

Case Report

IN PURSUIT OF PHRENIC NERVE-SPARING REGIONAL ANESTHESIA FOR AWAKE SHOULDER MANIPULATION IN PATIENTS WITH ADHESIVE CAPSULITIS

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ABSTRACT

Introduction. While interscalene brachial plexus block remains the gold standard of any shoulder procedure, including shoulder manipulation in patients with adhesive capsulitis, anesthesiologists are reluctant to face the risk of phrenic nerve paresis, especially in patients with preexisting pulmonary conditions. Hence, many studies have targeted specific regional anesthesia of the shoulder low enough by the blockade level, leaving phrenic nerve function intact but still providing satisfying anesthesia for shoulder procedures. Until recently, no comparison between these regional anesthesia techniques focusing on shoulder manipulation for adhesive capsulitis has been published. **Case Report.** We compared the profiles between suprascapular nerve block, shoulder interfascial plane block, and superior trunk block as the sole anesthesia technique in patients with adhesive capsulitis undergoing awake shoulder manipulation. **Conclusion.** This report descriptively signifies superior trunk block excellence among other regional anesthesia techniques in achieving complete anesthesia for awake shoulder manipulation in patients with adhesive capsulitis while sparing the phrenic-nerve function.

Keywords: Adhesive Capsulitis; Brachial Plexus; Nerve Block; Neglected Disease; Phrenic Nerve.

ABSTRAK

Pendahuluan. Blok pleksus brakhialis interskalenus merupakan standar emas anestesi regional untuk prosedur daerah bahu, termasuk manipulasi bahu pada pasien dengan adhesive capsulitis. Namun sayangnya banyak dokter anestesi enggan melakukan teknik anestesi regional ini mengingat resiko paresis *phrenic nerve* yang tidak diharapkan terjadi pada pasien dengan riwayat penyakit paru. Terkait hal ini, banyak studi dilakukan dalam usaha menemukan anestesi regional yang ideal untuk daerah bahu namun cukup distal sehingga *phrenic nerve* tidak ikut terblok oleh anestesi lokal. Hingga saat ini belum ada studi yang membandingkan beberapa alternatif teknik anestesi regional selain blok pleksus brakhialis interskalen terutama untuk anestesi prosedur manipulasi bahu pada pasien dengan adhesive capsulitis. **Laporan Kasus.** Penulis membandingkan profil tiga teknik anestesi regional, diantaranya blok saraf suprascapularis, blok shoulder interfascial plane dan blok trunkus superior, sebagai teknik anestesi tunggal pada pasien dengan adhesive capsulitis yang menjalani prosedur manipulasi bahu. **Kesimpulan.** Laporan kasus ini mendeskripsikan keunggulan blok trunkus superior sebagai anestesi tunggal pada pasien yang menjalani prosedur manipulasi bahu dibanding dua teknik anestesi regional lain, berikut dengan fungsi *phrenic nerve* yang masih utuh.

Kata Kunci: Adhesive Capsulitis; Plexus *Brachialis*; Blok Saraf; Penyakit Terabaikan; *Phrenic Nerve*.

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INTRODUCTION

Adhesive capsulitis is the most prevalent pathological condition of the shoulder, with a 2-5% lifetime incidence in the general population (1). Albeit it is a limited number of occurrences, this inflammatory, painful joint

disease may leave the shoulder joint contracted, leading to long-term disability in 35% of the subjects (2). Hence, early interventions are paramount in improving functional outcomes; one of them is the manipulation of the shoulder (3).



The fact that severe pain in this population may lead to low adherence to active and passive voluntary shoulder exercise puts the anesthesiologists in an essential role during its therapeutic activity, including manipulating the shoulders(4). Manipulation of the shoulders under anesthesia can be accomplished both by general or regional anesthesia, with the primary concerns being the patients' preference and underlying medical conditions.

While avoiding potential cardiopulmonary side effects from procedural sedation and analgesia, regional anesthesia has still opted with caution with phrenic nerve paresis as its complication (5). The typical approach for complete shoulder anesthesia is interscalene brachial plexus block (6).

