 1: Characteristics of the studies included

Source	Number of patients	Adult/Children/ All age	Setting	Guided method	Performed by experts or not	Main exposure	Comparator
Dronen 1982[25]	89	Adult	ED	Landmark	Mix	SC (*n*=44)	IC (*n*=45)
Sterner 1986[24]	500	All age	ED	Landmark	Mix	SC (*n*=245)	IC (*n*=255)
Kocum 2011[22]	195	Adult	OT	Landmark	Expert	SC (*n*=65)	IC (*n*=65), IJ (*n*=65)
Aziz 2013[31]	138	Adult	OT and ICU	Landmark	Unclear	SC (*n*=69)	IC (*n*=69)
Byon 2013[26]	98	Children	OT	Realtime US	Expert	SC (*n*=49)	IC (*n*=49)
Thakur 2014[27]	60	Adult	OT	Landmark	Expert	SC (*n*=30)	IC (*n*=30)
Momin 2017[20]	50	Adult	OT	Landmark	Unclear	SC (*n*=25)	IC (*n*=25)
Anand 2018[6]	60	Adult	ICU	Landmark	Unclear	SC (*n*=30)	IC (*n*=30)
Govindswamy 2018[7]	80	Adult	OT	Landmark	Expert	SC (*n*=40)	IC (*n*=40)
Tarbiat 2018[28]	280	Adult	OT	Landmark	Expert	SC (*n*=140)	IC (*n*=140)
Khapung 2020[21]	70	All age	OT	Landmark	Expert	SC (*n*=35)	IC (*n*=35)
Prasad 2020[23]	110	Adult	ICU	Realtime US	Unclear	SC (*n*=55)	IC (*n*=55)
Becem 2021 (NCT04637347)	110	Adult	ICU	Realtime US	Expert	SC (*n*=55)	IC (*n*=55)
Bodkhe 2021[29]	120	Adult	OT and others	Landmark	Unclear	SC (*n*=60)	IC (*n*=60)
Mageshwaran 2021[30]	90	Adult	OT	Realtime US	Expert	SC (*n*=45)	IC (*n*=45)
Kim 2022[3]	401	Adult	OT	Realtime US	Expert	SC (*n*=200)	IC (*n*=201)
Saini 2022[5]	96	Adult	OT	Realtime US	Expert	SC (*n*=48)	IC (*n*=48)

ED=emergency department; IC=infraclavicular; IJ=internal jugular; ICU=intensive care unit; SC=supraclavicular; OT=operation theatre; US=ultrasound

Incidence of puncture-related complications

In our meta-analysis, data from 16 trials comprising 2344 participants in whom the incidence of arterial puncture and pneumothorax was measured were pooled [Table 2, Figure 3c and Supplementary Digital Content File 8]. (NCT04637347).[3,5-7,20-30] The comprehensive results revealed that the SC approach may decrease the incidence of puncture-related

Table 2: Summary of findings

Supraclavicular approaches compared with infraclavicular approaches for subclavian vein catheter insertion

Patient or population: Patients requiring subclavian vein catheter insertion

Setting: Patients treated in the operation theatre, intensive care unit, emergency department and other settings

Intervention: SC approach

Comparison: IC approach

Outcome	Expected absolute effects* (95% CI)		Relative effect (95% CI)	Number of participants (studies)	Certainty of evidence (grade)	Findings
	Risk with IC	Risk with SC				
Failure proportion	100 per 1000	63 per 1000 (47–86)	RR 0.63 (0.47–0.86)	2482 (17 RCTs)	⊕⊕⊕◯ Moderate[a]	SC approach likely reduces the failure proportion
Incidence of malposition	82 per 1000	19 per 1000 (11–32)	RR 0.23 (0.13–0.39)	2214 (14 RCTs)	⊕⊕⊕◯ Moderate[a]	SC approach likely reduces the incidence of malposition
Incidence of artery puncture and pneumothorax	27 per 1000	16 per 1000 (8–33)	RR 0.59 (0.29–1.22)	1564 (14 RCTs)	⊕⊕◯◯ Low[a, b]	SC approach may reduce the incidence of puncture-related complications slightly
Access time	The mean access time was 186.3 s	MD 34.29 s lower (47.48 lower to 21.1 lower)	Not available	1369 (12 RCTs)	⊕⊕◯◯ Low[a, c]	SC approach may reduce access time slightly
First-attempt success proportion	768 per 1000	860 per 1000 (783–937)	RR 1.12 (1.02–1.22)	2393 (16 RCTs)	⊕⊕◯◯ Low[a, d]	SC approach may increase the first-attempt success proportion slightly

Certainty of evidence: high, we are highly confident that the estimate of the effect closely approximates the actual effect; moderate, we are a modest level of confidence in the estimated effect; there is a probability that the actual effect resembles the estimated effect; however, it is also able to differ significantly; low, we are restricted confident in the effect estimate; the actual effect may differ considerably from the estimated effect; very low, we are quite low confident in the effect estimate; there is a probability that the actual effect differs considerably from the estimated effect. CI, confidence interval; IC, infraclavicular; OR, odds ratio; RCTs, randomised controlled trials; RR, risk ratio; SC, supraclavicular; MD, mean difference. *The risk with SC group (and its 95% confidence interval) is determined by considering the estimated risk with the IC group. [a]Reduced one level because of imprecision due to the limited sample size. [b]Reduced one level because of imprecision due to the 95% CI of relative effect. [c]Reduced one level because of inconsistency due to heterogeneity. [d]Reduced one level because of publication bias

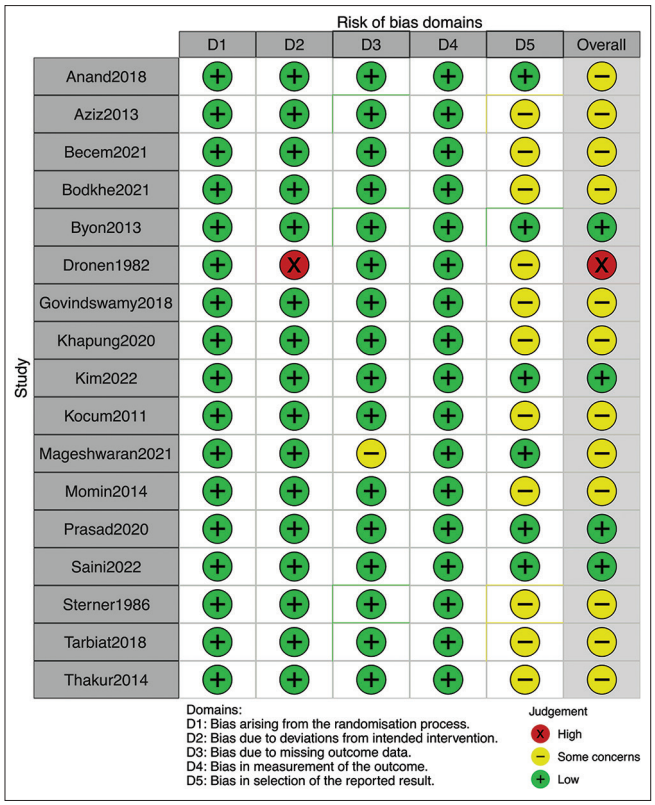


Figure 2: Risk of bias in the included studies evaluating the failure proportion

complications slightly compared with the IC approach (RR, 0.61; 95% CI, 0.36–1.03; I^2 = 0%; low quality) [Table 2, Figure 3c]. In addition, seven trials that met our definition of arterial puncture and pneumothorax were subjected to sensitivity analysis [Supplementary Digital Content File 9]. The results of the sensitivity and main analyses were comparable. Subgroup analyses were performed based on the cannulation method (landmark- or ultrasound-guided), although the results were comparable with those of the primary analysis [Supplementary Digital Content File 10].

