Systematic Review and Meta-Analysis

Comparison of the classical approach and costoclavicular approach of ultrasound-guided infraclavicular block: A systematic review and meta-analysis

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ABSTRACT

Background and Aims: The infraclavicular brachial plexus block (ICB) provides analgesia and anaesthesia of the upper limb. It is given using the classical or the more recently described costoclavicular (CC) approach at the level of cords. This systematic review aimed to assess which approach is better for the ICB in terms of onset, performance, and safety. **Methods:** This PROSPERO (vide registration number CRD42022361636) registered meta-analysis included randomised trials of patients undergoing upper limb surgery in ultrasound-guided ICB from MEDLINE, EMBASE, SCOPUS, and IRCTP from inception to March 2023. The quality of evidence was assessed using GradePro software. The primary outcomes were sensory and motor block onset time and the number of patients having complete block at 30 minutes. Secondary outcomes included block performance time (BPT), number of attempts, duration of the block, and any incidence of complications. **Results:** Five trials with 374 adult patients (classic = 185, CC = 189) were included. No significant difference was found in the sensory (Mean difference (MD): 1.44 minutes [95% confidence interval (CI): 3.06, 5.95]; I^2 = 95%; very low level of evidence (LOE); P = 0.53) and motor block onset times (MD: 0.83 minutes [95% CI: 0.96, 2.62]; I^2 = 84%; very low LOE P = 0.36) and BPT (MD: 5.06 seconds [95% CI: 38.50, 48.63]; I^2 = 98%; very low LOE; P = 0.82) in classic and CC approach of ICB. Trial sequential analysis revealed our sample size to be 0.65% of the required sample size to achieve 80% power, deeming our study underpowered. **Conclusion:** Costoclavicular approach was not superior or inferior to the classical technique for infraclavicular brachial plexus block. However, the quality of evidence is low and further studies are needed to corroborate the findings.

Keywords: Anaesthesia, analgesia, brachial plexus block, costoclavicular approach, infraclavicular brachial plexus block, nerve block, ultrasound, upper extremity

INTRODUCTION

The infraclavicular brachial plexus block (ICB), given at the level of the cords, distal to the clavicle, provides analgesia and anaesthesia of the upper limb (UL) from mid-humerus to fingertips.[1] It negates the adverse effects associated with the interscalene approach (ISB), supraclavicular block (SCB), and axillary brachial plexus block, namely, phrenic nerve palsy, Horner's syndrome, pneumothorax, and sparing of the musculocutaneous nerve.[2]

The ultrasound (USG)-guided ICB was initially performed via the classical approach, also known as the paracoracoid

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or lateral sagittal approach, with visualisation of the plexus in the parasagittal orientation, just caudal to the clavicle and medial to the coracoid process. The cords appear hyperechoic in a horse-shoe-shaped fashion around the axillary artery (AxA), with the lateral cord cephalad, the posterior cord posterior, and the medial cord appearing caudal to the artery. The block needle inserted parasagittally is forwarded posterior to the artery, and the local anaesthetic (LA) is deposited between 3 and 11 o'clock.[2]

Subsequently, a new costoclavicular (CC) approach was introduced to perform the ICB, wherein the ultrasound probe is parallel to the clavicle.[3] The anticipated advantage of the CC block is the presence of the three cords as a cluster lateral to the artery rather than the separate placement, which might lead to faster onset due to a relatively more uniform and predictable spread of LA.[3]

Though multiple studies have compared the classical and CC approaches, a review is lacking. This systematic review and meta-analysis aims to determine if the CC approach allows faster onset and better analgesia, making it superior to the classical approach of ultrasound-guided ICB in terms of efficacy and safety.

METHODS

This systemic review was reported as per Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement guidelines (Equator Network).[4] We sought randomised controlled trials (RCTs) that compared ICB's classic and CC approaches in adult patients undergoing UL surgery. The study protocol was registered with the International Prospective Register of Systematic Reviews (PROSPERO) (vide registration number CRD42022361636).

Types of studies

We included RCTs comparing the classical and CC approaches of ICB. Studies including children comparing ICB to other blocks and where the block was administered via landmark-guided technique or using a nerve stimulator without USG were excluded. The criteria included:

- Patient/population: Patients receiving infraclavi cular block
- Setting: Upper limb surgery
- Intervention: Costoclavicular approach
- Comparison: Classical approach.

Eligibility criteria

We included RCTs with adults that compared the ultrasound-guided CC and classical approaches with any volume of LA for UL surgery with or without intraoperative sedation without general anaesthesia (GA).

Outcome measures

The primary outcomes assessed were sensory and motor block onset time and the number of patients having complete block at 30 minutes. Secondary outcomes included block performance time (BPT), number of attempts and redirections, duration of the block, and any incidence of complications.