Lately, however, some literature has offered superior trunk block, suprascapular nerve block, and shoulder interfascial plane block each as the sole anesthetic technique for shoulder procedures while sparing the phrenic nerve function (7,8). Yet, none of the comparisons between them has focused on shoulder manipulation for adhesive capsulitis.

We performed superior trunk block, shoulder interfascial plane block, and suprascapular nerve block each on three patients with adhesive capsulitis requiring awake manipulation of the shoulders. The objectives were to compare each technique's profile, effectiveness, and review the corresponding literature on the subject.

CASE REPORT

Technical Descriptions

Under strict aseptic technique, the author commenced nerve blocks in a supine (shoulder interfascial plane and superior trunk block) and sitting position (suprascapular nerve block posterior approach) with a 4-12 MHz high-frequency linear array probe (Mindray M7, Shenzhen, China) and a non-stimulating 100-mm-long, 21-gauge, short-beveled needle (Locoplex®, Vygon, Padova, Italy). All procedures commenced after local skin infiltration.

The local anesthetic administered was 1.5% Lidocaine with epinephrine (5 µg.mL⁻¹). The illustrative probe positions and needle directions for each block are shown in Figure 2-4.

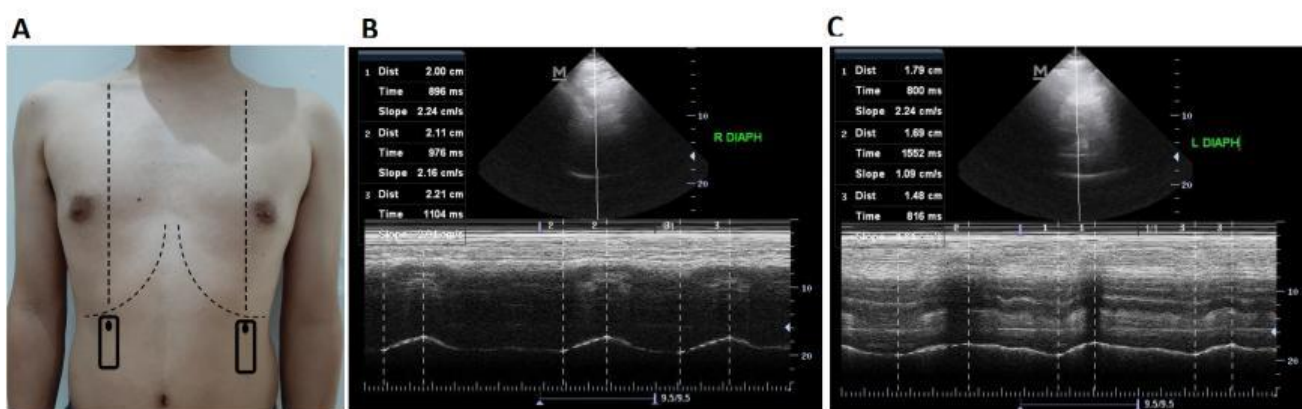


Figure 1. A. Illustration of probe positions for ultrasonographic measurement of ipsilateral diaphragmatic excursion in M-Mode. B. Right diaphragm. C. Left diaphragm.

The diaphragmatic excursion (DE) measurement was carried out with a 2-4 MHz phased-array probe (Mindray M7, Shenzhen,

China) placed at the junction of the ipsilateral midclavicular line and the subcostal margin, where the probe tilted postero-cephalad, parallel to the diaphragmatic movement.

The diaphragmatic movement toward the probe during inspiration and expiration was recorded in the M-mode tracing, where the amplitude of DE was the maximum vertical point downward to the lowest point in M-mode tracing (Figure 1) (9). The average DE was acquired from three consecutive breaths during a single period measurement.