Secondary outcomes

Access time

In our meta-analysis, data from 12 trials, which included 1369 participants in whom the access time was measured, were pooled [Table 2, Figure 3d and Supplementary Digital Content File 11] (NCT04637347).[3,5-7,20-23,27,29,30] In the forest plot, statistical heterogeneity was observed as I^2 was high and the CIs did not overlap [Figure 3d]. The comprehensive results revealed that the SC approach may reduce the access time slightly more than the IC approach (MD, 34.29 s shorter; 95% CI, 47.48 shorter to 21.1 shorter; I^2 = 95%; low quality) [Table 2, Figure 3d].

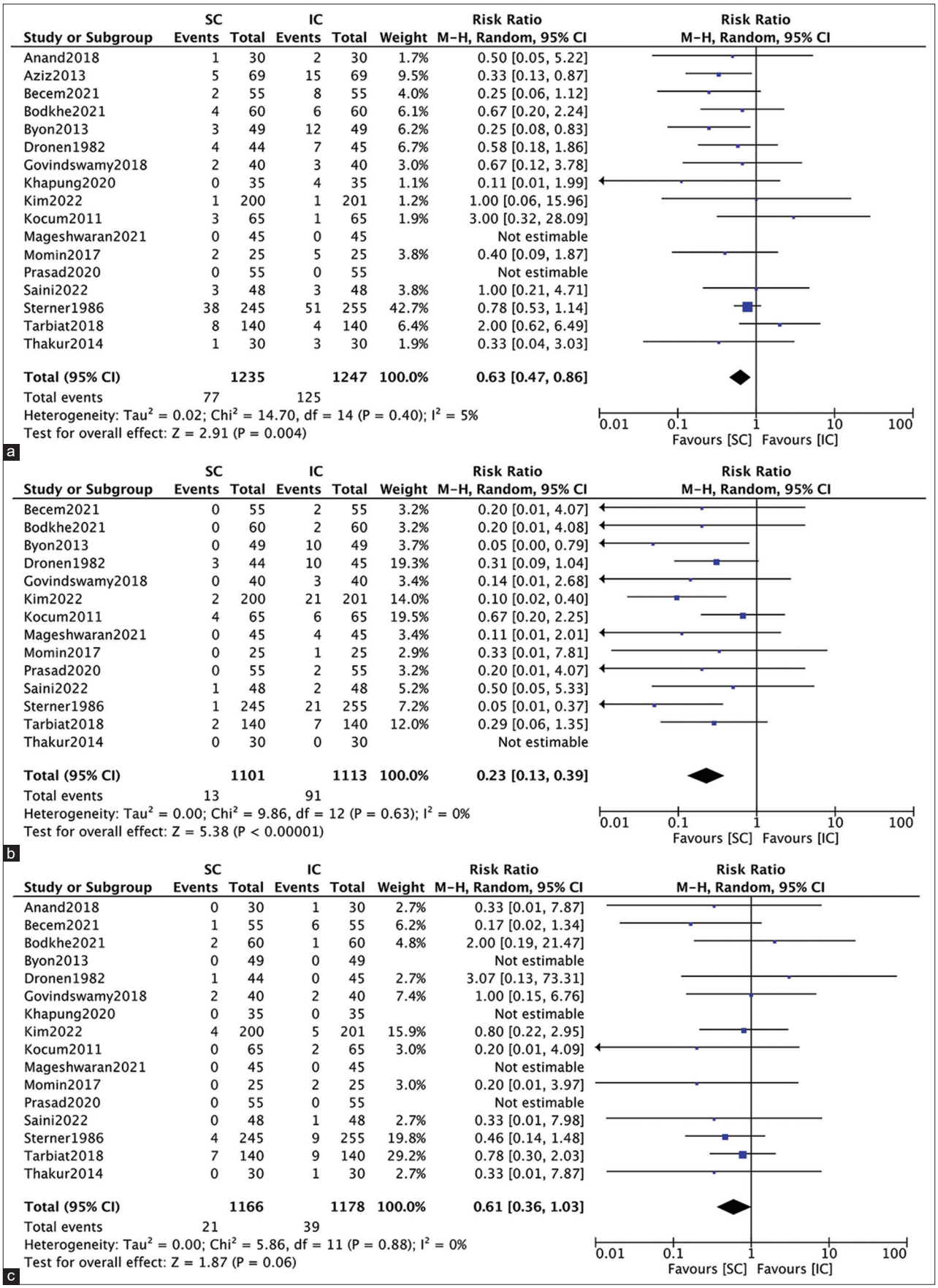


Figure 3: Contd...

