

Supraclavicular regional anesthesia is a safer alternative in the immediate postoperative period after shoulder arthroscopy: A systematic review & meta-analysis

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ABSTRACT

Introduction: Interscalene nerve blocks (ISB) are commonly used for arthroscopic shoulder surgeries due to their efficacy but carry a risk of hemidiaphragmatic paralysis (HDP). Supraclavicular nerve blocks (SCB) have been proposed as an alternative, offering similar analgesic benefits with potentially lower respiratory complication rates. The purpose of this systematic review and meta-analysis was to compare ISB and SCB respiratory outcomes following arthroscopic shoulder surgery.

Methods: A systematic review was conducted per PRISMA guidelines, with articles from Medline, Embase, and the Cochrane Library. Five double-blinded randomized controlled trials, comprising 420 patients, met the inclusion criteria. Primary outcomes included rates of HDP, diaphragmatic excursion, pulmonary function tests, and additional postoperative complications such as Horner's syndrome, dyspnea, and nausea. Statistical analyses were performed to evaluate differences between ISB and SCB groups.

Results: ISB was associated with a significant reduction in postoperative forced expiratory volume in one second (FEV1) compared to SCB in both the post-anesthesia care unit (PACU) ($P = 0.04$) and on postoperative day one ($P = 0.002$). While complete and partial HDP rates were numerically higher in the ISB group, the differences were not statistically significant. No significant differences were found between ISB and SCB in diaphragmatic excursion, Horner's syndrome, dyspnea, or postoperative nausea and vomiting.

Conclusions: SCB may serve as a viable alternative to ISB as it offers comparable pain control and better preserves postoperative respiratory function. Given the significant reduction in FEV1 demonstrated by ISB, the SCB may be a better option for patients, particularly those with comorbidities and increased respiratory demand.

1. Introduction

Interscalene nerve blocks (ISB) are the gold standard for arthroscopic shoulder surgeries as they anesthetize the brachial plexus and provide adequate regional anesthesia. However, this block also carries the risk of postoperative respiratory complications such as Hemidiaphragmatic Paralysis (HDP) secondary to phrenic nerve paralysis.^{1,2} These postoperative complications can be detrimental to those with pre-existing pulmonary conditions, such as chronic obstructive pulmonary disease (COPD) and asthma.³

There has been a 39.8% increase over the past 30 years in adults living with chronic respiratory diseases in the United States.⁴ Complications arising from nerve blocks for arthroscopic shoulder procedures may exacerbate these diseases. Patients with impaired postoperative respiratory status from nerve block complications may return to the emergency department after surgery, be readmitted to the hospital, and experience worse postoperative outcomes.⁵ The supraclavicular nerve block (SCB) is a potential alternative to the ISB that may limit postoperative respiratory complications.⁶

Previous studies have shown that the SCB is equally effective as ISB when evaluating acute pain control and postoperative opioid

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Abbreviations:

- ISB Interscalene nerve blocks
- SCB Supraclavicular nerve blocks
- HDP Hemidiaphragmatic paralysis
- POD1 Postoperative day one
- PFT Pulmonary function test
- PONV Postoperative nausea and vomiting
- FEV1 Forced expiratory volume in one second

consumption.⁷ Studies have also suggested that SCB has phrenic nerve-sparing capabilities, which may allow it to be better tolerated, leading to fewer postoperative respiratory complications.⁸ However, there are inconsistencies in the current literature, as some trials suggest that SCB preserves postoperative respiratory function and decreases the incidence of HDP when compared to ISB, while others show no significant differences between the two blocks.^{5,6,9,10}

This study is the first meta-analysis of its kind to evaluate outcomes and rates of respiratory complications in the immediate postoperative period after using ISBs or SCBs in patients undergoing arthroscopic shoulder surgery. We hypothesize that SCBs lead to fewer respiratory complications due to decreased phrenic nerve involvement.