Case Illustrations

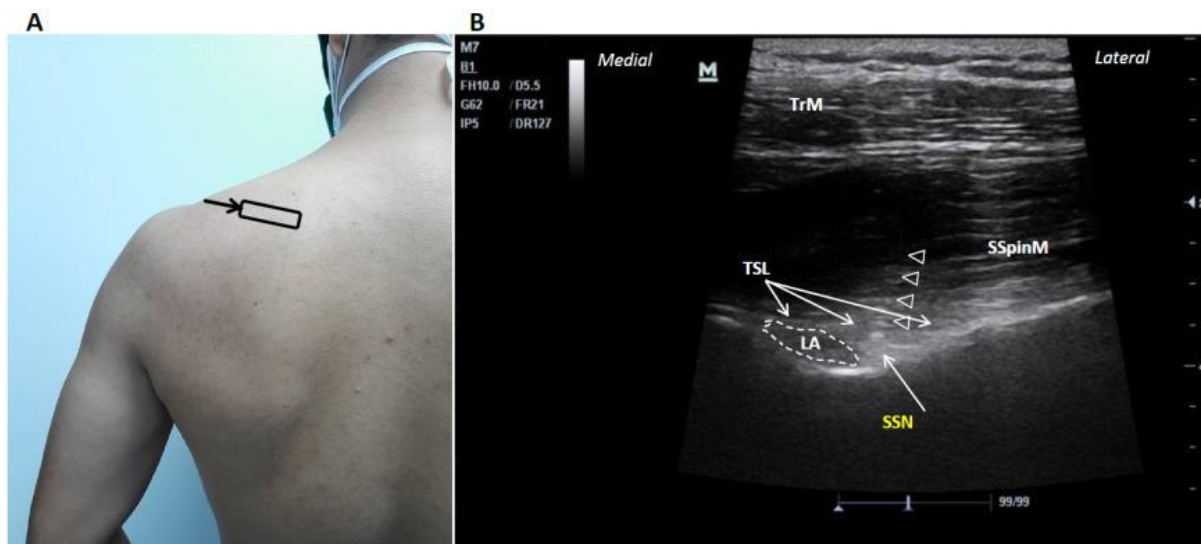


Figure 2. A. Illustration of probe positions and needle directions for suprascapular block (SSB) B. Ultrasound image of the needle entering suprascapular notch, where local anesthetic (LA) is injected beneath transverse scapular ligament (TSM), overlaid by the supraspinatus (SSpinM) and the trapezius muscle (TrM).

For the suprascapular nerve block posterior approach, the probe was placed parallel to the scapular spine and then moved just superior to it, with clear identification of suprascapular fossa, then slid laterally to locate the suprascapular notch. The suprascapular nerve was visible as a hyperechoic round shape beneath the transverse scapular ligament. The needle was inserted in-plane to the ultrasound beam with the endpoint of the needle tip located within the suprascapular notch, where a 10 ml local anesthetic was deposited (Figure 2B).

Case 1 – Suprascapular nerve block

A 57-year-old male patient of 50 kg weight and 148 cm height was scheduled for elective awake frozen shoulder manipulation under regional anesthesia. The patient had chronic right shoulder pain for almost a year despite undergoing routine physical rehabilitation and received shoulder joint injections. He denied general anesthesia and interscalene brachial plexus block but instead consented for suprascapular nerve block to no definite reason.

Despite complete pre-procedural pain relief (Table 1), there was significant pain in the shoulder's frontal area elicited by an external rotation procedure, followed by the administration of rescue analgesia (intravenous 50 mcg Fentanyl). During a visit before hospital discharge, the patient did not mention any subsequent problems related to the procedure. Still, he would prefer another