Search strategy

A systematic search was done from Embase (via OvidSP), MEDLINE, Cochrane Central Register of Controlled Trials (CENTRAL), World Health Organization (WHO), International Clinical Trials Registry Platform (ICTRP) search portal for all prospectively registered and ongoing trials, Scopus, and ClinicalTrials.gov from inception to March 2023. The strategy included the keywords "infraclavicular block", "costoclavicular block", "paracoracoid approach", "lateral sagittal approach", "ultrasound", and "upper limb". Additional hand searching was done with Google Scholar and ResearchGate using the keywords.

Selection of included studies

Two authors (HG and SK) independently screened all titles and abstracts for eligibility. They assessed the full articles of all potentially eligible RCTs for relevance based on the pre-specified inclusion criteria. Any disagreement was resolved by discussion with a third author (DJ), who decided on the inclusion or exclusion of the study. The study selection process was recorded in the PRISMA flow diagram. If further information was required to decide about the trial inclusion, PM contacted the authors of the relevant trial. We did not impose any language restrictions and included all peer-reviewed journals.

Assessment of risk of bias

Two independent reviewers assessed the risk of bias (ROB) using the Cochrane Collaboration Risk of Bias 2.0 tool (DJ, SK).[5] The domains assessed for ROB were selection bias, performance bias, detection bias, attrition bias, and reporting bias. Any discrepancies were resolved by discussion. A loss to follow-up rate of >15% was considered as the

threshold for attrition bias. The ROB was attributed a rating of low, unclear, or high risk. The overall level of evidence (LOE) for each statistically pooled outcome was assessed using the guidelines created by the Grades of Recommendation, Assessment, Development and Evaluation (GRADE) working group (https://www.gradepro.org/).[6] The LOE was classified as high, moderate, low, or very low-quality evidence.

Measurement of outcome data

For continuous data like onset time, BPT, and block duration, we calculated the mean difference (MD). The sensory and motor block onset time data were converted to minutes and the BPT to seconds.

For dichotomous outcomes like the incidence of the number of attempts and redirections, the number of patients requiring rescue and complications at 0–24 hours, the risk ratio (RR) and 95% confidence interval (CI) were calculated from a fixed-effect or random-effects model analysis depending on the presence of heterogeneity. We used a random-effects model analysis if the I^2 statistic value was greater than 50%.[5]

Data were presented as mean and standard deviation (SD). The median and interquartile range (IQR) values were converted to mean and SD using the guidelines by Hozo *et al*.[7] SDs were derived using the Cochrane Handbook, where mean values of scores and *P* values were available.[8] We considered a heterogeneity of <30% as low, 30–60% as moderate, and >60% as high.[8] Statistical significance was defined as $P < 0.05$. The risk of small study effects was assessed for all statistically pooled outcomes by creating a funnel plot. ROB, funnel, and forest plots were created using Review Manager Software (RevMan V.5.4.1). A trial sequential analysis (TSA) was done by using the TSA software [0.9.5.10 Beta, Copenhagen Trial Unit Centre for Clinical Intervention Research Department 3344, Rigs Hospitalet DK-2100 Copenhagen Ø Denmark].

RESULTS

There were 326 publications identified in the electronic database search, and 245 duplicates were removed [Figure 1]. Eighty-one studies were screened, and six RCTs in English were included in the qualitative analysis.[9-14] One study was excluded as only median values were provided without range or CI.[13] Hence, five studies were included in the final quantitative analysis. No additional studies were found by hand-searching. The total number of participants in the five studies was 374, with 185 participants in the classical group and 189 in the CC group [Table 1].

Risk of bias in included studies

The ROB judgments for the included studies are summarised in Figure 2. Four studies were deemed of high quality due to no selection bias.[9,11,12,14] Five studies provided details on the random sequence generation method,[9,12,14] but one had an unclear risk due to an inadequately described allocation method.[10]

All studies mentioned blinding of the outcome assessor[9,12,14], but three studies did not explicitly state blinding of the patient and participant, resulting in a high-risk rating.[10] One study with more than 15% attrition in one arm received an unclear ROB rating.[9]

Methodological differences between studies were identified when evaluating other potential sources of bias. One study described drug injection in a classical approach at only the 6 o'clock position, while others targeted all the cords, resulting in an unclear ROB rating.[12] These variations in methodology across studies may have implications for the assessment of block efficacy.

