

Regional anesthesia for shoulder surgery: A narrative review on current techniques and clinical considerations

Omuz cerrahisinde rejyonal anestezi: Güncel teknikler ve klinik değerlendirmelere ilişkin anlatsal derleme

Hüseyin Erdoğan¹, Rafet Onur Görgülü¹, Ata Cem Akbaba², Teoman Toprak³, İrem Özdemir⁴, Yavuz Gürkan¹

¹Department of Anaesthesiology and Reanimation, Koç University Faculty of Medicine Hospital, İstanbul, Türkiye

²Department of Orthopaedics and Traumatology, Koç University Faculty of Medicine Hospital, İstanbul, Türkiye

³Department of Biology, University of Washington, Seattle, WA, USA

⁴Department of Algology, Koç University Faculty of Medicine Hospital, İstanbul, Türkiye

ABSTRACT

An aging population and longer lifespans have markedly increased the number of shoulder surgeries. Technological advances have made arthroscopic techniques increasingly prominent owing to their minimally invasive nature and lower risk to surrounding structures. Effective postoperative pain management is, therefore, essential and has prompted continued advances in nerve block techniques. Although the interscalene brachial plexus block (ISBPB) is widely regarded as the standard technique for shoulder surgery, phrenic nerve involvement may result in hemidiaphragmatic paresis. The clinical significance of this effect depends largely on the patient's respiratory reserve. The search therefore continues for techniques that optimize postoperative analgesia while preserving respiratory function. In this review, we aim to provide an evidence-based overview to assist anesthesiologists in selecting patient- and procedure-specific regional anesthesia techniques that achieve an appropriate balance between analgesic efficacy and safety.

Keywords: Brachial plexus, regional anesthesia, phrenic nerve, postoperative pain, shoulder.

Inadequate control of postoperative pain prolongs hospitalization and increases complications and costs. However higher opioid use to manage pain increases the incidence of adverse effects, including nausea, vomiting, hypotension, respiratory depression, and drug dependence.^[1,2]

Postoperative pain that is not effectively treated leads to delayed recovery from anesthesia within the

ÖZ

Yaşlanan nüfus ve uzayan yaşam süresi, omuz cerrahisi sayısını belirgin biçimde artırmıştır. Teknolojik gelişmeler, minimal invaziv olmaları ve çevre yapılarına daha az zarar vermeleri nedeniyle artroskopik teknikleri giderek öne çıkarmıştır. Bu nedenle, etkili postoperatif ağrı yönetimi zorunlu hale gelmiş ve sinir bloku tekniklerindeki gelişmeleri hızlandırmıştır. İnterskalen brakial pleksus bloku (ISBPB) omuz cerrahisinde geniş ölçüde standart teknik olarak kabul edilmekle birlikte, frenik sinir tutulumu hemidiyafragmatik pareziye yol açabilir. Bu etkinin klinik önemi, büyük ölçüde hastanın solunum rezervine bağlıdır. Bu nedenle, postoperatif analjeziyi optimize ederken solunum fonksiyonunu koruyan tekniklere yönelik arayış sürmektedir. Bu derlemede, analjezik etkinlik ile güvenilirlik arasında uygun bir denge sağlayan, hastaya ve cerrahi işleme özgü rejyonal anestezi tekniklerinin seçilmesinde anesteziyoloji uzmanlarına yardımcı olmak amacıyla kanıta dayalı bir genel bakış sunuldu.

Anahtar sözcükler: Brakial pleksus, rejyonal anestezi, frenik sinir, postoperatif ağrı, omuz.

first 24 h, prolonged hospitalization, and hospital readmission within 30 days postoperatively. To prevent pain and reduce the side effects of opioids, the importance of peripheral nerve blocks in surgery has progressively increased.^[3]

Selecting a regional anesthesia technique tailored to the planned surgical procedure and the patient's analgesic requirements is of utmost importance for

Corresponding author: Hüseyin Erdoğan, MD.

E-mail: rgorgulu@kuh.ku.edu.tr

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achieving optimal outcomes.^[4] A comprehensive understanding of the shoulder's unique anatomy, associated structures, and regional innervation is essential for selecting the most appropriate regional anesthesia technique for different surgical procedures. To better understand the neural innervation of the shoulder, the nerves contributing to its sensory and motor innervation are summarized in Table 1.^[5] The main goal of the anesthetic approach in shoulder surgery is to preserve respiratory function while providing effective anesthesia/analgesia, given the widespread use of regional techniques.

