



# Comparison of subomohyoid plane block and interscalene nerve block for arthroscopic shoulder surgery

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## ABSTRACT

**Background:** Ultrasound guided interscalene nerve block (ISB) is a popular procedure for pain relief in shoulder surgery patients. The subomohyoid plane block is a new reliable and technically easy regional technique that can be properly used for pain management with fewer adverse effects. The aim of this study was to validate whether there is a difference in postoperative pain scores and morphine consumption between interscalene and subomohyoid plane blocks.

**Method:** Eighty patients scheduled for shoulder arthroscopy were enrolled in this controlled blinded study and randomized to interscalene or subomohyoid plane blocks using 15 ml 0.5% bupivacaine in each group and general anesthesia. The primary outcome was pain severity at rest using VAS. Secondary outcomes were first 24 h total morphine consumption, patient satisfaction and adverse effects.

**Results:** All patients completed the study through the primary outcome analysis. VAS scores at PACU 2 h were similar in both groups, and VAS scores at 4, 8, 12, 18 and 24 h were statistically lower in the interscalene block group (ISB) than in the subomohyoid group ( $p < 0.001$ ), with no clinical significance. Total morphine consumption was lower in ISB group than in the subomohyoid group ( $p < 0.001$ ). Time to the first rescue analgesic request and patients' satisfaction were similar in both groups. Ipsilateral phrenic nerve was blocked in 37.5% of patients in ISB group vs. 7.5% in the subomohyoid group ( $p < 0.001$ ).

**Conclusion:** Subomohyoid plane block can be considered as an alternative to interscalene block for shoulder arthroscopy surgery.

## ARTICLE HISTORY

Received 10 September 2022  
Revised 17 September 2022  
Accepted 28 September 2022

## KEYWORDS

Subomohyoid; interscalene; nerve block; shoulder arthroscopy

## 1. Introduction

Ultrasound guided interscalene nerve block (ISB) is a popular procedure for pain relief in shoulder surgery patients [1]. Although it is well tolerated by most patients, it is sometimes associated with phrenic nerve block with consequent hemidiaphragmatic paresis [2]. The unintended spread of local anaesthetics to the phrenic nerve causes this adverse effect, which is a critical concern to both the anesthetists and surgeons in outpatient shoulder surgery [3].

The main postoperative complaint is dyspnea which is challenging to deal with and preventing the hospital discharge on the same operative day [4]. Many clinical trials have been tested to lessen this respiratory dysfunction [5], accompanied brachial plexus block [6]. One alternative to avoid the paresis of the diaphragm is to perform the block more distally alongside the brachial plexus, thus, increasing the distance between the phrenic nerve and the block site.

A good example of a more distal block in the interscalene plane is the block in the suprascapular nerve. The suprascapular nerve block (SNB) has been considered to offer adequate analgesia for shoulder surgery with a low incidence of phrenic palsy in comparison to

ISB and has consequently been taken as an ISB proper alternative [7,8].

More recently, Seigenthaler et al. [9] have performed an ultrasound-guided selective anterior suprascapular nerve block just below the inferior belly of the omohyoid muscle in the supraclavicular fossa. Selective block of the anterior suprascapular nerve was very effective in total shoulder arthroplasty providing sufficient analgesia and without compromising the diaphragm [10].

These preliminary results showed that performing an anterior suprascapular block alone may be a reasonable analgesic modality for shoulder outpatient surgery. From many different anatomical literatures, it becomes evident that shoulder joint innervation usually passes through multiple intermuscular planes before emerging the shoulder, and these intermuscular planes are effectively viewed by musculoskeletal ultrasonography [11]. One of these intermuscular planes is the subomohyoid plane, a high-frequency ultrasound probe is used to define the brachial plexus, subclavian artery, and inferior belly of the omohyoid muscle across the supraclavicular fossa. The suprascapular nerve is tightly connected to this fascial

plane, which runs between the neck's strap muscles and the inferior belly of the omohyoid alongside the whole path to the suprascapular notch [12].

The subomohyoid plane block is a recent reliable and technically easy regional technique that can be properly used for pain management; it is not extensively examined in regards to efficacy and safety in comparison to the standard ISB.

The aim of this study was to compare the novel brachial plexus nerve block approach (the subomohyoid plane block) with the known standard interscalene nerve block after shoulder arthroscopic surgery. We assumed that the subomohyoid plane block would offer satisfactory analgesia if compared to the interscalene block whereas producing less respiratory dysfunction as it was associated with less diaphragm paralysis. The primary outcome (analgesic efficacy) was pain severity at rest using the visual analog scale (VAS) at PACU 2, 4, 6, 12, 18 and 24 h postoperatively, and secondary outcomes were first 24 h total morphine consumption, patient satisfaction, and adverse effects, including, oxygen desaturation, pneumothorax, dyspnea, and phrenic nerve palsy, block and opioid-related side effects in the first postoperative day.

