Section: Anaesthesiology

Original Research Article

INTERSCALENE VERSUS REDUCED-VOLUME SUPRACLAVICULAR NERVE BLOCK IN SHOULDER SURGERY: A RANDOMIZED EVALUATION

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Received *: 19/02/2026*
Received in revised form *: 06/04/2026*
Accepted *: 24/04/2026*

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DOI: 10.70034/ijmedph.2026.2.204

Source of Support: Nil,
Conflict of Interest: None declared

Int J Med Pub Health
2026; 16 (2); 1212-1217

ABSTRACT

Background: Interscalene block (ISB) is considered the gold standard for analgesia in shoulder surgery but is frequently associated with hemidiaphragmatic paralysis (HdP). Supraclavicular block (SCB) may offer a potential diaphragm-sparing alternative. This study aimed to compare the incidence of HdP and respiratory outcomes between ultrasound-guided ISB and SCB.

Materials and Methods: In this randomized study, 80 patients undergoing shoulder surgery were allocated to receive either ISB (n = 40) or SCB (n = 40) using 20 mL of 0.5% bupivacaine. Diaphragmatic excursion was assessed using M-mode ultrasonography at baseline, 30 minutes at 3hours and 6 hours post-block. Oxygen saturation (SpO_2), oxygen supplementation requirements, and perioperative complications were recorded. HdP was classified as partial (25–75% reduction in excursion) or complete (≥75% reduction or paradoxical movement).

Results: The incidence of total HdP was significantly higher in the ISB group compared with the SCB group (52.5% vs 10%, $p < 0.0001$), while partial HdP was also more frequent with ISB. Oxygen saturation was significantly lower in the ISB group at multiple postoperative time points (30 minutes to 6 hours), and oxygen supplementation was required more frequently (52.5% vs 10%, $p < 0.0001$). Diaphragmatic excursion at 30 minutes was significantly reduced in the ISB group ($p < 0.0001$). No significant differences were observed in other complications, including dyspnoea, Horner syndrome, hematoma, or paraesthesia.

Conclusion: Although SCB does not completely eliminate hemi diaphragmatic dysfunction, it is associated with significantly lower incidence and severity of HdP compared with ISB and provides better preservation of postoperative oxygenation. SCB may be a safer alternative in patients where respiratory function preservation is a priority.

Keywords: Interscalene block; supraclavicular block; hemi diaphragmatic paralysis; diaphragmatic excursion.

INTRODUCTION

The interscalene block (ISB) is widely regarded as the gold standard for postoperative pain management in shoulder surgery.[1] However, its use is often limited by the high incidence of hemi diaphragmatic paralysis (HdP), which occurs due to unintended involvement of the phrenic nerve in the interscalene region.[2,3] This adverse effect is particularly concerning in patients with compromised respiratory function. As the brachial plexus and phrenic nerve diverge anatomically in the caudal direction, the ultrasound-guided supraclavicular block (SCB) has emerged as a potentially safer and effective alternative.[4]

Despite this, the reported incidence of HdP following SCB—especially when targeting the "corner pocket"—remains inconsistent across

studies.[5,6] Additionally, there is ongoing debate regarding the adequacy of postoperative analgesia provided by SCB in shoulder procedures.[4] Diaphragmatic ultrasonography offers a simple, non-invasive, and reliable technique for evaluating diaphragmatic function. Using motion-mode (M-mode), diaphragmatic excursion can be measured during a voluntary sniff manoeuvre, in which the patient performs a forceful nasal inhalation.[7]

The primary aim of this study was to evaluate and compare the incidence of hemi diaphragmatic paralysis, as assessed by diaphragmatic ultrasonography, following supraclavicular and interscalene blocks using 20 mL of 0.5% bupivacaine. We hypothesized that the occurrence of HdP with the supraclavicular approach would be approximately half that observed with the interscalene block.