The clinical significance of unilateral hemidiaphragmatic paresis (HDP) depends far more on the patient's respiratory reserve than on the presence of the paresis itself. In patients with normal pulmonary function, it is usually well tolerated, typically producing a 20 to 30% reduction in forced vital capacity (FVC) and forced expiratory volume in 1 sec (FEV1) with minimal or no symptoms, and resolving fully as the block regresses. In such patients, the effect is usually of limited clinical significance. However, it may not be tolerated in patients with limited respiratory reserve those with severe chronic obstructive pulmonary disease (COPD) or other advanced parenchymal lung disease, morbid obesity, restrictive or neuromuscular disorders, and pre-existing contralateral diaphragmatic dysfunction or phrenic nerve palsy. In these patients, even transient unilateral paresis may precipitate clinically significant

dyspnea, hypoxemia, or respiratory failure, and diaphragm-sparing techniques should therefore be prioritized.^[6]

Balancing adequate pain control against respiratory function is a key determinant of clinical success. In this review, we aim to provide an evidence-based overview to assist anesthesiologists in selecting patient- and procedure-specific regional anesthesia techniques that achieve an appropriate balance between analgesic efficacy and safety. Both established and emerging techniques are reviewed. Given the wide range of approaches available for many of these blocks, we focus on techniques that are currently used in our clinical practice.

REGIONAL ANESTHESIA TECHNIQUES USED IN SHOULDER SURGERY

Interscalene Brachial Plexus Block (ISBPB)

The first use of the ISBPB, as currently understood, was described by Alon P. Winnie^[7] in 1970. It is performed at the level of the roots and achieved by injecting local anesthetic (LA) to block the C5-C7 nerves between the anterior and middle scalene muscles.^[8] The inferior trunk (C8-T1) is usually not affected, unless the LA injection is administered more distally along the brachial plexus.^[9]

The target of the ISBPB as a nerve block is to provide anesthesia and analgesia in the upper extremity, in the region extending to the shoulder

Table 1. Neural innervation of shoulder anatomy showing related nerves and their route, motor and sensory functions^[4,8]

Source of the nerve	Nerves	Motor innervation (Muscles innervated)	Sensory innervation
Cervical plexus	Supraclavicular nerve (C3-4)	Neck muscles	Upper trapezius, clavicle, deltoid (superior shoulder)
Brachial plexus-roots	Dorsal scapular nerve (C4-5)	Levator scapulae, rhomboid major/minor	None
	Long thoracic nerve (C5-7)	Serratus anterior	None
Brachial plexus-upper trunk	Suprascapular nerve (C5-6)	Supraspinatus, infraspinatus fossa	Shoulder joint capsule
	Subclavian nerve (C5-6)	Subclavius	None
Brachial plexus-lateral cord	Lateral pectoral nerve (C5-7)	Pectoralis major (clavicular portion), pectoralis minor (pectoral nerve)	None
Brachial plexus-medial cord	Medial pectoral nerve (C8-T1)	Pectoralis major (sternal portion), pectoralis minor	None
Brachial plexus-posterior cord	Upper subscapular nerve (C5-6)	Subscapularis (upper port)	None
	Thoracodorsal nerve (C6-8)	Latissimus dorsi	None
	Lower subscapular nerve (C5-6)	Teres major, subscapularis (lower port)	None
	Axillary nerve (C5-6)	Deltoid (deep branch), teres minor (superficial branch)	Lateral proximal arm (superior lateral cutaneous nerve)

joint and proximal humerus. It covers the shoulder and forearm region, much like a cape.^[10,11]

In the literature, ISBPB has been shown to be an effective technique for anesthesia and analgesia in shoulder surgery. In shoulder surgery, adding a cervical plexus block or selective supraclavicular nerve block to the ISBPB provides more comprehensive regional anesthesia. When combined with a cervical plexus block, it can also be applied in clavicle surgeries.

Technique

The linear ultrasound probe is placed in the supraclavicular fossa parallel to the clavicle and directed cephalad. After identifying the subclavian artery, brachial plexus, and pleura, the probe is slid cephalad to trace the nerve trunks up to the interscalene groove. Both in-plane and out-of-plane techniques can be used; with the in-plane approach, care must be taken to avoid the dorsal scapular and long thoracic nerves within the middle scalene muscle.^[12]

A 5-cm, 22-gauge, short-bevel, insulated stimulating needle is sufficient. As anatomical variations in the neck are common, Doppler imaging before needle insertion may reduce the risk of vascular puncture. As the volume of the LA increases, it may spread across multiple fascial planes, including the epidural space.^[13] In adults, an average of 5 to 10 mL of LA is enough for successful ISBPB (Figure 1).^[14]

While some clinics use the interscalene block alone for surgical anesthesia, our clinic's preference,

to enhance patient comfort and safety, is to combine regional anesthesia with general anesthesia, depending on factors such as patient positioning, surgical duration, and other considerations. A single injection of LA into the interscalene area provides analgesia for an average of 12 h. A plexus catheter can be placed to provide prolonged analgesia; however, the interscalene region is a site where catheters are most frequently dislodged.

