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Ultrasound-guided phrenic sparing block in proximal humerus surgery – An observational study

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ABSTRACT

Background: Traditional interscalene brachial plexus block of C_5 and C_6 roots provides excellent anesthesia and analgesia for shoulder surgery and proximal humerus surgery, but frequently results in hemidiaphragmatic paresis. Superior trunk block (STB) along with local infiltration to supraclavicular nerve branches gives equal analgesic potency and distribution as interscalene brachial plexus block without affecting the phrenic nerve. The present study was carried out on 30 patients undergoing shoulder and proximal humerus surgery under STB of brachial plexus. **Aims and Objectives:** This study was designed to evaluate the incidence of hemidiaphragmatic paralysis and minimum numerical rating scale (pain score) at rest in the post-anesthesia care unit, block duration, and patients' satisfaction in patients receiving STB along with local infiltration to supraclavicular nerve branches. **Materials and Methods:** Thirty patients undergoing shoulder and proximal humerus surgery between 18 and 80 years age group with the American Society of Anesthesiologists-Physical Status I-III of either sex were given ultrasound-guided STB (15 mL) along with a local infiltration (5 mL) superficial to scalenus medias muscle using 0.5% ropivacaine. Primary outcomes and secondary outcomes (patients' satisfaction, block duration, and pain score) were recorded and analyzed by the Statistical Package for the Social Sciences version 26. **Results:** Mean sensory block duration (hours) was 16.99 ± 1.27 (95% confidence interval [16.51–17.47]). Incidence of hemidiaphragmatic palsy was minimum (3.3%). Post-operative analgesia was good as reflected by 28 (93.33%) patients having Visual Analog Scale score < 3 at 24 h after completion of surgery. Patient satisfaction was also excellent (Likert scores 4 and 5 in 93.33% of patients). **Conclusion:** STB along with local infiltration superficial to scalenus media's muscle is associated with excellent intraoperative anesthesia and analgesia with minimal respiratory complication and remarkable patient satisfaction.

Key words: Superior trunk block; Ultrasound; Shoulder anesthesia; Hemidiaphragmatic paresis

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INTRODUCTION

Interscalene brachial plexus block (ISB) remains the most commonly used peripheral nerve block for shoulder surgery.[1] As the injection site for ISB is in much closer proximity to the phrenic nerve, the incidence of phrenic nerve palsy leading to hemidiaphragmatic paralysis has been reported to occur in up to 100% of interscalene recipients.[2]

The superior trunk block (STB) using a low volume of local anesthetic agent is a variation of the interscalene brachial plexus block (ISB), with similar sensory blockade, non-inferior analgesia, and significantly less phrenic nerve involvement.[3-5] An additional infiltration of local anesthetic agent superficial to the scalenus media's muscle blocks the intermediate and lateral branches of the supraclavicular nerve supplying the shoulder cape. Together these two

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techniques may produce effective shoulder anesthesia and analgesia necessary for proximal humerus surgeries, which are on the rise nowadays. Therefore, the purpose of this study was to investigate whether a low-dose STB along with a local infiltration superficial to the scalenus media's muscle would be as effective in providing analgesia for proximal humerus surgeries as an interscalene brachial plexus block while minimizing the occurrence of hemidiaphragmatic paralysis.

Aims and objectives

This study was undertaken to evaluate the incidence of hemidiaphragmatic paralysis and minimum numerical rating scale (pain score) at rest in the post-anesthesia care unit, block duration, and patients' satisfaction in patients receiving superior trunk block along with local infiltration to supraclavicular nerve branches.