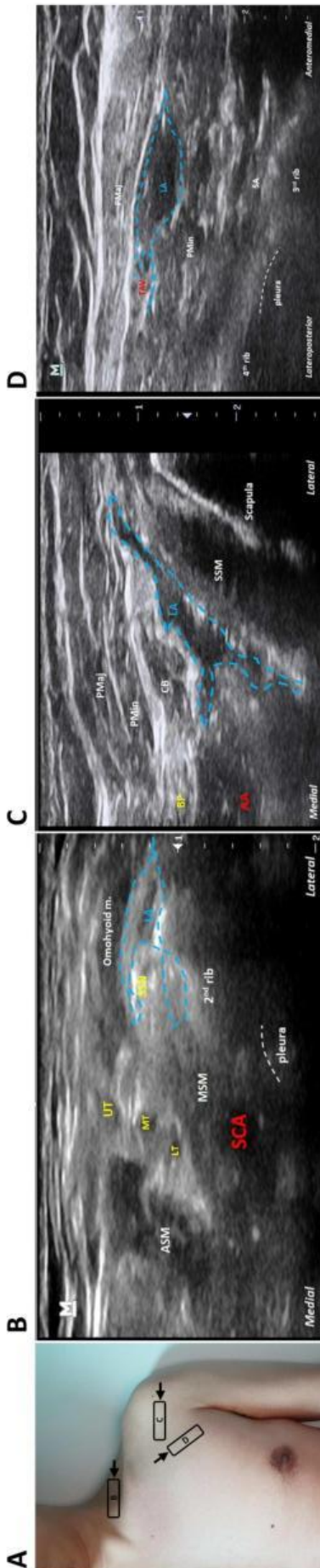


Figure 3. A. Illustration of probe position and needle direction for subomohyoid plane block (B), subscapular plane block (C) and PECS-1 block (D). B. Ultrasound image of local anesthetic (LA) deposited under omohyoid muscle inferior belly. Suprascapular nerve (SSN) is seen immediately deep to omohyoid muscle, separating from brachial plexus: upper trunk (UT), middle trunk (MT) and lower trunk (LT) laterally when probe swipes caudad. C. Ultrasound image of local anesthetic (LA) deposited anteriorly from the surface of subscapular muscle (SSM). The three layers of muscle at the anterior border of subscapular plane are coracobrachialis (CB), pectoralis minor (PMin), and pectoralis major (P.Maj) muscle. D. Ultrasound image of the fascial

option of regional anesthesia that may offer complete pain reduction for the next session of shoulder manipulation.

Case 2 – Shoulder interfascial plane block

A 75-year-old female patient of 50 kg weight and 150 cm height was scheduled to undergo awake frozen shoulder manipulation for her left shoulder's painful adhesive capsulitis. The patient had persistent shoulder pain for four weeks despite frequent physical rehabilitation visits. The patient refused an interscalene brachial plexus block due to her history of recurrent asthma attacks.

For the sub-omohyoid plane block, the probe was placed just superior to the clavicle with clear identification of brachial plexus, subclavian artery, and omohyoid muscle inferior belly, below which a 5 ml local anesthetic was deposited (Figure 3B). Subsequently, the probe was moved to the axial plane of the shoulder, where a lesser trochanter of the humerus and subscapularis muscle was well identified. Later, a 15 ml local anesthetic was deposited at the ventral surface of the subscapularis muscle (Figure 3C). The last one was the PECS-1 block with the probe positioned at midclavicular level, aligned, and moved inferolaterally until the thoracoacromial artery was seen sandwiched between the pectoralis major and minor muscle, within which a 10 ml local anesthetic was deposited (Figure 3D).

The post-block sensory evaluation resulted in complete anesthesia of axillary and suprascapular nerve dermatome with no anterior shoulder pain during voluntary movement. However, the surgeon sensed muscle resistance during external rotation at zero degrees abduction of the shoulder, originating from subscapularis muscle, with significant palpable trigger points on the subscapularis muscle belly. No rescue analgesia was required, and the procedure

went uneventful. Within the first two days' follow-up evaluation by phone, the patient did not mention any subsequent problems related to the procedure and was satisfied with the regional anesthesia technique.

Case 3 – Superior trunk block

A 74-year-old male patient of 52 kg weight and 151 cm height was scheduled for awake frozen shoulder manipulation for adhesive capsulitis on the left shoulder. The patient experienced moderate shoulder pain and stiffness for two years with a history of physical rehabilitation non-adherence. The patient refused interscalene brachial plexus block and general anesthesia due to the previous two events of myocardial infarction

requiring stent placement with subsequent cardiac decompensation.

For the superior trunk block, the probe was placed at the level of the C5 nerve root first, then slid caudally until C5 and C6 nerve roots merged, but right before the suprascapular nerve left bundle (Figure 4C). Color Doppler evaluation is paramount to identify the transverse cervical artery and dorsal scapular artery, which may cross over the brachial plexus. The needle was inserted in-plane to the beam in a lateral-to-medial direction, superficial to middle scalene muscle with the needle tip's endpoint just lateral to the superior trunk where a 10 ml local anesthetic was deposited circumferentially (Figure 4B).