The volume of the LA administered in the ISBPB affects respiratory complications. Respiratory function is less affected with use of low-dose LA. No significant difference was observed between the two groups in pain scores, sleep quality, or total morphine consumption.^[14] Potential complications after ISBPB are presented in Table 2.^[3,15-19]

Among brachial plexus blocks, the ISBPB has the highest reported risk of serious neurological injury. Quadriparesis is thought to result from needle-induced trauma, potentially as the C8-T1 nerve roots contain relatively little protective connective tissue.^[16]

Catastrophic neurologic complications, such as acute and permanent quadriparesis, have also been reported when ISBPB is performed after induction of general anesthesia.^[20] Complications such as phrenic nerve paralysis and subsequent diaphragmatic paralysis may occur, potentially leading to serious clinical consequences particularly in patients with pre-existing respiratory compromise.^[21] The incidence of diaphragmatic paralysis is significantly lower in the 5 mL LA volume group, compared to the 20 mL LA volume group (45% vs. 100%).^[14] Respiratory

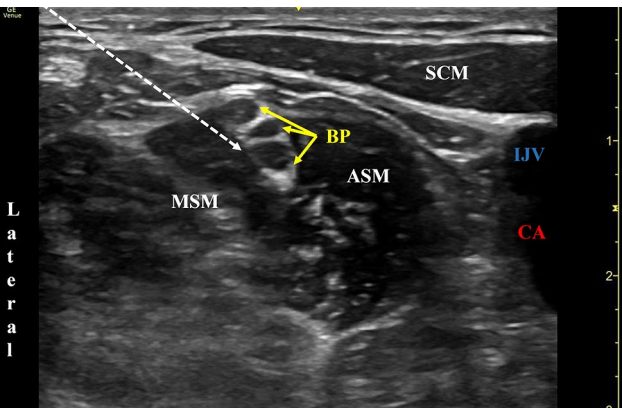


Figure 1. Ultrasound image of the interscalene brachial plexus block. The linear probe is placed in the transverse plane at the level of the cricoid cartilage. SCM, sternocleidomastoid muscle; BP, brachial plexus; ASM, anterior scalene muscle; MSM, middle scalene muscle; IJV, internal jugular vein; CA, carotid artery. The white arrow indicates the needle trajectory in the lateral-to-medial in-plane approach.

Table 2. Complications that may be seen following the interscalene block ^[2,24,31,43,52,59]
Hoarseness (recurrent laryngeal nerve)
Epidural or subarachnoid injection
Total spinal anesthesia
Horner syndrome
Hemi diaphragmatic paralysis
Permanent nerve injury
Quadriparesis (spinal cord injury)
Bezold–Jarisch reflex
Vertebral artery puncture
Pneumothorax
Intraneural injection
Persistent neuropathy

dysfunction due to permanent phrenic nerve injury is rarely seen after the interscalene block. Proposed mechanisms include intraneural injection, scarring from LA myotoxicity, a “double-crush” mechanism involving pre-existing cervical spinal stenosis, and a “triple-crush” mechanism that additionally includes pressure ischemia from high-volume LA. When the phrenic nerve is injured or the diaphragm is paralyzed, inspiration relies largely on the accessory respiratory muscles; pleural pressure falls, intrathoracic volume expands, and ventilation becomes impaired, particularly in the lower lobes of the affected lung. Dyspnea is the main symptom of phrenic nerve injury following ISBPB.^[6] Despite its effective analgesia, the interscalene block's phrenic nerve involvement leads to growing interest in diaphragm-sparing alternatives. These techniques are discussed sequentially in the following sections.

The Superior Trunk Approach

The superior trunk approach is a technique in which LA is administered more distally at the level of the superior trunk rather than the nerve roots to reduce the phrenic nerve involvement and associated respiratory compromise that may follow the ISBPB. The main advantage of the superior trunk block over the ISBPB is its greater preservation of the phrenic nerve and the diaphragmatic function while maintaining comparable quality of surgical anesthesia and analgesia. Both blocks are performed along the brachial plexus, but at different levels. The superior trunk block is performed more distally, at the level where the suprascapular nerve branches off and the risk of phrenic nerve involvement is lower.^[22]

Although the superior trunk approach reduces the incidence of HDP compared to the ISBPB, this risk is lowered rather than eliminated; even 5 mL of LA injected above the clavicle may involve the phrenic nerve. Therefore, in patients with severe respiratory disease, techniques performed above the clavicle are usually better avoided even those carrying a lower risk of phrenic nerve involvement in favor of more distal, diaphragm-sparing alternatives.

Superficial Cervical Plexus Block (SCPB)

While the articular innervation of the shoulder is provided predominantly by the anterior branches of the C5, C6, and to a lesser extent C7 cervical nerves, C3 and C4 primarily provide the cutaneous innervation via the superficial cervical plexus.^[23] The SCPB, therefore, does not target the suprascapular nerve, which arises from the upper trunk of the brachial plexus; instead, it blocks the

cutaneous branches of the cervical plexus (C2-C4) particularly the supraclavicular nerve that supply the skin over the shoulder. It is, thus, used as an adjunct to complement the cutaneous innervation of the shoulder rather than to provide articular analgesia. Superficial cervical plexus block appears very unlikely to affect the phrenic nerve, due to the protective barrier provided by the prevertebral fascia.^[24]

In our clinical practice, this technique is performed by administering 5 mL of LA beneath the deep cervical fascia located under the sternocleidomastoid muscle, using an out-of-plane approach.