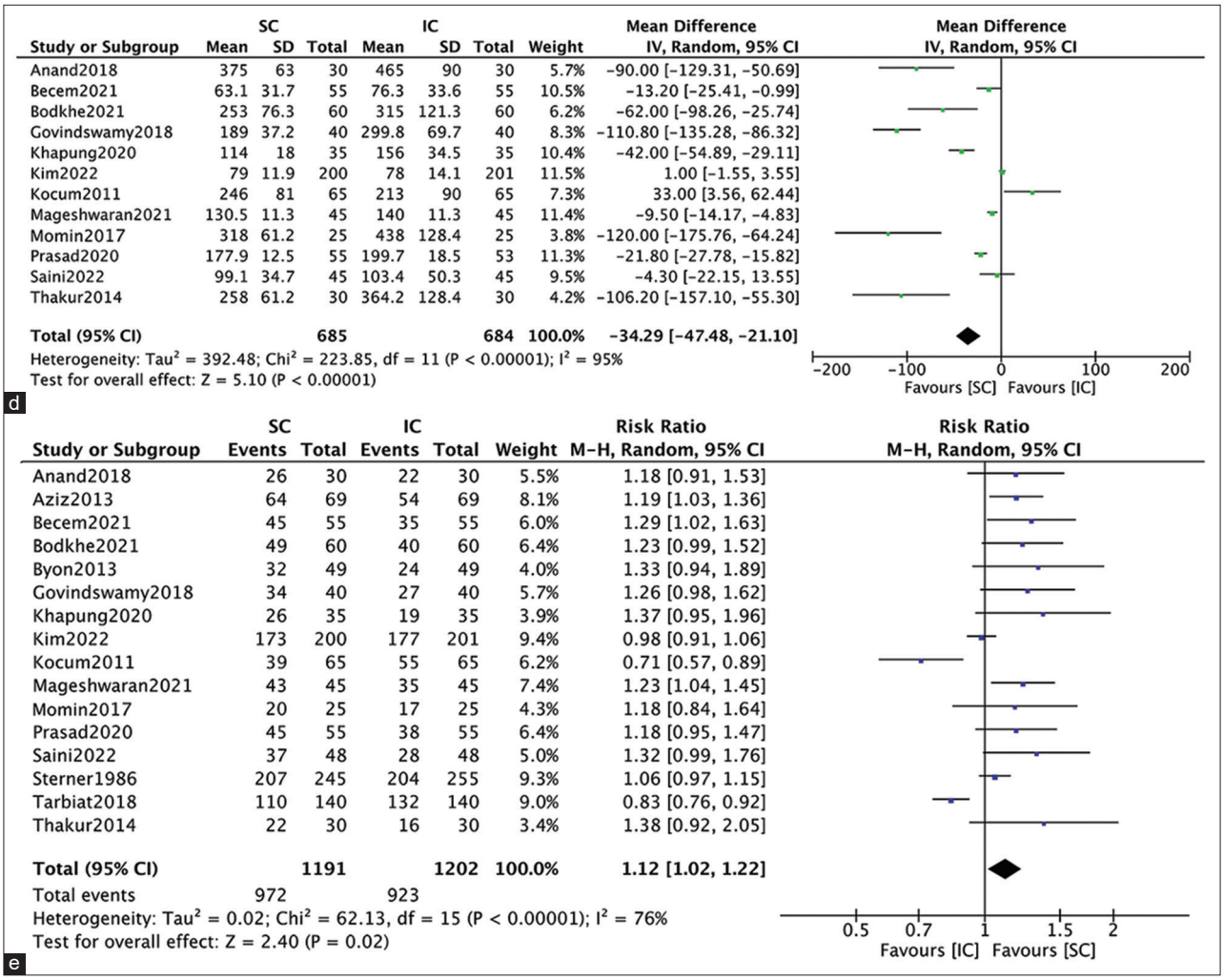


Figure 3: Forest plot of the primary outcomes. a. Forest plot of the failure proportion. b. Forest plot of the incidence of malposition. c. Forest plot of the incidence of arterial puncture and pneumothorax. d. Forest plot of the access time. e. Forest plot of the first-attempt success proportion. CI = confidence interval; df = degrees of freedom; IC = infraclavicular; M–H = Mantel–Haenszel; SC = supraclavicular; SD = standard deviation

First-attempt success proportion

In our meta-analysis, data from 16 trials comprising 2393 participants in whom the first-attempt success proportion was measured were pooled [Table 2, Figure 3e and Supplementary Digital Content File 12] (NCT04637347).[3,5-7,20-24,26-31] The comprehensive results revealed that the SC approach may increase the first-attempt success proportion slightly more than the IC approach (RR, 1.12; 95% CI, 1.02–1.22; I^2 = 76%; low quality) [Table 2, Figure 3e].

Adverse events

Among the studies involved in this review, sixteen described the incidence of arterial puncture and pneumothorax (NCT04637347).[3,5-7,20-30] Fourteen studies reported malposition (NCT04637347). [3,5,7,20,22-30] Twelve studies reported haemothorax (NCT04637347),[3,5-7,20-23,27,29,30] ten reported haematomas (NCT04637347),[3,5,6,20,22,23,27-29] and three reported arrhythmias.[6,20,21] Two studies reported hydrothorax,[22,23] and two reported cardiac perforation/tamponade.[5,22] Kocum *et al*.[22] investigated air embolism; similarly, Anand *et al*.[6] examined cardiac arrest; and Prasad *et al*.[23] investigated infectious complications. Saini *et al*.[5] evaluated damage to the brachial plexus and phrenic nerve, and Sterner *et al*.[24] examined kinked catheters.

Publication bias

In the funnel plot reporting the first-attempt success proportion, the lower left parts were found to be missing (Egger's test, $P = 0.08$) [Figure 4]. The funnel plots for access time were asymmetric with the lower right parts missing; however, Egger's test indicated the absence of a potential publication bias (P = 0.10). Finally, the funnel plots for failure proportion and the incidence of malposition, puncture-related complications were not asymmetric (Egger's test, P = 0.59, 0.88 and 0.42, respectively).

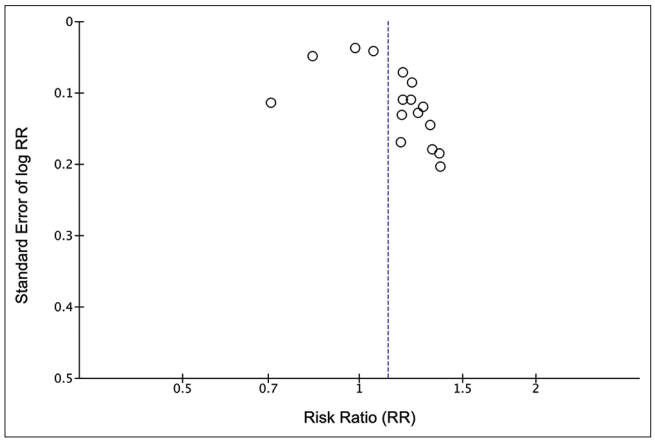


Figure 4: Funnel plot of the first-attempt success proportion. RR = risk ratio

DISCUSSION

Our study showed that the SC approach likely reduced the failure proportion and incidence of malposition more than the IC approach with moderate evidence. Additionally, the SC approach may slightly increase the first-attempt success proportion and decrease the access time and the incidence of arterial puncture and pneumothorax. This updated systematic review provides robust evidence regarding the effectiveness and safety of the SC approach using the GRADE approach.

In contrast to a previous systematic review,[2] the present study indicated that the certainty of evidence regarding failure proportion changed from very low to moderate. Furthermore, compared to the IC approach, the SC approach exhibited a shorter access time and a higher first-attempt success rate. The GRADE approach was not used in the previous systematic review; however, when the certainty of evidence was evaluated by the GRADE approach, it was deemed improbable owing to inconsistency, imprecision and the inclusion of a non-RCT. Therefore, the efficacy of the SC approach could not be determined in the previous systematic review. In the present study, we included only RCTs and additionally included seven newly published RCTs unlike the previous systematic review (NCT04637347).[3,5,21,23,29,30] The sample size was approximately doubled from 1333 cases to 2482 cases. We demonstrated a robust evidence base for the SC approach using the GRADE approach.

The clinical implication of this study is that the SC approach should be selected for catheterisation of the subclavian vein. In the SC approach, a well-known insertion point (such as the clavi-sternomastoid angle) makes it easy to use the landmark method,[5] and the short length from the body surface to the vein also makes it easy to visualise the vein under ultrasound guidance.[26] The superficial location of the vein also leads to stable ultrasound images and allows easy access of the needle to the vein. In addition, the vein has a large target area and is easy to cannulate.[3,23] Therefore, these anatomical characteristics may result in fewer failures and shorter access times with the SC approach. Furthermore, the SC approach makes it easier to obtain a long-axis image and proceed directly to the vein,[30] and unlike the IC approach, it does not penetrate the pectoralis major. Because of the other anatomical features described above, it is considered to result in lesser malpositioning.[26,32] The incidence of complications such as pneumothorax has been reported to have reduced when the CVC is performed by experienced operators.[33] Thus, operators with extensive experience with the IC approach may find it acceptable. However, those without such experience should use the SC approach, particularly for new subclavian venepunctures.

