

Incidence of Hemidiaphragmatic Paresis After Low Volume of Anterior Suprascapular Nerve Block for Arthroscopic Shoulder Surgery: A Randomized, Double-Blind Controlled Trial

Choosak Tunprasit , Pornpatra Areeruk, Chonthicha Chawachart, Waraporn Nitithamakul, Lalisa Saeae, Sivaporn Termpornlert , Vanlapa Arnuntasupakul

Department of Anesthesiology, Faculty of Medicine Ramathibodi Hospital, Mahidol University, Bangkok, Thailand

Correspondence: Pornpatra Areeruk, Department of Anesthesiology, Faculty of Medicine Ramathibodi Hospital, Mahidol University, Bangkok, Thailand, Email pornpatra@yahoo.com

Background: The anterior suprascapular nerve block (ASSB) is an alternative block to the interscalene block (ISB) for arthroscopic shoulder surgery. Notably, using ASSB can mitigate the incidence of hemidiaphragmatic paralysis while providing comparable analgesia to that achieved using ISB. However, hemidiaphragmatic paralysis still occurs in a considerable proportion of patients receiving a 10 mL local anesthesia dose. This study investigates whether reducing the local anesthetic volume to 5 mL in ASSB significantly lowers the incidence of hemidiaphragmatic paralysis.

Methods: Seventy-eight patients undergoing arthroscopic shoulder surgery were randomly administered either 5 mL (V5 group) or 10 mL (V10 group) of 0.5% bupivacaine for ultrasound-guided ASSB. The primary outcome was the incidence of hemidiaphragmatic paralysis 30 minutes after the block, as determined by ultrasound assessment of diaphragmatic excursion. Secondary outcomes were the time to first opioid request, 24-hour morphine consumption, block success rate, length of hospital stay, patient satisfaction, and pain scores determined in the PACU, 6, 12, and 24 hours after surgery.

Results: A total of 72 patients were eligible for analysis. All type of hemidiaphragmatic paralysis occurred in 33.33% of the patients in the V10 group and 5.56% of the patients in the V5 group ($p = 0.006$). Complete hemidiaphragmatic paralysis was observed in 16.67% of the V10 group and 0% of the V5 group ($p = 0.025$). There were no significant differences in secondary outcomes between the groups.

Conclusion: Decreasing the volume of the ASSB from 10 to 5 mL of 0.5% bupivacaine effectively mitigated the risk of complete hemidiaphragmatic paralysis while maintaining comparable pain control.

Keywords: brachial plexus block, regional anesthesia, local anesthesia, diaphragmatic paralysis, anterior suprascapular nerve block, shoulder joint

Introduction

Shoulder surgery is one of the most painful orthopedic surgeries, which requires effective and adequate perioperative pain control. The interscalene brachial plexus block (ISB) is an effective peripheral nerve block to provide adequate pain control for shoulder surgery because it covers the entire nerve supply to the shoulder. However, the ISB frequently results in hemidiaphragmatic paralysis and Horner's syndrome.¹ The incidence of hemidiaphragmatic paralysis reaches up to 100%, especially when a high volume of local anesthesia is used.² This may lead to adverse events in patients with obesity,³ low pulmonary reserve, or underlying pulmonary disease. In the recent literature, various nerve blocks have been studied to avoid phrenic nerve block after shoulder surgery. The suprascapular nerve block is an effective alternative to control postoperative pain. In addition, it reduces the incidence of diaphragmatic paralysis because it is performed via a greater distance from the phrenic nerve. The suprascapular nerve block has two approaches: the anterior and posterior approaches. The posterior approach was reported to provide inferior postoperative pain control compared with the ISB.^{4,5}

Conversely, evidence suggests that the anterior approach provides non-inferior postoperative pain control compared with the ISB.^{6–8} However, even with a 10 mL injection volume of local anesthesia for the anterior suprascapular nerve block (ASSB), 40% of patients experienced hemidiaphragmatic paralysis.⁹ According to a recent cadaveric investigation, the least effective volume of local anesthesia for the ASSB that does not spread to the phrenic nerve is 4.2 mL.¹⁰ Therefore, 5 mL of local anesthesia was hypothesized to be adequate for the ASSB, while sparing the phrenic nerve. The primary outcome of this study was to assess the incidence of hemidiaphragmatic paralysis 30 minutes after applying the block in patients who received 5 or 10 mL of 0.5% bupivacaine for the ASSB. The incidence of hemidiaphragmatic paralysis was expected to decrease to 10% in the 5 mL group.

The secondary outcomes included the time to first opioid request, 24-hour morphine consumption, pain scores determined in the PACU, 6, 12, and 24 hours after surgery, block success rate, length of hospital stay, and patient satisfaction.

Materials and Methods

Prospective Randomized Double-Blind Controlled Trial

This study was conducted in accordance with the Declaration of Helsinki and was approved by the Human Research Ethics Committee in the Faculty of Medicine Ramathibodi Hospital at Mahidol University (MURA2021/917) and registered (<https://www.thaicalclinicaltrials.org>, TCTR20220105002) on January 5, 2022. The patients were enrolled from 20 January 2022 to 1 March 2023. The last data was collected on March 3, 2023. Written informed consent was obtained from all participants.

Study Participants

A total of 78 patients scheduled for elective arthroscopic shoulder surgery were recruited for this study, and informed consent was obtained before the operation. The inclusion criteria were age 18–75 years and physical status I–III according to the American Society of Anesthesiologists. Patients who had chronic opioid use, severe chronic lung disease, a body mass index of more than $30 \text{ kg} \cdot \text{m}^{-2}$, coagulopathy, an allergy to local anesthetic drugs, or a skin infection at the injection site were excluded from this study.

Training of Study Investigator

All study investigators are certified regional anesthesiologists at Ramathibodi Hospital.

Randomization and Blinding

Randomization was conducted using a random number generator provided by an online service (www.sealedenvelope.com), and block sizes of 6 were implemented. After obtaining informed consent, the patients were randomly allocated 1:1 into the two groups. Both groups underwent the ASSB, the V5 group received 5 mL, and the V10 group received 10 mL of 0.5% bupivacaine. The anesthesiologist who conducted the intraoperative care and the investigator who performed the nerve block were different people. The investigator who evaluated diaphragmatic function and performed the postoperative assessment was blinded.