MATERIALS AND METHODS

Following approval from the institutional ethics committee, a total of 80 patients scheduled for elective shoulder surgery were recruited for this study. Written informed consent was obtained from all participants prior to enrolment. Patients aged between 18 and 80 years, classified as American Society of Anaesthesiologists (ASA) physical status I to III, and with a body mass index (BMI) ranging from 20 to 35 kg/m² were considered eligible for inclusion.

Exclusion criteria comprised inability to provide informed consent, presence of pre-existing pulmonary disease (either obstructive or restrictive), coagulopathy, active infection or sepsis, hepatic or renal impairment, pregnancy, known hypersensitivity to local anaesthetic agents, chronic pain conditions requiring regular opioid use, and any history of previous surgery involving the neck or supraclavicular region.

Upon arrival in the induction area, a 20-gauge intravenous cannula was inserted into the upper limb opposite to the surgical site. All patients received intravenous premedication consisting of midazolam 1 mg and fentanyl 50 µg. Supplemental oxygen was administered via nasal cannula at a flow rate of 2 L/min, and standard American Society of Anaesthesiologists (ASA) monitoring was maintained throughout the procedure.

A 5–13 MHz linear ultrasound transducer (General Electric LOGIQ E; GE Healthcare) was used for all blocks, and the same local anaesthetic solution (0.5% bupivacaine) was administered in each case. Stimuplex Ultra 360, 22-gauge block needles (B. Braun) were utilized, with needle lengths of 5 cm for the interscalene block group and 10 cm for the supraclavicular block group.

Operators were categorized based on their prior experience with each technique. Those who had performed 60 or more blocks of a given type before the study were classified as experts, while those with fewer procedures were considered trainees. Patients were randomly assigned to either the interscalene block (ISB) group (n = 40) or the supraclavicular block (SCB) group (n = 40) using a computer-generated randomization sequence and a sealed-envelope allocation method.

Before performing either ISB or SCB, all patients received an ultrasound-guided intermediate cervical plexus block. This was done to minimize confounding from postoperative pain related to surgical procedure and skin closure. Using a standardized technique, 5 mL of local anesthetic was injected into the intermuscular plane between the sternocleidomastoid and scalene muscles at the level of the thyroid cartilage.[8,9]

For patients in the ISB group, the ultrasound transducer was placed in a sterile manner over the lateral aspect of the neck at the level of the cricoid cartilage to visualize the brachial plexus roots or trunks as three hypoechoic structures. After raising a skin wheal with 2 mL of 1% lidocaine, a block needle was advanced using an in-plane approach from lateral to medial. The needle tip was positioned beneath the prevertebral fascia between the two most superficial elements of the plexus, and 20 mL of 0.5% bupivacaine was injected at this site.[10]

In the SCB group, the ultrasound probe was positioned in the supraclavicular fossa to obtain a short-axis view of the subclavian artery and the brachial plexus cluster. Following infiltration of the skin with 2 mL of 1% lidocaine, the needle was inserted using an in-plane lateral-to-medial approach and directed toward the “corner pocket.” Initially, 3 mL of local anaesthetic was deposited at this location. The needle was then repositioned posterolateral to the neural cluster, where the remaining 17 mL of anaesthetic solution was administered.

Diaphragmatic Excursion: Diaphragmatic movement was evaluated at baseline (prior to block placement) and again 30 minutes after administration of regional anaesthesia by a designated study investigator. Ultrasonographic assessment of the diaphragm was performed with the patient in a strictly supine position using a 3.5–5 MHz cardiac probe (X-Porte, Fujifilm Sonosite).

The probe was positioned just below the costal margin along the anterior axillary line and angled medially, cephalad, and posteriorly toward the posterior third of the hemidiaphragm. Initially, two-dimensional imaging was used to obtain an optimal view, after which motion mode (M-mode) was employed to quantify diaphragmatic movement. Inspiratory (caudal) and expiratory (cephalad) excursions were recorded along the selected ultrasound line. The liver on the right side and the spleen on the left served as acoustic windows for visualization. Diaphragmatic excursion was measured as displacement in centimetres.