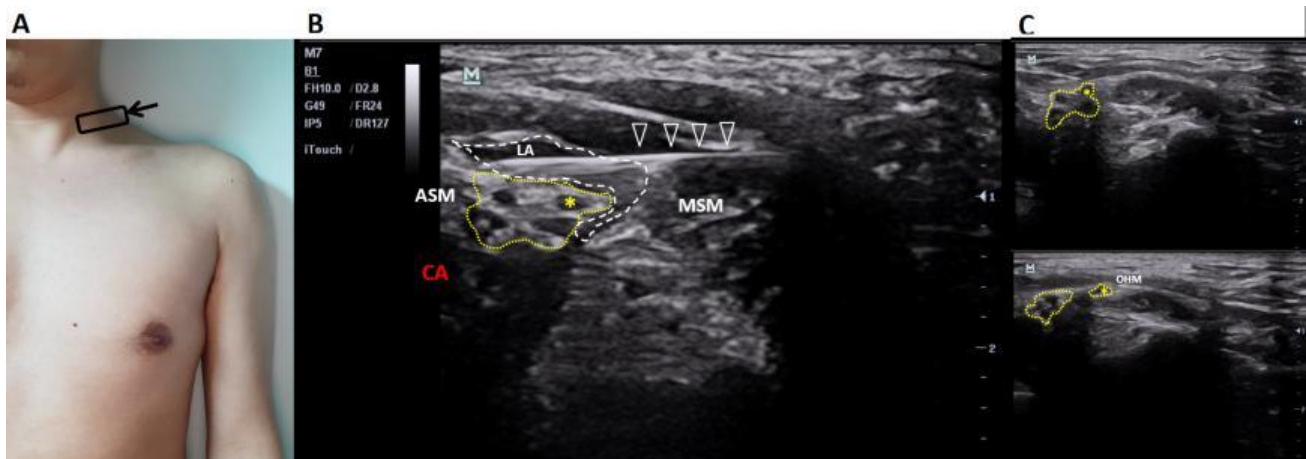


Figure 4: A. Illustration of probe positions and needle directions for superior trunk block (STB) B. White asterisk mark suprascapular nerve (SSN). Triangles correspond to the needle shaft. The level of injection is determined to right before the suprascapular nerve leaving off the superior trunk laterally beneath the omohyoid muscle (OHM), while the suprascapular nerve (SSN) still within the same nerve bundle (yellow dashed line) with C5 and C5. The needle tip is placed anteriorly to the superior trunk as local anesthetic (LA) is injected (local anesthetic spread in white dashed line). C. Ultrasonography depicted suprascapular nerve (SSN) leaving superior trunk nerve bundle.

Complete anesthesia at the level of C5 and C6 was achieved while sparing the motor function of the hand. There were no signs of dyspnea nor decreased diaphragmatic excursion following complete anesthesia of superior trunk block until post-anesthesia care unit (PACU) discharge. The procedure went uneventful without any need for rescue

analgesia. Within the first-day follow-up evaluation by phone, no problems related to the nerve block were found, and the patient was satisfied with the regional anesthesia technique.

DISCUSSION

Achieving complete anesthesia for shoulder procedures requires specific knowledge of its structure and related sensory innervation. A better understanding of the glenohumeral and acromioclavicular joint capsules neuroanatomy and related sensory implication for anesthesiologists' intervention was just recently revealed by Tran et al., (10) in , leaving the simple concept of cutaneous and osteotome sensory mapping apart toward more specific nerves targeting during regional anesthesia. His study answered the previous dogma of brachial plexus block at the level of interscalene compulsory as the sole anesthesia of shoulder procedures, with evidence of nerves originating only from C5 and C6. The only nerve derived not from C5-6 is the lateral thoracic nerve (C5-C7) in only one from 15 cadavers. Regarding this finding, we have to reconsider routine interscalene brachial plexus block for shoulder anesthesia as C7 and C8 nerve roots blockade is unnecessary and weighs the almost 100% risk of phrenic nerve paralysis from this level of block.

