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ORIGINAL ARTICLE

Ultrasound-Guided Supraclavicular Brachial Plexus Block: A Decade of Advancements in Efficacy, Safety, and Clinical Outcomes – An Updated Systematic Review and Meta-Analysis

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Introduction Ultrasound-guided regional anesthesia has been the go-to choice for most upper limb surgical procedures. Traditionally, anesthetists have preferred the supraclavicular brachial plexus block (SCB) over the infraclavicular approach due to the lower complication rate. In the wake of ultrasound guidance, all these procedures have become less cumbersome. Therefore, this systematic review aimed to critically appraise the evidence on the comparative efficacy and safety of ultrasound-guided SCB (USG-SCB) to other brachial plexus blocks and provide a summary.

Methods We carried out a comprehensive literature search on three databases, i.e., Cochrane Central Register for controlled trials (CENTRAL), PubMed, and Science Direct, for all the relevant articles on the use of USG-SCB. Studies were then included in the review according to the inclusion criteria. The Review Manager (RevMan 5.4) was then used in the statistical analysis.

Results The comprehensive search found 582 articles, among which 30 met our inclusion criteria for this study. Our statistical synthesis found statistically insignificant block success rates (OR 1.15; 95% CI [0.63, 2.08] p= 0.65) and the procedure time (MD -0.15min; 95% CI [-1.00, 0.70] p= 0.73) between the USG-SCB and the other approaches to brachial plexus block. While overall the incidence of adverse events such as Horner's syndrome (OR 3.08; 95% CI [0.76, 12.48] p= 0.12) and vascular puncture (OR 0.65; 95% CI [0.27, 1.55] p= 0.34) was not significantly different between USG-SCB and the other approaches combined, a subgroup analysis indicated that the incidence of adverse events was significantly higher in USG-SCB compared to ultrasound-guided infraclavicular brachial plexus block (USG-ICB) and ultrasound guided costoclavicular block (USG-CCB). However, the ultrasound-guided interscalene block (USG-ISB) was associated with a significantly higher incidence of adverse events than the USG-SCB.

Conclusions These study findings showed that the USG-SCB has not significantly different efficacy to the other ultrasound-guided brachial plexus blocks. However, it is associated with a higher incidence of adverse events than the other blocks, apart from the USG-ISB. Therefore, the choice of this method of regional anesthesia should be made by considering its advantages and disadvantages.

Keywords Anesthesia, Brachial plexus blockade, Infraclavicular brachial plexus block, Supraclavicular brachial plexus block, Ultrasound-guided costoclavicular block.
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INTRODUCTION

There are various approaches in which the brachial plexus blockade (BPB) can be accomplished, with the most common being approaches to the clavicular and axillary spaces [1]. Moreover, there are different ways in which the blockade can be achieved, with multiple injections being favored as they achieve more effective BPB [2].

The use of ultrasound is currently widely applied in various medical procedures. In BPB, the US has been verified to determine the brachial plexus, enabling anesthesiologists to direct the needle and precisely target the brachial plexus while observing in real time [3]. Moreover, it allows the physician to visualize how the local anesthetics spread in real time [3,4]. Ultrasound-guided BPB using the supraclavicular approach effectively achieves analgesia and anesthesia for various upper limb procedures [4]. The supraclavicular approach is well-recommended among the methods as it's associated with faster onset times, better block success rates, and lower risks of complications [3].

While previous systematic reviews have compared the various ultrasound-guided BPB approaches, including SCB, none of them have comprehensively analyzed the efficacy of SCB compared to the other methods, incorporating all the latest evidence [2,5]. Therefore, this systematic review and meta-analysis summarize the existing literature evidence about the efficacy of SCB in providing analgesia and anesthesia for various upper limb approaches. Additionally, we strive to analyze the comparative effectiveness of the different techniques used in SCB and thus offer recommendations on the most effective way to achieve SCB.

METHODS

We adhered to the guideline of “PRISMA 2020 (Preferred Reporting Items for Systematic Reviews and Meta-Analyses)” [6]. The review protocol was not registered in any of the databases.

Literature search:

Two reviewers used two approaches to carry out the electronic search on three electronic databases, namely, ScienceDirect, Cochrane Central Register for controlled trials (CENTRAL), and PubMed, for all the relevant articles published until April 2025. The search criterion for the first approach was defined by the reviewers for each of the electronic databases. The criterion contained keywords combined using Boolean operators. The keywords applied to the PubMed database were as follows: ("Ultrasound Guidance" OR "Ultrasound Guided") AND ("supraclavicular") AND (Infraclavicular OR Costoclavicular OR "retro clavicular" OR Axillary) AND ("Brachial plexus block"). The keywords were then applied to the other two remaining databases. After the database search, the second approach involved manually reviewing the references of the already found articles for additional studies that the initial electronic search would have missed.

Eligibility criteria:

All the articles that were retrieved from the database search were then assessed against the reviews' eligibility criteria. The studies that met the set conditions were then used for the data extraction of the study and subsequently included in the review. The inclusion criteria for the review were as follows:

1. Studies that included patients undergoing procedures of the upper limb.
2. Studies that included ultrasound-guided supraclavicular block for either analgesia or anesthesia.
3. Studies that included a comparator to ultrasound-guided supraclavicular block.
4. Studies designed as interventional studies.
5. Studies that reported outcomes of USG-SCB.