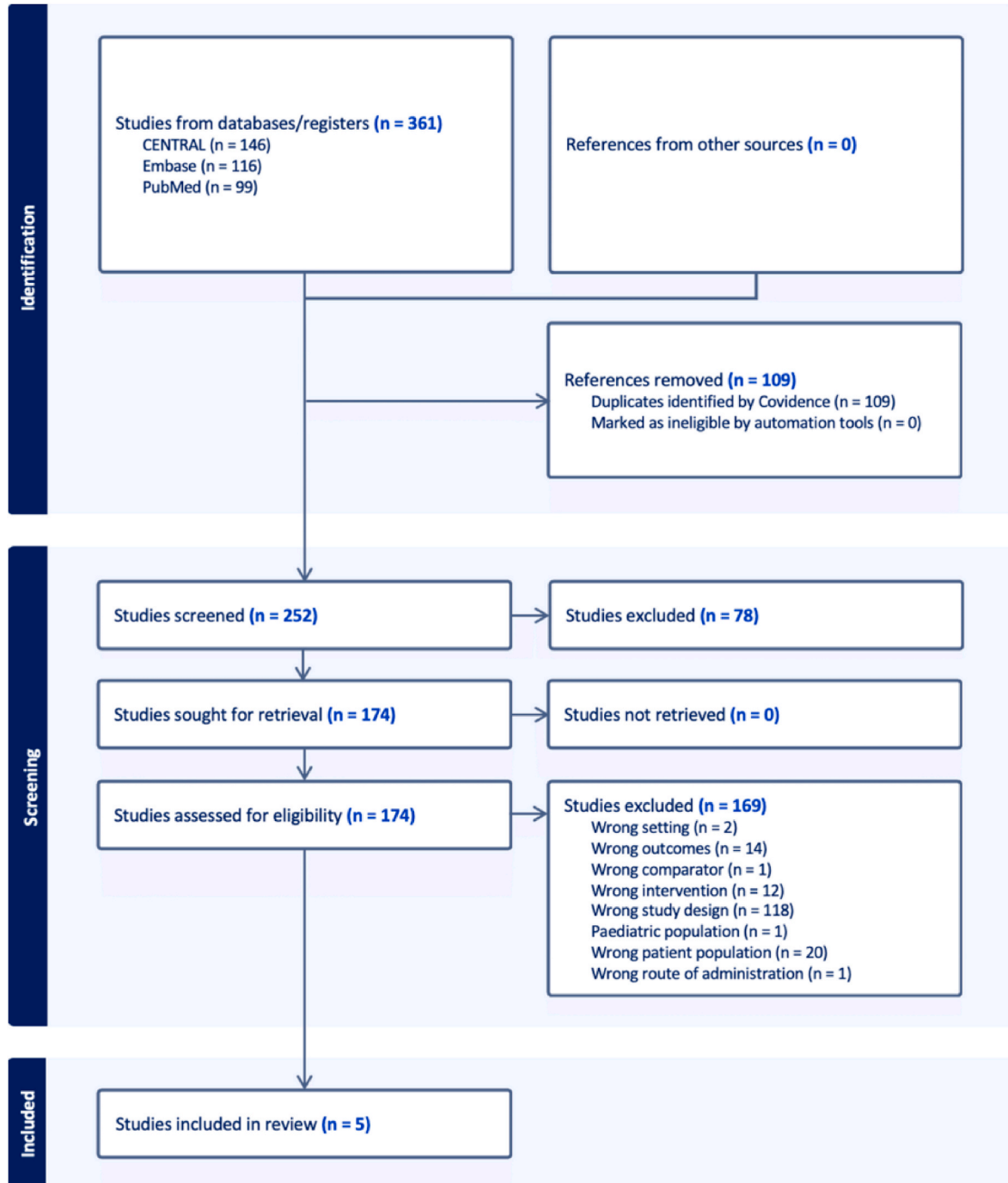


Fig. 1. PRISMA flow diagram.

2. Methods

This review was performed according to the PRISMA guidelines for reporting systematic reviews.

2.1. Search strategy

This study was registered on the PROSPERO International Prospective Register of Systematic Reviews (CRD42024539510) database. Articles were gathered from three major databases: Medline, Embase, and Cochrane Library. The initial search was conducted in June 2024. The search strategy aimed to identify sources that compared interscalene and supraclavicular nerve blocks in arthroscopic shoulder surgeries. In these studies, we also aimed to identify specifically reported respiratory complications. Examples of search terms include: ‘interscalene nerve block’, ‘supraclavicular nerve block’, ‘respiratory complications’, and ‘shoulder arthroscopy’ were used to identify relevant articles.

2.2. Eligibility and study selection

Two reviewers screened titles, abstracts, and full texts of retrieved studies, with a third reviewer resolving any disagreements. Full texts were evaluated independently, and studies were selected according to the following inclusion criteria: (1) arthroscopic shoulder surgery; (2) studies evaluating both interscalene and supraclavicular nerve blocks; (3) ASA status I-II; (4) respiratory complications reported; (5) healthy patients without existing medical comorbidities.

Exclusion criteria were as follows: (1) Patients under the age of 18; (2) history of respiratory complications; (3) pregnancy; (4) non-English studies; (5) open procedures; (6) humeral fractures; (7) arthroplasty procedures. A PRISMA flowchart of the search strategy is illustrated in Fig. 1. After screening titles, abstracts, and full texts, five double-blinded randomized controlled trials were included.

2.3. Data extraction

Data was extracted according to the following categories: (1) study information: author, publication year, study design, and level of evidence; (2) Patient baseline characteristics: gender, BMI, and age; (3) surgical procedure performed (arthroscopic shoulder procedures); (4) mean follow up period; (5) results of primary and secondary outcomes of interest: diaphragmatic paralysis/excursion, pulmonary function tests, and other additional complications such as Horner’s Syndrome, postoperative nausea and vomiting, and dyspnea. Postoperative pulmonary function tests and adverse event data were extracted from the following periods: baseline, post-anesthesia care unit (PACU) 30–60 min after the operation, and postoperative day one (POD1).