Alternatively selective supraclavicular nerve block can be performed just above the medial scalene muscle with a low volume of LA.^[25]

Suprascapular Nerve Block

Posterior suprascapular nerve block (PSSNB) is used to avoid the hemidiaphragmatic complications of the ISBPB. The posterior approach was first described by Wertheim and Rovenstine^[26] in 1941 for chronic shoulder pain, and the ultrasound-guided anterior approach by Siegenthaler et al.^[27] in 2012. The suprascapular nerve arises from the C5-C6 spinal nerves (occasionally with a C4 contribution) within the upper trunk of the brachial plexus. It runs laterally, parallel to the inferior belly of the omohyoid muscle, enters the suprascapular notch, and passes into the infraspinatus (IS) fossa. It innervates the supraspinatus and IS muscles, supports arm abduction and external rotation, and provides the sensory innervation of the acromioclavicular and glenohumeral joints.^[28] Accordingly, the PSSNB is effective in both acute and chronic shoulder pain, including the movement restriction and reduced range of motion seen in frozen shoulder.^[29]

The target site differs by approach. Anesthesiologists usually prefer the anterior approach, in which the nerve is blocked proximally in the neck at the level of the inferior belly of the omohyoid, where it is superficial and readily visualized.^[30] However, this approach carries a risk of LA spread to the brachial plexus and, less often, the phrenic nerve. A cadaveric dye study demonstrated limited phrenic nerve involvement following a 5-mL subomohyoid injection in a proportion of specimens.^[31] In contrast, pain physicians often prefer the posterior approach for chronic pain, blocking the nerve more distally at the supraspinous fossa near the suprascapular notch; this approach reduces

plexus and phrenic spread and offers a safer profile.^[32] The choice, thus, reflects differing priorities: potent perioperative analgesia for anesthesiologists versus safety in repeated procedures for pain physicians.

At the scapular notch, the suprascapular artery and nerve pass beneath the scapular spine and the supraspinatus fascia. In the classic technique, the needle is advanced perpendicular to the skin, until it contacts the bony floor of the fossa and is then redirected into the notch; this narrow corridor risks pneumothorax, brachial plexus injury, and damage to the suprascapular vessels and nerve.^[33] Another approach described by Dangoisse et al.^[34] is that the needle is advanced into the fossa parallel to the scapula, toward the cephalad direction of the midpoint of the scapular spine, until the bony floor is reached, and 8 mL of 0.5% bupivacaine is injected.

Anterior Suprascapular Nerve Block (ASSB)

A linear ultrasound probe is placed over the suprascapular region in a coronal oblique orientation, allowing the suprascapular nerve to be identified beneath the belly of the omohyoid muscle (Figure 2). In experienced hands, the procedure can usually be performed safely using 3.0 to 4.2 mL of LA. Postoperative analgesia with the anterior approach has been found to be like that of the ISBPB. At the same time, phrenic nerve function was preserved in the majority of patients.^[35,36]

The anterior approach can be readily identified using anatomically easily detectable landmarks such as the omohyoid muscle. Regarding analgesic effect during the first 24 h postoperatively, studies indicate that the anterior approach is more effective than PSSNB. As the administered dose of LA increases, the anterior suprascapular block will behave like a low-dose distal ISBPB.^[37,38]

In a cadaveric study by Sehmbi et al.,^[31] injection of 5 mL of dye into the subomohyoid space stained the suprascapular nerve in 90% of specimens, while the superior and middle trunks were involved in 90% and 80% of dissections, respectively. The inferior trunk was stained in only 20% of specimens, and the phrenic nerve likewise showed mild staining in only 20%. Therefore, for LA doses higher than 3 mL we recommend that the block be applied with caution in patients who may not tolerate a phrenic nerve block.^[39]

Following ASSB, reductions in pulmonary function tests were less pronounced compared to ISBPB. These results suggest that ASSB may be a safer alternative for patients at increased risk of pulmonary complications.^[3]

Shoulder Block

An alternative to the interscalene block for postoperative analgesia after shoulder surgery is the combined suprascapular and axillary (circumflex) nerve block. Since these two nerves supply much of the sensory innervation of the shoulder joint, the technique relies on their selective blockade without blocking the entire brachial plexus. Price^[40] reported that this combination achieved complete analgesia without phrenic nerve involvement and named it the “shoulder block.” The suprascapular nerve is traditionally blocked in the supraspinous fossa using the Meier technique. An alternative approach, blocking the nerve as it courses along the posterior surface of the humerus, has also been described together with the author’s initial clinical experience.