## 2. Patients and methods

This randomized, controlled, clinical study was approved by the ethics committee of the Faculty of Medicine, Alexandria University, and was registered in The Pan African Clinical Trial Registry prior to patient enrolment (PACTR201911762148834, date of registration 25 November 2019). All study participants submitted their written, informed consent. The study was conducted at EL-Hadra University Hospital, Alexandria, during the period from 1 December 2019 to 31 March 2021.

It was planned to enroll a total of 80 patients – 40 participants in each group – in this study. The study physicians assessed the eligibility of the patients before they underwent general anaesthesia for unilateral shoulder arthroscopy. Patients between the ages of 18 and 70, with a BMI of less than 35, and an ASA physical status of I to II were qualified as inclusion criteria

The exclusion criteria were as follows: known allergy to local anesthetics, coagulation deficiency, chronic opioid use, contralateral hemidiaphragmatic paralysis or vocal cord palsy, neurologic deficit in the side of the surgery, psychiatric disorder, inflammation at the puncture site, respiratory insufficiency, pneumonectomy, autonomic dysfunction, serum electrolyte abnormality, and patient refusal.

The study was a randomized controlled clinical trial, as the study participants ( $n = 80$ ) were randomly arranged into two groups using a computer-generated method to eliminate any selection bias.

The experimental group in which the brachial plexus block was conducted uses the subomohyoid plane block (SPB). However, the other group is considered as the control group for whom the interscalene brachial plexus block (ISB) was done.

The patients were not given the details of the type of the block, the anesthesiologist executing the technique did not have any further role in the study and the outcome variables were assessed by investigators not involved in the block technique; therefore, except the anesthesiologist (who performed the intervention), all participants were blinded to the anesthetic technique.

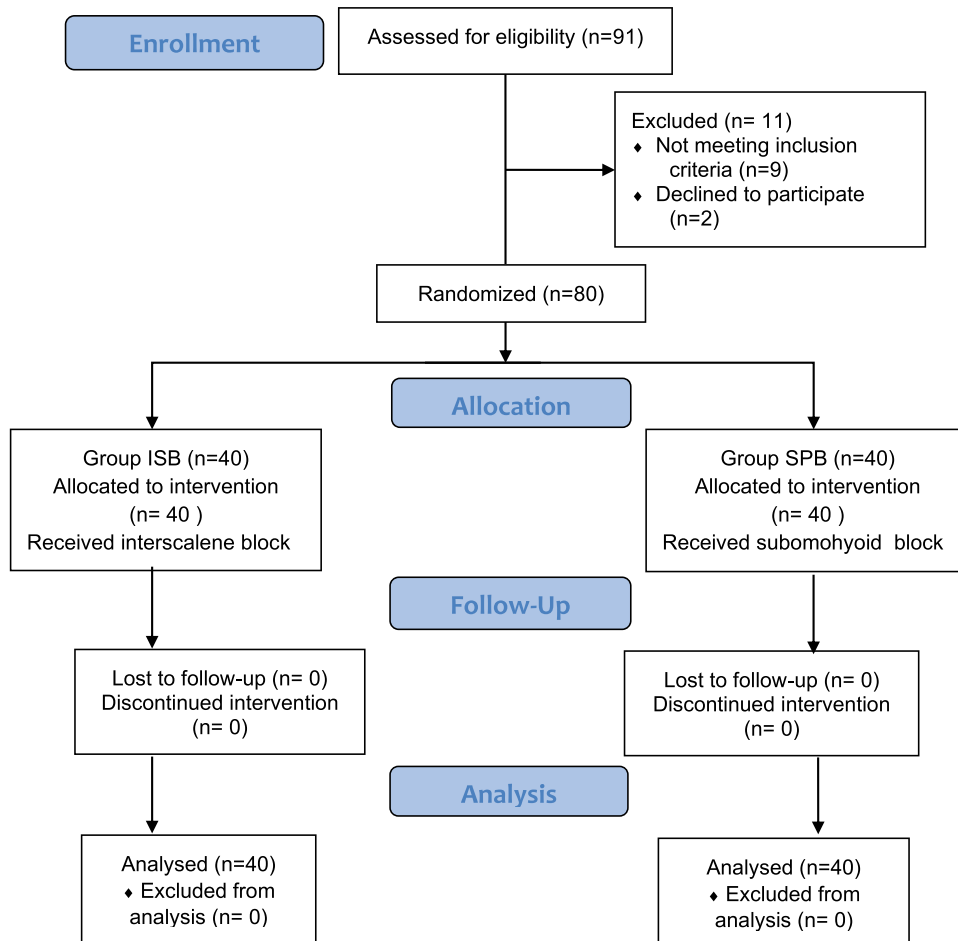
A research nurse not participating in the study distributed the groups to sealed envelopes labeled with consecutive numbers. After seeing the patient's written consent, the research nurse opened the sealed envelopes immediately before the nerve block intervention (Figure 1).