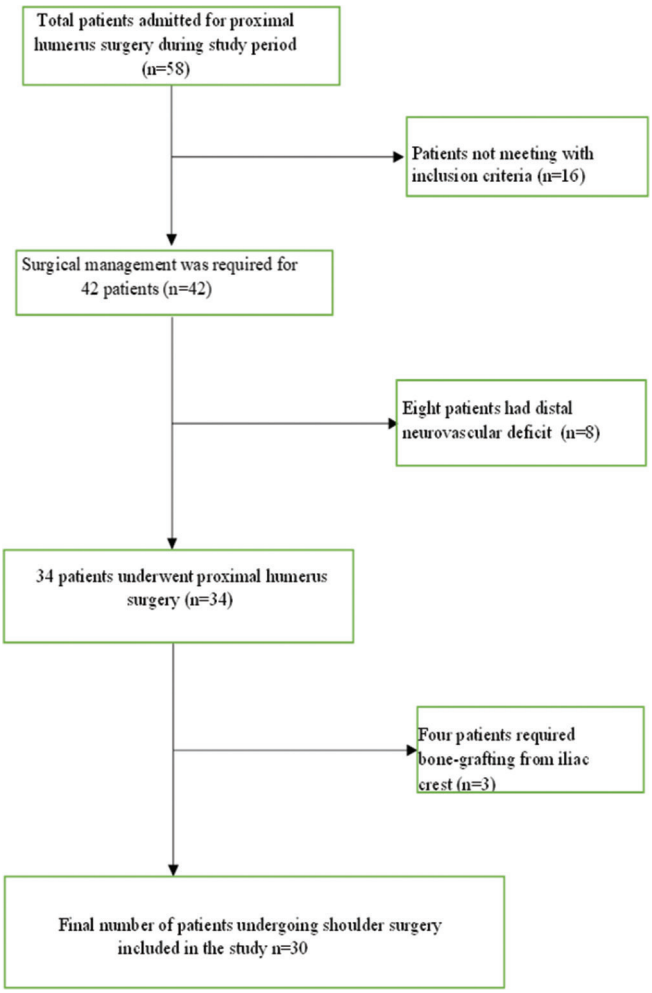
MATERIALS AND METHODS

After necessary clearance from the Institutional Ethics Committee, this single-arm prospective interventional study was undertaken in patients undergoing proximal humerus surgery including shoulder surgery. The study was registered with the clinical trial registry (CTRI/2023/05/052716). Adult patients belonging to the age group 18–80 years with American Society of Anesthesiologists-Physical Status (ASA-PS) I - III, of either sex, patients with controlled hypertension, ischemic heart disease, valvular heart disease, dilated cardiomyopathy, chronic obstructive airway disease (COPD) patients, and pregnant patients beyond 1st trimester were included in this study. Pre-existing neurological deficits or neuropathy of the brachial plexus, allergy to local anesthetics, body mass index (BMI) of more than 35 kg/m^2, and patients' refusal were the exclusion criteria. The primary outcome of this study was the evaluation of the incidence of hemidiaphragmatic paralysis and minimum numerical rating scale (pain score) at rest in the post-anesthesia care unit and secondary outcomes were block duration and patients' satisfaction.

Inclusion criteria

A total of 58 patients were admitted for proximal humerus surgery from May 21, 2023 to September 21st, 2023. Sixteen patients did not meet the inclusion criteria and eight patients had a distal neurovascular deficit. Surgical intervention was carried out on 34 patients. Finally, data from 30 patients were collected and analyzed (Flow Diagram 1).

Demographic parameters of the patients were recorded. Patients were assessed for any comorbidities and investigation results were noted. On the day of surgery, patients were shifted to a designated anesthetic procedure



Flow Diagram 1: Enrollment of case

room, 18-gauge intravenous access was secured, and routine monitoring (electrocardiogram, pulse oximetry, and non-invasive blood pressure) was initiated. Following this, blocks were performed. Procedural sedation was administered with 1–1.5 mg of IV midazolam. Sedation was avoided in pregnant patients. Patients were placed in a supine position with face turned to the side opposite to the block side. The ultrasound screen was positioned in an ergonomic way before the initiation of the block procedure. In addition, patients' bed heights were suitably adjusted for comfortable scanning.

Before performing the block, a pre-scan was done to identify major blood vessels and nerves, using a 6–15 MHz high-frequency linear array transducer (L3–12t). USG E Cube 8 machine with different probes was used in all patients.