Complete hemi diaphragmatic paresis was defined as either a paradoxical response during a sniff manoeuvre or a reduction in diaphragmatic

excursion exceeding 75% compared with baseline values. A decrease in movement ranging from 25% to 75% was classified as partial paresis.[5,6]

A composite outcome termed "compound paresis" was calculated by combining the incidences of both complete and partial hemi diaphragmatic paresis for each group at the specified time points. Ultrasonographic assessments were performed by the same investigator both before block placement in the induction area and postoperatively in the post-anesthesia care unit (PACU), with patients maintained in an identical supine position during each evaluation.

A blinded investigator recorded baseline demographic characteristics, including sex, age, weight, and height, as well as intraoperative variables such as duration of surgery. The occurrence of adverse effects, including hoarseness and Horner syndrome, was assessed 30 minutes to 6 hours after block administration. Hemodynamic parameters and oxygen saturation (SpO_2) were also documented.

At one day following surgery, all patients were contacted by the blinded investigator to assess for any complications, including persistent numbness, paraesthesia, or motor deficits. For the analysis of secondary outcomes, all performed blocks were included, regardless of whether they were deemed complete or incomplete.

Sample Size Calculation: The sample size was determined based on previously reported incidences of hemi diaphragmatic paralysis following supraclavicular block (59.5%) and interscalene block (95%), as described in earlier literature. Considering these proportions, the estimated absolute difference between groups was 35.5%.[5]

With a two-sided significance level (α) of 0.05 and a statistical power of 90% (β = 0.10), the required sample size was calculated using the standard formula for comparison of two proportions:

$$N = \frac{(Z_{\alpha/2} + Z_{\beta})^2 \times [P_1(1-P_1) + P_2(1-P_2)]}{(P_1 - P_2)^2}$$

Where:

- P_1= proportion of hemidiaphragmatic paralysis in the supraclavicular block group (0.595)
- P_2= proportion in the interscalene block group (0.95)
- $Z_{\alpha/2}$corresponds to a two-tailed α of 0.05
- Z_{β}corresponds to a power of 90%

Based on this calculation, the required sample size was 40 patients per group. Therefore, a total of 80 patients were included in the study.

Statistical Analysis: Normality was assessed using the Shapiro–Wilk test. Continuous variables are presented as mean ± SD or median (range) as appropriate. Group comparisons were performed using the unpaired t-test for normally distributed data and the Mann–Whitney U test for non-normal data. Categorical variables were expressed as number (%) and compared using the Chi-square or Fisher's exact test, as appropriate.

The association between hemidiaphragmatic paralysis and block type (ISB vs SCB) was expressed as relative risk (RR) with 95% confidence intervals (CI). Logistic regression (stepwise generalized linear model) was used to identify predictors of hemidiaphragmatic paralysis.

Statistical analysis was performed using MedCalc software (version 12.6.1). A p-value < 0.05 was considered statistically significant.

RESULTS

Overall, 80 patients were recruited and all of them completed study. Baseline demographic and intraoperative characteristics were comparable between the supraclavicular block and interscalene block groups. There were no statistically significant differences in age, sex distribution, BMI, ASA physical status, smoking status, duration of surgery, block execution time, or intraoperative fentanyl requirement (all p > 0.05), indicating well-matched study groups. [Table 1]