## 3. Preoperative management

Demographic and baseline data were registered in the arthroscopy unit, on the day of surgery and before any interventions. Upon entrance to the operating room, an intravenous (IV) cannula was inserted, and 0.05 mg/kg IV midazolam was given as a premedication titrated to a Ramsay Sedation Scale score of 2 to 3. Standard monitoring (electrocardiogram, non-invasive blood pressure and pulse oximetry) was attached for all patients. All blocks were done under aseptic technique. An ultrasound well-experienced anesthesiologist performed all the interventions. Patients were kept in a supine position with their shoulders in a neutral position, and their necks bent to the other side away from the shoulder being blocked. All the blocks were established using 15 ml 0.5% bupivacaine (Marcaine; AstraZeneca, Egypt).

For the interscalene nerve block group, the brachial plexus was located between the middle and anterior scalene muscles using a high-frequency linear array ultrasound transducer probe in a sterile sheath (6–13 MHz, SonoSite M-Turbo, USA). Using ultrasound in the transverse plane, the cervical nerve roots and trunks were visualized as stacked mono- or bifascicular patterns. [13] After applying 1 ml of 1% lidocaine to the epidermis and subcutaneous tissues, a 5–22 cm gauge insulated needle (B. Braun Medical Inc., USA) was inserted using an in-plane approach with the probe in a lateral to medial needle direction and the tip near to C5 and C6 roots into the interscalene groove. At this level, the injection endpoint was lying posterior to the brachial plexus. [14]

The brachial plexus, subclavian artery, and inferior belly of the omohyoid muscle were all defined for the sub-omohyoid plane block using the same high-frequency (6–13 MHz) ultrasound probe. Following

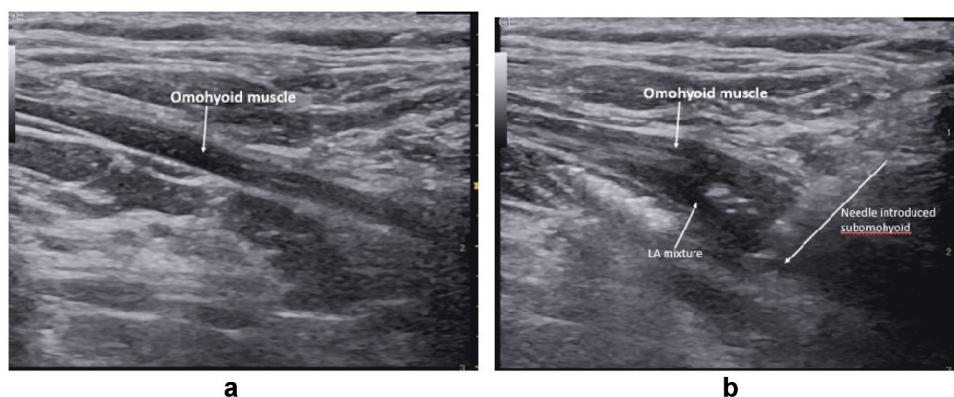


**Figure 1.** Consort flow chart. Group ISB: General anesthesia and interscalene block, Group SPB: General anesthesia and subomohyoid plane block.

the infiltration of the skin and subcutaneous tissue with 1 ml of 1% lidocaine, 15 ml of the local anaesthetic solution was administered using an in-plane lateral to medial needle approach under the inferior belly of the omohyoid (Figure 2). The suprascapular nerve is properly attached to the fascial plane between the strap neck muscles and the inferior belly of the omohyoid, alongside its course till the suprascapular notch. [12]

Ultrasonography was selected as a tool to demonstrate diaphragmatic movement on deep inspiration by performing another ultrasonography to all the patients by the same anesthesiologist before and 10 min after the block to evaluate diaphragmatic. It reliably displays paradoxical movement of the diaphragm in the case of phrenic nerve palsy [15].

A curved ultrasound probe (C60, 5-2 MHz) was positioned in the mid-axillary line over one of the lower



**Figure 2.** Ultrasound-guided sub-omohyoid plane block, identifying the omohyoid muscle (a), introducing the needle to the subomohyoid plane (b).

intercostal spaces to visualize the dome of the diaphragm on the same side of the block. The point of the diaphragm that lies close and superior to the maximal longitudinal length of the kidney was identified. The distal shift at this point, from the resting expiratory position to the maximal deep inspiration position, was measured. Diaphragmatic paresis was defined as a 50% decrease in the diaphragmatic excursion [16].