Until recently, apart from interscalene brachial plexus block, studies on complete shoulder regional anesthesia approaches have been mainly focusing on superior trunk (C5-6) block, suprascapular nerve block, and selective nerves block (7,11,12). While superior trunk and suprascapular nerve blocks' sensory coverage are self-explanatory, the selective nerves block covers three different nerves and/or plane blocks; subscapular plane block targeting subscapular and axillary nerves, suprascapular nerve block, and PECS-1 block for the lateral pectoral nerve (7).

Despite limited evidence, in this case report, the author demonstrated that both superior trunk and selective nerve block approach provided complete shoulder anesthesia, which allowed for awake

manipulation of the shoulder for patients with adhesive capsulitis without any rescue analgesia and hemidiaphragmatic paralysis. Although many authors have published its utility, the suprascapular nerve block technique covers only 70% of shoulder girdle sensory innervation, rendering patients' resistance from pain elicited during shoulder manipulation (13).

Previous studies did not mention complaints following shoulder manipulation under the suprascapular nerve block alone (12). However, the author found that passive shoulder external rotation with the arm at the side raised significant pain at the anterior portion of the shoulder, with subsequent resistance from the patient. This condition is plausible as theoretically, this specific maneuver during shoulder manipulation is aimed at complete tearing of the anterior capsule of the shoulder, where the sensory innervations are from the axillary and subscapular nerves, instead of the suprascapular nerve (10).

Any shortcoming of the previous approach was discovered by incorporating additional axillary and subscapular nerve blockade, first described in correspondence by Sondekoppam et al., who applied the shoulder interfascial plane block technique with or without PECS-1 (for the lateral pectoral nerve) for analgesia of shoulder surgeries in high-risk patients. Taking advantage of the relevant anatomical position of both nerves that lie in the common potential plane, subscapularis plane, Sondekoppam et al. deposited local anesthetic at the said plane, directly beneath the epimysium of the subscapularis muscle (7).

The clinical finding from Sondekoppam et al., (7) precisely explained in the cadaveric study of Drake et al., (14) showed that a

specific volume of dye being injected at the subscapularis plane might stain axillary and subscapular nerves. A similar result was also achieved by injecting dye deep to subscapularis muscle, staining more distal branches of nerves in the vicinity of the shoulder capsule (15). However, considering the anatomical variation of nerve branches and no clinical studies following said publication has recommended such practice on living subjects, the author did not utilize this approach.

While the technique of shoulder interfascial plane block has been proven effective as part of analgesia in shoulder surgeries, the author still found that the patient frowned during external rotation at zero degree abduction of the shoulder and sensed muscle resistance, both originating from the subscapularis muscle, with significant palpable trigger points at the superior and inferior lateral aspects on the ventral surface of the subscapularis muscle belly (7).

A similar condition was not found in the patient that was given superior trunk block, in addition, to complete analgesia of the shoulder, and all muscles relevant to the pectoral girdle were also wholly relaxed, making manipulation of the shoulder tension-free. The possible mechanism of this subscapularis muscle-spared relaxation is unblocked lower subscapular nerve by subscapularis plane block. As the injected volume of local anesthetic was probably staining the upper subscapular nerve only, sparing the lower subscapular nerve, the subscapularis muscle relaxation did not occur.

The superior trunk block is comparably superior to the previous two regional anesthesia techniques for its nature of a proximal blockade at the trunk level immediately after C5, and C5 roots merged

right before the suprascapular nerve left it. With sufficient volume, local anesthetic may cover all sensory and motor nerves related to the shoulder and the pectoral girdle; the suprascapular, subclavian, lateral pectoral nerves (partial) and axillary, and lower and upper subscapular nerves.

The author found that both superior trunk block and shoulder interfascial plane block provided complete analgesia of the shoulder in a static condition, hence considered adequate for shoulder joint surgeries. However, one distinctive feature from the manipulation of frozen shoulder that anesthesiologists must be concerned about is its requirement of rotator cuff muscles relaxation during passive movement, which could only be achieved with the superior trunk block technique.

