

Ultrasonography-guided Peripheral Nerve Blocks in Orthopedic Upper Extremity Surgery: A Narrative Review

✉ Kadir Arslan, ✉ Ayça Sultan Şahin

Department of Anesthesiology and Reanimation, University of Health Sciences, Kanuni Sultan Süleyman Training and Research Hospital, İstanbul, Türkiye

ABSTRACT

Peripheral nerve blocks are frequently preferred in orthopedic upper extremity surgeries because they provide adequate postoperative analgesia, reduce the need for general anesthesia, and accelerate recovery. The integration of ultrasound (USG) guidance into these techniques has improved block success rates and significantly reduced complications. USG-guided nerve blocks allow real-time visualization of neural structures and surrounding anatomy. The brachial plexus supplies most of the innervation of the upper extremity. In clinical practice, the four most commonly performed brachial plexus blocks are the interscalene, supraclavicular, infraclavicular, and axillary approaches. In addition, terminal nerves can be selectively blocked along their course. For example, in clavicular surgeries, the interscalene block is often combined with a cervical plexus block; in rotator cuff repair and shoulder arthroscopy, the interscalene block is preferred; in humeral shaft fractures and elbow arthroplasty, supraclavicular or infraclavicular blocks are commonly used; and in distal radius fracture fixation, wrist arthrodesis, and metacarpal fracture surgeries, the axillary block is frequently chosen. Median nerve blocks are useful in carpal tunnel release and tenosynovitis; ulnar nerve blocks are employed in Dupuytren's contracture and flexor tendon repair of the fourth and fifth fingers; while radial nerve blocks are beneficial in de Quervain's tenosynovitis, scaphoid fracture surgery, and dorsal hand lesions. This review discusses the anatomical basis, techniques, indications, and complications of cervical and brachial plexus blocks, as well as distal nerve blocks, which are widely utilized in orthopedic upper extremity surgery.

Keywords: Orthopedic surgery, peripheral nerve blocks, postoperative analgesia, regional anesthesia, ultrasonography, upper extremity

How to cite this article: Arslan K, Şahin AS. Ultrasonography-guided Peripheral Nerve Blocks in Orthopedic Upper Extremity Surgery: A Narrative Review. *Compreh Med* 2025;17(4):338-349

INTRODUCTION

Upper extremity surgeries encompass a wide spectrum of orthopedic, traumatological, and reconstructive procedures, extending from the shoulder to the hand. These operations can cause severe pain intraoperatively and postoperatively. Regional anesthesia techniques are therefore highly valuable, as they provide surgical anesthesia, reduce opioid use, support early mobilization, and increase patient satisfaction.

One of the most significant developments in regional anesthesia in recent decades has been the use of peripheral nerve blocks (PNBs) under ultrasonographic (USG) guidance.^[1,2] USG enables real-time visualization of nerves, vascular structures, and needle advancement, significantly improving block success. Compared to landmark-based or nerve stimulator techniques, USG allows effective blocks with lower anesthetic volumes and reduces complication risks. USG

and nerve stimulators may also be used in a complementary fashion. Moreover, ultrasound facilitates quicker and more accurate placement of peripheral nerve catheters.^[3]

Among cervical and brachial plexus blocks, the interscalene, supraclavicular, infraclavicular, and axillary approaches are the most commonly used in orthopedic upper extremity surgery. Distal nerve blocks, on the other hand, can provide analgesia while preserving motor function—particularly valuable in hand surgery.^[4,5] Selection of the appropriate block should be guided by anatomical level, surgical site, and patient characteristics. With the safety and precision of USG, motor-sparing approaches are increasingly preferred.

This narrative review aims to summarize the anatomical basis, technical considerations, indications, and reported outcomes of USG-guided peripheral nerve blocks in upper extremity surgery.