#### 4. Intraoperative management

Using propofol (1 to 2 mg/kg), atracurium (0.5 mg/kg), and fentanyl (1 to 2  $\mu$ g/kg), general anaesthesia with an endotracheal tube was induced 30 minutes after the establishment of the nerve block without the assessment of the sensory block.

According to the choice made by the attending anaesthetist, the maintenance of anaesthesia was accomplished by administering isoflurane 1–1.5% and a mixture of 60:40 oxygen and air. Additional fentanyl doses of 0.5–1 mcg/kg titrated to keep hemodynamic stability and atracurium doses to preserve relaxation. Patients were ventilated in volume control mode with a tidal volume of 8 ml kg<sup>-1</sup> to ensure constant ventilation (end-tidal CO<sub>2</sub> maintained within the normal range), and adequate inspired O<sub>2</sub> concentration (FIO<sub>2</sub> was 60%) to keep a steady oxygenation during the operation. Neostigmine and atropine were administered in the appropriate doses to reverse the neuromuscular blockade after completion of the procedure. The patients were extubated after which they were taken to the postanesthesia care unit (PACU).

#### 5. Postoperative management

All patients were taken extubated to the PACU and received by a nurse blinded to the study. All measurements in the PACU and later in the ward were obtained by a blinded researcher 60 minutes after the completion of the surgery. All patients were discharged to their rooms after fulfilling the discharge criteria.

A standardized postoperative analgesic regimen was based on 8 h interval of regular IV ketorolac 30 mg and Patient Controlled Analgesia (PCA) that was started at the PACU and resumed during the first 24 h postoperatively. A patient-controlled analgesia (PCA) device was used for all patients to deliver a continuous IV infusion of 0.3 mg/h of morphine and a bolus of 1 mg IV morphine (as a rescue analgesic) with a 20 min lockout time. From the stay in the PACU till 24 h, postoperative pain only at rest was measured using a 10 cm visual analog scale (VAS) (0 cm means no pain and 10 cm is the worst possible pain). Patients with a VAS score >4 at any moment of time received 0.05 mg/kg IV bolus morphine. Pain was assessed at rest only as the surgeons restricted the active movement of the operated shoulder. Time (in min) from the end of local

anesthetics administration to the request of the first rescue analgesic, i.e., IV morphine bolus, which corresponded to VAS >4 was recorded, and it is as an alternative marker for sensory block duration. The number of patients who requested IV bolus morphine and overall morphine consumption in the first postoperative day was also documented. The number of patients who reported their experience of being satisfied or unsatisfied from analgesia (by a direct questionnaire) at the end of the postoperative day was confirmed.

During the first postoperative day, a chest radiograph was done for all patients to rule out the incidence of pneumothorax.

#### 6. Adverse effects

Opioid-related unfavorable effects (postoperative respiratory depression, nausea and vomiting, sedation and pruritus) were recorded along with the possible brachial plexus block side effects (e.g., hoarseness, Horner syndrome, oxygen desaturation, or dyspnea) and block-related complications (persistent paresthesia, tingling, and weakness) at the end of the first postoperative day.

#### 7. Sample size determination

Minimum required sample sizes of 30 patients receiving Subomohyoid plane block and 30 patients getting Interscalene brachial plexus nerve block to achieve 80% power to detect a mean difference in morphine consumption of 11.7 mg, assuming the mean morphine consumption in patients undergoing interscalene brachial plexus nerve block is 18.95 mg and 30.6 mg among patients who are assigned to Subomohyoid plane block [17]. Calculation was executed at 0.05 significance level ( $\alpha$ ) using a two-sided two-sample t-test.

#### 8. Data analysis

Data were analyzed using IBM SPSS statistics version 22. Data were described according to its type. Qualitative variables were expressed as frequency and percentage. Quantitative variables were tested for normality using Kolmogorov–Smirnov test at 5% level of significance. Data that were normally distributed were presented as mean and standard deviation; however, median and interquartile range were used for not normally distributed data. Comparison between groups was done using chi square test for qualitative variables, Mann–Whitney test, or Student's t-test for quantitative variables. The analysis was done at a 5% level of significance.

#### 9. Results

In regards to the characteristics of the studied patients in each group, the mean age, sex, and weight did not show a significant difference ( $p < 0.05$ ) (Table 1).