2.4. Statistical analysis

A departmental statistician performed formal comparative statistics using SAS/STAT software (SAS Institute Inc., Cary, North Carolina). Statistical tests included pooled T-tests for categorical variables, mean comparisons, calculation of standard deviations, calculation of I^2 values, and generation of forest plots to assess heterogeneity between studies, and a mixed model analysis for pulmonary function tests. Data were pooled for outcomes that were reported in ≥ 2 trials. A P-value ≤ 0.05 was used as a threshold to determine statistical significance.

2.5. Risk of bias assessment

Study quality was assessed using the Critical Appraisal Skills Programme (CASP) checklist for randomized controlled trials.¹¹ Table 1 depicts the scores of the included studies ranged from 9 to 11, with an average score of 10.0, indicating good study quality.

Table 1

CASP checklist for randomized control trials.

CASP Question	Kim et al. ⁶	Aliste et al. ⁹	Auyong et al. ¹⁰	Wiesmann et al. ⁵	Karaman et al. ¹²
Q1: Clear question?	Y	Y	Y	N	Y
Q2: Randomized participants?	Y	Y	Y	Y	Y
Q3: Loss to follow-up	Y	Y	Y	Y	Y
Q4: Blinding	Y	Y	Y	N	Y
Q5: Similar groups	Y	Y	Y	Y	Y
Q6: Same level of care	Y	Y	Y	Y	Y
Q7: Adequate results reported	Y	N	Y	Y	Y
Q8: Precise results	Y	Y	N	Y	N
Q9: Benefits outweigh risks	Y	Y	Y	Y	Y
Q10: Generalizability	Y	Y	Y	Y	Y
Q11: Findings valuable to population	Y	Y	Y	Y	Y
Total Score	11	10	10	9	10

2.6. Assessment of study heterogeneity

Heterogeneity between study cohort demographics was assessed to evaluate the suitability of pooling data in our meta-analysis. There was no heterogeneity observed when evaluating the differences between the mean age and BMI of patients in both the ISB and SCB groups across studies. The I^2 value for each of these demographic metrics was 0%, indicating the absence of inter-study variability. Additionally, the distribution of males and females in each block group between studies was assessed. Our findings indicate that there was no heterogeneity between studies in the ISB group, demonstrated by an I^2 value of 0%. However, when evaluating the SCB group, significant interstudy variability exists, demonstrated by an I^2 value of 84.3%. This finding suggests that significant variability existed in the proportion of male patients in the SCB group across studies.

2.7. Study outcomes

The primary outcomes assessed are: complete HDP, defined as a reduction in diaphragmatic movement of greater than 75% compared to baseline⁹; partial HDP, defined as a reduction in diaphragmatic movement between 25-75%⁸; and pulmonary function tests. Secondary outcomes included in this study are: diaphragmatic excursion, incidence of postoperative Horner’s Syndrome, dyspnea, and postoperative nausea and vomiting (PONV). All outcomes were collected across three distinct timelines: baseline, PACU, and POD1 (24 h post-surgery).

3. Results

The initial search of Medline, Embase, and Cochrane Library yielded 361 studies. Inclusion and exclusion criteria were applied to the collected studies. After title and abstract screening, the full-text review of 252 studies yielded five double-blinded, randomized controlled trials with a total of 420 patients.

3.1. Baseline demographics

The weighted mean age of patients in this study was 56.1 ± 4.5 (P = 0.79). The weighted mean number of males in this study was 255 ± 16 (P = 0.04). The weighted mean BMI of patients in the ISB group was 27.4 ± 1.4 , and the weighted mean in the SCB group was 27.3 ± 1.6 . There was no significant difference between the groups (P = 0.81). Further

information on baseline demographics can be referenced in [Table 2](#) and [Fig. 2A, 2B-4A, 4B](#).

3.2. Partial hemidiaphragmatic paralysis

HDP was reported in three of the five studies. The weighted mean proportion of patients with partial HDP in the PACU after ISB was 52.5% ± 37.5. The weighted mean proportion of patients with partial paralysis in the PACU after SCB was 22.1% ± 11.6. There was no statistically significant difference between groups (P = 0.25). Of the patients observed on POD1, the weighted mean proportion of patients with partial paralysis after ISB was 31.6% ± 14.9. The weighted mean proportion of patients with partial paralysis after SCB was 25.5% ± 4.9. There was no statistically significant difference between groups (P = 0.64). Further information on cases of partial HDP reported across studies can be referenced in [Table 3](#).

3.3. Complete hemidiaphragmatic paralysis

The weighted mean proportion of patients with complete HDP in the PACU after ISB was 58.4% ± 21.7. The weighted mean proportion of patients with complete HDP in the PACU after SCB administration was 12% ± 16.9. There was no statistically significant difference between the groups (P = 0.14). Of the patients observed on POD1, the weighted mean proportion of patients with complete HDP after ISB was 36.2% ± 15.8. The weighted mean proportion of patients with complete HDP on POD1 after SCB administration was 17.8% ± 8.3. Further information on reported rates of complete HDP can be referenced in [Table 3](#). There was no statistically significant difference between groups (P = 0.28).

3.4. Diaphragmatic excursion

Diaphragmatic excursion was measured at baseline, PACU, and POD1 ([Table 3](#)). The weighted mean diaphragmatic excursion in the ISB group was 7.2 cm ± 1.8, while the weighted mean in the SCB group was 4.5 cm ± 0.8. There was no statistically significant difference between groups (P = 0.19).