Preoperative Management

The vital signs were measured at the holding area before the procedure. In the supine position, baseline diaphragmatic function was evaluated. Fentanyl (0.5 mcg/kg) and midazolam (0.02 mg/kg) were given before procedure. The anesthesiologist opened the sealed envelope after the patients were sedated. In semi-sitting position, the injection site was prepared using aseptic technique with 2% chlorhexidine in alcohol. An 4–18 MHz linear transducer (Konica Minolta SONIMAGE HS1) was used to perform the ASSB. The suprascapular nerve is the first branch of the superior trunk, which runs beneath the inferior belly of the omohyoid muscle. The nerve was followed as laterally as possible under the omohyoid muscle (Figure 1). Once the suprascapular nerve was identified, a Stimuplex Ultra 22G 80 mm needle (B. Braun Aesculap Japan Co., Ltd.) was inserted from the lateral to medial supraclavicular fossa with short axis in plane technique. After the needle was in the proper position,

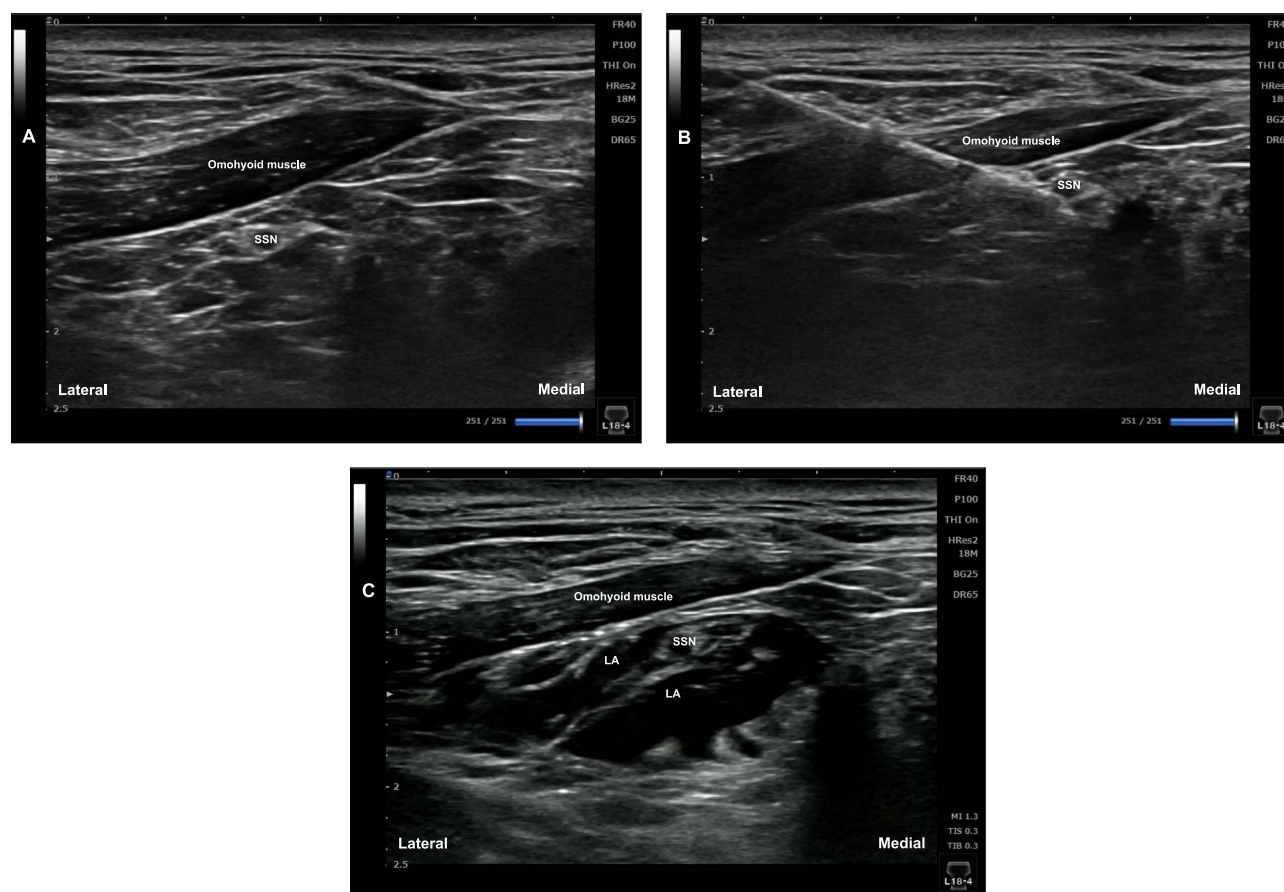


Figure 1 (A) Suprascapular nerve lies beneath the omohyoid muscle. (B) The needle was advanced from lateral to medial, targeting the suprascapular nerve. (C) Local anesthetic spread around suprascapular nerve.

Abbreviations: SSN, suprascapular nerve; LA, local anesthetic.

electrical stimulation was used to identify and confirm the nerve by observing a twitch of the shoulder or contractions of the supra and infraspinatus muscle at a current of 0.4–0.5 mA. Then, the current was decreased until the contractions disappeared. After negative blood aspiration, 0.5 mL of 5% Dextrose water was injected to confirm the position of the needle tip. Subsequently, 0.5% bupivacaine was injected (5 mL in the V5 group and 10 mL in the V10 group). Intravenous dexamethasone (5 mg) was given following the block to enhance its duration.

Intraoperative Management

General anesthesia was induced with fentanyl (1 mcg/kg), propofol (1–2 mg/kg), and atracurium (0.6 mg/kg). Furthermore, anesthesia was maintained using 2–6% desflurane in combination with 60% nitrous oxide to achieve a MAC of 0.8–1.0. Intraoperative morphine was given based on changes in vital signs and the individual judgment of the anesthesiologist, who was blinded to the group allocation. At the end of surgery, atropine (0.02 mg/kg) and neostigmine (0.05 mg/kg) were given as reversal agents.