This is a block combination that emerged to mitigate the side effects of the ISBPB. As the suprascapular nerve block alone is not sufficient, it has been found that better analgesia is provided by the addition of axillary nerve blockade. The suprascapular nerve can be blocked safely and rapidly at the lateral base of the supraspinous fossa, and the axillary nerve at the point where it crosses over the bone on the posterior surface of the humerus.^[41]

These two nerves usually innervate the muscles that provide glenohumeral joint stabilization. The suprascapular nerve innervates the IS and supraspinatus muscles, while the axillary nerve innervates the deltoid, the long head of the triceps, and the teres minor (Tm) muscles. The axillary nerve can be identified within the quadrangular space, next

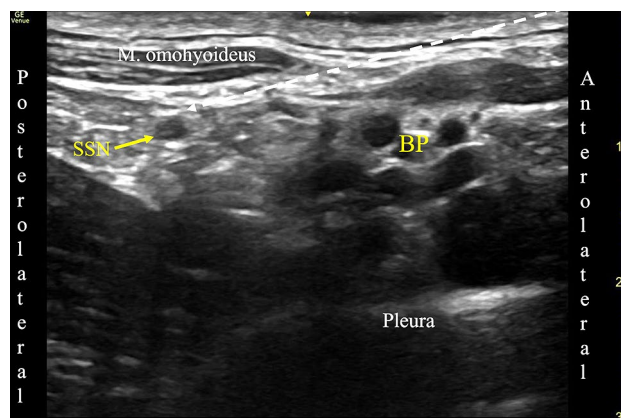


Figure 2. Ultrasound image of the anterior (subomohyoid) suprascapular nerve block. The probe is placed in the supraclavicular fossa and directed cephalad.

SSN, suprascapular nerve; BP, brachial plexus. The arrow indicates the path the needle will follow and the site where the local anesthetic will be injected.

to the circumflex artery, where the ultrasound probe is placed parallel to the long axis of the humeral shaft (Figure 3). Together, these two nerve blocks can constitute an alternative to the interscalene block.^[42] Chong et al.^[43] evaluated the role of axillary nerve block interacting with chronic shoulder pain using different windows.

Posterior Suprascapular Nerve Block

Small volumes of LA can be used in this approach, and as it is anatomically quite distant from the phrenic nerve, phrenic nerve block is technically not observed. In the posterior approach, the US probe is placed parallel to the scapular spine and scanned upward over the supraspinous fossa until the supraspinous notch is reached (Figure 4). Local anesthetic is injected to surround the nerve in the suprascapular fossa. When the PSSNB is combined with an axillary nerve block, HDP should be avoided.^[44] In experienced hands, it can be applied as an alternative for patients at risk of postoperative pulmonary complications.^[37] According to clinical studies, the safe drug dose required for PSSNB is 5 mL of LA, which is sufficient.^[45]

Infraspinatus-Teres Minor (ITM) Interfascial Block

This block, described by Kim et al.,^[46] was defined to preserve respiration while providing adequate analgesia in shoulder surgery. This regional anesthesia technique is performed over the scapular region on the posterior aspect of the shoulder, which is at a considerable distance from the interscalene area. As a result, phrenic nerve involvement and

respiratory side effects are not expected. As a single approach rather than two separate approaches, the ITM interfascial block was described by injecting LA into the interfascial plane between the IS and teres minor muscles. In the block procedure, the Tm and IS muscles extend latero-superiorly from the posterior aspect of the shoulder. The target is the interfascial plane between these two muscles. The aim is for the LA injected into this region to spread to the target suprascapular and axillary nerves. With the in-plane technique, injection of 20 mL of LA into the fascial plane appears to be sufficient.

Some clinicians have shown that ITM contributes to postoperative analgesia to some extent.^[46,47] In our clinical experience, the ITM block alone does not consistently provide adequate analgesia for shoulder surgery. In our previous case series, analgesic outcomes with this technique were variable: while some patients had minimal postoperative pain and low PCA use, others reported significant pain within the first 24 h. In one patient, insufficient sensory loss over the posterolateral shoulder necessitated a rescue ASSB. This variability may reflect inconsistent spread from the interfascial plane to the suprascapular and axillary nerves.^[48]

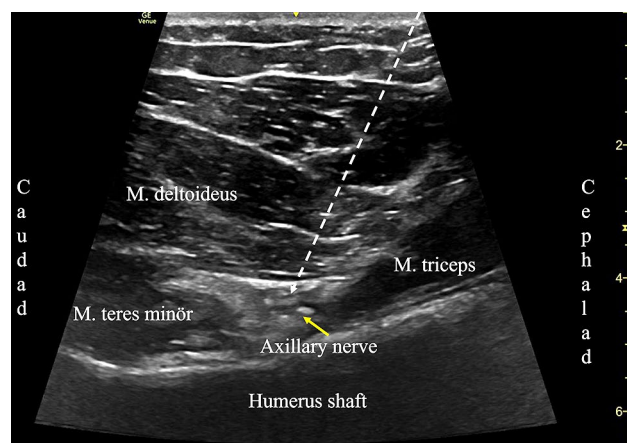


Figure 3. Ultrasound image of the axillary nerve block. The probe is placed parallel to the long axis of the humeral shaft over the quadrangular space.