3.5. Oxygen saturation

PACU Oxygen saturation (SpO2) was measured in three studies. The weighted mean PACU SpO2 in the ISB group was 97% ± 1.4, while the weighted mean SpO2 in the SCB group was 97.5% ± 0.7. There was no statistically significant difference between groups (P = 0.70).

3.6. Pulmonary function testing

The only pulmonary function test (PFT) evaluated across the included studies was the forced expiratory volume in one second (FEV1) at baseline, PACU, and POD1. Further information on specific FEV1 measurements across studies can be referenced in [Table 4](#).

3.7. FEV1 measurements

The weighted mean baseline FEV1 across patients in the ISB group

was 2.6 L ± 0.2. The weighted mean baseline FEV1 across patients in the SCB group was 2.6 L ± 0.4. There was no statistically significant difference between the two groups at baseline (P = 0.99). The weighted mean FEV1 in the PACU across patients in the ISB group was 1.7 L ± 0.1. The weighted mean FEV1 in the PACU across patients in the SCB group was 2.0 L ± 0.1. There was a statistically significant difference in FEV1 between groups in the PACU (P = 0.04). The weighted mean FEV1 on POD1 across patients in the ISB group was 1.9 L ± 0.1. The weighted mean FEV1 on POD1 across patients in the SCB group was 2.1 L ± 0.4. There was no statistically significant difference between ISB and SCB groups on POD1 (P = 0.56). Lastly, changes in FEV1 across various timepoints were also evaluated. Our findings revealed that the ISB significantly decreased FEV1 values from baseline to PACU (P = 0.0002) and baseline to POD1 (P = 0.002) when compared to the SCB.

3.8. Additional complications

The rates of additional PACU postoperative complications, such as Horner’s syndrome, dyspnea, and PONV, were also measured across the included studies.^{5,6,9,10,12} The weighted mean rate of Horner’s syndrome in the ISB group was 15.6% ± 11.6, while the weighted mean rate of Horner’s syndrome in the SCB group was 7.4% ± 9.5. There was no significant difference between these groups (P = 0.26). The weighted mean rate of PACU dyspnea in the ISB group was 6.4% ± 4.6, while the weighted mean rate in the SCB group was 3.1% ± 2.8. There was no significant difference between these groups (P = 0.28). Further information on additional postoperative complications can be referenced in [Table 5](#).

4. Discussion

This study is the first meta-analysis of its kind to evaluate outcomes and rates of respiratory complications in the immediate postoperative period after using ISBs and SCBs in patients undergoing arthroscopic shoulder surgery. The most important finding of this study is that patients in the ISB group demonstrated significantly decreased FEV1 values from baseline to PACU and from baseline to POD1. Additionally, there were no significant differences in complete and partial HDP rates between the two block groups. Therefore, our findings suggest that SCB may be used as a potential alternative to ISB due to its ability to better preserve FEV1 in patients undergoing arthroscopic shoulder surgery. Additional outcomes, such as diaphragmatic excursion, postoperative Horner’s syndrome, dyspnea, and PONV, did not reveal significant differences between the groups.

While reductions in FEV1 that occur with ISB and SCB are typically well tolerated by healthy individuals, prior studies have shown that this reduction can be detrimental to individuals with pre-existing conditions like obesity and COPD.¹³ Incremental decreases in postoperative FEV1 values can cause symptomatic dyspnea and oxygen desaturation, especially in vulnerable populations.¹³ This should be taken into account when selecting an appropriate nerve block, as ISB decreases postoperative FEV1, which may lead to higher rates of adverse outcomes in patients with comorbidities.

SCB may also be a good alternative to ISB, as prior studies have shown that it leads to no difference in 24 h acute pain control and 24 h

Table 2
Patient baseline demographics.

Authors	Total Patients (#)	Mean Age (ISB)	Mean Age (SCB)	Mean BMI (ISB)	Mean BMI (SCB)	Gender % Male (ISB)	Gender % Male (SCB)
Kim et al. ⁶	76	62.9 ± 8.3	61.8 ± 10.7	25.5 ± 2.9	24.9 ± 2.9	63.2	47.4
Aliste et al. ⁹	44	58.4 ± 8.7	58.0 ± 14.1	27.2 ± 3.3	27.5 ± 3.1	54.5	31.8
Auyong et al. ¹⁰	126	54.0 ± 13.0	53 ± 14.0	27.8 ± 5.6	28.1 ± 4.5	60.0	62.0
Wiesmann et al. ⁵	114	53.0 ± 13.0	52.7 ± 13.0	28.9 ± 6.0	28.6 ± 5.0	60.7	58.6
Karaman et al. ¹²	60	52.0 ± 20.0	59.0 ± 16.5	–	–	64.5	44.8
P-values		0.79		0.81		0.04	

ISB: Interscalene Block, SCB: Supraclavicular Block.