Table 1: Study characteristics

Study	Classical/Costoclavicular approach (*n*)	Local anaesthetic used	Intraoperative analgosedation
Leurcharusmee 2017	45/45	35 ml 1% lignocaine + 0.25%bupivacaine + epinephrine 5 µ/ml	Propofol infusion (25-80 µg/kg/min)
Songthamwat 2018	20/20	25 ml 0.5% ropivacaine	No sedation
Brown 2020	30/34	35 ml 0.5% ropivacaine	Intercostobrachial nerve block 5 ml 1.5% lignocaine for tourniquet pain
Cesur 2021	40/40	25 ml mixture 1% lidocaine + 0.25% bupivacaine	No sedation
Dost 2021	50/50	20 ml 0.5% bupivacaine	Remifentanil infusion 0.05-0.1 µg/kg/min

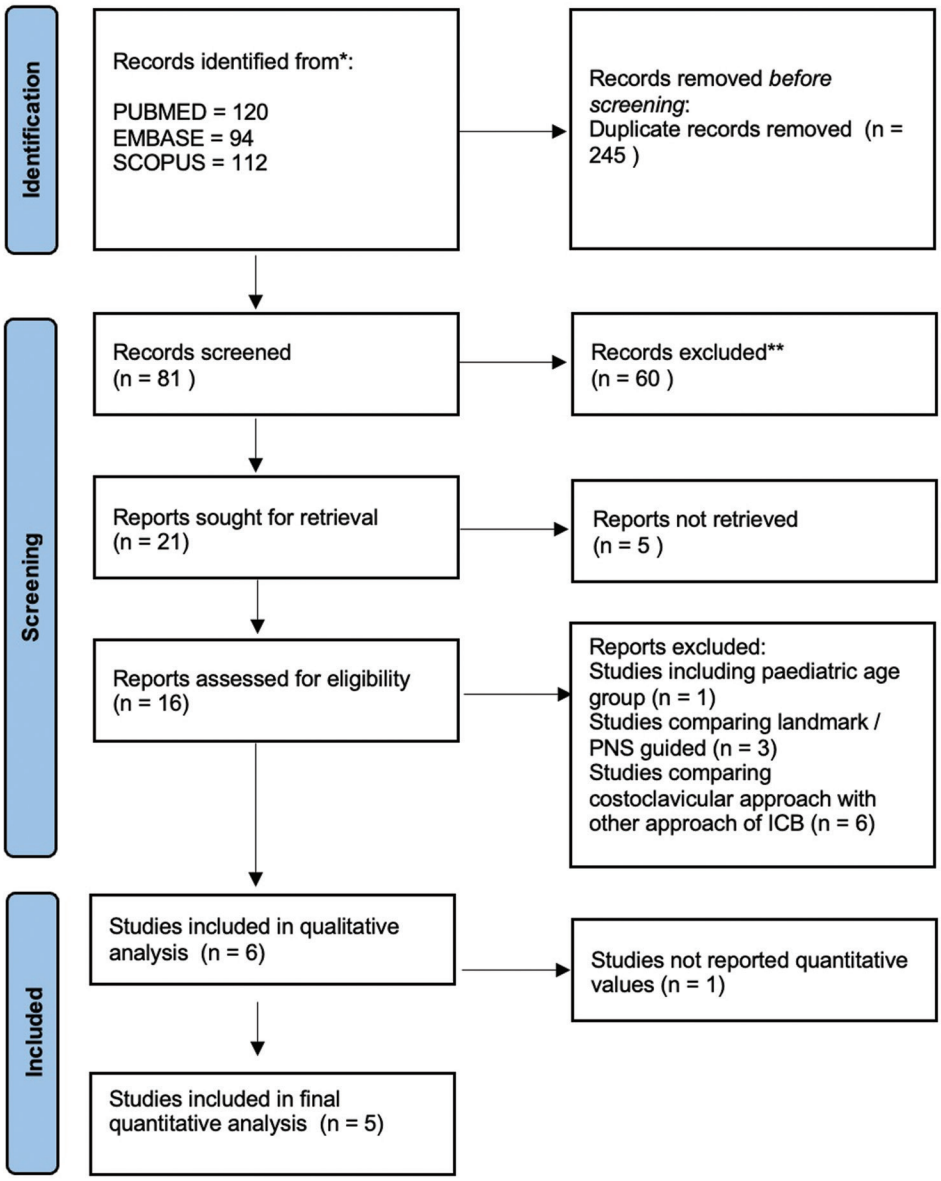

Figure 1: Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) flow diagram. ICB = infraclavicular block

Effects of interventions

Table 2 depicts the summary of the outcomes' findings.

Primary outcome

Sensory block onset time: Three studies, including 204 participants, evaluated the outcome of time to achieve the sensory blockade.[9,11,14] Two studies evaluated sensory block by loss of sensation to cold,[9,14] compared to the pinprick test in one study.[11] We did not find any difference in the sensory block onset time (MD: 1.44 min [95% CI: 3.06, 5.95]; I^2 = 95%; very low LOE; P = 0.530) [Figure 3a].