Postoperative Management

In the PACU, the patient-controlled analgesia machine (IV PCA) was connected after the patient gained full consciousness, with the following settings: morphine (1 mg/mL), PCA dose of 1 mg, lockout interval of 5 min, limit to the maximum of 40 mg/4 hours, and no continuous infusion. For oral postoperative pain control, patients received paracetamol 500 mg every 6 hours, paracetamol with codeine (300/15 mg) every 6 hours, etoricoxib 90 mg daily, and gabapentin 25 mg daily.

Outcome Variables

The primary outcome was the incidence of diaphragmatic paralysis 30 minutes after performing the ASSB. Deep respiration was used to identify diaphragmatic paralysis. Complete diaphragmatic paralysis was defined as a decrease in diaphragmatic excursion of more than 75% compared with the baseline (Figure 2), partial diaphragmatic paralysis was defined as a decrease in diaphragmatic excursion of 25–75% compared with the baseline, and a decrease in diaphragmatic excursion of less than 25% was defined as no diaphragmatic paralysis (Figure 3).

Secondary outcomes included the time to first opioid request, 24-hour morphine consumption, block success rate, length of hospital stay, patient satisfaction, and pain scores determined in the PACU, 6, 12, and 24 hours after surgery. The pain score was rated using a numeric rating scale of the pain experienced at rest and with movement (0 = no pain, 10 = worst pain imaginable). Patient satisfaction was rated from 1 (least satisfied) to 10 (most satisfied). Block success defined as decrease cold sensation at C5 or C6 dermatome at any time point within 30 minutes after block.

Assessment of Diaphragmatic Function

In supine position, the diaphragmatic function was evaluated before and 30 minutes after the block. A 3.5 MHz curve ultrasound transducer in the M mode (Toshiba Aplio 300) was placed below the costal margin at the midclavicular line on the right side or the anterior axillary line on the left side using the liver or spleen as an acoustic window to assess diaphragmatic function. The evaluation consisted of deep respiration and sniffing test (brief, forced inspiration). Three measurements for each respiratory pattern were made to determine the average value. If the value of deep inspiration decreased by less than 25% compared with the baseline, the test was interpreted as no hemidiaphragmatic paralysis. If the

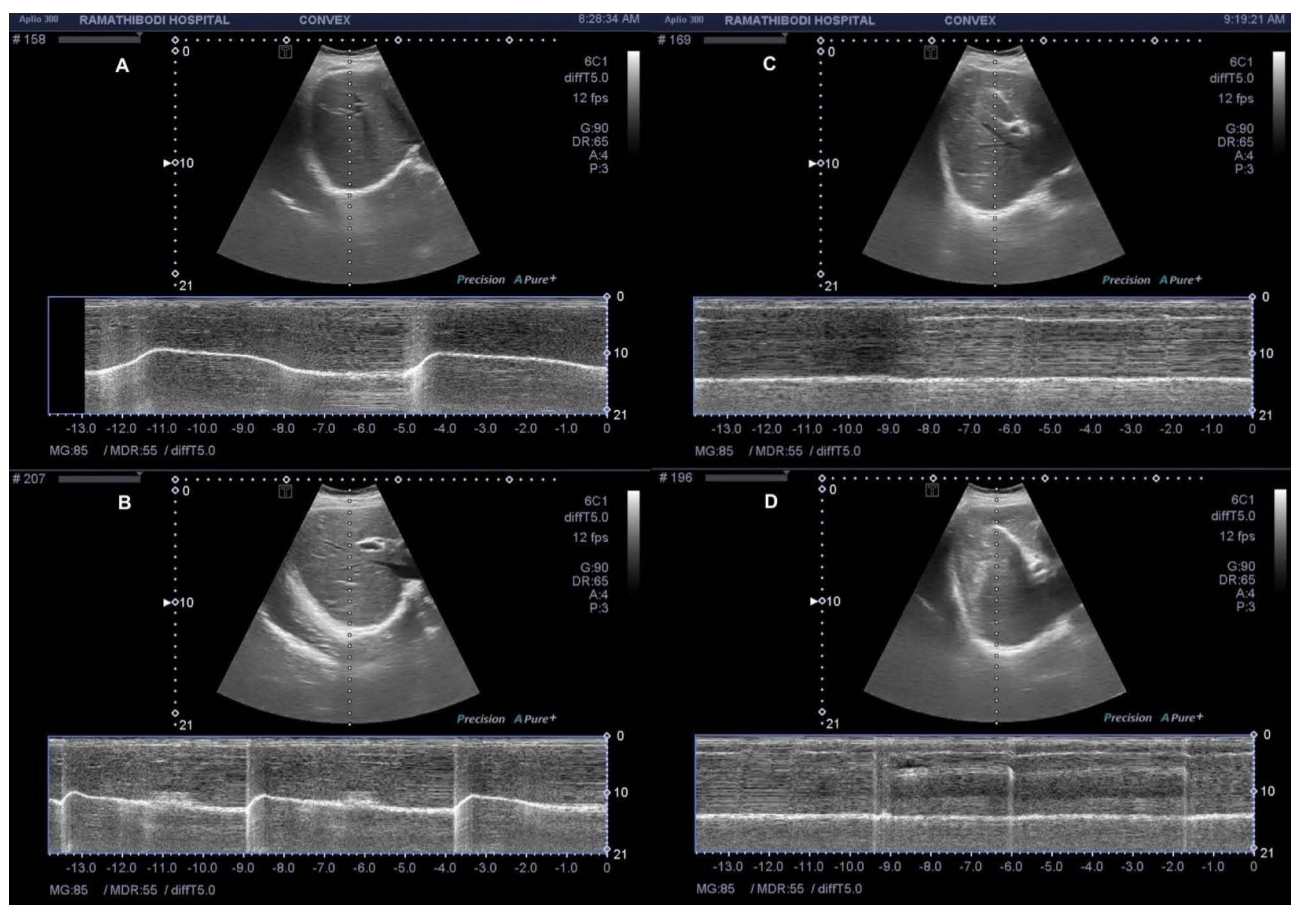


Figure 2 Assessment of diaphragmatic function shows complete hemidiaphragmatic paralysis. (A) Pre-block, deep breathing. (B) Pre-block, sniff test. (C) Post-block, deep breathing. (D) Post-block, sniff test.