**Table 1.** Comparison between the two methods of anesthesia according to patients' baseline characteristics.

Baseline characteristics	Mode of brachial plexus block		p-Value
	Interscalene nerve block (n = 40)	Subomohyoid plane block (n = 40)	
Age (year)			
Min-max	50-65	50-65	0.835
Mean ± SD	57.6 ± 45	57.7 ± 4.1	
Sex	<b>No. (%)</b>	<b>No. (%)</b>	
Male	48 (53.3)	43 (46.7)	0.374 <sup>#</sup>
Female	42 (46.7)	49 (53.3)	
Body mass index			
Min-max	24-34	24-34	0.942
Mean ± SD	28.5 ± 3.03	28.5 ± 3.1	

Normally distributed quantitative variables presented as mean ±SD and tested using the Student t-test. Variables not normally distributed presented as median (IQR) and tested using Mann-Whitney test.

# p value for chi square test.

The results demonstrated that ASA was I for approximately two-thirds of each of the studied groups, compared to the other third (ASA II), with no significant difference between the studied groups regarding the ASA score. Regarding the type of surgery, nearly two-thirds of patients in each group were operated on for rotator cuff repair with no remarkable difference between the studied groups regarding the type of surgery ( $p = 0.885$ ). No significant difference among the studied groups regarding the mean duration of surgery in min ( $106 \pm 8.95$  versus  $105.9 \pm 8.5$ ) (Table 2).

Pain-free recovery was achieved in all patients of both groups, this was considered as an indicator of a successful block in both techniques. It is shown that the pain scores were proved similar between both groups at PACU, 2 hours, and significantly lower among the interscalene nerve block as compared to the subomohyoid group at postoperative, 4 hours, 8 hours, 12 hours, 18 hours, and 24 hours (this statistically significant difference does not necessarily mean a clinically significant difference). Regarding the number of patients indicated for IV morphine bolus, 17.5% of the interscalene group was compared to 27% in the subomohyoid group; however, this difference was not statistically significant as  $p < 0.05$ . Among those who

received morphine bolus, no significant difference between groups regarding the time to the first rescue analgesic request ( $p$  value for Mann-Whitney test = 0.085) (Table 3 and Figure 3).

The overall dose of analgesics required in the first 24 hours by patients in the interscalene group is significantly lower than that required by patients in the subomohyoid group as  $p < 0.001$  (Table 3 and Figure 4).

Regarding the Brachial plexus-related side effects, 37.5% of those with the interscalene anaesthesia developed phrenic nerve palsy as compared to only 7.5% of subomohyoid groups and this difference was statistically significant as  $p = 0.001$ . No one in the subomohyoid group developed Horner syndrome; however; 7.5% of those in the interscalene group experienced it, but this difference was statistically insignificant. No statistically significant difference between groups regarding the frequency of occurrence of any of the side effects neither those related to nerve block (paresthesia, weakness, tingling) nor opioid-related (nausea, respiratory depression, pruritus, and sedation) (Table 4). Meanwhile, the majority of patients in both studied groups were satisfied (95% & 92.5%, respectively), and this difference was not significantly different as  $p = 1$

## 10. Discussion

This study revealed that postoperative analgesia assessed by pain scores during the first postoperative 24 h in patients receiving subomohyoid plane block was near similar to the ISB group, and despite VAS scores were statistically lower in ISB group, their values in both groups were clinically satisfactory and did not reach critical high values. Thus, postoperative pain was well limited by the subomohyoid technique when compared to the standard ISB. This efficacy was confirmed again through the demonstration of the 24 post-surgical morphine consumption that was lower than expected from published data [18], and secondary outcomes showed comparable durations of

**Table 2.** Comparison between the two methods of anesthesia based on their operative data.

Operative data	Mode of brachial plexus block		Test of significance
	Interscalene nerve block (n = 40)	Subomohyoid plane block (n = 40)	
ASA status	<b>No. (%)</b>	<b>No. (%)</b>	0.809
I	27 (67.5)	28 (70.0)	
II	13 (32.5)	12 (30.0)	
Type of surgery			0.885
Rotator cuff repair	28 (70.0)	26 (65.0)	
Bankart repair	8 (20.0)	9 (22.5)	
Decompression	4 (10.0)	5 (12.5)	
Duration of operation (min)			0.721
Min-max	91-120	92-119	
Mean ±SD	106 ± 8.95	105.9 ± 8.5	