Yellow arrow: Axillary nerve. The arrow indicates the needle trajectory.

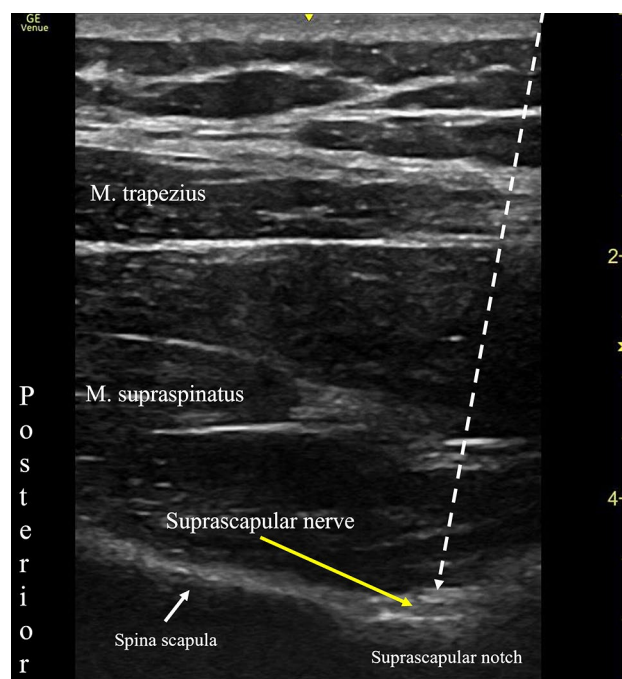


Figure 4. Ultrasound image of the PSSNB. The probe is placed parallel to the scapular spina over the supraspinous fossa. The arrow indicates that the needle is advancing parallel to the scapula toward the bony base of the scapular notch.

PSSNB, posterior suprascapular nerve block.

Supraclavicular Plexus Block

The supraclavicular plexus block is best known for its rapid onset of anesthesia of the brachial plexus. It targets the blockade of the portions of the brachial plexus coursing over the subclavian area and the first rib. The targeted region comprises the upper roots of the suprascapular nerve (C5-C6), which lie more distal than the interscalene region. Since the phrenic nerve is close to the targeted region, phrenic nerve involvement is observed in more than 50% of expected cases. The use of this block may further increase potential respiratory symptoms in patients at high risk of pulmonary complications.^[49]

For ultrasound-guided supraclavicular block, it has been reported that the required LA effect can be achieved with a volume of 23 to 42 mL of a mixture of 2% lidocaine and 0.5% bupivacaine.^[50]

Although the supraclavicular plexus block can provide analgesia comparable to that of ISBPB for shoulder surgery, the large volume of LA required is associated with significant phrenic nerve involvement and is not a preferred block in our clinical practice.

Costoclavicular Brachial Plexus Block (CCB)

The costoclavicular block targets the cords of the brachial plexus within the costoclavicular space and reliably blocks the axillary nerve, which arises from the posterior cord. The suprascapular nerve, however, branches from the upper trunk proximal to this injection site is not covered by this block. For complete shoulder analgesia, the costoclavicular block is, therefore, combined with a suprascapular nerve block.

Totally, 20 mL of 0.25% bupivacaine is administered as a LA.^[51] Several studies have shown that the CCB provides analgesia similar to the ISBPB, with a single injection reaching the retrograde brachial plexus, the subclavian and supraclavicular trunks, and the axillary and suprascapular nerve branches. This distribution supports its lower incidence of HDP compared to the ISBPB, although pain scores during the first 24 h are higher with the CCB.^[52]

One study comparing the CCB and the ISBPB classified the reduction in diaphragmatic excursion relative to baseline.^[52] In the CCB group, complete HDP occurred in only 7.3% of patients, 31.7% developed partial (incomplete) HDP, and 61.0% showed no diaphragmatic paresis. In contrast, complete HDP was observed in 78.0% of patients in the ISBPB group, with no patient retaining fully

preserved diaphragmatic function. An identical LA dose of 20 mL of 0.2% ropivacaine was administered in both the CCB and ISBPB groups.^[52]

The costoclavicular block has been used effectively for shoulder surgery when combined with a suprascapular nerve block, such as the combined infraclavicular and suprascapular nerve blocks described for total shoulder arthroplasty.^[53]

Given that ASSB alone provides effective analgesia with only 3 to 4.2 mL of local anesthetic, combining it with these additional blocks is unlikely to provide a clinically meaningful additional benefit.