All the studies that fall under exclusion criteria below were subsequently excluded:

1. Studies that were published in languages other than English.
2. Studies that did not include USG-SCB as one of the interventions.
3. Studies that did not report any of the required outcomes.
4. Studies designed as single-arm studies.
5. Secondary studies, including other systematic reviews, meta-analyses, narrative reviews, and editorials.

Data extraction:

Two reviewers independently conducted the data extraction for the review. In case there was any lack of consensus during the data extraction process, the two reviewers discussed the arising discrepancies until they reached a consensus. Per the PRISMA guidelines, the authors reviewed all the references obtained through various phases before data extraction. The initial phases

entailed abstract screening for the relevance of the articles, after which all irrelevant articles were eliminated. All the relevant articles were retrieved from the respective journals and then assessed against the eligibility criteria before inclusion or exclusion from the review. Data was only extracted from the studies that met the inclusion criteria. The information obtained from each article included the first author's last name and the year, the setting of the study and its design, its inclusion criteria, the characteristics of the sample, including the sample size, mean age, and male-to-female ratio. Procedural characteristics were also extracted, including the drug used, the approach used, the injection technique, and the reported outcomes of the study.

Quality assessment:

The risk of bias (ROB) of the randomized controlled trials (RCTs) was assessed using the ROB tool (ROB-2). Using this tool, the reviewers analyzed the ROB in five domains, including the ROB due to the randomization process, the blinding of the study, the measuring of the outcomes, outcome reporting, and deviation from the intended interventions. A summary of the ROB was then presented using a figure.

Statistical analysis:

We collected and synthesized data from the selected articles using the Review Manager 5.4.1 software. The continuous outcomes were analyzed using the mean difference (MD) and 95% confidence interval (CI). On the other hand, we utilized the risk ratios (RRs), odds ratios (ORs), and corresponding 95% CIs for dichotomous variables. The heterogeneity among the reported outcomes was assessed using the I2 statistic. Statistical significance of any of the differences observed in any of the analyzed outcomes was indicated by a p-value <0.05.

RESULTS

Literature search outcome:

Our literature search yielded 582 articles, among which 342 were duplicates and thus were excluded from the study. This led to 240 abstracts being screened. After the abstract screening, 137 were deemed irrelevant to the topic of study and were thus excluded from the study, and we sought to retrieve 166 articles. All the articles sought after were retrieved and assessed for eligibility for our review. After the eligibility assessment, 30 articles were included. The reasons for exclusion of the remaining studies were as follows: 9 were published in languages other than English, 14 were non-randomized studies, 17 did not include SCB as one of the approaches to BPB, 12 were other secondary studies, and 22 did not have any of the outcomes of interest. The search strategy was then summarized using a PRISMA diagram as shown in Figure (1).

Characteristics of the selected studies:

We included RCTs from different countries in North America, Asia, and New Zealand. All the trials included USG-SCB, which was compared to USG-ICB, USG-CCB, USG-ISB, and ultrasound-guided retroclavicular approach (USG-RCB). The drugs used as local anesthetics across the studies included lidocaine with epinephrine, ropivacaine, mepivacaine, bupivacaine, and levobupivacaine. Detailed aspects of the selected studies are shown below (Table 1).

ROB assessment outcomes:

The outcomes of the evaluated ROB for the selected RCTs are shown in Figure (2). Only three studies did not provide detailed information regarding all five domains [18,22,24]. Arcand *et al*., [22]. selection of reported outcomes had selective reporting which might have led to high ROB in this domain. Nevertheless, the study had low ROB among other domains. Conversely, El-Sawy *et al*., [18]. and Kapral *et al*., [24]. had “some concerns” under missing outcome info and outcome assessment domains, respectively.

Block success rate:

Fourteen of the included studies compared the success rates of USG-SCB and other approaches to BPB. Our analysis found that the success rate of USG-SCB was not significantly different to that of other USG BPB (OR 1.15; 95% CI [0.63,2.08], p= 0.65). There was moderate heterogeneity across the studies. We did a subgroup analysis to compare USG-SCB to the other approaches. Similarly, we found that the success rate of USG-SCB was not significantly different to that of USG-ICB (OR 0.91; 95% CI [0.46, 9.81] p= 0.79), USG-AXB (OR 3.52; 95% CI [0.56, 22.06] p= 0.18), USG-ISB (OR 1.13; 95% CI [0.20, 6.39] p= 0.89), and USG-CCB (OR 0.98; 95% CI [0.06, 16.09] p= 0.99) (Figure 3).

Block performance time:

Fourteen of the included studies reported the block performance time of the USG-SCB compared to the other approaches. A pooled analysis of the outcomes reported outcomes, found that the performance time of the USG-SCB was not significantly different to those of different approaches to BPB (MD -0.15min; 95% CI [-1.00, 0.70] p= 0.73). The performance time was highly heterogeneous across the studies, I2= 94%. A subgroup analysis found that the performance time of USG-SCB was significantly shorter than that of CCB (MD -0.37min; 95% CI [-0.65, -0.09] p= 0.73). On the hand the performance time of USG-SCB was not significantly different to that of USG-ICB (MD -0.02min; 95% CI [-1.62, 1.59] p= 0.98), USG-AXB (MD -0.07min; 95% CI [-4.87, 4.73] p= 0.98), USG-ISB (MD -0.43min; and 95% CI [-1.35, 0.50] p= 0.36 (Figure 4).