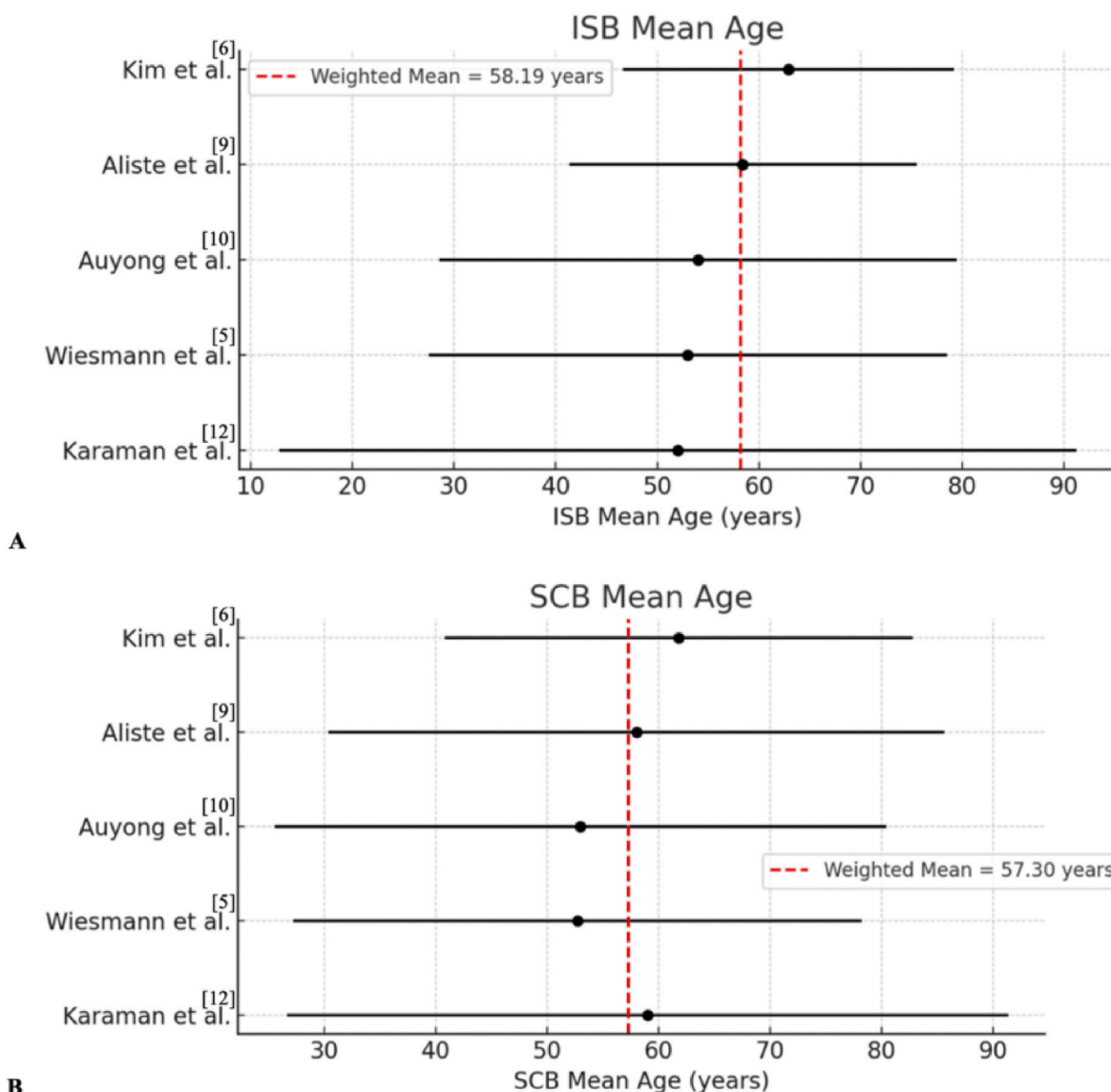


Fig. 2. Mean age of participants in ISB and SCB groups across included studies. A: ISB mean age; B: SCB mean age. ISB: Interscalene Block, SCB: Supraclavicular Block.

postoperative opioid consumption in comparison to ISB.¹⁴ Therefore, similar levels of pain control in conjunction with better preservation of respiratory function suggest that SCB may lead to better postoperative outcomes.

Hemidiaphragmatic paralysis impairs diaphragm function and leads to significant respiratory impairment. Previous studies have reported higher rates of partial and complete HDP in the ISB group.^{9,14,15} However, in our study’s pooled analysis, there was no difference in HDP rates between ISB and SCB groups. Due to the proximity of the origin of the phrenic nerve to the shoulder, anesthetic spread to the phrenic nerve can paralyze the diaphragm, causing postoperative respiratory distress.^{16,17} Healthy individuals can compensate for this decline with the use of accessory pulmonary muscles.¹⁸ However, patients with COPD have already exhausted their accessory pulmonary musculature. Therefore, such patients and those with similar conditions with increased respiratory demand see a significant decline in pulmonary function in cases of phrenic nerve paralysis.¹⁹

Depressed postoperative respiratory status can potentially lead to increased rates of return to the ED and hospital readmissions, along with decreased postoperative rehabilitation outcomes.^{20,21} In a prior study by Jones et al., increased ED readmission following ISB administration for

shoulder surgeries revealed that most readmissions were due to hypoxemia.⁸ It was also reported that the average cost for these return to hospital visits was approximately \$6849.¹³ Similarly, Malige et al. reported a postoperative complication rate of 16.5% following shoulder surgery with ISB use, with 6% of those patients returning to the ED due to new onset of shortness of breath or chest pain.¹⁵ These findings suggest that an alternative block like the SCB that better preserves respiratory function may lead to fewer postoperative ED readmissions and may also end up being more cost-effective, especially for patients with comorbidities.