High Thoracic Erector Spinae Plane Block (HT-ESPB)

The erector spinae plane block (ESPB), first described for thoracic neuropathic pain, has since been applied for acute and chronic pain at various levels.^[54] The block is performed by injecting LA into the fascial plane beneath the erector spinae muscle. Its analgesic effect is thought to result from spread into the paravertebral space, blocking the intercostal nerves and the sensory afferents of the ventral rami. Performed at the T2-T3 level, HT-ESPB provides analgesia after shoulder surgery without phrenic nerve involvement. Compared with ISBPB, this block produced no ultrasonographic evidence of HDP and preserved spirometric respiratory function, although pain scores tended to be higher during the early postoperative period. Although cervical ESPB is gaining popularity, injection above the T2 level is not preferred for shoulder surgery, as LA spread approaches the C3-C5 origins of the phrenic nerve, thereby compromising the diaphragm-sparing advantage of the block. As it accomplishes both phrenic nerve preservation with reasonable analgesia, the HT-ESPB may be preferred in patients with low functional residual capacity. This block can also provide analgesia of the apical axillary region, which is not innervated by the brachial plexus.^[55-57]

The block can be performed using 20 mL of 0.25% bupivacaine. Sensory loss may be observed in the cervical plexus distribution, the T1-T5 dermatomes, and the axillary region (Figure 5).^[58]

Although this block has been shown to be less effective than ISBPB in shoulder analgesia, it may be considered as an alternative analgesic method in patients at high-risk for postoperative respiratory distress or when ISBPB cannot be performed for any other reason.^[56] Table 3 summarizes the efficacy of

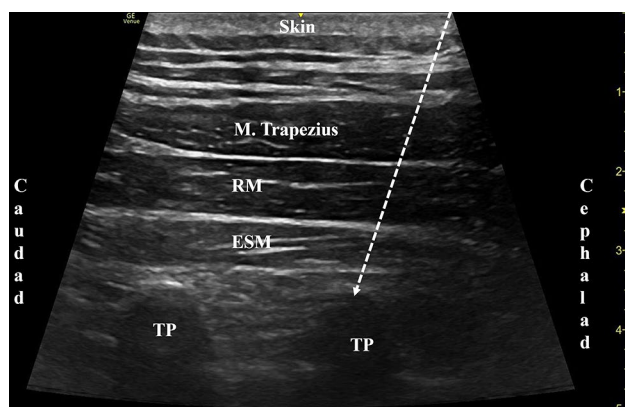


Figure 5. Ultrasound image of the high HT-ESPB at the T2-T3 level. The probe is placed in the parasagittal plane, lateral to the spinous process.

RM, rhomboid major muscle; ESM, erector spinae muscles; TP, transverse process; HT-ESPB, high thoracic erector spinae plane block. The arrow indicates the path the needle will follow and the site where the local anesthetic will be injected.

regional anesthesia techniques used for shoulder blocks.

DISCUSSION

Regional anesthesia techniques play an important role in providing effective analgesia and improving patient outcomes in shoulder surgery. The ISBPB

is widely regarded as the standard technique, as it reliably blocks the nerves innervating the glenohumeral joint. However, ISBPB may lead to serious respiratory complications due to ipsilateral phrenic nerve involvement. The risk of diaphragmatic paralysis is reduced when low-volume LA is administered during ISBPB. Minimal effective volume studies have indicated that surgical anesthesia can be achieved with a high success rate with only 5 mL of 0.75% ropivacaine in the cohort examined.^[59] Anterior suprascapular nerve block using as little as 3 mL LA has also been found to provide analgesia comparable to that of ISBPB for shoulder surgery.^[60] However, when doses higher than 5 to 10 mL of LA to provide surgical anesthesia are used, the phrenic nerve involvement is unpredictable. Therefore, reliably achieving effective surgical anesthesia while simultaneously preserving phrenic nerve function remains challenging.^[14]

The regional anesthesia technique selected for shoulder surgeries may vary with the anesthesiologist's experience, the type of surgery, and patient-related factors. Interest in diaphragm-sparing techniques has grown rapidly in recent years.