Table 1: The characteristics of the included studies:

Author ID	Study design	Setting	Inclusion criteria	Approach	Sample size	Mean age	Male: Female	Drugs	Outcomes.
Tran *et al.,* 2009 [7].	RCT	Canada	Patients undergoing hand, wrist, elbow, and forearm surgery.	SCB	40	40±18	25:15	1.5% Lidocaine with 5µg epinephrine.	Block performance and incidence of adverse events.
				ISB	40	42±16	25:15		
				AB	40	51±17	21:19		
Petrar *et al.,* 2015 [8].	RCT	Canada	Patients undergoing right upper limb surgery.	SCB	32	40(28-52)	21:11	0.5% ropivacaine	Scan time, needle time, and incidence of diaphragmatic paralysis.
				ICB	32	37(25-55)	20:12		
Yazer *et al.,* 2015 [9].	RCT	Canada	Patients undergoing hand, wrist, elbow, and forearm surgery.	Targeted intracluster injection (TII) SCB	32	44.6±15.8	23/9	1.5% Lidocaine with 5µg of epinephrine	Onset time, rates of surgical anesthesia, needle passes, and incidence of complications.
				ICB	32	43.1±16.5	20/12		
Bharti *et al.,* 2015 [10].	RCT	India	Patients undergoing forearm and upper arm surgery.	SCB	21	34±14	14:7	0.5ml/kg of 2% lignocaine-adrenaline (1:200,000) and 0.75% ropivacaine mixed in equal volumes.	Block performance data, onset and duration of sensory and motor blocks, and incidence of adverse events.
				ICB	20	36±12	12:8		
				ISB	19	37±15	11:8		
Dhir *et al.,* 2018 [11].	RCT	Canada	Patients scheduled for ambulatory elbow surgery.	SCB	73	50.6±15.6	51:22	35mL of ropivacaine 0.5%.	Sensory block success, procedure time, and complications.
				ICB	71	47.8±15.3	49:22		
Narayanan *et al.,* 2022 [12].	RCT	India	Adults scheduled for hand, wrist, elbow, and forearm surgery.	SCB	20	39.1±16.88	11:9	30mL of bupivacaine 0.25%.	Motor block scores, block performance time, and analgesia duration.
				ICB	20	31.60±14.17	14:6		
Yang *et al.,* 2010 [13].	RCT	South Korea	Adult patients scheduled for surgery of the elbow, hand, or forearm.	SCB	50	49±18	24/26	30mL of ropivacaine 0.5%.	Sensory and motor block quality and duration, and incidence of adverse events.
				ICB	50	46±18	28/21		
Fredrickson *et al.,* 2009 [14].	RCT	New Zealand	Patients scheduled for surgeries of the hand and wrist.	SCB	30	52:14	5:25	30mL of lidocaine 2% with adrenaline (1:200,000)	Onset of sensory and motor blockade, block success rate, and incidence of adverse events.
				ICB	30	47:15	9:21		
Vazin *et al.,* 2016 [15].	RCT	Denmark	Adult patients scheduled for surgery of the elbow, hand, or forearm.	SCB	40	59±26	NR	20mL of ropivacaine 0.75%.	Time to sensory block, total-anesthesia related time, duration of analgesia, success rate, and incidence of adverse events.
				ICB	40	52±38	NR		
				AB	40	60±35	NR		
Auyong *et al.,* 2017 [16].	RCT	USA	Patients scheduled for shoulder arthroplasty	SCB	25	73.7±7.3	12:13	Ropivacaine 0.2%	Block performance data and postoperative pulmonary function.
				ICB	25	69.8±10.3	12:13		
				ISB	25	73.2±7.3	7:18		
Guru *et al.,* 2023 [17].	RCT	India	Patients undergoing below-elbow upper limb surgeries	SCB	30	NR	15:15	30ml of 0.5% bupivacaine	Block performance data
				ICB	30	NR	21:9		
Elsawy *et al.,* 2014 [18].	RCT	Egypt	Patients scheduled for arteriovenous fistula creation	SCB	30	44.4±11.3	18:12	1:1 volumes of 0.5% bupivacaine and 2% lidocaine	Block performance data and adverse events.
				ICB	30	47.83±7.80	17:13		
Harrison *et al.,* 2015 [19].	RCT	USA	Patients scheduled for upper extremity surgery at or distal to the elbow.	SCB	21	60(34-69)	4:17	30 mL of mepivacaine 2% epinephrine 2.5µg/mL.	Onset time, procedure time, and procedure-related discomfort.
				ICB	24	62(38-65)	1:23		
Gurav *et al.,* 2021 [20].	RCT	India	Adult patients undergoing forearm, distal arm, and hand surgery were included.	SCB	40	32.40±11.25	32/8	30mL of bupivacaine 0.5%, with 5 µg of dexmedetomidine.	Anesthesia data and changes in mean arterial pressure and heart rate during surgery.
				ICB	40	33.53±14.21	32/8		
Abhinaya *et al.,* 2017 [21].	RCT	India	Adult patients undergoing forearm, distal arm, and hand surgery were included.	SCB	30	32.40±11.25	22:8	30mL of ropivacaine 0.5%.	Anesthetic data and changes in vitals during surgery (Heart rate and blood pressure)
				ICB	30	33.53±14.21	22:8		
Arcand *et al.,* 2005 [22].	RCT	Canada	Adult patients undergoing surgery of the forearm, distal arm, and hand were included in the review.	SCB	40	48±16	29/11	0.5% bupivacaine and 2% lidocaine with 1:200,000 epinephrine mixed in a 1:3 ratio	Block performance time, block related pain, sensory, and motor block.
				ICB	40	45±14	27/13		
Nielsen *et al.,* 2009 [23].	RCT	Denmark	Patients undergoing upper extremity surgery.	SCB	60	44.8±17	41/19	A mixture of mepivacaine 20mg/mL with 5µg/mL adrenaline and ropivacaine 7.5mg/mL.	Block performance data and transient adverse events.
				ICB	60	51.1±16.9	38/22		
Kapral *et al.,* 1994 [24].	RCT	Austria	Patients undergoing hand or forearm surgery	SCB	20	NR	NR	30 mL of 0.5% ropivacaine. (Mixed with 10 mL of nonionized radiopaque dye.	Onset of sensory and motor blocks.
				AB	20	NR	NR		
Arnuntasupakul *et al.,* 2015 [25].	RCT	Canada	Patients undergoing hand or forearm surgery.	SCB	20	42.6±18.9	11:9	Lidocaine 1.5% with adrenaline 5µg/mL; 32 mL for SCB and 29mL for the AB.	Block performance data and complication rates.
				AB	20	45.6±19.4	9:11		
Liu *et al.,* 2010 [26].	Non-randomized trial.	USA	Patients undergoing ambulatory arthroscopic surgery.	SCB	654	46±16	425:229	50mL Mepivacaine 1.5% ± epinephrine.	Incidence of post-operative neurological symptoms.
				ISB*	515	46±16	371:144		
Wiesman *et al.,* 2016 [27].	RCT	Germany	Patients undergoing arthroscopic shoulder surgery.	SCB	58	52.7±13	34:24	10mL of ropivacaine	Phrenic function, respiratory function, and other adverse events.
				ISB	56	53±13	34:22		
Aliste *et al.,* 2018 [28].	RCT	Chile	Arthroscopic shoulder surgery.	SCB	22	58±14.1	7:15	20mL levobupivacaine 0.5% with epinephrine 5µg/mL.	Pain scores, performance time, needle passes, and complication rates.
				ISB	22	58.4±8.7	12:10		
Ryu *et al.,* 2015 [29].	RCT	South Korea	Patients undergoing arthroscopic shoulder surgery.	SCB	46	58.5(53.8-64)	19:27	25mL of LA containing 12.5mL of mepivacaine 1% and 12.5mL of ropivacaine 0.75%.	Sensory and motor blockade scores, procedural time, and complications.
				ISB	47	60(53-65)	28:19		
Koh *et al.,* 2016 [30].	RCT	South Korea	Patients undergoing open rotator cuff repair with acromioplasty.	SCB	37	61.9±6.8	15:22	20mL of 0.375% ropivacaine	Mean and worst pain scores, post-operative analgesic requirements.
				ISB	38	64.7±8.4	20:18		