This study is not without limitations. The included studies only reported respiratory complications up to 24 h postoperatively. No study evaluated long-term complications, despite diaphragmatic paralysis being reported as lasting months to years.²² Additionally, there is notable heterogeneity between block administration techniques. Some studies reported single-inject block use while others reported continuous catheterization.^{5,10,23} The difference in anesthetic time course and mode of delivery may impact outcomes as more complications (e.g., shortness of breath, bradycardia, hypotension) are often reported with continuous catheterization.¹⁹

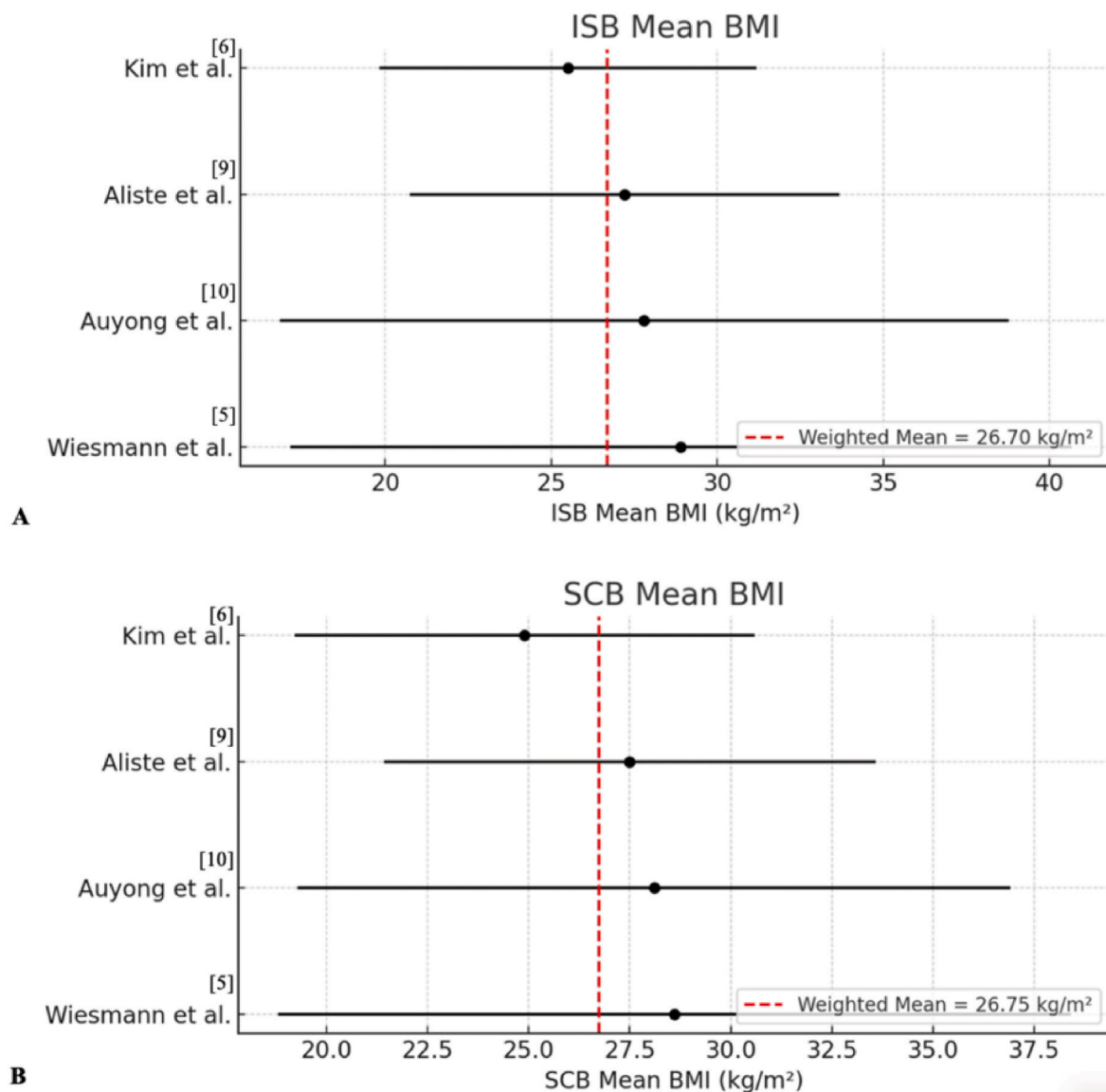


Fig. 3. Mean BMI of participants in ISB and SCB groups across included studies. A: ISB mean BMI; B: SCB mean BMI. ISB: Interscalene Block, SCB: Supraclavicular Block.