A key theme across these techniques is that phrenic nerve involvement is not a fixed property of a given block; its frequency and severity depend

Table 3. Comparative table of the effects of the blocks used for shoulder surgery

	Target	Analgesic effect	Surgical anesthesia	Diaphragmatic involvement	Risk of neurological damage	Hemodynamic effect
Cervical plexus block	C2-C4	Low	None	Low*	None	None*
Interscalene brachial plexus block	C5-C7	High	High	High	Moderate	Moderate
The superior trunk approach	C5-C6	High	High	Low*	Moderate	Moderate
Infraspinatus-teres minor interfascial block	Axillary and suprascapular nerve	Low	None	None	None	None
Anterior suprascapular nerve block (ASSB)	Anterior suprascapular nerve	High	Low	Low*	Moderate	Low
Posterior suprascapular nerve block (PSNB)	Posterior suprascapular nerve	Moderate	None	None	Moderate	None
Combined anterior suprascapular and axillary nerve block	Anterior suprascapular and axillary nerve	High	Low	Low*	Moderate	Low
Costoclavicular brachial plexus block	C5-C7	High	None	Low	Moderate	None
High thoracic erector spinae plane block	T2-5 fascial plane block	Moderate	None	None	None	Low

These findings may vary in a volume-dependent manner. For the blocks above the clavicle, phrenic nerve involvement and effects on the respiratory system are directly related to the drug dose and volume. * This effect may vary according to the administered volume of the local anesthetic.

strongly on the volume, concentration, and total dose of LA and on the proximity of the injection site to the C3-C5 phrenic contributions. Recognizing this dose dependence is clinically important, as it reframes HDP not as an inevitable consequence of interscalene injection, but as a partly modifiable complication.

Alternative approaches may benefit patients with limited pulmonary reserve, particularly those with COPD, obesity, or neuromuscular disorders, although non-ISBPB techniques may remain limited in postoperative pain control. When preserving diaphragm function is the priority, using a lower LA volume at a more distal injection site is far more reliable than simply reducing the volume at the interscalene level. Shoulder block using the posterior suprascapular nerve in combination with axillary nerve blocks can spare respiratory function.

Interfascial plane blocks are among the alternative approaches currently being investigated. Of note, HT-ESPB provides comparable analgesia for shoulder surgery without jeopardizing respiratory function.

Rebound pain is another important consideration in technique selection and is a well-recognized limitation of single-shot peripheral nerve blocks, including ISBPB, in shoulder surgery. As the block regresses, typically within 12 to 24 h, patients may experience a sudden and severe increase in pain requiring rescue analgesia.^[61] This phenomenon is directly relevant to the comparisons presented here, since the analgesic advantage of a block during its effective period does not necessarily translate into better overall pain control once it resolves. Multimodal analgesia should, therefore, be initiated before block regression, and patients should be informed about the expected timing of this transition; continuous catheter techniques or perineural adjuvants may also be considered to prolong analgesia in selected patients.^[62]

In conclusion, the selection of a regional block in shoulder surgery should balance respiratory function against analgesic efficacy. The ISBPB provides the most effective analgesia, but may cause phrenic nerve involvement and HDP. The incidence of phrenic nerve involvement depends on the volume of LA. The risk of clinically apparent phrenic nerve involvement is decreased when the LA volume is limited to 5 mL. Similarly, an ASSB performed with a low LA volume of as little as 3 mL has been used to provide analgesia for shoulder surgery. When phrenic nerve involvement must be avoided, a PSSNB combined with an axillary nerve block, or a

HT-ESPB, provides clinically effective analgesia for shoulder surgery.

Take-Home Message

The optimal block depends on both the type of shoulder surgery and the patient's respiratory reserve. Since phrenic nerve involvement is driven mainly by LA volume and the proximity of the injection site to the phrenic nerve, site and dose should be chosen together:

- **Major surgery (arthroplasty, RTSA, fracture fixation) + normal respiratory reserve:** ISBPB provides the most complete anesthesia; limiting LA to 5 mL lowers clinically apparent phrenic involvement while maintaining efficacy.
- **Major surgery + limited respiratory reserve (COPD, morbid obesity, neuromuscular disease, contralateral diaphragmatic dysfunction):** Prefer techniques avoiding the brachial plexus above the clavicle a posterior suprascapular plus axillary nerve block, or a **HT-ESPB**. Even low-volume blocks above the clavicle may not guarantee avoiding the phrenic nerve involvement.
- **Arthroscopic/less extensive surgery + normal reserve:** A low-volume anterior suprascapular (as little as 3 mL) or superior trunk block offers effective analgesia with a lower, though not absent, risk of HDP.
- **Arthroscopic/less extensive surgery + limited reserve:** A posterior suprascapular block ($\pm$ axillary) or **HT-ESPB** is preferred, as diaphragm sparing outweighs the modestly reduced analgesia.

No available technique fully matches ISBPB analgesia while completely preserving respiratory function; block selection should, therefore, be individualized against analgesic intensity, block duration, and respiratory safety.

Author Contributions

H.E.: This author was responsible for methodology, writing review and editing preparation; R.O.G.: This author was responsible for the data curation, writing-original draft preparation, visualizations and editing sections of the article; A.C.A.: This author was responsible for preparing the first draft of the manuscript and contributed to the preparation of visualizations; T.T.: This author was responsible for conducting the literature review and for proofreading the English text; İ.Ö.: This author was responsible for reviewing the literature and for drafting and editing the final version of the manuscript; Y.G.: This author contributed to the methodology, resources, writing-original draft preparation, visualizations and supervision sections of this paper.

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