Motor block onset time: Three studies, including 204 participants, evaluated the outcome of time to achieve the motor blockade.[9,11,14] The motor blockade was assessed and graded according to a 3-point qualitative scale in two studies[9,14] and by the time of achievement of a Lovett score of 5 in at least one of the three cords in the extremity in one study.[11] No difference was found in the motor block onset time (MD: 0.83 min [95% CI: 0.96, 2.62]; I^2 = 84%; very low LOE; P = 0.36) [Figure 3b]. Trial sequential analysis revealed our sample size to be 0.65% of the required sample size to achieve 80% power, deeming our study to be underpowered [Figure 4].

Sensorimotor block onset time: Two studies evaluated the block onset time as the time required to obtain more than 14 points after the end of LA injection

through the block needle via a composite sensorimotor score.[10,12] The onset time was significantly shorter in the CC group (MD: 1.53 min [95% CI: 0.16, 2.90]; I^2 = 0%; low LOE; P = 0.03) [Figure 3c].

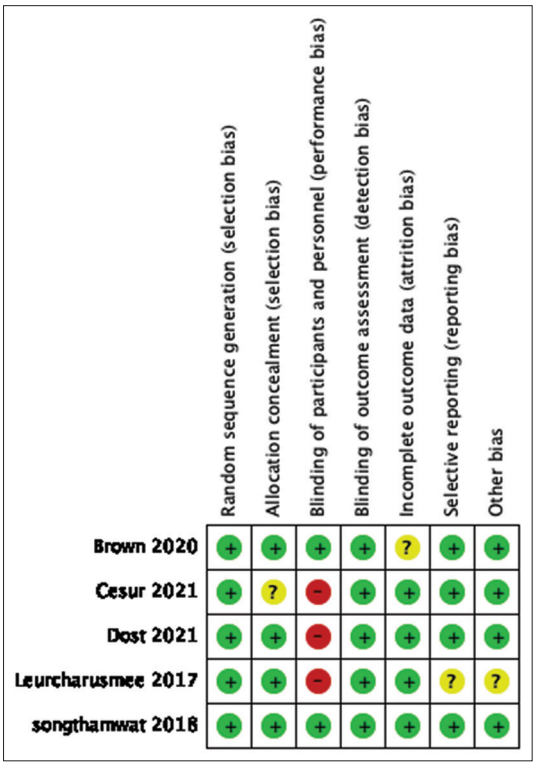

Figure 2: Risk of bias in included studies

Number of patients having complete block at 30 minutes: Three studies gave data on the number of patients attaining complete sensory and motor block at 30 minutes.[9,12,14] In one study, the average of four values for different nerves was taken and rounded up to the nearest integer.[12] No significant difference was found between the two groups for sensory block (RR 0.96 [95% CI: 0.79, 1.17], I^2 = 65%; low LOE; P = 0.72) [Figure 5a] and motor block (RR 0.96 [95% CI: 0.85, 1.07], I^2 = 0%; moderate LOE; P = 0.45) [Figure 5b].

Secondary outcomes

Block performance time (BPT): Three studies (n = 234) evaluating the imaging time did not find any difference between the groups (MD: 3.93 seconds [95% CI: -11.02, 3.16]; I^2 = 87%; very low LOE; P = 0.28) [Figure 6a].[9,10,12] BPT was defined as the time from insertion of the needle into the skin until the block needle was removed from the skin after procedure completion,[11,13] the time taken from the start of the local skin infiltration to the end of the LA injection,[12,14] and the time elapsed from the local

Table 2: Summary of the findings of the outcomes

Outcomes	Anticipated absolute effects* (95% CI)		Relative effect (95% CI)	Number of participants (studies)	Certainty of the evidence (GRADE)	Comments
	Risk with costoclavicular approach	Risk with classical approach				
Sensory block onset time (minutes)	Mean sensory onset was 0	MD 1.44 higher (3.06 lower to 5.95 higher)	-	204 (3 RCTs)	⊕◯◯◯ Very low[a,b]	
Sensorimotor block onset time (minutes)	Mean sensorimotor onset time was 0	MD 1.53 higher (0.16 higher to 2.9 higher)	-	170 (2 RCTs)	⊕⊕◯◯ Low[c]	
Motor block onset time (minutes)	Mean onset time was 0	MD 0.83 higher (0.96 lower to 2.62 higher)	-	204 (3 RCTs)	⊕◯◯◯ Very low[a,b]	
Complete sensory block at 30 minutes	838 per 1,000	805 per 1,000 (662 to 981)	RR 0.96 (0.79-1.17)	194 (3 RCTs)	⊕⊕◯◯ Low[b,d]	
Complete motor block at 30 minutes	869 per 1,000	834 per 1,000 (738 to 929)	RR 0.96 (0.85-1.07)	194 (3 RCTs)	⊕⊕⊕◯ Moderate[d]	
Imaging time (seconds)	Mean imaging time was 0	MD 3.93 lower (11.02 lower to 3.16 higher)	-	234 (3 RCTs)	⊕◯◯◯ Very low[b,e]	
Block performance time (seconds)	Mean needling time was 0	MD 5.06 higher (38.5 lower to 48.63 higher)	-	374 (5 RCTs)	⊕◯◯◯ Very low[b,f]	

Grading of Recommendations Assessment, Development and Evaluation (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.