This study has some limitations. First, we could not obtain unpublished data for all the studies involved in this review. We inquired of the original authors about the data on more than two occasions over a 2-week period and obtained some data (NCT04637347).[5] We also obtained data from several studies by searching trial registries (NCT02478749, NCT04265703, NCT03879954, NCT05140668, NCT04637347). Second, the femoral vein, the IJ vein or peripherally inserted central venous catheters (PICCs) were not compared with the subclavian vein. Previous network meta-analyses (NMAs) have compared catheter-related bloodstream infection risk, mechanical complications and thrombotic complications among the three (SVC, IJ vein and femoral vein) or four (PICC combined) approaches.[34,35] No comparison has been performed for the failure proportion, access time and first-attempt success proportion in these groups; however, these factors are also crucial in emergency situations. Therefore, NMAs including this comparison will be useful in the future. A higher clinical priority may be determined by limiting SVC to the SC approach and comparing it with other approaches.

CONCLUSION

This updated meta-analysis shows that the SC approach likely reduces the failure proportion and incidence

of malposition compared with the IC approach, with moderate levels of evidence. These results imply that the SC approach should be selected based on the clinician's preference and expertise. Further studies are required to compare the SVC limited to the SC approach only with IJ vein cannulation, femoral vein cannulation or PICCs.

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Conflicts of interest

There are no conflicts of interest.

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Supplementary Digital Content File 1. Search strategy

MEDLINE via Pubmed (accessed on May 17, 2022)

#1	("catheterization, central venous"[mh] OR "subclavian vein*"[mh] OR subclavian*[tiab] OR "central venous cathete*"[tiab]) OR CVC[tiab]
#2	supraclavicular[tiab] AND (approach*[tiab] OR catheterization[tiab] OR technique[tiab])
#3	#1 AND #2

CENTRAL (accessed on May 20, 2022)

#1	([mh "catheterization, central venous"] OR [mh ("subclavian" NEXT vein*)] OR subclavian*:ti,ab OR ("central venous" NEXT cathete*):ti,ab) OR CVC:ti,ab
#2	supraclavicular:ti,ab AND (approach*:ti,ab OR catheterization:ti,ab OR technique:ti,ab)
#3	#1 AND #2

EMBASE via ProQuest (accessed on May 22, 2022)

S1	EMB.EXACT.EXPLODE("catheterization")
S2	EMB.EXACT.EXPLODE("catheter")
S3	EMB.EXACT.EXPLODE("central venous catheterization")
S4	EMB.EXACT.EXPLODE("central venous catheter")
S5	EMB.EXACT.EXPLODE("subclavian vein")
S6	(ab(central venous cathete*) OR ti(central venous cathete*))
S7	(ab(subclavian*) OR ti(subclavian*))
S8	(ab(CVC) OR ti(CVC))
S9	S1 OR S2 OR S3 OR S4 OR S5 OR S6 OR S7 OR S8
S10	((ab(supraclavicular) OR ti(supraclavicular)) AND (ab(approach*) OR ti(approach*)))
S11	((ab(supraclavicular) OR ti(supraclavicular)) AND (ab(catheterization*) OR ti(catheterization*)))
S12	((ab(supraclavicular) OR ti(supraclavicular)) AND (ab(technique*) OR ti(technique*)))
S13	S10 OR S11 OR S12
S14	S9 AND S13

ICTRP (accessed on May 20, 2022)

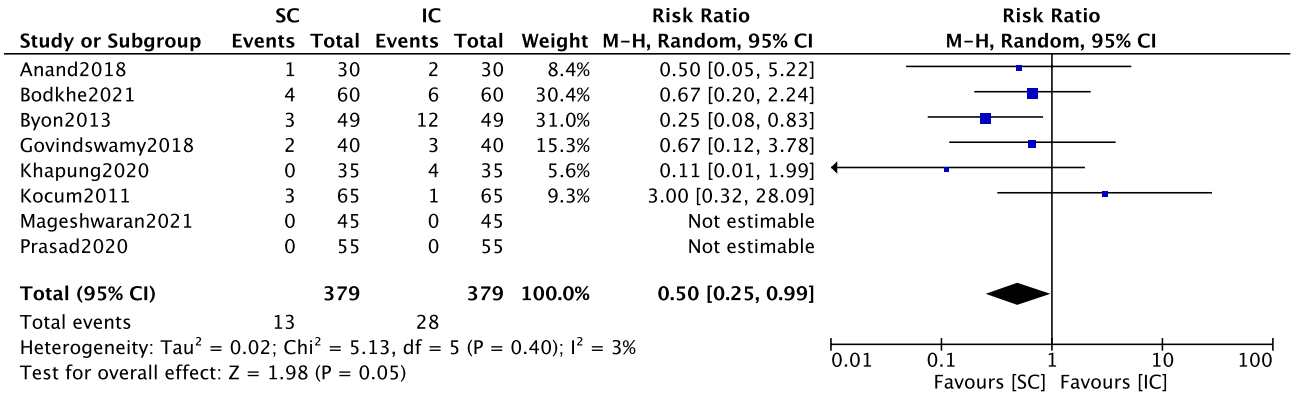
#1	(subclavian OR "central venous" OR CVC)
#2	(supraclavicular AND (approach OR catheterization OR technique))
#3	#1 AND #2

ClinicalTrials.gov (accessed on May 20, 2022)

Condition or disease	(subclavian OR "central venous" OR CVC)
Intervention	(supraclavicular AND (approach OR catheterization OR technique))

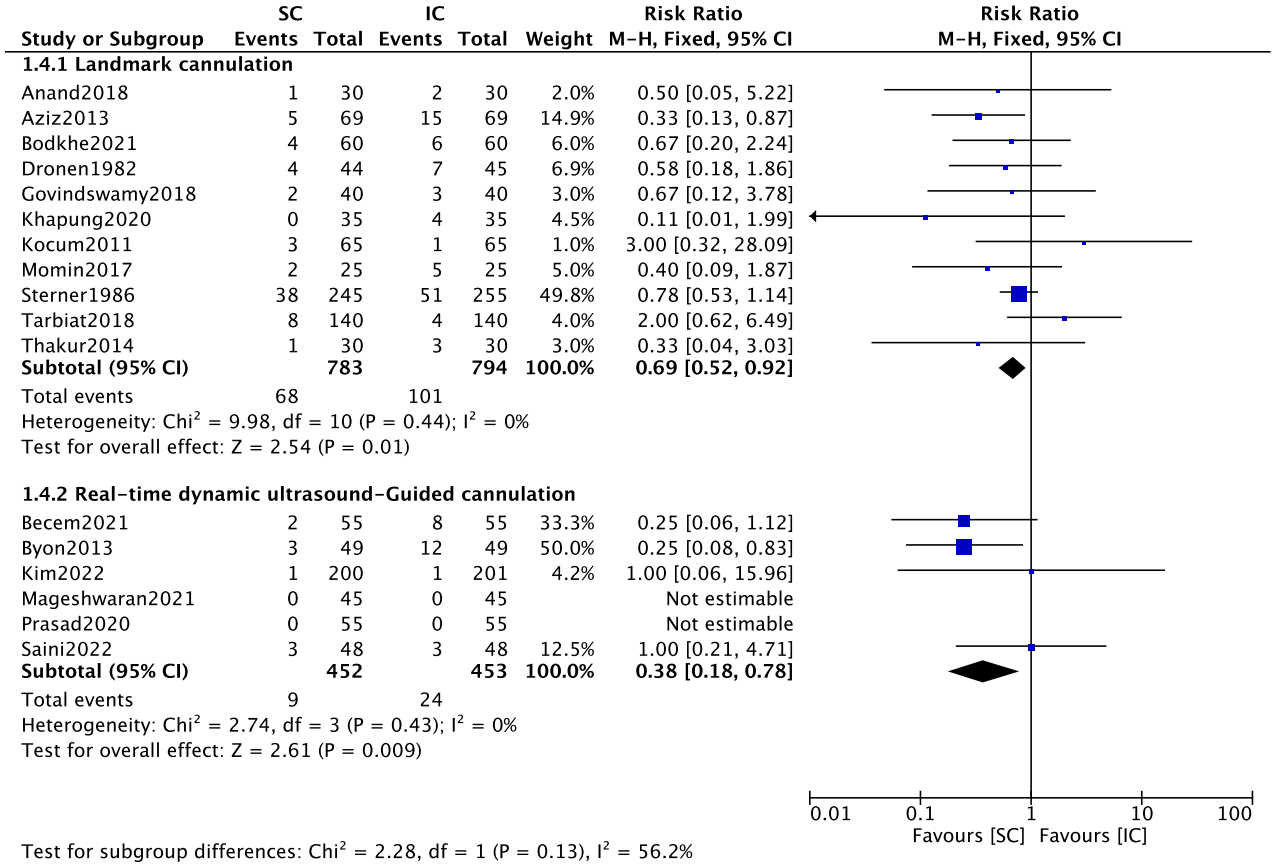
Supplementary Digital Content File 2. Excluded studies