Address for Correspondence: Kadir Arslan, Department of Anesthesiology and Reanimation, University of Health Sciences, Kanuni Sultan Süleyman Training and Research Hospital, İstanbul, Türkiye
E-mail: kadir.arslan@sbu.edu.tr **ORCID ID:** 0000-0003-4061-0746

Received date: 10.07.2025
Revised date: 15.09.2025
Accepted date: 20.09.2025
Online date: 08.10.2025

MATERIALS and METHODS

A literature search was conducted in PubMed and Google Scholar for articles published between June 2020 and June 2025 using the keywords ultrasound-guided, peripheral nerve block, upper extremity, and orthopedic surgery. Randomized controlled trials, observational studies, cohort studies, systematic reviews, and meta-analyses were included. Titles and abstracts were screened first, followed by full-text review. Additional manual searching was performed by screening reference lists and citations of key articles.

This review followed the SANRA (Scale for the Assessment of Narrative Review Articles) checklist to improve reporting quality.

ANATOMICAL INNERVATION OF THE UPPER EXTREMITY

The brachial plexus, formed by the anterior rami of spinal nerves C5–T1, provides the majority of upper extremity innervation. It is organized sequentially into roots, trunks (upper, middle, lower), divisions (anterior, posterior), fascicles (lateral, posterior, medial), and terminal branches. Major peripheral nerves arising from the plexus include the musculocutaneous, median, ulnar, radial, and axillary nerves.

A thorough understanding of this anatomy is essential for successful regional anesthesia.^[6] At the interscalene level, roots of the plexus lie between the anterior and middle scalene muscles—ideal for shoulder and upper arm surgeries. At the supraclavicular level, trunks are clustered, enabling blockade of the entire upper extremity. At the infraclavicular level, blocks target the fascicles around the axillary artery, suitable for procedures below the elbow and for catheter placement. The axillary block targets terminal branches and is frequently employed in hand surgery.

Additionally, the cervical plexus (C1–C4) contributes to upper extremity innervation. The supraclavicular nerves and phrenic nerve are particularly relevant for the shoulder region. Inadvertent phrenic nerve involvement during interscalene blocks may cause hemidiaphragmatic paralysis, highlighting the importance of careful planning. For tourniquet-related pain, thoracic nerves such as the intercostobrachial may also need to be blocked.

CERVICAL PLEXUS BLOCKS

The cervical plexus (C1–C4) contributes sensory and motor innervation to the cervical region and upper thorax. Its superficial branches provide sensation to the auricle, clavicle, deltoid, and upper shoulder, while deep branches supply

motor innervation to muscles including the sternocleidomastoid, trapezius, and diaphragm (via the phrenic nerve).^[7]

Superficial Cervical Plexus Block (CPB)

The superficial cervical plexus arises from C2–C4. Sensory innervation includes the auricle, clavicle, acromioclavicular joint, and anterolateral neck. Four terminal branches (lesser occipital, greater auricular, transverse cervical, and supraclavicular nerves) emerge near the posterior border of the sternocleidomastoid.^[8]

Superficial CPB is used for supraclavicular and subclavicular skin interventions such as lymph node biopsy, central venous catheterization, and clavicle fixation. In USG-guided CPB, the patient is placed supine, and a linear probe is positioned at the midline of the sternocleidomastoid muscle. The sensory branches beneath the fascia at the posterior muscle margin are targeted. The needle is advanced in-plane, and 5–10 mL of 0.25–0.5% ropivacaine is injected (Fig. 1).

Complications are less common than in deep blocks but may include intravascular injection, hematoma, infection, and systemic toxicity. Adequate anatomical knowledge and awareness of local anesthetic toxicity are essential to minimize risks.^[9]

Deep Cervical Plexus Block (CPB)

The deep CPB targets C2–C4 nerve roots between the anterior and middle scalene muscles, just anterior to the transverse processes. It can be used alone or in combination with interscalene blocks for shoulder surgery.