5. Conclusions

The SCB may serve as a viable alternative to ISB in patients who undergo arthroscopic shoulder surgery, as it offers comparable pain control and better preserves postoperative respiratory function. Given the significant reduction in FEV1 demonstrated by ISB, the SCB may be a more suitable option for patients, particularly those with comorbidities and increased respiratory demands. Integrating SCB into clinical practice could reduce postoperative pulmonary complications and readmission rates secondary to respiratory compromise. Additional randomized controlled trials with standardized outcome assessments and larger cohorts are essential to validate these findings. Overall, nerve block selection should be individualized to attain optimal analgesic management and promote patient safety.

Guardian/patient’s consent

As this was a systematic review of published literature, there were no patients to consent.

Ethical statement

As this was a systematic review, there were no ethical concerns while conducting this study.

Author contributions

Dev Dayal: Conceptualization (supporting), Data curation (lead), Formal Analysis (equal), Investigation (lead), Methodology (lead), Project Administration (lead), Visualization (lead), Writing-Original Draft (lead), Alexa Smitherman: Data curation (supporting), Investigation (supporting), Methodology (supporting), Writing-Original Draft (supporting) Andrew Manush: Data curation (supporting), Investigation (supporting), Methodology (supporting), Clay Rahaman: Data curation (lead), Visualization (supporting), Writing – Review & Editing (supporting), Maxwell Harrell: Data curation (supporting), Investigation (supporting), Elizabeth Powell: Writing – Review & Editing (supporting), Vamsisaikrishna Morla: Formal Analysis (equal), Thomas Evely: Supervision (supporting), Writing – Review & Editing (supporting), Project Administration (supporting), Walter Smith: Supervision

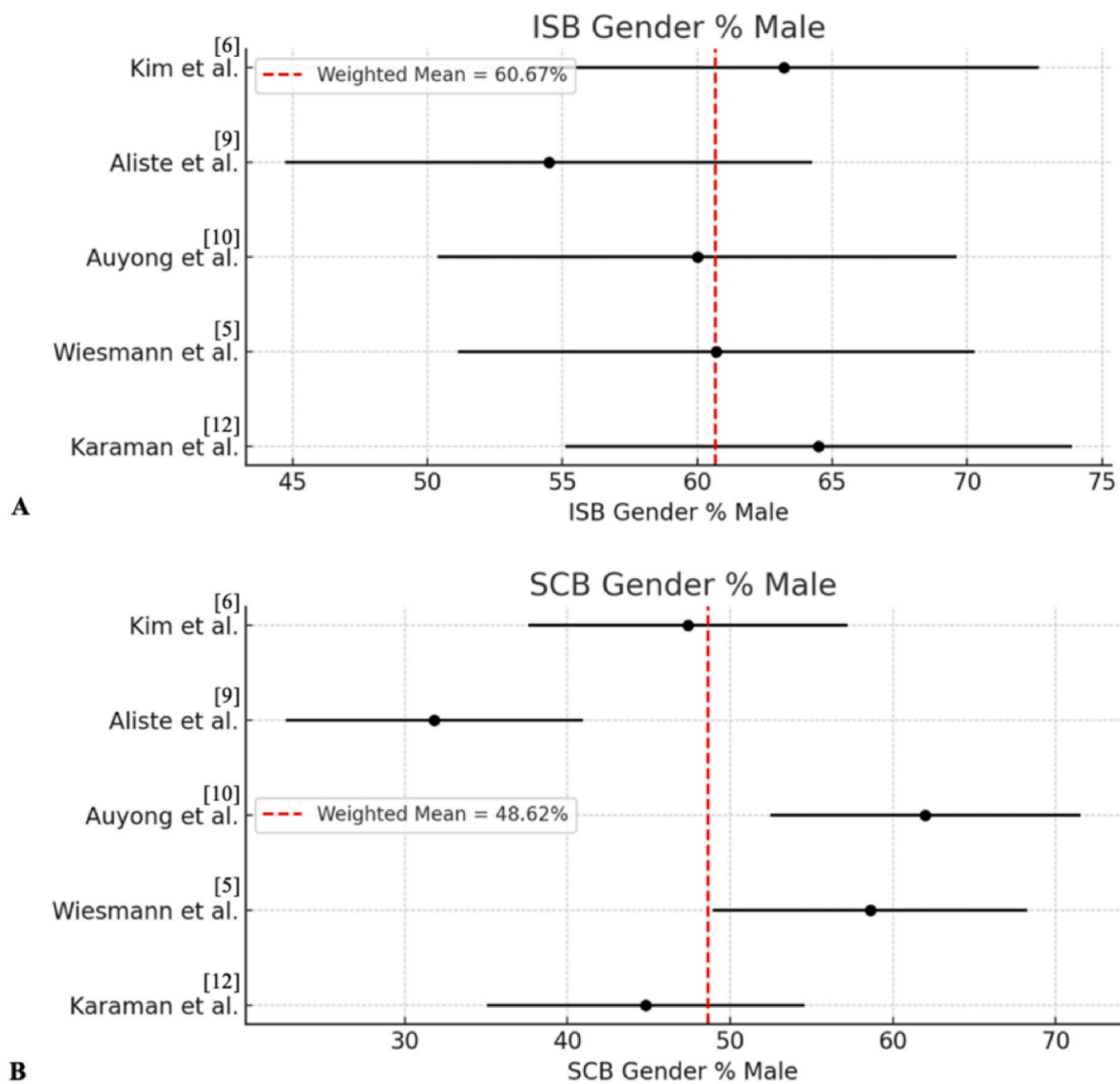


Fig. 4. Mean percentage of male participants in ISB and SCB groups across included studies. A: ISB gender % male; B: SCB gender % male. ISB: Interscalene Block, SCB: Supraclavicular Block.