**Table 3.** Comparison between the two methods of anesthesia regarding postoperative pain scores and analgesic need.

	Mode of brachial plexus block		Test of significance
	Interscalene nerve block (n = 40)	Subomohyoid plane block (n = 40)	
	Median (IQR)	Median (IQR)	
Postoperative pain score			
PACU	0(0)	0 (0–1)	0.019
2 hours	0(0)	0 (0–1)	0.186
4 hours	1 (1–1.75)	2 [2,3]	<0.001*
8 hours	2 (1.25–2)	3 [2,3]	<0.001*
12 hours	2 (1.25–2)	3 [2–4]	<0.001*
18 hours	2 (1.25–2)	3 [2–4]	<0.001*
24 hours	2 (1.25–2)	3 [2–4]	<0.001*
Need for morphine bolus			
Yes	7 (17.5)	11 (27.5)	0.284
Time (in min) to the first rescue analgesic request (n = 18)			0.085
Min–max	459–1546	333–817	
Median (IQR)	827 (459–1182)	465 (460–812)	
Overall dose of morphine (mg) given in the first 24 hours			<0.001*
Min–max	7.5–22	8.2–26.5	
Median (IQR)	8.8 (7.9–9.2)	9.8 (9.0–18.5)	

Normally distributed quantitative variables presented as mean  $\pm$ SD and tested using the Student *t*-test. Variables not normally distributed presented as median (IQR) and tested using Mann–Whitney test.

\*Significant at  $p < 0.05$ .

postoperative analgesia, lower incidence of opioid-related side effects used in the trial, and equal adequate patient satisfaction in both groups.

Since Siegenthaler et al. [9] described for the first time their novel technique of blocking the anterior suprascapular nerve underneath the inferior belly of omohyoid muscle and later on Sondekoppam et al. [12] for the first time presented sub-omohyoid plane block and Subscapularis block as a substitute to

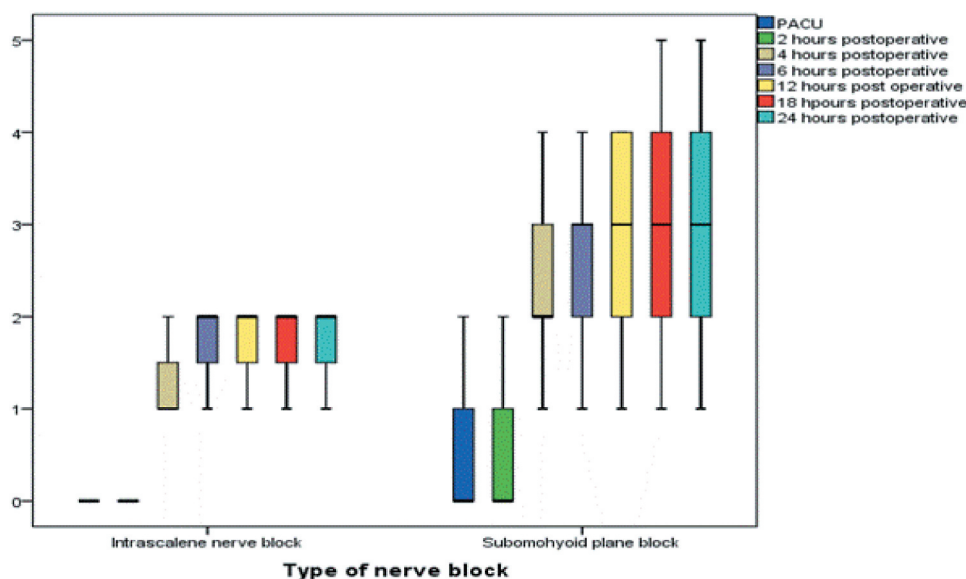
peripheral nerve blocks for shoulder analgesia, they have explored an unintentional approach to block the superior trunk that far from the ipsilateral phrenic nerve.

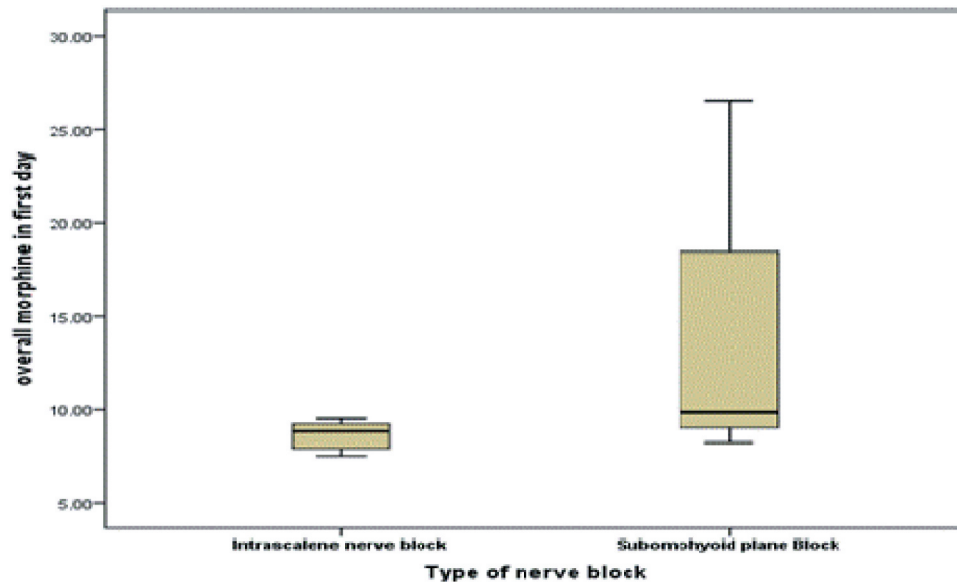
Anatomical studies proved that the posterior division of the superior trunk is present very close to the suprascapular nerve [19]. The posterior division of the superior trunk was blocked as a result of their close relationship. [20] For this reason, the subomohyoid brachial plexus block is suitable for delivering significant analgesia for shoulder surgery [21,22].