Author ID	Study design	Setting	Inclusion criteria	Approach	Sample size	Mean age	Male: Female	Drugs	Outcomes.
Kim *et al.,* 2017 [31].	RCT	South Korea	Patient undergoing shoulder surgery.	SCB	24	64±9	11:13	20mL of 0.375% ropivacaine	Duration of postoperative analgesia, pain scores, diaphragmatic paralysis, sensory block, and incidence of adverse events.
				ISB	25	58±13	12:13		
Kim *et al.,* 2024 [32].	RCT	South Korea	Patients scheduled for arthroscopic shoulder surgery.	SCB	40	61.8±10.67	18:22	0.75 ropivacaine	Incidence of hemi-diaphragmatic paresis.
				ISB	40	62.9±8.29	24:16		
Grape *et al.,* 2019 [33].	RCT	Switzerland	Patients undergoing hand or forearm surgery.	SCB	58	51(45, 56)	33/25	30mL of ropivacaine 0.5% and mepivacaine 1% in a ratio of 1:1.	Success rate, block-related outcomes, and pain-related scores.
				RCB	59	46(42, 51)	37/22		
Sivashanmugam *et al.,* 2019 [34].	RCT	India	Patients undergoing hand or forearm surgery	SCB	20	33±13	8/12	30mL of ropivacaine 0.5% and mepivacaine 1% in a ratio of 1:1.	Ipsilateral hemidiaphragmatic excursion, incidence of hemidiaphragmatic paresis.
				CCB	20	37±14	5/15		
Luo *et al.,* 2019 [35].	RCT	China	Patients for hand, elbow, wrist, or forearm surgery.	SCB	55	44.5±14.2	31:24	21mL of LA (lidocaine 2% mixed with ropivacaine 1% in a 1:1 ratio)	Block performance, onset times, and complication rates.
				CCB	55	40.3±13.3	29:26		
Hong *et al.,* 2021 [36].	RCT	South Korea	Patients undergoing orthopedic upper limb surgery.	SCB	40	44.5(35.5 to 58)	18:17	25mL of LA (lidocaine1% plus ropivacaine 0.75% mixed in a 1:1 ratio.	Incidence of hemidiaphragmatic paresis and changes in respiratory function.
				CCB	35	47(41 to 61.5)	21:19		

RCT: Randomized controlled trials; SCB: Supraclavicular brachial plexus block; ISB: Infraclavicular brachial plexus block; CCB: Costoclavicular block; RCB: Retro-clavicular block; ISB*: Interscalene brachial plexus block; AB: Axillary brachial plexus block; NR: Not reported.