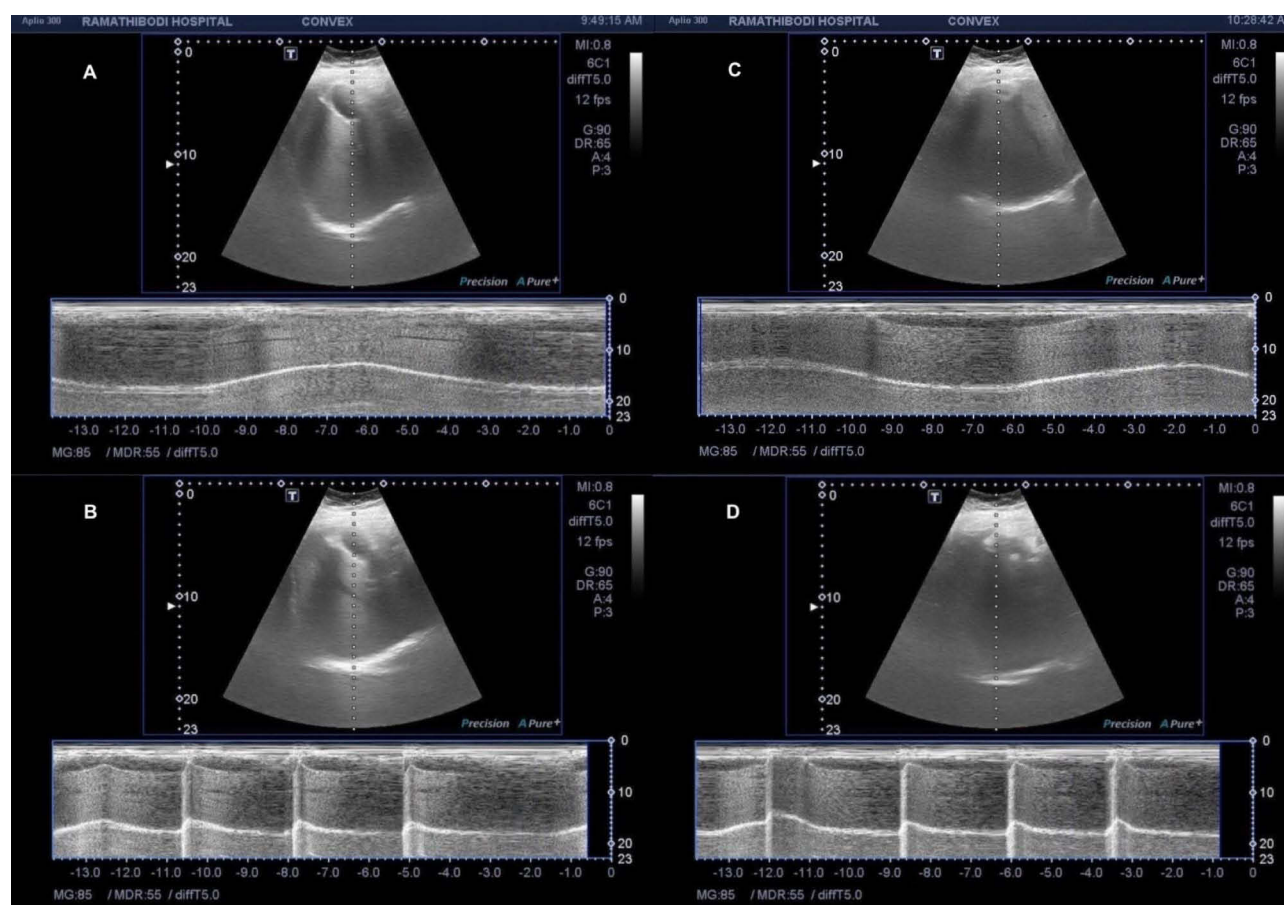


Figure 3 Assessment of diaphragmatic function shows no paresis. (A) Pre-block, deep breathing. (B) Pre-block, sniff test. (C) Post-block, deep breathing. (D) Post-block, sniff test.

value decreased by 25%–75%, the test was interpreted as partial hemidiaphragmatic paralysis. If the value decreased by more than 75%, the test was interpreted as complete hemidiaphragmatic paralysis.^{3,9}

Assessment of Sensory Functions

Sensory function was evaluated every 5 minutes for 30 minutes. Testing was performed using gauze soaked in 2% chlorhexidine in alcohol and graded on a 3-point scale: (0) normal sensation, (1) decreased cold sensation (can feel touch, not cold), and (2) no sensation (cannot feel touch). Sensory blockade was assessed at the C5 and C6 dermatomes, defined as the lateral shoulder (C5) and the thumb (C6). Block success was determined by sensory coverage of these dermatomes, which correspond to the surgical incision site. This rationale is based on the principle that an effective suprascapular nerve block allows local anesthetic to spread to the superior trunk, thereby providing analgesia in these dermatomes.

Sample Size Calculation

The sample size calculation was based on previous reports indicating that the incidence of hemidiaphragmatic paresis 30 minutes after a 10 mL of local anesthetic for ASSB was approximately 40%.⁹ In the absence of prior ASSB data for a 5 mL dose, a conservative incidence of 10% was assumed based on findings from a superior trunk block study.¹¹ Assuming that administering 5 mL of local anesthetic can reduce the absolute incidence of ipsilateral hemidiaphragmatic paresis to 10%, we calculated that 32 subjects would be required for each group (total of 64) to detect this difference with an α error of 0.05 and a power of 80%. Allowing for a 20% dropout rate, we planned to recruit 78 subjects.