The findings of this study provided conclusive proof that both the anterior suprascapular nerve and the posterior division of the superior trunk had been effectively blocked by infiltrating local anesthetics to the subomohyoid plane.

Different previous anatomical studies confirmed the same principle. Sehmbi et al. [23] in a cadaveric dye study found 90% brachial plexus staining following the targeting of subomohyoid suprascapular nerve. Laumonerie et al. [24] also in the cadaveric study noticed a 100% staining of the superior trunk. Siegenthaler et al. [9] reported a block of brachial plexus even with 0.1 ml of local anesthetic given.

HT Minimum effective local anesthetic volumes for brachial plexus block are reported with a wide range, being from 0.95 ml for interscalene nerve block to 42 ml for the supraclavicular block [25,26]. Moreover, some clinical trials advised that a larger volume of local anesthetic is accompanied by a longer duration of the block when compared to lower volume injections [27]. However, there were no previously reported trials on the minimal effective local anesthetic volumes for sub-omohyoid plane block. Based on the previous observations, we used in our trial a 15 ml standard volume of local anesthetic in both techniques to allow evaluation of the differences between both blocks as regards

**Figure 3.** Box plot shows the median VAS scores at different intervals among the studied groups.



**Figure 4.** Box plot shows the median overall dose of morphine(mg) in the first 24 hours among the studied groups.

**Table 4.** Comparison between the two methods of anesthesia regarding postoperative side effects.

Postoperative side effects	Mode of brachial plexus block		Test of significance
	Intrascapular nerve block (n = 40) no (%)	Subomohyoid plane block (n = 40) no (%)	
Brachial plexus side effects			
Phrenic nerve palsy	15 (37.5)	3 (7.5)	0.001*
Pneumothorax	0	0	-
O <sub>2</sub> desaturation	0	0	-
Dyspnea	2	2	1
Horner	3 (7.5)	0	0.077
Hoarseness	0	0	-
Opioid-related side effects			
Nausea and vomiting	3 (7.5)	4 (10.0)	0.692
Respiratory depression	0	0	-
Pruritis	0	0	-
Sedation	0	0	-
Block-related complications			
Persistent paresthesia	2 (5.0)	1 (2.5)	0.556
Weakness	0	0	-
Tingling	0	0	-

\*Significant at  $p < 0.05$ .

location of injection along the course of brachial plexus rather than local anesthetic volume variation.

This standard dose was selected to facilitate the success of both techniques and, at the same time, evaluate the adverse effects [28]. We believe that the subomohyoid plane block is another relevant approach to block the utmost contributions of shoulder innervations, providing adequate postoperative analgesia that is nearly comparable to ISB. At the same time, in patients who received subomohyoid plane block, there was a statistically lower incidence of hemidiaphragmatic paresis when compared to ISB patients. This result demonstrates that injection of local anesthetics in the

subomohyoid fascial plane was safe enough to avoid phrenic nerve affection when compared to the usual ISB that was associated with a higher incidence of diaphragmatic affection (37.5% versus only 7.5%).

None of our patients in both groups experienced symptoms or signs of pulmonary compromise (pneumothorax, O<sub>2</sub> desaturation, dyspnea, respiratory depression) secondary to diaphragmatic affection or technique related. As none of our subjects had any previous pulmonary disease, they were mostly adequately compensated for phrenic nerve palsy. It has been previously documented that hemidiaphragmatic paresis in healthy patient does not usually progress to desaturation or severe dyspnea and so has limited clinical drawbacks. [29] The risk of block related pulmonary complications may exceed its benefits especially in certain patient categories, for example, morbid obesity [30], obstructive sleep apnea [31], and chronic obstructive pulmonary diseases [32]. Phrenic nerve block always occurs significantly in conjunction with interscalene approach to brachial plexus block. The phrenic nerve and the brachial plexus are located extremely close to one another; therefore, phrenic nerve block resulted from interscalene block occurs in a great percentage of patients [33]. Hemi diaphragmatic paresis incidence up to 100% was reported in many clinical trials. They announced that paresis of the phrenic nerve should be managed as an evident side effect rather than a block complication [33].