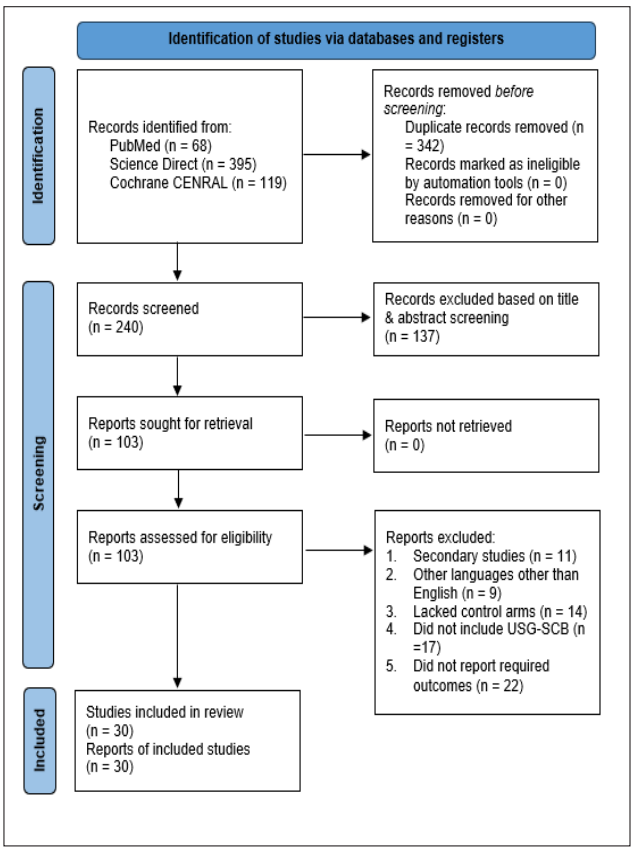

Fig. 1: A PRISMA flowchart indicating the search strategy. USG-SCB: ultrasound guided supraclavicular brachial plexus block.

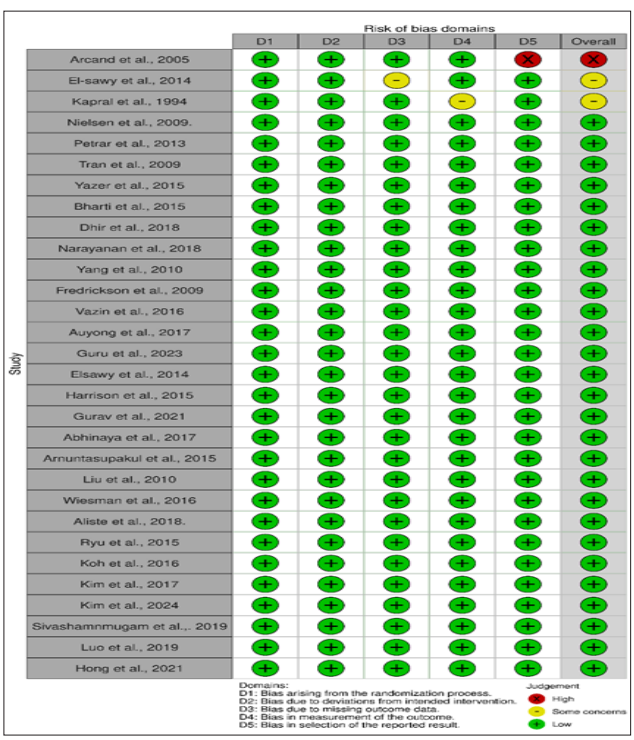

Fig. 2: A risk of bias (ROB) summary of the included studies.

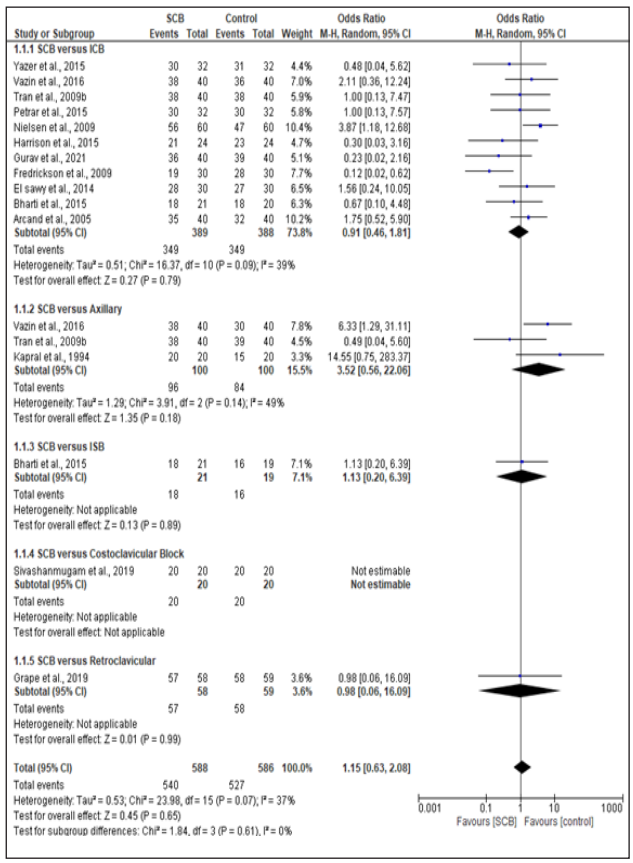

Fig. 3: The block success rate of ultrasound guided-supraclavicular brachial plexus block (USG-SCB) compared to other approaches.