Study	Rationale for Exclusion
Charters 1987	This is a letter and does not include a randomised clinical trial component. Thus, this paper was excluded.
Kim 2015	This is a non-randomised clinical trial and evaluates the effect of arm retraction on the supraclavicular approach by using ultrasound.
Kore 1999	This is an observational study. Thus, it was excluded from the inclusion.
Miguel 2021	This is a randomised clinical trial on central venous access; however it compares the internal jugular vein, subclavian vein, and innominate vein. Thus, this is a different interventional study.
Mohamed 2022	This is a randomised study that evaluated the supraclavicular and infraclavicular approaches for right subclavian venous catheterization. The study is still in the process of recruiting; we inquired about the data from the authors but received no response.
Nutsiri 2021	This is a randomized controlled trial; however it compares the surgical tunnel-type catheter placement and that of the femoral approach. Thus, this is a different interventional study.
Richter 1973	This study compared the supraclavicular and infraclavicular approaches for subclavian venous catheterization. However, this is an observational study. Therefore, this study was excluded as the study design was wrong.
Tunisie 2019	This is a randomised controlled trial; however it compares the internal jugular vein and subclavian vein. Thus, this is a different interventional study.
Zhonghua 1974	This is an observational study. Thus, this study was excluded as the study design was wrong.



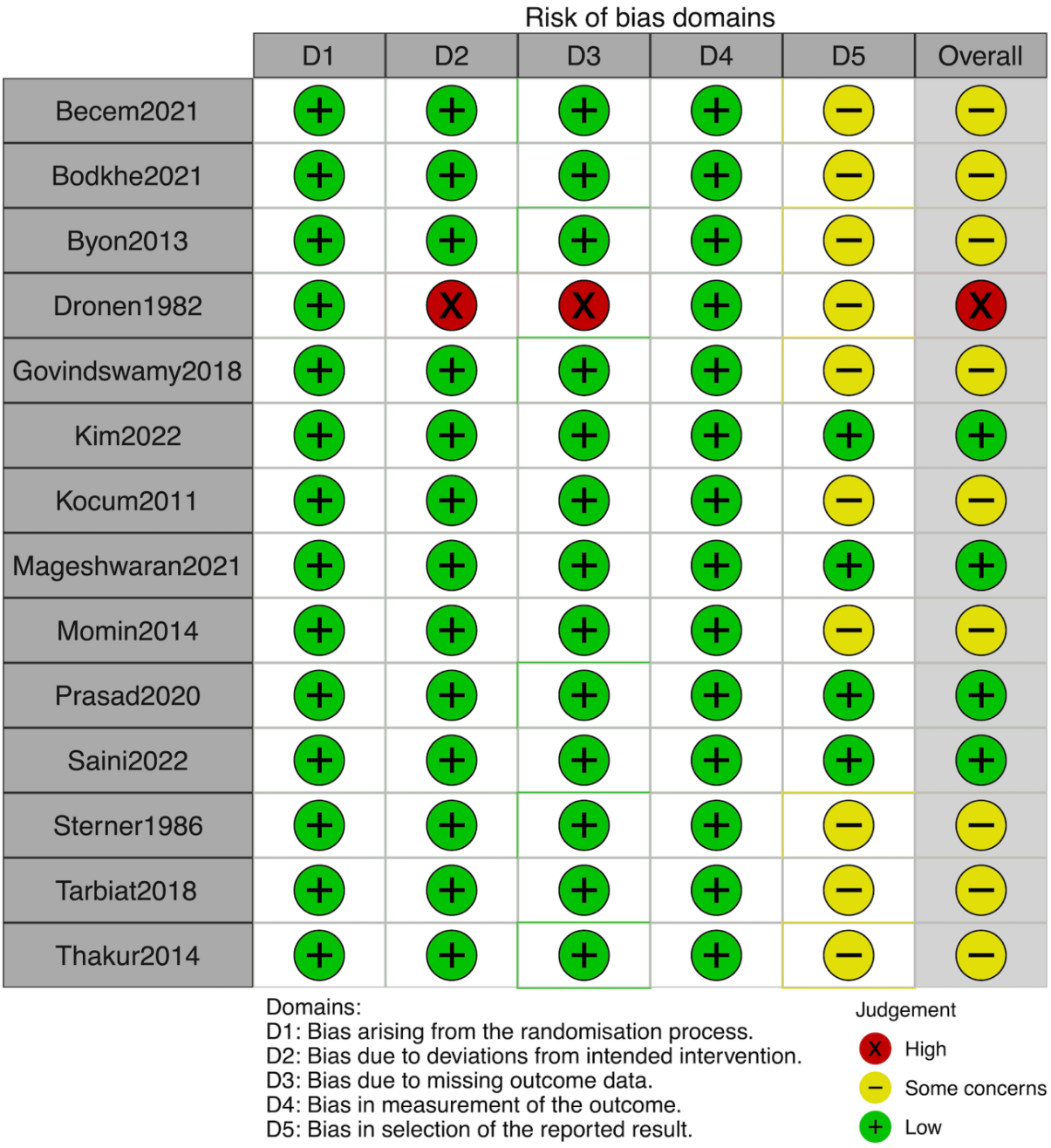
Supplementary Digital Content File 3. Forest plot of the sensitivity analysis in the failure proportion.