Table 1: Demographic parameters of the participants

Parameter	SCB group (n=40) Mean ± SD	ISCB group (n=40) Mean ± SD	p-value
Age (years)	39.98 ± 12.72	39.15 ± 11.93	0.76
Gender Male (%): female (%)	33 (82.50%):7 (17.50%)	31 (77.5%):9 (22.50%)	0.57
BMI (kg/m2)	22.31 ± 2.62	21.99 ± 2.38	0.50
ASA I(%):II(%)	21 (52.50%):19 (47.50%)	20 (50%):20 (50%)	0.82
Smoking status Yes No	 24(60%) 16(40%)	 24(60%) 16(40%)	 1
Duration of surgery in minutes	125.50 ± 23.93	126.70 ± 12.22	0.65
Block execution time in minutes	6.28 ± 1.06	6.68 ± 1.07	0.09
Intraoperative fentanyl requirement in µg	100(50-150)	80(50-130)	0.77

Baseline demographic and intraoperative characteristics were comparable between the supraclavicular block and interscalene block groups. There were no statistically significant differences in age, sex distribution, BMI, ASA physical status, smoking status, duration of surgery, block execution time, or intraoperative fentanyl requirement (all p > 0.05), indicating well-matched study groups.

Preoperative oxygen saturation (SpO_2) was comparable between the two groups. However, post-block SpO_2 values were significantly lower in the interscalene block group compared to the supraclavicular block group at 30 minutes, 60

minutes, 3 hours, and 6 hours (all $p \leq 0.001$). Additionally, the requirement for supplemental oxygen was significantly higher in the interscalene group (52.5% vs 10%, $p < 0.0001$), indicating better preservation of respiratory function in the supraclavicular block group. [Table 2]

Table 2: Perioperative Oxygenation Differences Following Supraclavicular Versus Interscalene Block

Parameter	SCB group (n=40) Mean ± SD	ISCB group (n=40) Mean ± SD	p-value
Preoperative SpO2%	98.68 ± 0.79	98.75 ± 0.71	0.657
30 minutes after RA SpO2%	97.50 ± 2.64	94.78 ± 2.89	< 0.0001
60 minute after RA SpO2%	97.35 ± 2.29	94.85 ± 2.35	< 0.0001
3 hours after RA SpO2%	97.58 ± 2.07	95.53 ± 2.18	< 0.0001
6 hours after RA SpO2%	97.90 ± 1.26	96.95 ± 1.28	0.001
O2 supplementation			< 0.0001
Yes	4(10%)	21(52.5%)	
No	36(90%)	19(47.5%)	

Values are presented as mean ± standard deviation (SD) or number (%), as appropriate. A total of 80 patients were included (SCB group: n = 40; ISCB group: n = 40). Comparisons between groups were performed using the unpaired t-test or Chi-square/Fisher's exact test, as appropriate. A p-value < 0.05 was considered statistically significant. SCB: supraclavicular block; ISCB: interscalene block; RA: regional anesthesia; SpO_2: peripheral oxygen saturation; O_2: oxygen. Baseline diaphragmatic excursion was comparable between groups. At 30 minutes after block, diaphragmatic excursion was significantly more reduced in the interscalene block group compared with the supraclavicular group ($p < 0.0001$). Although a trend toward reduced excursion persisted at 3 hours in the interscalene group, it did not reach statistical significance. By 6 hours, diaphragmatic excursion returned to near baseline values in both groups, with no significant difference observed between them. [Table 3]

Table 3: Comparison of diaphragmatic excursion

Parameter	SCB group (n=40) Mean ± SD	ISCB group (n=40) Mean ± SD	p-value
Before RA	34.78 ± 3.35	34.90 ± 2.88	0.85
30 minutes after RA	29.23 ± 10.01	15.63 ± 12.48	< 0.0001
3 hours	16.10 ± 6.06	11.93 ± 6.14	0.07
6 hours	32.30 ± 4.97	34.53 ± 3.00	0.09

Values are presented as mean ± standard deviation (SD). A total of 80 patients were included (SCB group: n = 40; ISCB group: n = 40). Between-group comparisons were performed using the unpaired t-test. A p-value < 0.05 was considered statistically significant. SCB: supraclavicular block; ISCB: interscalene block; RA: regional anaesthesia.