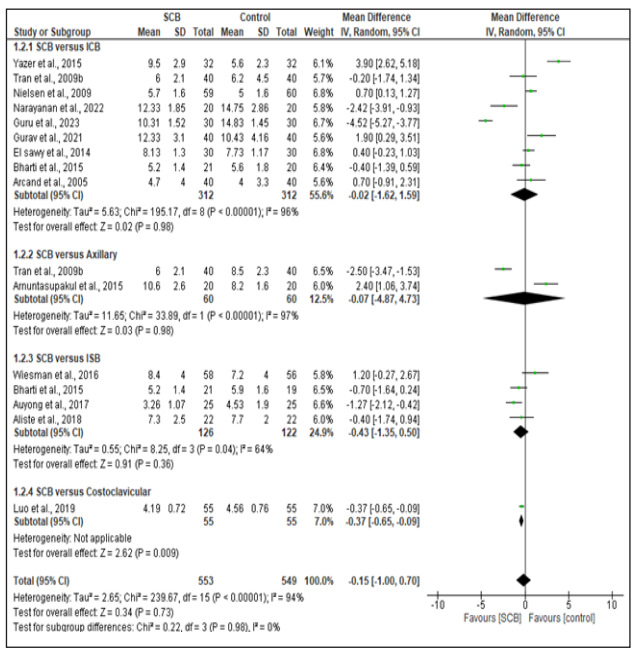

Fig. 4: A forest plot showing the block performance time of ultrasound guided-supraclavicular brachial plexus block (USG-SCB) compared to other approaches. SCB - supraclavicular brachial plexus block; ISB - Interscalene brachial plexus block.

Onset times:

Five of the included studies reported the onset of sensory and motor blockade after USG-SCB compared to the USG-ICB A pooled analysis of the outcomes found that the onset times of USG-SCB were not significantly different to those of USG-ICB both the sensory blockade (MD -0.81min; 95% CI [-4.81,3.19] *p*= 0.69) and motor blockade (MD 0.25min; [-0.85,1.35] *p*= 0.66) (Figures 5, 6).

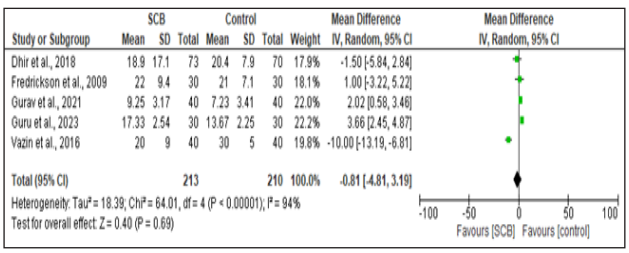

Fig. 5: A forest plot showing the sensory onset times of USG-SCB compared to USG-ICB. USG – ultrasound guided; SCB - supraclavicular brachial plexus block; ICB - infraclavicular brachial plexus block.

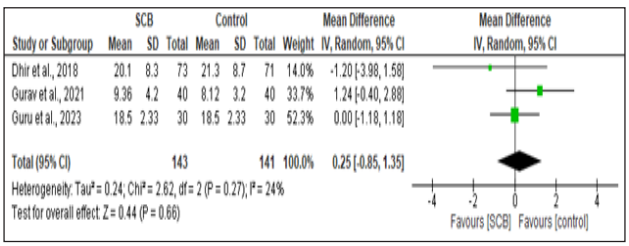

Fig. 6: Onset of motor blockade in USG-SCB compared to USG-ICB. USG– ultrasound guided; SCB- supraclavicular brachial plexus block; ICB - infraclavicular brachial plexus block.

Safety analysis:

Various adverse events were reported in the included studies, including Horner's syndrome, vascular puncture, hemidiaphragmatic paresis, and paresthesia. The pooled analysis of the incidence of Horner's syndrome found no significant difference in its incidence after USG-SCB and the other approaches (OR 3.08; 95% CI [0.76, 12.48] *p*= 0.12). There was significant heterogeneity across the studies, I2= 87%. However, a subgroup analysis found that the incidence of Horner's syndrome was significantly increased in USG-SCB compared to USG-ICB (OR 20.23; 95% CI [6.43, 63.70] *p*<0.00001), USG-AXB (OR 41.03; 95% CI [5.29, 318.04] *p*= 0.004), and USG-CCB (OR 77.94; 95% CI [4.49, 1353.48] *p*= 0.003). Conversely, the incidence of Horner's syndrome was significantly reduced in those patients who received USG-SCB than those who received USG-ISB (OR 0.35; 95% CI [0.15, 0.80], *p*= 0.01). The analysis had moderate heterogeneity, I2= 48% (Figure 7).