CI, confidence interval; df, degrees of freedom; MH, Mantel-Haenszel; SD, standard deviation

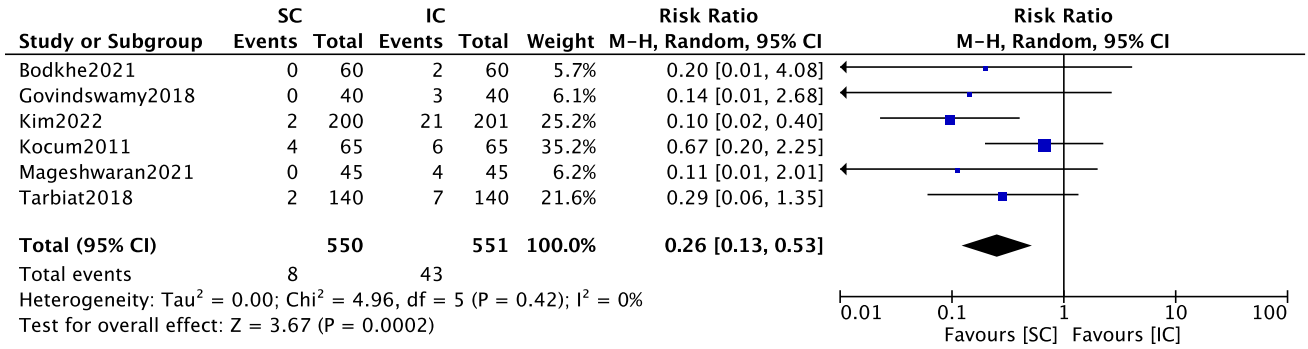


Supplementary Digital Content File 4. Forest plot of the subgroup analysis in the failure proportion.

CI, confidence interval; df, degrees of freedom; MH, Mantel-Haenszel; SD, standard deviation

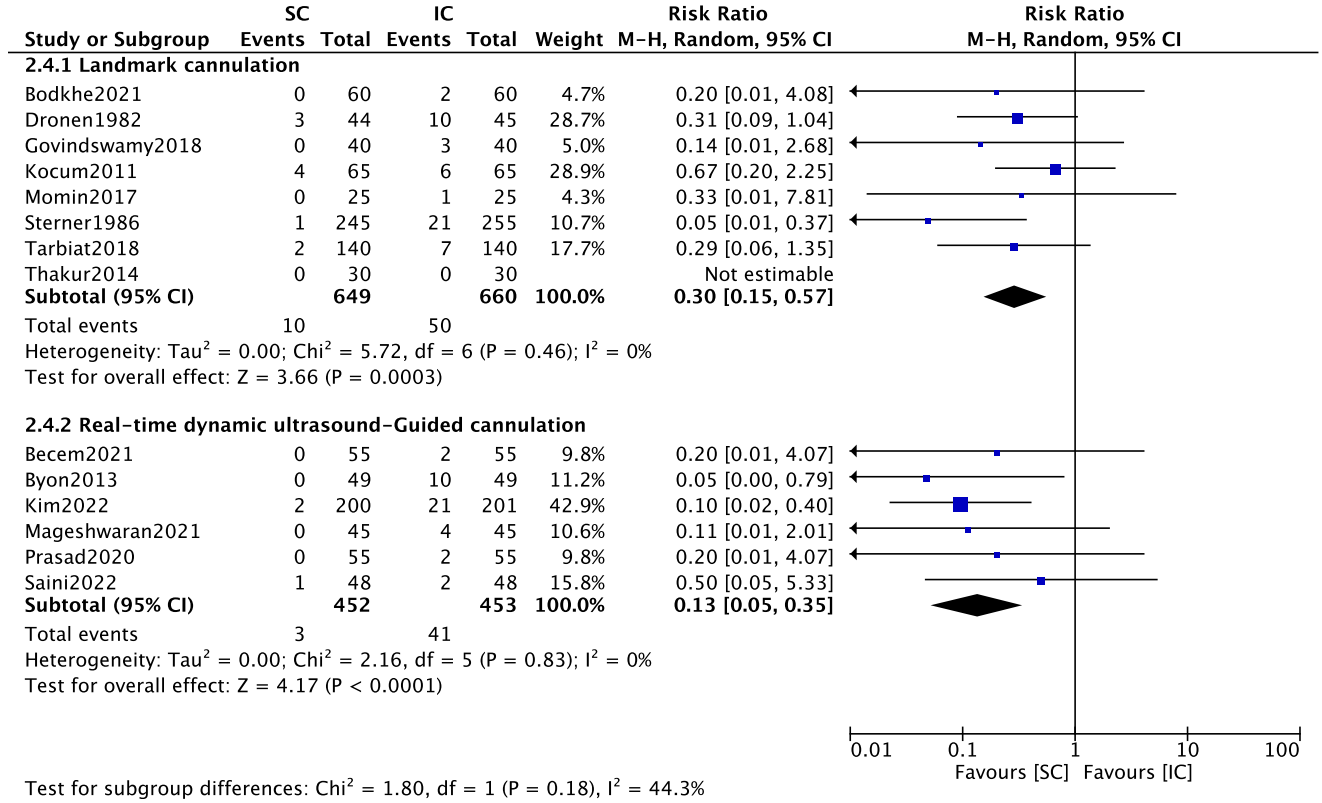


Supplementary Digital Content File 5. Risk of bias in the included studies evaluating the incidence of malposition



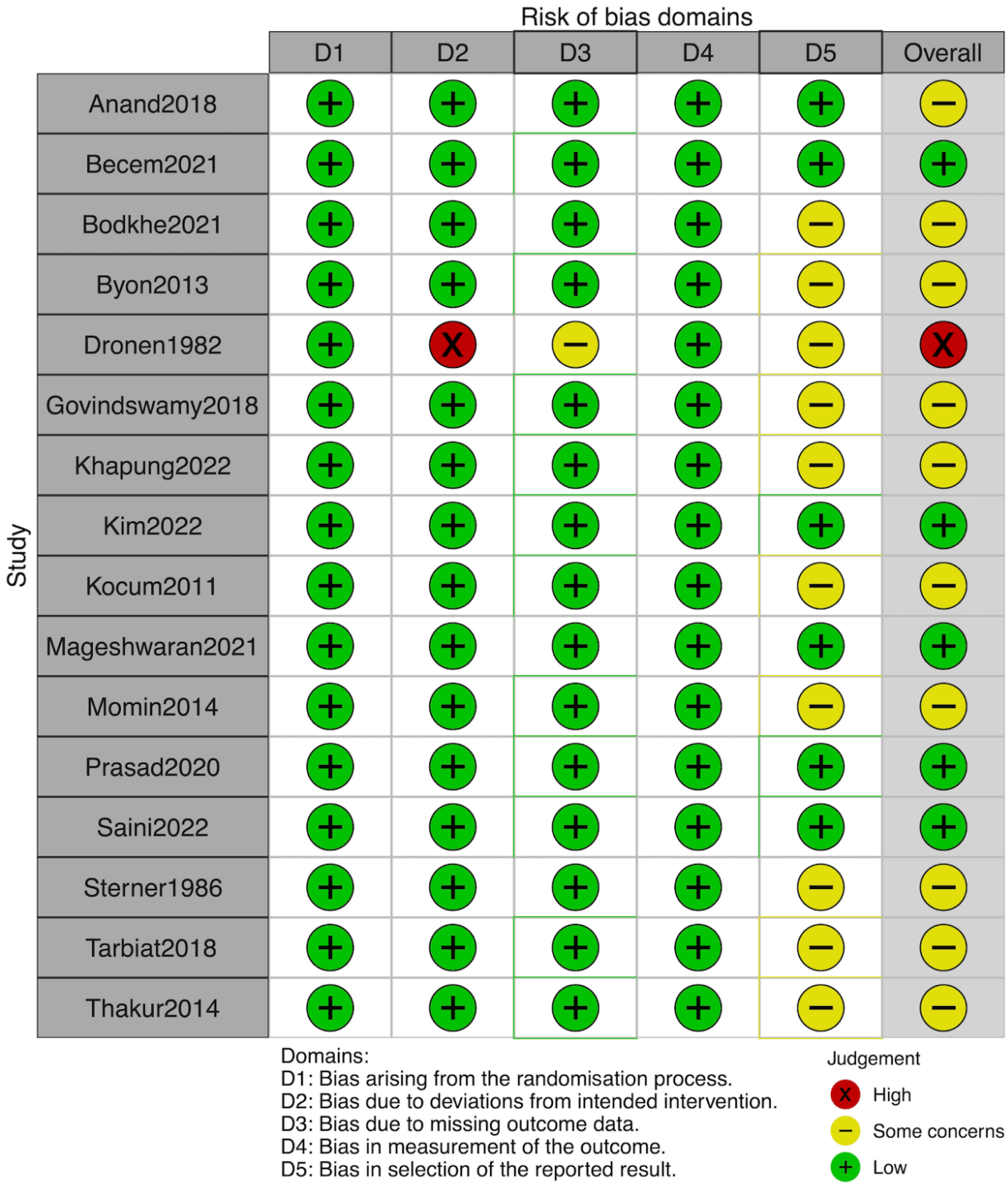
Supplementary Digital Content File 6. Forest plot of the sensitivity analysis in the incidence of malposition.