Explanations:
a. Out of the three studies, one study (Dost 2021) showed high risk of bias and one study (Brown 2020) showed unclear risk of bias
b. High heterogeneity was seen across all studies
c. Two studies (Cesur 2021, Leurcharusmee 2017) showed high risk of bias
d. Out of the three studies, one study (Leurcharusmee 2017) showed high risk of bias and one study (Brown 2020) showed unclear risk of bias
e. Two studies (Cesur 2021, Leurcharusmee 2017) showed high risk of bias and one study (Brown 2020) showed unclear risk of bias
f. Three out of five studies (Cesur 2021, Dost 2023, Leurcharusmee 2017) showed high risk of bias and one study (Brown 2020) showed unclear risk of bias
*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). RR=relative risk; CI=confidence interval; MD=mean difference, RCT=randomized controlled trials

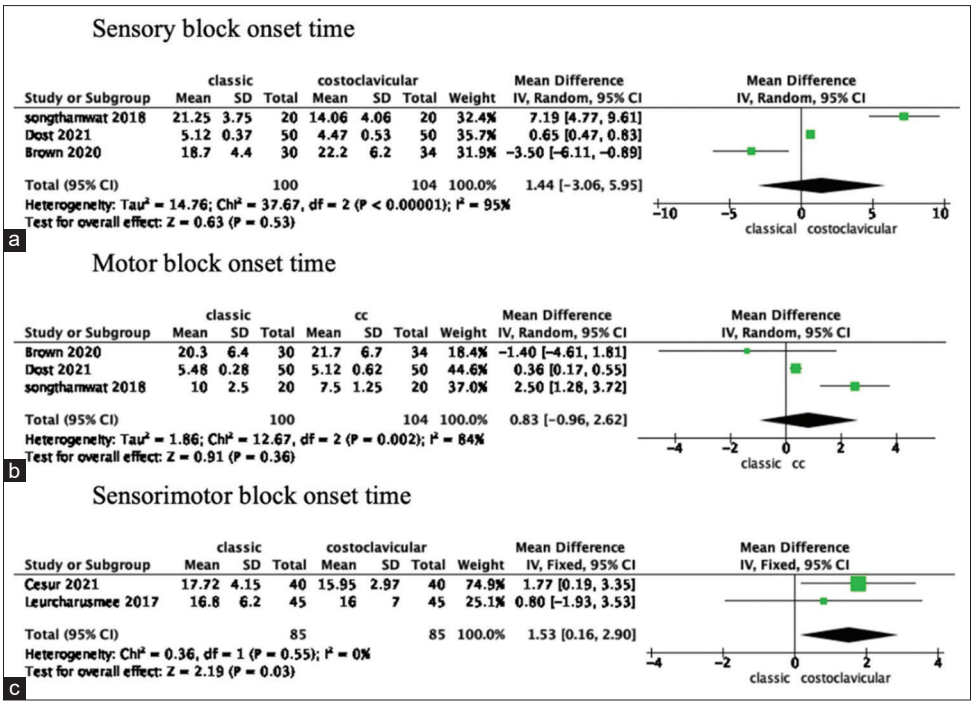

Figure 3: Forest plot of comparison: Block onset time-(a) sensory block onset time, (b) motor block onset time, (c) sensorimotor block onset time. CI = confidence interval, SD = standard deviation, CC = costoclavicular approach

skin infiltration to the end of LA injection in another study.[10] One study did not define needling time.[9] However, the total performance time was described in the two studies, including both imaging and needling time.[9,12] Only needling time was included in the analysis for BPT. No difference was seen in the BPT (mean needling time) between both groups (MD: 5.06 seconds [95% CI: -38.50, 48.63]; I^2 = 98%; very low LOE; P = 0.82) [Figure 6b].

In two studies, the total performance time showed a significant difference with lesser time in the classical block group (MD: -30.08 seconds [95% CI: -53.98, -6.18]; I^2 = 0%; P = 0.010)[9,12] [Figure 6c].

Number of attempts and redirections: The number of needle attempts was defined in one study and was similar in both groups (one in 50 patients).[11] Needle redirection, defined as the number of attempts required to withdraw and redirect the needle without complete withdrawal from the skin, was evaluated in two studies.[11,12] The MD in the number of needle redirections was not different in the CC and classical groups in two studies, including 190 participants (RR 1.00 [95% CI: 0.30, 3.35]; I^2 = 0%, P = 1.00).

Number of patients having inadequate surgical anaesthesia: Inadequate surgical anaesthesia was defined as the need for intravenous narcotics, GA, rescue blocks, or LA infiltration by the surgeon in three studies.[9,11,12] No difference was observed in the two groups (RR 0.61 [95% CI: 0.25, 1.51]; I^2 = 0%, P = 0.29).