Apart from that, one also needs to consider the risk-benefit ratio of local anesthetic systemic toxicity with the transient phrenic nerve paralysis for the given high dose of the local anesthetic in the shoulder interfascial plane block. While it has apparent advantages over shoulder interfascial plane block in terms of potentially lesser risk of LAST, the superior trunk block's certainty in sparing the phrenic nerve remains questionable as anatomically, its needle endpoint is within the same deep prevertebral fascia compartment, separated from the phrenic nerve only by anterior scalene muscle (16).

Despite a sonoanatomy study conducted by Kessler et al. having found that the phrenic nerve was 1.8 to 2.0 mm away from the C5 nerve root in adults at the level of the cricoid cartilage, with the additional distance of 3 mm for every centimeter distal scanning, there is 30-35% variation of individuals whose C5 root travels with or over the anterior scalene muscle in adjacent with the phrenic nerve(17).

Table 1 : Individual peri-procedural events, rescue analgesia and adverse events.

Case Study	Pre-procedural block pain NRS (out of 10)	Pre-procedural Post-block pain NRS (out of 10)	Post-block Cutaneous Sensory Blockade Evaluation	Ipsilateral Diaphragmatic Excursion (cm)		Patient-reported intra-procedural pain or muscle spasm events	Location of intra-procedural shoulder pain	Rescue Analgesia	Adverse Events
				Pre-block	Post-block				
1	5	1	Suprascapular nerve dermatome	2.1	1.96	+	Anterior	Intravenous Fentanyl 50mcg	-
2	4	1	Suprascapular and axillary nerves dermatome	1.65	1.61	+	Subscapularis muscle belly	-	-
3	5	1	C5 and C6 dermatome	1.78	1.68	-	-	-	-

NRS : Numerical Rating Scale
 LAST : Local Anesthetics Systemic Toxicity

This anatomically relevant evidence regarding the higher chances of complete or partial phrenic nerve paresis after superior trunk block appeared unlikely to occur in the clinical scenario as the author did not find any diaphragmatic excursion decrease following the block, and parallel with the result of a randomized controlled trial (RCT) from Kang et al., superior trunk block saw lower decrease in the diaphragmatic excursion and respiratory function compared with interscalene brachial plexus block (8).

However, lower does not necessarily mean none, as in Kang et al. (8)'s RCT, there was one subject experiencing complete hemidiaphragmatic paresis. Therefore, anesthesiologists have to deliver adequate information regarding the potential risks and benefits of superior trunk block or shoulder interfascial block found during pre-anesthesia visits and earn patients' consent. The 29% incidence of hemidiaphragmatic paresis found in the mentioned RCT might be related to administering a 15 ml volume of local anesthetic, 5ml higher than what Kim et al. (18) administered in his RCT. A smaller volume of LA may translate into a lower risk of phrenic nerve staining; hence Kim et al. (18) found only a 3% incidence of hemidiaphragmatic paresis. Considering the result of these two RCTs, the author opted for the administration of a 10 ml local anesthetic with no decrease in the diaphragmatic excursion.

Despite convincing results supporting superior trunk block as the sole anesthesia technique for shoulder procedures, there are limitations in this case report. As a single-subject study, the author could not provide the differences and efficacy of each regional anesthesia technique statistically other than descriptive clinical experiences. Consequently,



further generalization of the result to routine practice should be carefully weighed. There has yet to be firm evidence regarding the technique's potencies and adverse effects and the indeterminacy of the minimum adequate volume for the lower incidence of hemidiaphragmatic paresis. With a single anesthesiologist performing nerve block, it cannot be interpreted as increasing performance bias; instead, it may limit the generalizability of the finding. Finally, the absence of a standard technique in performing the superior trunk block approach and its anatomical endpoint may result in the varying incidence of phrenic nerve involvement during daily clinical practices.

CONCLUSION

In conclusion, this case report exhibits that, compared to suprascapular nerve block and shoulder interfascial plane block, the superior trunk block provides complete sensory and motor blockade required during shoulder manipulation for adhesive capsulitis cases, with the absence of hemidiaphragmatic paresis. Therefore, one may appraise the superior trunk block's potential feasibility in patients at high risk of respiratory complications. Nonetheless, future studies are required to confirm this finding further.

Declaration of Patient Consent

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient (s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published, and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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