CI, confidence interval; df, degrees of freedom; MH, Mantel-Haenszel; SD, standard deviation

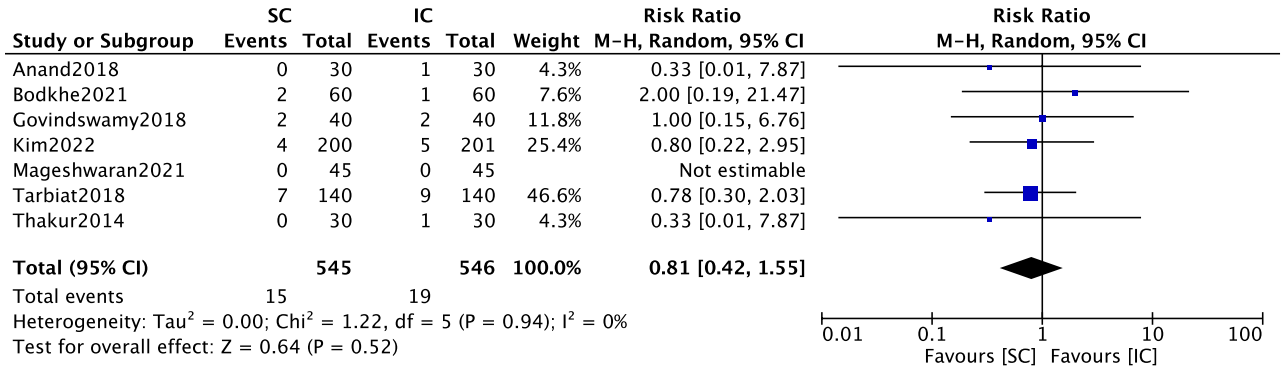


Supplementary Digital Content File 7. Forest plot of the subgroup analysis in the incidence of malposition.

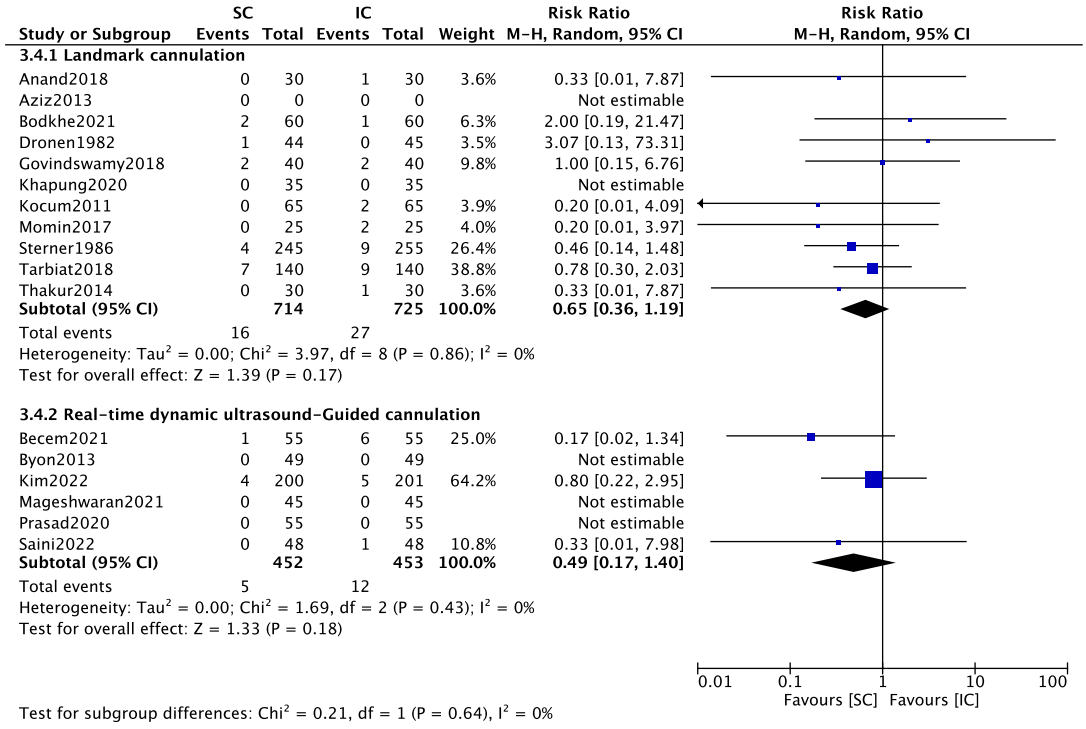
CI, confidence interval; df, degrees of freedom; MH, Mantel-Haenszel; SD, standard deviation