Table 3
Diaphragmatic excursion and paralysis.

Authors	Block Type	Hemidiaphragmatic Paralysis (Complete) (%)		Hemidiaphragmatic Paralysis (Partial) (%)		Hemidiaphragmatic Excursion (cm)			PACU SpO ² (%)
		PACU	POD1	PACU	POD1	Baseline	PACU	POD 1	POD1
Kim et al. ⁶	ISB	73.7	47.4	23.7	42.1	6.1 ± 0.9	0.9 ± 0.8	1.9 ± 1.7	–
	SCB	0	23.7	26.3	28.9	5.6 ± 0.6	5.0 ± 0.6	3.7 ± 1.2	–
Aliste et al. ⁹	ISB	–	–	95.0	–	–	–	–	–
	SCB	–	–	9.0	–	–	–	–	–
Auyong et al. ¹⁰	ISB	–	–	–	–	–	^a 5.9 ± 2.1	–	96.0 ± 3.0
	SCB	–	–	–	–	–	^a 3.9 ± 2.8	–	97.0 ± 2.0
Wiesmann et al. ⁵	ISB	43.0	39.0	39.0	21.0	–	–	–	98.0 (96.0–99.0)
	SCB	24.0	31.0	31.0	22.0	–	–	–	98.0 (96.0–99.0)
Karaman et al. ¹²	ISB	–	–	–	–	–	–	–	–
	SCB	–	–	–	–	–	–	–	–
P-Values		0.84	0.61	0.17	0.40	–	0.53	–	0.59

PACU: Post-Anesthesia Care Unit, POD1: Postoperative Day One, SpO²: Oxygen Saturation.

^a Reduction in diaphragmatic excursion.

Table 4
Pulmonary function tests.

Authors	Block Type	Baseline FEV1 (L)	PACU* FEV1 (L)	Post-op Day 1 FEV1 (L)
Kim et al. ⁶	ISB	2.4 ± 0.6	1.7 ± 0.4	1.8 ± 0.5
	SCB	2.2 ± 0.6	2.1 ± 0.5	1.9 ± 0.5
Aliste et al. ⁹	ISB	–	–	–
	SCB	–	–	–
Auyong et al. ¹⁰	ISB	2.8 ± 0.8	1.9 ± 0.2	–
	SCB	2.8 ± 0.8	2.1 ± 0.3	–
Wiesmann et al. ⁵	ISB	2.6 ± 0.4	1.8 ± 0.6	2.0 ± 0.4
	SCB	2.8 ± 0.4	1.9 ± 0.5	2.4 ± 0.5
Karaman et al. ¹²	ISB	–	–	–
	SCB	–	–	–
P-Values		0.0002 ^a 0.002 ^b –	0.38 ^c	–

ISB: Interscalene Block, SCB: Supraclavicular Block, PACU: Post-Anesthesia Care Unit, FEV1: Forced Expiratory Volume in One Second.

^a Comparison between baseline FEV1 and PACU FEV1.

^b Comparison between baseline FEV1 and POD1 FEV1.

^c Comparison between PACU FEV1 and POD1 FEV1.

Table 5
Additional complications.

Authors	Block Type	PACU Horner's Syndrome (%)	PACU Dyspnea (%)	PONV (%)
Kim et al. ⁶	ISB	7.9	10.5	–
	SCB	5.3	2.6	–
Aliste et al. ⁹	ISB	13.6	–	4.5
	SCB	4.5	–	4.5
Auyong et al. ¹⁰	ISB	29.0	6.0	14.3
	SCB	24.0	3.0	7.9
Wiesmann et al. ⁵	ISB	1.8	8.9	–
	SCB	0.0	6.9	–
Karaman et al. ¹²	ISB	25.8	0.0	–
	SCB	3.4	0.0	–
P-Values	–	0.7	0.45	–

ISB: Interscalene Block, SCB: Supraclavicular Block, PACU: Post-Anesthesia Care Unit, PONV: Postoperative Nausea and Vomiting.

(supporting), Writing – Review & Editing (supporting), Project Administration (supporting), Amit Momaya: Supervision (supporting), Writing – Review & Editing (supporting), Project Administration (supporting), Eugene Brabston: Conceptualization (lead), Supervision (lead), Project Administration (supporting), Writing – Review & Editing (lead)

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Declaration of interest

All other authors and their immediate families report no disclosures.

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