The incidence of hemi diaphragmatic paralysis differed significantly between groups, with a higher rate of total paralysis observed in the interscalene block group ($p < 0.0001$), while partial paralysis was more common compared to the supraclavicular group. Other complications, including dyspnoea, hematoma, Horner syndrome, paraesthesia, and local anaesthetic systemic toxicity, were infrequent and showed no statistically significant differences between groups. Hoarseness of voice was observed only in the interscalene group, but this did not reach statistical significance. [Table 4]

Table 4: Comparison of complications

Parameter	SCB group (n=40) Mean ± SD	ISCB group (n=40) Mean ± SD	p-value
Hemi-diaphragmatic paralysis			
Partial	6(15%)	9(22.5%)	0.39
Total	4(10%)	21(52.5%)	< 0.0001
None	30(75%)	10(25%)	< 0.0001
Dyspnoea	2(5%)	2(5%)	1.00
Hematoma	1(2.5%)	1(2.5%)	1.00
Horner syndrome	2(5%)	3(7.5%)	0.64
Hoarseness of voice	0(0%)	3(7.5%)	0.07
Paraesthesia	0	0	>0.99
LAST	0	0	>0.99

Values are presented as number (%). A total of 80 patients were included (SCB group: n = 40; ISCB group: n = 40). Between-group comparisons were performed using Chi-square test or Fisher's exact test, as appropriate. A p-value < 0.05 was considered statistically significant. SCB: supraclavicular block; ISCB: interscalene block; LAST: local anesthetic systemic toxicity.

DISCUSSION

In this randomized study, we compared ultrasound-guided supraclavicular block (SCB) using 20 mL of 0.5% bupivacaine with interscalene block (ISB) for shoulder surgery, focusing on hemi diaphragmatic paralysis (HdP), respiratory parameters, and postoperative complications.

Baseline demographic and intraoperative variables were comparable between groups [Table 1], confirming adequate randomization and homogeneity. No significant differences were observed in age, BMI, ASA status, duration of surgery, or intraoperative opioid requirement, ensuring that postoperative respiratory outcomes were primarily attributable to the block technique rather than confounding factors.

A key finding of our study was the significantly higher incidence of total HdP in the ISB group compared with the SCB group (52.5% vs 10%, $p < 0.0001$), while partial HdP was also more frequent with ISB [Table 4]. These findings confirm that ISB is strongly associated with near-complete phrenic nerve involvement, consistent with its anatomical proximity to the C3–C5 nerve roots. Although SCB significantly reduced the severity of diaphragmatic dysfunction, it did not eliminate it entirely, as 15% of patients still developed partial and 10% developed total paresis.

The mechanism of phrenic nerve involvement following ISB is well established. High-volume interscalene injections (≥20 mL) inevitably result in phrenic nerve blockade due to cephalad spread of local anaesthetic to the C3–C5 nerve roots.[3] Even with ultrasound guidance, diaphragmatic paralysis remains frequent because of the close anatomical relationship between the brachial plexus and the phrenic nerve.[11] Previous studies have demonstrated that reducing local anaesthetic volume or concentration can significantly decrease the incidence of HdP without compromising analgesia. For example, ultrasound-guided ISB using 10 mL reduces HdP incidence to approximately 60%, while 5 mL may further reduce it to 30–45%, with preserved analgesic efficacy.[12,13] Similarly, lowering local anaesthetic concentration has been shown to reduce phrenic nerve involvement, highlighting the dose-dependent nature of this complication.[14]

In addition to volume and concentration, injection site also influences phrenic nerve involvement. Periplexus or extra fascial approaches have been shown to significantly reduce diaphragmatic dysfunction compared with intrafascial injections, further supporting the concept that spread of local anaesthetic within fascial planes is a key determinant of phrenic nerve blockade.[6,15]