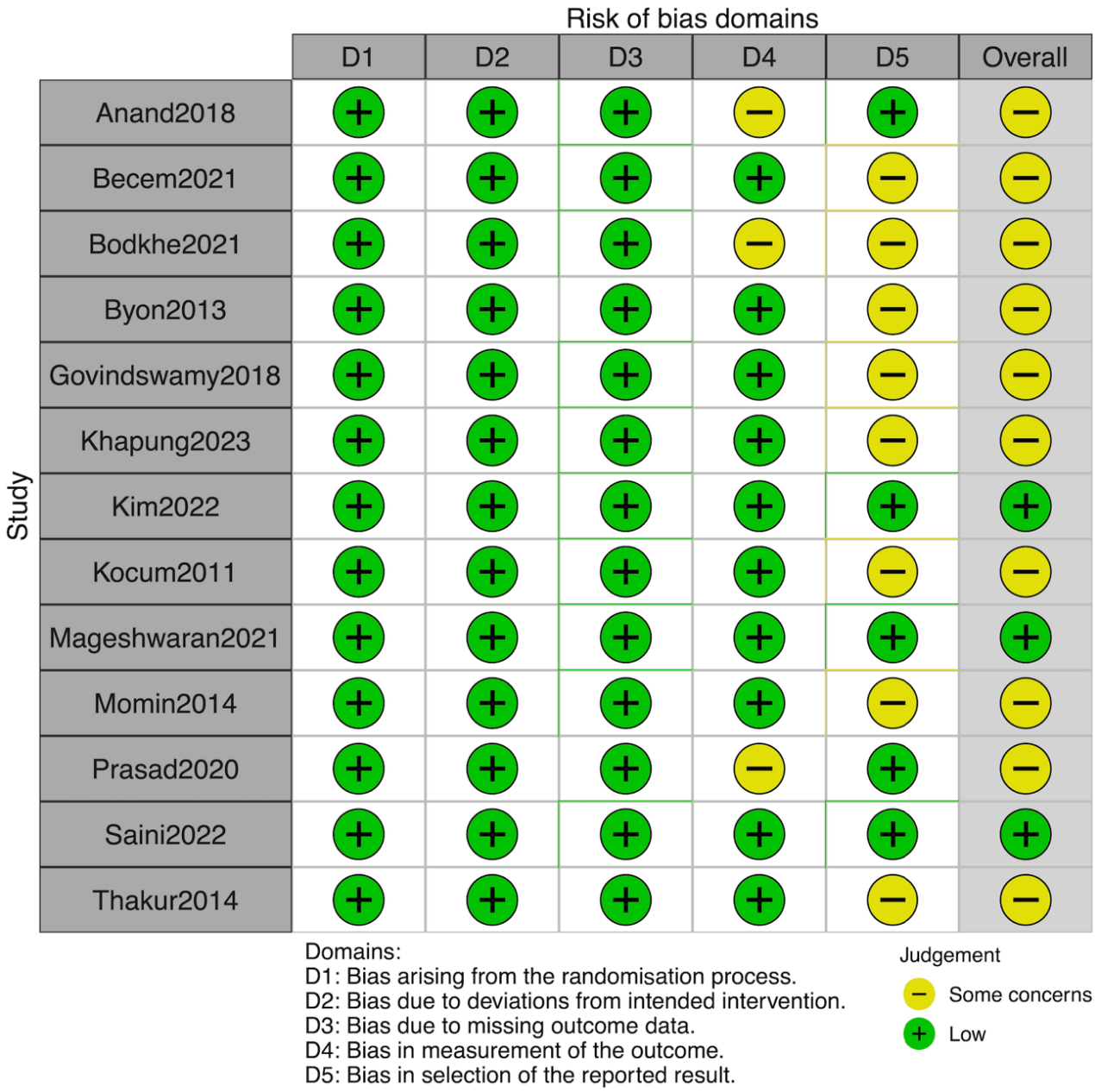
Supplementary Digital Content File 8. Risk of bias in the included studies evaluating the incidence of arterial puncture and pneumothorax



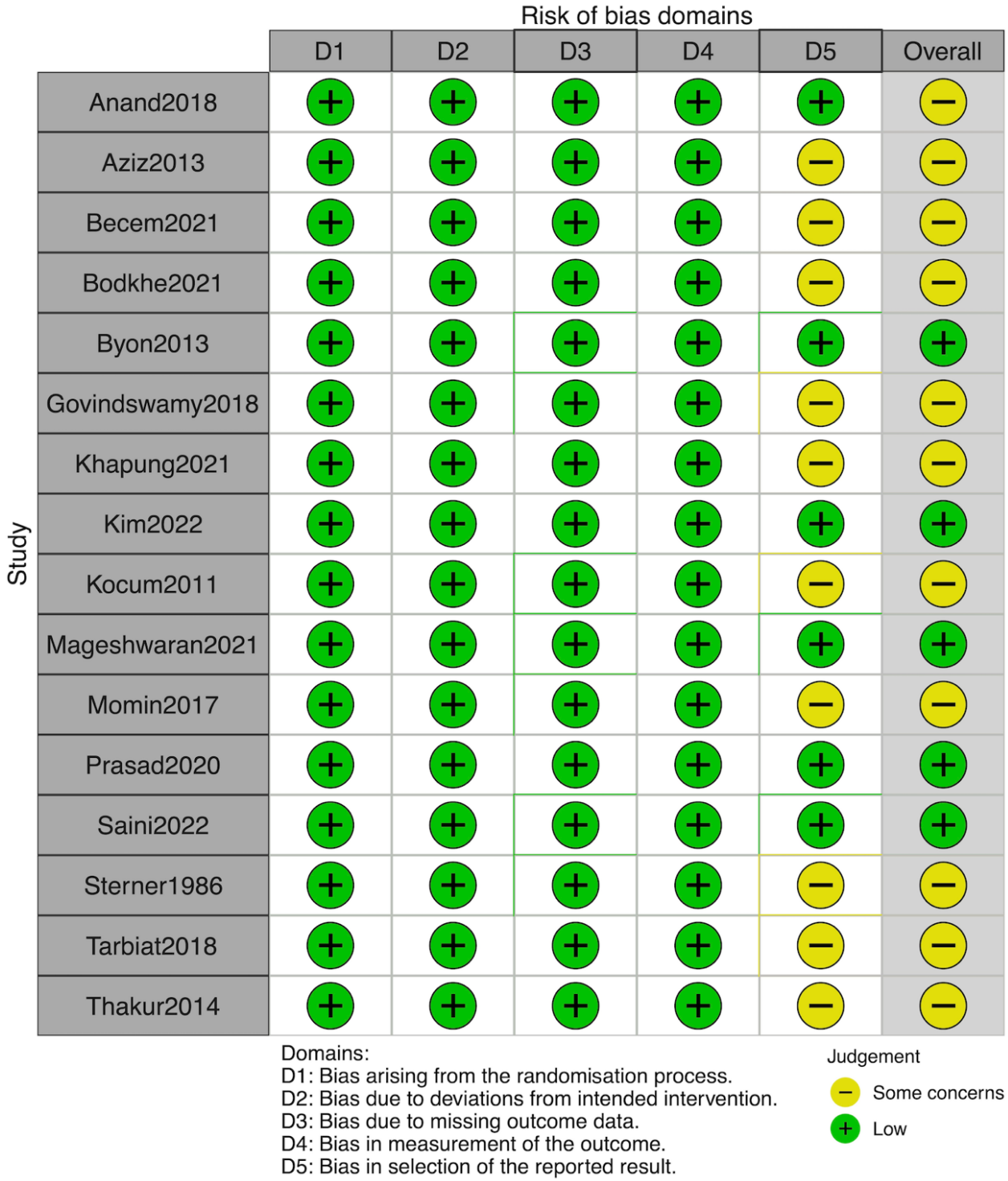
Supplementary Digital Content File 9. Forest plot of the sensitivity analysis in the incidence of arterial puncture and pneumothorax
CI, confidence interval; df, degrees of freedom; MH, Mantel-Haenszel; SD, standard deviation



Supplementary Digital Content File 10. Forest plot of the subgroup analysis in the incidence of arterial puncture and pneumothorax
CI, confidence interval; df, degrees of freedom; MH, Mantel-Haenszel; SD, standard deviation



Supplementary Digital Content File 11. Risk of bias in the included studies evaluating the access time



Supplementary Digital Content File 12. Risk of bias in the included studies evaluating the first-attempt success proportion