Duration of block: Sensory block: The CC group showed a lower duration of the sensory block than the classical group in only one study.[11]

Motor block: Two studies assessing the duration of the motor block did not find any statistically significant difference in the two groups [MD: 0.68 minutes (95% CI: -44.64, 46) I^2 = 95%; P = 0.98].[10,11]

Complications paraesthesia – Three studies reported no significant difference in the incidence of paraesthesia between the two groups (RR 1.08 [95% CI: 0.65, 1.80]; I^2 = 35%; P = 0.76).[9,12,14]

Vascular puncture – No significant difference was observed between the two groups in the incidence of vascular puncture in three studies (RR 3.80 [95% CI: 0.64, 22.53]; I^2 = 0%; P = 0.14).[9,12,14]

Horner's syndrome – No significant difference was observed between the two groups in two studies on the incidence of Horner's syndrome (RR 1 [95% CI: 0.21, 4.84]; I^2 = 55%; P = 1.0).[12,14]

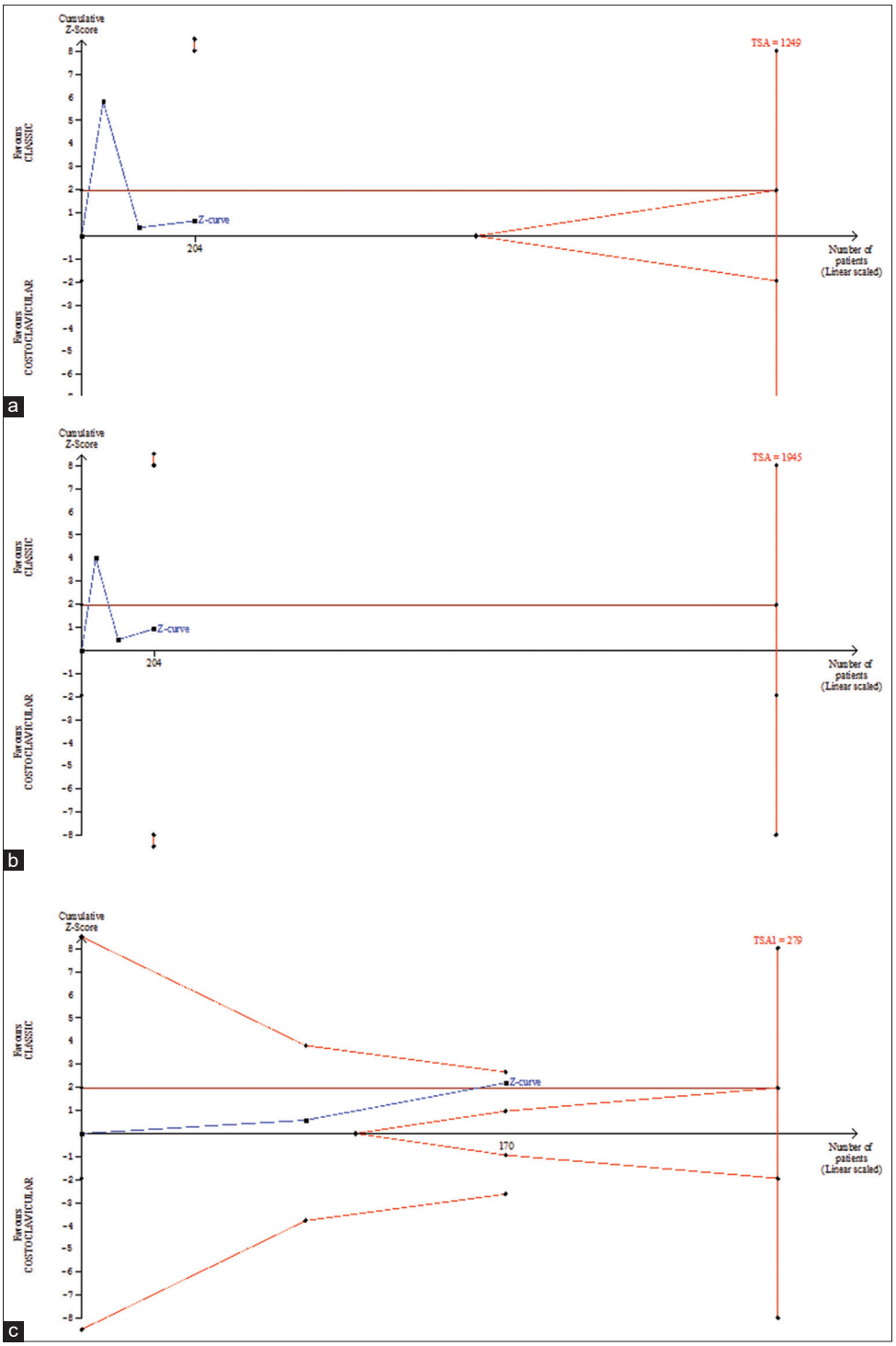

Figure 4: Trial Sequenatial Analysis. (a) Sensory block. (b) Motor block. (c) Sensorimotor block