The STB (Figure 1) was visualized distal to the convergence of C_5–C_6 nerve routes but proximal to the take-off of the suprascapular nerve (SSN). After sterile skin preparation and skin infiltration with 1 mL of 1% lidocaine, a 22-gauge

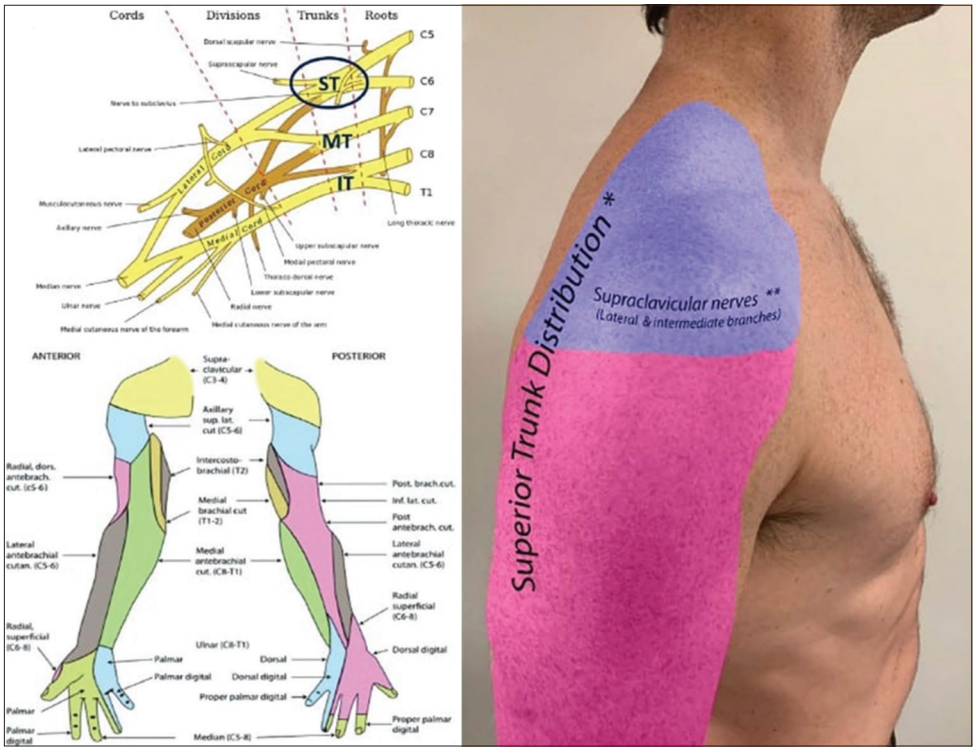


Figure 1: (a) Brachial plexus and its typical branching pattern. (b) Sensory innervation of the (c) sensory distribution of shoulder innervation

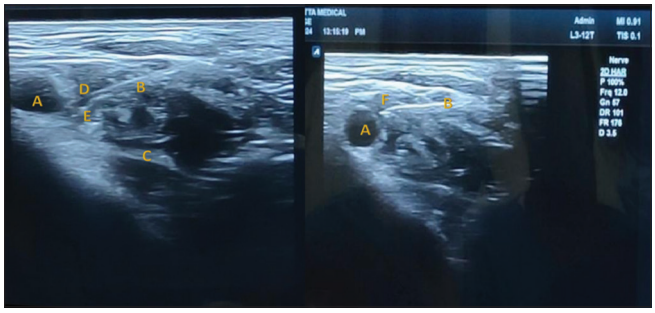


Figure 2: Ultrasound picture showing superior trunk block. (A) Subclavian artery, (B) needle, (C) pulmonary pleura lying inferior to subclavian artery, (D) middle trunk of brachial plexus (BP), (E) inferior trunk of BP, and (F) superior trunk of BP

100 mm block needle was advanced in the plane to the ultrasound beam in a lateral to the medial direction under the deep cervical fascia and superficial to the middle scalene muscle until the needle tip was immediately adjacent to the lateral border of the superior trunk (Figure 2). Then, 15 mL of 0.5% ropivacaine was injected locally (by recurrent aspiration technique).

Five mL of local anesthetic was infiltrated superficial to the scalenus media's muscle. On block completion, motor and sensory function evaluations were done to assess for block success. Sensory assessment of the upper limb was done by a blinded observer using an alcohol-soaked cotton ball and pinprick techniques and motor assessment of upper limb movements was done in superior trunk brachial plexus territories. The duration of the sensory block was defined as the time taken to perceive a pinprick from the time the block was administered. Sensory and motor blocks were separately graded using a 3-point qualitative scale[6] as follows: grade 0 – indicated the presence of cold and touch and normal motor function (power 5/5 and 4/5); grade 1 – indicated a loss of cold sensation, but touch intact and decreased motor function (power 3/5 and 2/5); and grade 2 indicated the loss of both cold and touch and no motor power (power 0/5 and 1/5).