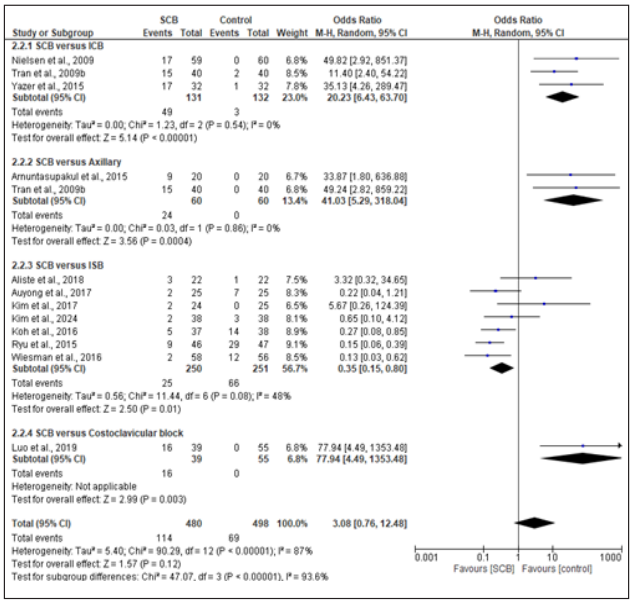

Fig. 7: A forest plot showing the incidence of Horner Syndrome in USG-SCB compared to other approaches. SCB - supraclavicular brachial plexus block; ISB - Interscalene brachial plexus block; ICB - infraclavicular brachial plexus block.

Vascular puncture:

Our analysis showed that the incidence of vascular puncture was not significantly different in USG-SCB compared to all the other methods combined (OR 0.65; 95% CI [0.27,1.55] *p*= 0.34). The outcomes had no heterogeneity across the studies, I2= 0%. Similar results were also found on subgroup analysis which found that the incidence of vascular puncture was not significantly different between USG-ICB and USG-ICB (OR 0.67; 95% CI [0.24,1.88] *p*= 0.45), USG-AXB (OR 3.08; 95% CI [0.12,77.80] *p*= 0.50), USG-RCB (OR 0.20; 95% CI [0.01, 4.18] *p*= 0.30), and USG-CCB (OR 0.48; 95% CI [0.04, 5.47] *p*= 0.34) (Figure 8).

Hemi diaphragmatic paresis (HDP):

Our pooled analysis found that the incidence of HDP was not significantly different between USG-SCB and the other approaches (OR 1.66; 95% CI [0.49, 5.63] *p*= 0.42). The outcome had significant heterogeneity across the studies, I2= 80%. However, a subgroup analysis found that the incidence of HDP was significantly higher in USG-SCB compared to USG-ICB (OR 16.60; 95% CI [3.00, 91.68] *p*= 0.001), and USG-CCB (OR 12.29; 95% CI [2.67, 56.54] *p*= 0.0004). On the other hand, the incidence of HDP was significantly lower in the USG-SCB compared to USG-ISB (OR 0.36; 95% CI [0.20, 0.63], *p*= 0.004). No heterogeneity was observed in all the subgroups, I2= 0% (Figure 9).

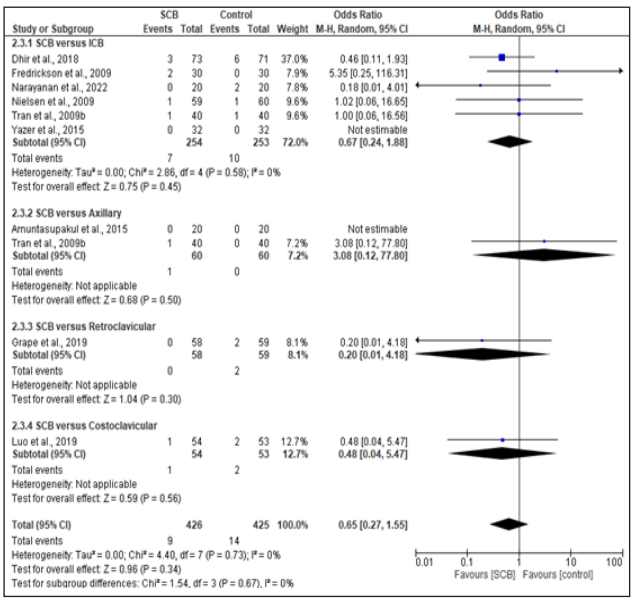

Fig. 8: A forest plot showing the incidence of vascular puncture in USG-SCB compared to other approaches. SCB - supraclavicular brachial plexus block; ICB - infraclavicular brachial plexus block.

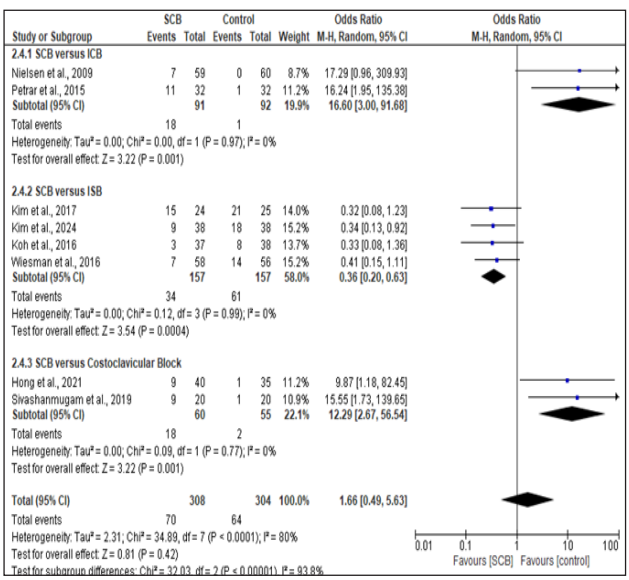

Fig. 9: A forest plot showing the incidence of hemidiaphragmatic paresis in USG-SCB compared to other approaches. ICB - infraclavicular brachial plexus block; SCB - supraclavicular brachial plexus block; ISB - Interscalene brachial plexus block.