Other complications – One patient in the CC group developed LAST and required intralipid for resuscitation in one study.[9] While patient follow-up one week after the surgery revealed no persistent sensory or motor deficits in one study,[12] weakness (0/30 VS 2/34; $P = 0.160$) and persistent paraesthesia (5/30 VS 6/34; $P = 0.920$) in classical and CC groups, respectively, were found in one study after a follow-up of 7 days.[9] The incidence of hemi-diaphragmatic paralysis was similar in both groups (4/45) in one study.[12] No significant complications were observed directly related to the technique or LA injection in the two studies.[10,11] The incidence of pneumothorax was not seen to be increased with the CC approach in another study.[11]

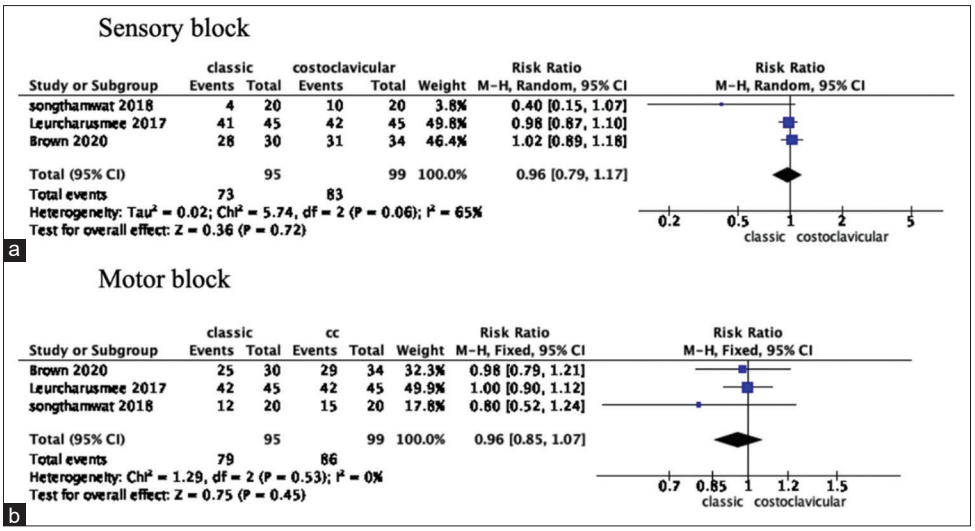

Figure 5: Forest plot of comparison: Number of patients with complete block at 30 minutes. (a) complete sensory block, (b) complete motor block. CI = confidence interval, SD = standard deviation, CC = costoclavicular

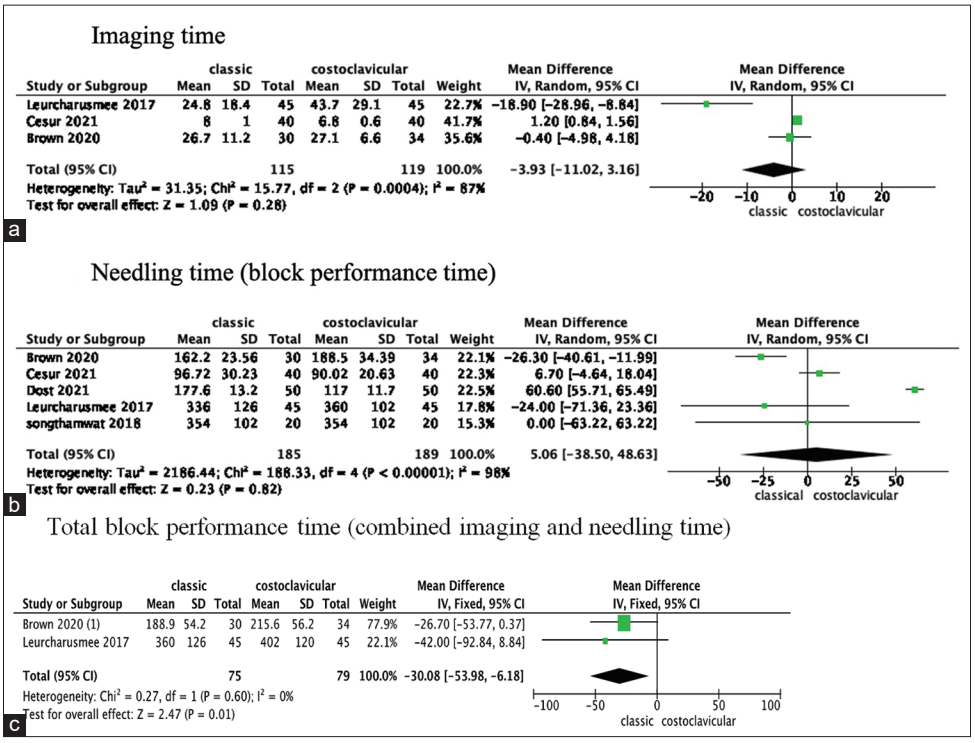

Figure 6: Forest plot of comparison: Block performance time. (a) Imaging time, (b) block performance time, (c) total block performance time comprising combined imaging and needling time. CI = confidence interval, SD = standard deviation