Blockade was classified as adequate (complete sensory anesthesia) and inadequate (partial or no loss of sensation). In case of an inadequate block, general anesthesia was administered.

Post-operative pain was assessed by the attending anesthesiologist using the Visual Analog Scale (VAS). VAS >4 was considered significant pain, intravenous tramadol was administered, and time was noted for calculation of duration of analgesia. Patient satisfaction score was assessed based on a five-point Likert scale in the post-operative care unit (PACU) with a score of 1 depicting not at all satisfied and a score of 5, very much satisfied.[7,8] The diaphragmatic excursion was assessed using M-mode ultrasonography with the patient in the sitting position with the help of a 5–2 MHz curvilinear transducer (USG E CUBE 8).[9] Diaphragmatic excursion between full inspiration and expiration was measured in centimeters. The severity of hemidiaphragmatic paralysis was

measured by the decrease in diaphragmatic excursion between baseline and 30 min after block completion.

In this pilot trial, a minimal sample size was calculated based on the rule-of-thumb method proposed by Browne. According to this rule, a minimum sample size of 30 was appropriate for estimating a parameter.[9] Statistical calculation was done using the Statistical Package for the Social Sciences version 26. Continuous data such as duration of sensory block, and surgery duration were presented as mean and standard deviation (SD). Categorical data such as gender were presented as number. Continuous data with skewed distribution, such as age, and BMI, were presented as the median and interquartile range (IQR). Descriptive statistics were used in the study (estimation of mean [SD] and median [IQR]).

RESULTS

The physical characteristics and the average surgical duration in the 30 patients finally included in the study are depicted in Table 1.

The mean sensory block duration (hours) was 16.99±1.27

(95% confidence interval [16.51–17.47]). No patient required the administration of general anesthesia. Two patients required intraoperative opioid (75 mg tramadol in each patient) administration. Twenty-eight patients had no complications (Table 2). Two (6.6%) complained of dyspnea, of them one was diagnosed to have hemidiaphragmatic paresis and none had hoarseness of voice.

Table 1: Patient characteristics (n=30)

Parameters (unit)	Values
Age (years)	48.77±18.81 46 (34–66.75)
Sex (male/female)	21 (70%)/9 (30%)
Body mass index (kg/m^2)	26.99±3.85 26 (24–30.75)
American Society of Anesthesiology (ASA) status (I/II/III)	19 (63.33%)/8 (26.67%)/3 (10%)
Duration of surgery (minutes)	90.93±9.67 90 (84–94.5)

Data are expressed as mean (standard deviation), median (interquartile range), or number (percentage)

Table 2: Complications (n=30)

Complications	Number of patients	Percentage
Dyspnea	2	6.6
Hoarseness of voice	0	0
Hemidiaphragmatic paresis	1	3.33
No complication	28	93.33

Twenty-eight (93.33%) patients had post-operative VAS score <3, whereas it was more than 4 in the remaining 2 (6.67%) patients. Patient satisfaction was high among the blocked patients, with 24 (80%) patients gave Likert scale score of 5, 4 (13.33%) gave 4, and 2 (6.6%) gave score of 3.

DISCUSSION

The conventional ultrasound-guided interscalene brachial plexus block is one of the most commonly used peripheral nerve block for shoulder surgery.[1] It involves injection directly around the C5 and C6 nerve roots. Although it provides highly effective post-operative analgesia after shoulder surgery,[10,11] it almost always results in hemidiaphragmatic paresis.[12] Other side effects include: Risk of intraneural injection into the relatively unprotected roots[13] and injury to the dorsal scapular nerve or long thoracic nerve.[14]

In an attempt to spare the phrenic nerve, clinicians first investigated variations of the interscalene brachial plexus block, targeting different locations (such as posterior to the C5 root), using various local anesthetic concentrations as well as different volumes.

The STB was described by Laurent et al.,[3] as a refinement of the conventional interscalene brachial plexus block technique that addresses these limitations.