Different modifications were previously studied to lessen the incidence of phrenic nerve block like to decrease the volume of local anesthetics or to go more distally away from the phrenic nerve with variable results [34]. Decreasing the volume of local anesthetics seems to be not enough to avoid phrenic nerve affection. Some studies have not found any difference

in reducing the local anesthetic volume from 20 to 10 ml in the incidence of phrenic paresis [35]. We believe that in the current trial, targeting local anesthetics in the subomohyoid fascial plane was the main cause of lower incidence phrenic nerve affection because the site of injection was relatively far away from the ipsilateral phrenic nerve.

Petroff et al. [36] in their trial compared lung ventilation and diaphragmatic activity on the operated side in ISB and electrical impedance tomography for blocking the anterior suprascapular nerve. In some cases, utilising ultrasonography to find the suprascapular nerve was insufficient, therefore local anaesthetic was administered to the brachial plexus, which is situated behind the inferior belly of the omohyoid muscle in the supraclavicular position. They found that, when compared to the subomohyoid anterior suprascapular nerve block, ISB was linked to significantly more unbalanced ventilation, and inactivity of hemidiaphragm was significantly higher in the ISB group as a result of ultrasound evaluation.

On the other hand, supraclavicular fossa and subomohyoid plane are close anatomical spaces, and any injection high up to the level of the clavicle can directly spread either retrograde or antegrade to the phrenic nerve, and this could explain the occurrence of phrenic nerve block in some cases in subomohyoid group [37]. Sehmbi et al. [23] during the cadaveric dye study could confirm our explanation where the suprascapular nerve beneath the inferior belly of omohyoid muscle in the posterior triangle of the neck was delineated. Ten bilateral subomohyoid suprascapular nerve injections with ultrasound guidance were carried out using a 5 mL contrast dye in five fresh cadavers. They found that following injection of only 5 ml of dye, 20% of the cases had staining of the phrenic nerve. Currently, no trials demonstrate the spread of local anesthetics from the subomohyoid plane to contiguous spaces, and future research is warranted.

Regarding other brachial plexus-related side effects, no one in the subomohyoid group developed Horner syndrome; however, 7.5% of those in the interscalene group experienced it, but this difference was statistically insignificant. The frequency of occurrence of any of the side effects neither those related to nerve block (paresthesia, weakness, tingling) nor opioid-related (nausea, respiratory depression, pruritis, and sedation) were statistically insignificant between groups. ISB usually results in many undesirable blockades of recurrent laryngeal nerve, cervical plexuses, stellate ganglion, and weakness in hands and forearm with variable incidences [38]. The clinical impact of these blocks is of little importance because the operating upper limb is usually supported in a sling in the postoperative period. Moreover, Horner and hoarseness usually resolve with local anesthetic resolution [39].

We believe that using small doses of local anesthetics in both groups was the real cause of the low incidence of

Horner and hoarseness in the present trial [40]. Also, in our trial both techniques were performed by the same ultrasound well-experienced anesthesiologist to facilitate proper safe injection and spread of local anesthetics around the selected nerves in all patients without the possibility of neurologic or vascular injury [41].

HT There are several limitations of the present trial. First, the sample size is relatively small to confirm the clinical or statistically significant differences between study outcomes, as the results of the present trial could be changed according to the change of local anesthetic volume or concentration. Second, evaluation of the patients' outcomes was only for the first 24 hours, i.e., during the acute postoperative period only which is a short duration, so we did not investigate long-term drawbacks, and also, we did not evaluate pain at movement due to the restraint of the upper limb. Third, we used pain-free recovery as an indicator of successful block in both techniques without evaluation of other criteria of adequate block (sensory or motor distribution) though important, it was beyond the scope of this study. Fourth, we did not measure the duration of the fading of the sensory block by the usual pin prick technique. We used, instead, the time to first request of the rescue analgesia as an alternative marker for sensory block duration. Fifth, we used ultrasound to evaluate diaphragm excursion, and despite it being a well-established method for evaluation [42], there are no validated criteria to define the involvement of diaphragm in the state of brachial plexus block [43]. It is also not easy to quantify the dysfunction of the diaphragm as partial or complete using only the ultrasound. There are also operator variations in the measurement techniques [44].

In conclusion, compared with ISB, the subomohyoid plane block appears to be a new, simple, and safe technique that resulted in similar postoperative analgesia with significantly less frequent diaphragmatic involvement. Therefore, it may be considered as an adequate alternative technique for pulmonary high-risk patients.

## Disclosure statement

No potential conflict of interest was reported by the author(s).

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