Statistical Analysis

The Shapiro–Wilk test was used to verify the normality of the data. A comparison between the V5 and V10 groups for continuous variables was conducted using the independent sample *t*-test or Mann–Whitney *U*-test. Categorical variables were compared using either the chi-squared test or Fisher’s exact test. The change in pain score over time was analyzed using repeated measures ANOVA, considering two factors: the group effect (V5 versus V10) and the time effect. Statistical analysis was carried out using SPSS version 18.0 (SPSS Inc., released 2009, PASW Statistics for Windows, Chicago: SPSS Inc.), using a significance level of $p < 0.05$.

Results

Seventy-eight patients were recruited for the study. The final analysis included 72 eligible patients: 36 in the V5 group and 36 in the V10 group. One patient in the V5 group had an operation canceled owing to suspected intraoperative myocardial infarction. Two and three patients dropped out of the V5 and V10 groups, respectively, because their operations were converted to open surgeries. The observed incidence of hemidiaphragmatic paralysis in the intervention group was 5.56%, lower than the anticipated 10%. The resulting effect size exceeded the original estimate, confirming adequate power to detect a between-group difference. The baseline characteristics and demographic data are shown in Table 1. The median intraoperative morphine equivalent dose was 5 mg in both groups, which included fentanyl 1 mcg/kg administered for induction according to the study protocol. There was no significant difference between the groups ($p = 0.821$).

Primary Outcome

The complete hemidiaphragmatic paralysis did not occur in the V5 group, while it was observed in six patients in the V10 group (0% vs 16.67%, $p=0.025$). The overall incidence of hemidiaphragmatic paralysis was also lower in the V5 group compared to the V10 group (5.56% vs 33.33%, $p=0.006$) (Table 2).

Secondary Outcomes

The median time to first opioid request was 1 hour in both groups. The 24-hour morphine consumption also showed no significant difference between groups ($p = 0.968$). The postoperative pain scores did not differ between groups at any

Table 1 Patient’s Characteristics

	V5 (36)	V10 (36)
Age (year)	58.25 ± 11.58	56.89 ± 11.43
Body mass index (kg.m ⁻²)	24.72 ± 3.32	24.28 ± 3.13
The American Society of Anesthesiologists physical status I/II/III	9/25/2	6/27/3
Underlying disease(s).		
Hypertension	13 (36.11%)	12 (33.33%)
Diabetes mellitus	3 (8.33%)	8 (22.22%)
Dyslipidemia	20 (55.56%)	21 (58.33%)
Side of injury Left/Right	11/25	13/23
Type of operation		
ASK Bankart repair	3 (8.34%)	2 (5.56%)
ASK capsular release	1 (2.78%)	0 (0%)
ASK GT fixation	0 (0%)	1 (2.78%)
ASK repair RC	19 (52.78%)	19 (52.78%)
ASK repair RC c acromioplasty	12 (33.33%)	14 (38.89%)
ASK SLAP repair	1 (2.78%)	0 (0%)
Anesthetic time (min)	200.36 ± 48.13	208.97 ± 50.9
Operation time (min)	114.78 ± 39.67	120.56 ± 43.7

Note: Data are mean ± standard deviation, median (interquartile range), or n (%).

Abbreviation: ASK, Arthroscopy of the Shoulder.

Table 2 Incidence of Diaphragmatic Paralysis at 30 min After Block

	V5 (36)	V10 (36)	P-value
Complete diaphragmatic paralysis	0 (0%)	6 (16.67%)	0.025*
All type of diaphragmatic paralysis	2 (5.56%)	12 (33.33%)	0.006*

Note: Interpretation using deep respiration, all type of diaphragmatic paralysis is complete or partial diaphragmatic paralysis, *p<0.05.

Table 3 Secondary Outcomes

	V5 (36)	V10 (36)	P-value
Morphine consumption			
At PACU	1 (1–3)	0.5 (0–2)	0.553
PO 6 hr.	2 (1–3)	1.5 (1–4)	0.723
PO 12 hr.	3 (2–6)	3 (1–6)	0.767
PO 24 hr.	3.5 (1–5)	4 (2–6)	0.968
Pain score			
At rest			
At PACU	3 (3–5)	1.5 (0–3)	0.475
PO 6 hr.	0.5 (0–2)	2 (2–3)	0.357
PO 12 hr.	0 (0–0)	1 (1–3)	0.436
PO 24 hr.	0 (0–0)	1 (1–4)	0.112
On movement			
At PACU	4 (4–5)	3 (2–6)	0.487
PO 6 hr.	2 (2–4)	3 (3–5)	0.814
PO 12 hr.	2 (2–3)	2 (1–4)	0.855
PO 24 hr.	2 (2–5)	2 (2–5)	0.564
Time to first opioid requested (total hour)	1 (1–5)	1 (1–5)	0.699
Length of hospital stay (hour)	49 (49–50)	49 (49–51)	0.430
Patient's satisfaction score	10 (10–10)	10 (10–10)	0.791

Note: Data are median (interquartile range).

Abbreviations: PACU, Post-operative care unit; PO, Post-operative.

time point (Table 3). The block success rate was 100% in both groups, the median length of hospital stay was 49 hours in both groups, and the median patient satisfaction score was 10 in both groups (Table 3).

Discussion

This study demonstrated that ASSB with 5 mL of 0.5% bupivacaine significantly decreased the incidence of hemidiaphragmatic paralysis, resulting in 0% complete paralysis and 5.56% partial paralysis. In contrast, the control group, which received 10 mL of 0.5% bupivacaine, demonstrated complete hemidiaphragmatic paralysis in 16.67% of patients, with an overall hemidiaphragmatic paralysis incidence reaching 33.33%. This is consistent with the results reported by Doğan et al, who found 3.7% partial diaphragmatic paralysis following 5 mL of 0.5% bupivacaine for the ASSB.¹² Furthermore, Ferré et al showed that the incidence of hemidiaphragmatic paralysis was 33% partial paralysis and 7% complete paralysis after using 10 mL of 0.375% ropivacaine for the ASSB.⁹ The occurrence of partial hemidiaphragmatic paralysis, even with a low volume such as 5 mL, is supported by findings from a cadaveric study in 2019,¹³ which demonstrated phrenic nerve staining in 20% of specimens following ASSB using 5 mL of methylene blue. Additionally, Maikong et al reported that the MEV90 of dye required to avoid phrenic nerve involvement during ASSB was 4.2 mL.¹⁰ Our study confirms that even a 5 mL volume of local anesthesia can spread sufficiently to cause partial hemidiaphragmatic paralysis in a clinical setting. Another possible cause of hemidiaphragmatic paralysis is blockade of the accessory

phrenic nerve, which commonly originates from the nerve to subclavius, the ansa cervicalis, or the nerve to the sternohyoid. If local anesthetic reaches this nerve, hemidiaphragmatic paralysis may still occur.¹⁴