DISCUSSION

This meta-analysis, encompassing five studies with 374 participants, revealed no significant disparities in motor and sensory block onset times, complete sensory and motor block achievement at 30 minutes, BPT, or complications between the classical and CC approaches in ICB for adult patients. Notably, the overall LOE for most outcomes was low [Table 2].

Sensory and motor block onset times exhibited no significant differences between classical and CC groups in three studies, albeit with considerable heterogeneity and a very low LOE.[9,11,14] The heterogeneity could be explained by varied methods used to evaluate the sensory and motor blockade across different studies. A mean difference of 1.53 minutes in sensorimotor onset time lacks clinical significance. Although two studies[9,12] demonstrate a statistically

higher proportion of initially faster sensory blocks in the CC group, this may be attributed to the larger LA volume (35 mL) and faster spread in the compact CC space.[15]

Dose variations in LA across studies underscore the lack of standardisation in classical and CC approaches. A dose-finding study in USG-guided CC block found 19 ml of 0.5% ropivacaine effective for surgical anaesthesia in 95% of patients.[16] Another study found 14 mL as the minimum effective volume (MEV) for 0.5% bupivacaine, albeit with a longer onset time of 40 minutes in the USG-guided classical ICB approach.[17] Tran *et al*.[18] established the MEV90 for ultrasound-guided classical ICB as 35 ml using 1.5% lidocaine with 5 μg/mL epinephrine.

Sivapurapu *et al*.[19] studied alternative approaches to the classical block with the assumption that the classical approach is at a disadvantage due to steeper needle trajectory causing decreased visibility of the needle while increasing procedural time and needle-nerve contact. While uniformity was observed in the injection technique used to administer the CC block in our analysis, a significant discrepancy was noted in the administration of the classical ICB as two studies utilised a single injection technique [12,14] Brown *et al*.[9] used a two-injection, and Dost *et al*.[11] used triple-injection technique. This poses a limitation while evaluating the BPT, the total dose of LA used, and the assessment of block onset thereafter.

Despite the hypothesis of shorter BPT with the CC approach due to the presence of the cords clustered in a compact space, our meta-analysis reveals no difference in BPT between both approaches, reflecting substantial heterogeneity due to varied BPT assessments. BPT has been defined differently across studies, considering the time from needle insertion to removal or skin infiltration to LA injection completion.[10-12,14] Notably, the classical approach group exhibits a significantly shorter total performance time, encompassing imaging and needling.[9,12] This discrepancy may be attributed to increased familiarity and experience with the classical approach.[9,12] Further studies are needed to evaluate a consistent approach in defining and measuring BPT to warrant its assessment as a primary outcome.

In the classical approach, cords around the axillary artery demand more needle manipulation than in the CC approach, where cords are bundled superiorly lateral to the artery.[1] In the CC approach, the lesser user experience may have resulted in inadequacies regarding additional analgesia or conversion to GA with both ICB approaches.[9,11,12] However, in our included studies, the number of needle redirections did not differ between classic and CC groups.[11,12] This again poses a challenge to generalisability due to insufficient participants in the analysis.

ICB has been reported to be a safer block when compared to ISB and SCB in terms of lower incidence of complications like Horner's syndrome, vascular injury, pneumothorax, and hemidiaphragmatic palsy. Both approaches showed similar safety profiles in our analysis. Using ultrasound guidance likely contributed to an overall reduction in complications associated with block performance.

Limitations of this meta-analysis include a small sample size comprising five studies. Heterogeneity in outcome definitions is noted, leading to low evidence grading—the use of varied types, concentrations, and volumes of LA results in inconsistent onset and duration measurements. Inconsistent follow-up methods pose limitations in ascertaining the actual sensorimotor block duration between the two techniques. The underutilisation of emerging techniques, such as the CC approach, is noted due to the lack of definitive evidence of superiority.[20] Addressing these limitations is essential for informed clinical practice and further research in ICB techniques.

CONCLUSIONS

Compared to the classical approach in patients undergoing upper limb surgery under infraclavicular brachial plexus block, the costoclavicular approach showed no statistically significant difference in block onset times, block performance time, and complications. However, the evidence for these outcomes is low and further studies are needed to evaluate the findings of the present meta-analysis.

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Conflicts of interest
There are no conflicts of interest.

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