Ultrasound-based M-mode assessment, used in our study, is a validated method for quantifying diaphragmatic excursion.[7] Normal diaphragmatic displacement values vary with breathing pattern and sex, with deeper inspiratory efforts producing greater excursion.[7] In our study, diaphragmatic function was assessed at baseline and 30 minutes post-block, a time point consistent with the expected peak effect of phrenic nerve involvement. Complete paralysis was defined as a ≥75% reduction or paradoxical movement, while 25–75% reduction indicated partial paresis.[5,16]

This diaphragmatic impairment translated into measurable respiratory effects. Oxygen saturation (SpO_2) remained comparable preoperatively between groups; however, postoperative values were significantly lower in the ISB group at all-time points from 30 minutes to 6 hours [Table 2]. Additionally, oxygen supplementation was required significantly more often in the ISB group (52.5% vs 10%, $p < 0.0001$), highlighting the clinical relevance of diaphragmatic dysfunction beyond ultrasound findings.[17,18]

Ultrasound assessment of diaphragmatic excursion further supported these findings [Table 3]. At 30 minutes post-block, a marked reduction in excursion was observed in the ISB group compared with SCB (15.63 ± 12.48 vs 29.23 ± 10.01, $p < 0.0001$), indicating significant early diaphragmatic impairment. Although partial recovery was observed over time, differences between groups were no longer statistically significant at 3 and 6 hours, suggesting gradual resolution of phrenic nerve blockade.[5,16]

Despite anatomical expectations that SCB should reduce phrenic nerve involvement due to increasing distance from the nerve, our results demonstrate that ultrasound-guided SCB still carries a meaningful risk of HdP. This may be attributed to local anaesthetic spread beyond the intended brachial plexus sheath or individual anatomical variability.[4,6] Importantly, although SCB did not eliminate HdP, it consistently preserved oxygenation better than ISB, indicating a clinically relevant respiratory advantage.

No significant difference was observed in secondary respiratory or neurological complications such as dyspnoea, Horner syndrome, hematoma, or paraesthesia between groups [Table 4]. Hoarseness was observed only in the ISB group, although this did not reach statistical significance, likely reflecting recurrent laryngeal or proximal spread effects associated with interscalene approaches.19 Overall, both techniques demonstrated acceptable safety profiles, with SCB showing a more favourable respiratory outcome profile.

We did not identify significant demographic predictors of HdP, suggesting that the occurrence of diaphragmatic dysfunction is more closely related to block characteristics rather than patient factors. However, the higher incidence of dyspnoea in patients with elevated BMI suggests that obesity may amplify the clinical impact of diaphragmatic dysfunction, even when statistically comparable between groups.

Our study has limitations. Ultrasound-based diaphragmatic excursion, while widely accepted, is not the gold standard compared to trans-diaphragmatic pressure measurements. Additionally, the absence of formal pulmonary function testing limits quantification of ventilatory impairment. Finally, although inclusion of high-risk pulmonary patients would have strengthened clinical

applicability, this was not ethically feasible given the known high incidence of HdP with ISB.

CONCLUSION

Ultrasound-guided supraclavicular block using 20 mL of 0.5% bupivacaine is associated with a significantly lower incidence and severity of hemi diaphragmatic paralysis compared with interscalene block. Although SCB does not completely eliminate diaphragmatic dysfunction, it results in better preservation of diaphragmatic excursion and improved postoperative oxygenation. In contrast, interscalene block is associated with near-universal phrenic nerve involvement and greater need for supplemental oxygen.

Clinical Implications

Supraclavicular block may serve as a more respiratory-friendly alternative to interscalene block in patients undergoing shoulder surgery, particularly in those where preservation of pulmonary function is desirable. While ISB remains the most reliable technique for shoulder analgesia, its routine use should be cautiously considered in patients with limited respiratory reserve. SCB, when performed under ultrasound guidance with appropriate local anaesthetic dosing, offers a balanced approach by providing effective analgesia with reduced respiratory compromise. However, clinicians should remain aware that hemi diaphragmatic paralysis can still occur and appropriate postoperative monitoring is advised.

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