However, a study by Coşarcan et al reported that when 6 mL or less of 0.5% bupivacaine was used for ASSB, diaphragmatic excursion decreased by less than 25% from baseline. Furthermore, when the injection volume was reduced to less than 4 mL, the decrease in excursion was less than 10%. These findings suggest that no significant diaphragmatic paralysis occurred when the injection volume did not exceed 6 mL.¹⁵ However, this study was not designed to evaluate the incidence of hemidiaphragmatic paralysis, and the small number of patients (n=10) receiving 5 or 6 mL precludes definitive conclusions regarding its incidence.

Compared to the ISB, the standard peripheral nerve block for shoulder surgery—which is known to cause hemidiaphragmatic paralysis in nearly all cases²—modifications such as using a low volume, a low concentration of local anesthetic, or administering the injection more laterally have not been effective in preventing phrenic nerve involvement.¹⁶ This is likely due to the close anatomical proximity of the phrenic nerve to the brachial plexus; at the level of the cricoid cartilage, they lie within 18–20 mm of each other, with an additional 3 mm of separation for every centimeter more caudal in the neck.^{17,18} In contrast, the suprascapular nerve block appears to reduce the risk of hemidiaphragmatic paralysis, as it is performed at a greater distance from the phrenic nerve.¹⁹

Hemidiaphragmatic paralysis following brachial plexus block can cause respiratory distress in clinical settings, particularly among obese patients, occasionally necessitating conversion to general anesthesia.²⁰ Marty et al reported that in patients with BMI ≥ 30 kg/m², hemidiaphragmatic paralysis after ISB or ASSB with axillary nerve block was associated with increased dyspnea, more frequent hypoxic events, and a higher incidence of ambulatory surgery failure during arthroscopic shoulder surgery.³ Moreover, even in non-obese patient, phrenic nerve palsy caused by cervical spondylosis has been documented to result in significant respiratory compromise requiring non-invasive ventilation.²¹ Although hemidiaphragmatic paralysis is generally well tolerated in healthy individuals, avoiding its occurrence remains important in patients at risk.

In terms of analgesic efficacy, the initial posterior approach of the suprascapular nerve block (PSSB) has been shown to reduce postoperative pain compared to placebo in arthroscopic shoulder surgery.²² However, its analgesic effect may be inferior to that of ISB, even when combined with an axillary nerve block.^{4,5} This limitation may be attributed to the fact that the PSSB does not cover certain sensory and articular branches of the suprascapular nerve that typically branch off proximally, before the nerve passes under the transverse scapular ligament.^{23–25} For this reason, the ASSB, which blocks the parent trunk of the suprascapular nerve, was investigated to determine whether it provides better analgesic outcomes compared with PSSB. Several studies show that ASSB using 15 mL of 0.5% ropivacaine provided non inferior analgesia compared with ISB using the same volume and concentration of local anesthesia for the first 24 hours.^{6,8} A meta-analysis of 6 randomized controlled trials demonstrated that the opioid consumption and pain scores at 6 and 24 hours were not significantly different between the ASSB and ISB groups, but significantly lower incidences of Horner's syndrome, voice hoarseness, and impaired respiratory function were observed in the ASSB group.⁷ Wiegel et al compared the analgesic outcome of shoulder surgery using the ASSB with 10 mL of 1% ropivacaine and the ISB with 20 mL of 1% ropivacaine, showing that even if the volume was reduced to 10 mL for the ASSB, pain control was not significantly different between groups.²⁶ Furthermore, the ASSB with 5 mL of 0.75% ropivacaine significantly reduced pain and opioid consumption compared to placebo.²⁷ Therefore, ASSB offers analgesic efficacy comparable to ISB when combined with general anesthesia.^{7,12,26}

Our results also showed that using 5 mL of 0.5% bupivacaine for the ASSB has no significant difference in providing postoperative pain control compared with using 10 mL of 0.5% bupivacaine. The pain scores recorded in the PACU and at 6, 12, and 24 hours, as well as overall opioid consumption at 24 hours showed no significant difference between groups. These results are consistent with a study in healthy volunteers, which demonstrated that administering 5 mL of local anesthetic for ASSB achieved a success rate comparable to that of 20 mL.²⁸

The effectiveness of the ASSB is not solely due to suprascapular nerve blockade. Considering that the suprascapular nerve provides the major innervation to the shoulder joint, the remaining innervation is supplied by the axillary, subscapular, and lateral pectoral nerves.^{29,30} Anatomical study show that the posterior division of the superior trunk lies close to the suprascapular nerve.³¹ Accordingly, local anesthetic injected around the suprascapular nerve is likely to

spread to the superior trunk and its branches, including the lateral pectoral nerve, which arises from the anterior division of the superior trunk, and the subscapular and axillary nerves, which originate from the posterior divisions of the superior and middle trunks. This was confirmed by the cadaveric study showing that using 10 mL of dye for the ASSB caused 100% staining in the superior trunk and 93% staining in the middle trunk.¹⁹ Even when the volume was reduced to 5 mL, the spreading of dye to the superior trunk and middle trunk was still seen in 90% and 80% of the specimens, respectively.¹³ Maikong et al further confirmed that a volume of 3 mL is sufficient for spreading the dye to the superior trunk.¹⁰ These findings may explain why both 5 mL and 10 mL provided equivalent analgesia, as 5 mL was sufficient not only to cover the suprascapular nerve but also to spread to the superior and middle trunks.