The superior trunk is formed by the fusion of C5 and C6 nerve roots, and therefore, local anesthetic injection around the superior trunk should produce similar analgesia of the shoulder because all the terminal nerves innervating the shoulder arise distal to the superior trunk.[11] Moreover, the site of injection is further away from the phrenic nerve, and this should theoretically reduce the risk of hemidiaphragmatic paresis.

The superior trunk lies proximal to the clavicle and gives off an important sensory branch, the SSN, which provides approximately 70% of the sensory innervation to the shoulder.[15] The SSN lies on the superficial-lateral aspect and must be identified and adequately blocked while performing an STB. The supraclavicular nerve branches (medial intermediate and lateral) arise from the lower aspect of the cervical plexus and provide sensory innervation to the neck (medial branch) and shoulder cape (intermediate and lateral branches). They lie superficial to the scalenus media's muscle and are easily blocked with the same needle pass as blocking the ST.[3]

This case study revealed that STB has a strong propensity to preserve respiratory function – only 1 (3.33%) incidence of hemidiaphragmatic paralysis and diaphragmatic

excursion reduction. Only 2 cases (6.6%) had dyspnea with preserved oxygen saturation. In one patient, dyspnea was due to hemidiaphragmatic paralysis and the other patient was anxious. None of the patients developed hoarseness of voice. Kim et al.,[4] in their study found that 8% of the patients undergoing STB had dyspnea and none developed hemidiaphragmatic paralysis.

Literature on STB described effective shoulder analgesia with minimal hemidiaphragmatic paresis, and this was attributed to the more distal site of injection.[3] The phrenic nerve and C5 nerve root are anatomically separated by a distance of 1.8–2.0 mm in adults at the level of the cricoid cartilage, and the distance between them increases by an additional 3 mm for every centimeter as the phrenic nerve courses more medially into the root of the neck.[16] The likelihood of local anesthetic spread to the phrenic nerve or its origins from the C3–C5 roots (and hence hemidiaphragmatic palsy) is therefore reduced with the STB. Hoarseness of voice was not seen due to limited spread to the recurrent laryngeal nerve.

Only 2 patients (6.6%) required intraoperative tramadol injection for pain relief which may be due to the sparing of few nerve fibers. Others had an excellent quality of surgical anesthesia and analgesia in the intraoperative period. Post-operative analgesia was good with 28 patients (93.33%) had VAS score <3 at 24 h after completion of surgery. This anesthetic and analgesic efficacy may be attributed to injecting the drug proximal to the exit of the SSN from the superior trunk coupled with blockade of the axillary nerve and subscapular nerve (arising from the posterior division of the superior trunk)[4] and blockade of intermediate and lateral branches of the supraclavicular nerve supplying the shoulder cape.

Patients' satisfaction was also excellent as revealed by a high Likert score (4–5 in 93.33% of patients) at 24 h after completion of surgery. This can be attributed to the little motor blockade of the hand with the majority of the patients being able to move their hands. This is likely a consequence of low volume (15 mL) local anesthetic drug administration with limited spread to inferior roots and trunks.[4]

Limitations of the study

It is a single-arm prospective interventional study with a relatively small sample size. Patient's feeling and response to pain intensity may vary according to educational, socioeconomic, and cultural background, which may be reflected in the VAS score. Observation beyond 24 h was not done to find long-term benefits or adverse effects.

CONCLUSION

This study shows that STB together with infiltration over intermediate and lateral branches of the supraclavicular nerve effectively provides surgical anesthesia and good post-operative shoulder analgesia in patients undergoing proximal humeral surgery. In addition, this anesthetic technique had a negligible incidence of hemidiaphragmatic paralysis and patients' satisfaction was excellent. Keeping all these findings in view, this combined anesthetic technique may be considered a viable alternative to the interscalene brachial plexus block in patients undergoing proximal humeral surgery and an effective anesthetic technique for daycare surgery.

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Authors Contribution:
SL- Definition of intellectual content, literature survey, prepared the first draft of the manuscript, implementation of the study protocol, data collection, data analysis, manuscript preparation, and submission of the article; **AKK-** Concept, design, clinical protocol, manuscript preparation, editing, and manuscript revision; **MR-** Design of study, statistical analysis, interpretation manuscript preparation, editing, and manuscript revision; **RB-** Coordination, and manuscript revision.

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