Paresthesia:

Eight of the included studies reported the incidence of paresthesia during USG-SCB compared to the other approaches. Our pooled analysis found that the incidence of paresthesia was significantly higher during USG-SCB compared to the other approaches (OR 1.78; 95% CI [1.01, 3.14], p= 0.05). The outcomes had moderate heterogeneity across studies, I2= 48%. Similarly, our subgroup analysis found that the incidence of paresthesia was significantly higher during USG-SCB compared to USG-ICB (OR 2.71; 95% CI [1.70, 4.31], p<0.0001). However, no significant difference was observed in the incidence of paresthesia during USG-SCB and that during USG-AXB (OR 1.89; 95% CI [0.18, 19.83] p= 0.60), USG-RCB (OR 0.65; 95% CI [0.27, 1.55] p= 0.33), and USG-ISB (OR 0.50; 95% CI [0.05, 5.12] p= 5.12) (Figure 10).

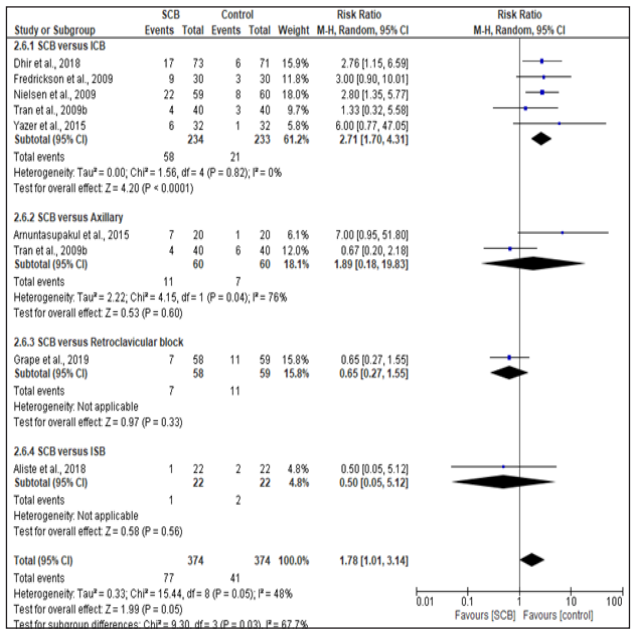

Fig. 10: A forest plot showing the incidence of paresthesia during USG-SCB compared to other approaches. SCB - supraclavicular brachial plexus block; ISB - Interscalene brachial plexus block; ICB - infraclavicular brachial plexus block.

DISCUSSION

Our analysis found that the efficacy of USG-SCB was not significantly different to that of other approaches to BPB. However, USG-SCB was significantly associated with a higher incidence of adverse events.

A significant proportion of the included studies reported the block success rate as one of the outcomes. Our analysis indicated that the block success rate was not significantly different between USG-SCB and the other USG-BPB. Similar to our study, Park *et al*., found that the incidence of successful blockade was not significantly different between patients who had ICB and those who had SCB [37]. While the study did not specifically include USG-SCB, most of the included studies were done under USG, similar to those in our review. However, unlike our review, a systematic review of RCTs focusing on orthopedic surgery by Muir *et al*., found that the block success rates were higher in the ICB compared to the SCB [38]. While lower success rates of an approach have been previously

linked to the inexperience of the clinicians doing the procedure [23]. the incorporation of USG may increase the performance of the investigators and may partly explain the similar success rates observed [39].

Overall, the incidence of adverse events was similar between the USG-SCB and the other approaches. However, the analysis had high heterogeneity, partly explained by the higher incidence of adverse events in the USG-ISB compared to the USG-SCB. Our subgroup analysis showed consistent results; no heterogeneity was observed across the studies. We found that the incidence of adverse events, such as Horner's syndrome and hemidiaphragmatic paresis, was higher in patients who had regional anesthesia using the USG-SCB than in those who had USG-ICB and the USG-AXB. Similar results were found by Muir *et al*., who found that the incidence of Horner's syndrome was significantly lower in patients who had ICB compared to those who had SCB [38]. Furthermore, the current review also found no significant difference in the incidence of vascular puncture between the two approaches, which was also found by the review by Muir *et al*., [38]. The Horner's syndrome was one of the majorly reported adverse events of USG-SCB. The approach with the highest predisposition to Horner's syndrome is the ISB, and our findings were in line with this, with the patients receiving USG-ISB having a higher incidence of Horner's syndrome than those with USG-ISB.

Limitations of the study:

Our study had some limitations. First of all, most of the included analyses had significant heterogeneity. While we employed the random effect model to account for the heterogeneity, the significant heterogeneity still limits the generalizability of the results. Secondly, while the review included a significant number of studies, the majority of the studies compared USG-SCB to USG-ICB and USG-ISB. A limited number of studies compared USG-SCB to USG-CCB and USG-RCB. This limited our ability to make meaningful conclusions regarding the comparative efficacy of USG-SCB to these two approaches.

CONCLUSIONS

Our study found that the efficacy of USG-SCB was not significantly different to that of other approaches, including USG-ISB and USG-AXB. However, we also found that the incidence of adverse events was increased in USG-SCB compared to other approaches, apart from USG-ISB, which had a higher incidence of adverse events. The results of this study indicate that while USG-SCB has not significantly different efficacy to most of the approaches to BPB, it is still associated with a higher incidence of adverse events. However, these adverse events are mostly benign and resolve within a few days of BPB.

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