The length of hospital stay in our study was 49 hours in both groups. This duration includes preoperative hospitalization for 1 day before the surgery, following the protocol established by orthopedic surgeons at our center. No delays in discharge were attributable to anesthetic factors.

Our study had several limitations. First, the duration of the ASSB was not directly evaluated. While comparable postoperative pain scores and opioid consumption between the two groups indirectly suggest a similar duration of effect, a direct measurement would provide a more precise assessment of the differential impact of local anesthetic dose and volume reduction. Second, block success was determined using superior trunk blockade as a surrogate marker, which represents only an indirect measure of suprascapular nerve blockade. A direct assessment of the suprascapular nerve—incorporating both motor and sensory evaluation—would yield a more precise and definitive determination of whether the nerve is adequately anesthetized. Third, opioid-related adverse effects were not assessed; although opioid consumption did not differ between groups in our study, any variation in opioid use could potentially have influenced these outcomes. Finally, it is acknowledged that in general clinical practice, particularly when performed by inexperienced operators, using a low volume of local anesthetic may potentially increase the incidence of block failure. This practical consideration should be considered when interpreting the results and translating them to routine clinical settings.

Conclusion

In summary, The ASSB using 5 mL of 0.5% bupivacaine significantly reduces the incidence of hemidiaphragmatic paralysis and provides comparable pain control to the ASSB using 10 mL of 0.5% bupivacaine. Therefore, a 5 mL volume is recommended to minimize phrenic nerve involvement without compromising analgesic efficacy, particularly in patients at risk of respiratory complications.

Declaration of Generative AI and AI-Assisted Technologies in the Writing Process

During the preparation of this work the author(s) used ChatGPT (OpenAI) for grammar correction and language translation. After using this tool, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the publication.

Data Sharing Statement

The datasets generated and analyzed during the current study are not publicly available due to privacy restrictions, but are available from the corresponding author on reasonable request.

Acknowledgments

We are thankful to all who participated in this study, including Miss Rojnarin Komonhirun, M.Ed. (research assistant), for helping in data analysis and other statistical works.

Funding

Support was provided solely from institutional and departmental sources.

Disclosure

The authors declare no competing interests.

References

- Hussain N, Goldar G, Ragina N, Banfield L, Laffey JG, Abdallah FW. Suprascapular and interscalene nerve block for shoulder surgery: a systematic review and meta-analysis. *Anesthesiology*. 2017;127(6):998–1013. doi:10.1097/ALN.0000000000001894
- Urney WF, Talts KH, Sharrock NE. One hundred percent incidence of hemidiaphragmatic paresis associated with interscalene brachial plexus anesthesia as diagnosed by ultrasonography. *Anesthesia Analg*. 1991;72(4):498–503. doi:10.1213/0000539-199104000-00014
- Marty P, Ferré F, Basset B, et al. Diaphragmatic paralysis in obese patients in arthroscopic shoulder surgery: consequences and causes. *J Anesth*. 2018;32(3):333–340. doi:10.1007/s00540-018-2477-9
- Aliste J, Bravo D, Finlayson RJ, Tran DQ. A randomized comparison between interscalene and combined infraclavicular-suprascapular blocks for arthroscopic shoulder surgery. *Can J Anaesth*. 2018;65(3):280–287. doi:10.1007/s12630-017-1048-0
- Dhir S, Sondekoppam RV, Sharma R, Ganapathy S, Athwal GS. A comparison of combined suprascapular and axillary nerve blocks to interscalene nerve block for analgesia in arthroscopic shoulder surgery: an equivalence study. *Reg Anesth Pain Med*. 2016;41(5):564–571. doi:10.1097/AAP.0000000000000436
- Abdallah FW, Wijesundera DN, Laupacis A, et al. Subomohyoid anterior suprascapular block versus interscalene block for arthroscopic shoulder surgery: a multicenter randomized trial. *Anesthesiology*. 2020;132(4):839–853. doi:10.1097/ALN.0000000000003132
- White L, Reardon D, Davis K, Velli G, Bright M. Anterior suprascapular nerve block versus interscalene brachial plexus block for arthroscopic shoulder surgery: a systematic review and meta-analysis of randomized controlled trials. *Journal of Anesthesia*. 2022;36(1):17–25. doi:10.1007/s00540-021-03000-z
- Auyong DB, Hanson NA, Joseph RS, Schmidt BE, Slee AE, Yuan SC. Comparison of anterior suprascapular, supraclavicular, and interscalene nerve block approaches for major outpatient arthroscopic shoulder surgery: a randomized, double-blind, noninferiority trial. *Anesthesiology*. 2018;129(1):47–57. doi:10.1097/ALN.0000000000002208
- Ferré F, Pommier M, Laumonerie P, et al. Hemidiaphragmatic paralysis following ultrasound-guided anterior vs. posterior suprascapular nerve block: a double-blind, randomised control trial. *Anaesthesia*. 2020;75(4):499–508. doi:10.1111/anae.14978
- Maikong N, Kantakam P, Sinthubua A, Mahakkanukrauh P, Tran DQ, Leucharusmee P. Cadaveric study investigating the phrenic-sparing volume for anterior suprascapular nerve block. *Reg Anesth Pain Med*. 2021;46(9):769–772. doi:10.1136/rapm-2021-102803
- Kim H, Han JU, Lee W, et al. Effects of local anesthetic volume (Standard Versus Low) on incidence of hemidiaphragmatic paralysis and analgesic quality for ultrasound-guided superior trunk block after arthroscopic shoulder surgery. *Anesth Analg*. 2021;133(5):1303–1310. doi:10.1213/ANE.0000000000005654
- Doğan AT, Coşarcan SK, Gürkan Y, Koyuncu Ö, Erçelen Ö, Demirhan M. Comparison of anterior suprascapular nerve block versus interscalene nerve block in terms of diaphragm paralysis in arthroscopic shoulder surgery: a prospective randomized clinical study. *Acta Orthop Traumatol Turc*. 2022;56(6):389–394. doi:10.5152/j.aott.2022.22044
- Sehmbi H, Johnson M, Dhir S. Ultrasound-guided subomohyoid suprascapular nerve block and phrenic nerve involvement: a cadaveric dye study. *Reg Anesth Pain Med*. 2019;44(5):561–564. doi:10.1136/rapm-2018-100075
- Loukas M, Kinsella CR Jr, Louis RG Jr, Gandhi S, Curry B. Surgical anatomy of the accessory phrenic nerve. *Ann Thorac Surg*. 2006;82(5):1870–1875. doi:10.1016/j.athoracsur.2006.05.098
- Coşarcan SK, Doğan AT, Koyuncu Ö, Gurkan Y, Erçelen Ö. The minimum effective analgesic volume of 0.5% bupivacaine for ultrasound-guided anterior suprascapular nerve block. *Cureus*. 2022;14(11):e31350. doi:10.7759/cureus.31350
- Tran DQ, Layera S, Bravo D, Cristi-Sánchez I, Bermúdez L, Aliste J. Diaphragm-sparing nerve blocks for shoulder surgery, revisited. *Reg Anesth Pain Med*. 2020;45(1):73–78. doi:10.1136/rapm-2019-100908
- El-Boghdady K, Chin KJ, Chan VWS. Phrenic nerve palsy and regional anesthesia for shoulder surgery: anatomical, physiologic, and clinical considerations. *Anesthesiology*. 2017;127(1):173–191. doi:10.1097/ALN.0000000000001668
- Kessler J, Schafhalter-Zoppoth I, Gray AT. An ultrasound study of the phrenic nerve in the posterior cervical triangle: implications for the interscalene brachial plexus block. *Reg Anesth Pain Med*. 2008;33(6):545–550. doi:10.1136/rapm-00115550-200811000-00006
- Laumonerie P, Ferré F, Cances J, et al. Ultrasound-guided proximal suprascapular nerve block: a cadaveric study. *Clin Anat*. 2018;31(6):824–829. doi:10.1002/ca.23199
- Lang J, Cui X, Zhang J, Huang Y. Dyspnea induced by hemidiaphragmatic paralysis after ultrasound-guided supraclavicular brachial plexus block in a morbidly obese patient. *Medicine*. 2022;101(2):e28525. doi:10.1097/MD.00000000000028525
- Fiott DL, Gauci J, Pace Bardon M, Balzan M. Type 2 respiratory failure secondary to left hemidiaphragmatic paralysis. *Breathe*. 2022;18(1):210165. doi:10.1183/20734735.0165-2021
- Ritchie ED, Tong D, Chung F, Norris AM, Miniaci A, Vairavanathan SD. Suprascapular nerve block for postoperative pain relief in arthroscopic shoulder surgery: a new modality? *Anesthesia Analg*. 1997;84(6):1306–1312. doi:10.1213/0000539-199706000-00024
- Vorster W, Lange CPE, Briët RJP, et al. The sensory branch distribution of the suprascapular nerve: an anatomic study. *Journal of Shoulder and Elbow Surgery*. 2008;17(3):500–502. doi:10.1016/j.jse.2007.10.008
- Ebraheim NA, Whitehead JL, Alla SR, et al. The suprascapular nerve and its articular branch to the acromioclavicular joint: an anatomic study. *Journal of Shoulder and Elbow Surgery*. 2011;20(2):e13–e17. doi:10.1016/j.jse.2010.09.004
- Borbas P, Eid K, Ek ET, Feigl G. Innervation of the acromioclavicular joint by the suprascapular nerve. *Shoulder & Elbow*. 2020;12(3):178–183. doi:10.1177/1758573219851005
- Wiegel M, Moriggl B, Schwarzkopf P, Petroff D, Reske AW. Anterior suprascapular nerve block versus interscalene brachial plexus block for shoulder surgery in the outpatient setting: a randomized controlled patient- and assessor-blinded trial. *Reg Anesth Pain Med*. 2017;42(3):310–318. doi:10.1097/AAP.0000000000000573
- Steen-Hansen C, Rothe C, Kjeldgaard LD, Lyngeraa TS, Lundstrøm LH, Lange KHW. Low volume proximal suprascapular nerve block after arthroscopic shoulder surgery – a randomised, controlled trial. *Acta Anaesthesiologica Scandinavica*. 2022;66(6):742–749. doi:10.1111/aas.14064

28. Steen-Hansen C, Madsen MH, Lange KHW, Lundstrøm LH, Rothe C. Single injection combined suprascapular and axillary nerve block: a randomised controlled non-inferiority trial in healthy volunteers. *Acta Anaesthesiologica Scandinavica*. 2023;67(1):104–111. doi:10.1111/aas.14147
29. Laumonerie P, Dalmas Y, Tibbo ME, et al. Sensory innervation of the human shoulder joint: the three bridges to break. *Journal of Shoulder and Elbow Surgery*. 2020;29(12):e499–e507. doi:10.1016/j.jse.2020.07.017
30. Tran J, Peng PWH, Agur AMR. Anatomical study of the innervation of glenohumeral and acromioclavicular joint capsules: implications for image-guided intervention. *Reg Anesth Pain Med*. 2019;44(4):452–458. doi:10.1136/rapm-2018-100152
31. Hanna A. The SPA arrangement of the branches of the upper trunk of the brachial plexus: a correction of a longstanding misconception and a new diagram of the brachial plexus. *J Neurosurg*. 2016;125(2):350–354. doi:10.3171/2015.5.JNS15367

Journal of Pain Research

Publish your work in this journal

The Journal of Pain Research is an international, peer reviewed, open access, online journal that welcomes laboratory and clinical findings in the fields of pain research and the prevention and management of pain. Original research, reviews, symposium reports, hypothesis formation and commentaries are all considered for publication. The manuscript management system is completely online and includes a very quick and fair peer-review system, which is all easy to use. Visit <http://www.dovepress.com/testimonials.php> to read real quotes from published authors.

Submit your manuscript here: <https://www.dovepress.com/journal-of-pain-research-journal>

Dovepress
Taylor & Francis Group