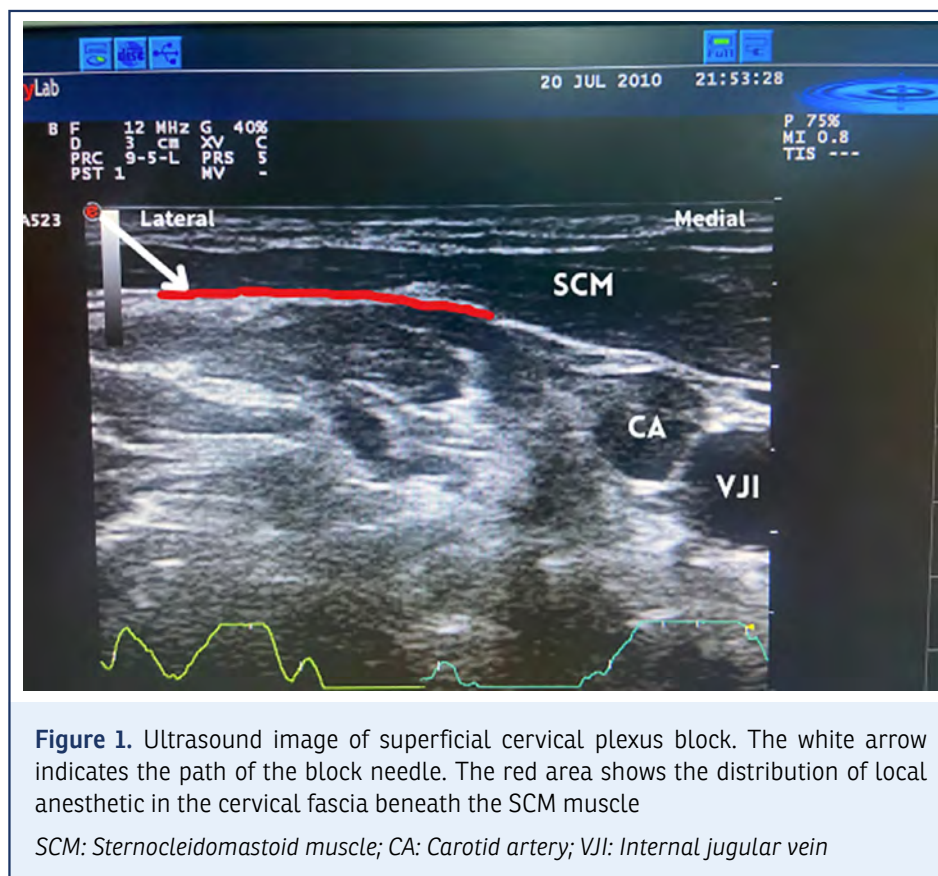
Because the injection is deeper, complications are more likely, including phrenic nerve palsy, vascular puncture, or epidural spread.^[10] Accidental injection into the vertebral artery carries a high risk, as even small anesthetic volumes can rapidly reach the CNS, producing neurotoxicity. Continuous patient communication during incremental injection is crucial to detect early warning signs (e.g., perioral numbness, confusion, tinnitus).

Unintended subdural injection is another risk, potentially causing abrupt loss of consciousness, hypotension, and requiring airway and hemodynamic support. For these reasons, deep CPB should be reserved for experienced practitioners and performed with extreme caution, especially in patients with limited pulmonary reserve.

BRACHIAL PLEXUS BLOCKS

Interscalene Block

The interscalene block is a regional anesthesia technique in which the brachial plexus is blocked at the C5–C7 root level, specifically targeting the upper (superior) and middle trunks.



It is particularly preferred for shoulder surgeries, proximal humerus interventions, clavicular procedures, and upper arm surgeries. However, because the lower trunk (C8–T1) is usually not affected, it is often insufficient when used alone for hand and forearm surgeries. The interscalene region is located behind the sternocleidomastoid muscle, between the anterior and middle scalene muscles.^[11] This anatomical relationship makes the block relatively easy to identify and apply safely.

For USG-guided interscalene block, the patient is positioned supine or in a slight lateral decubitus position, with the head turned contralaterally. A high-frequency (10–15 MHz) linear probe is placed laterally on the neck at the level of the cricoid cartilage (C6 level). On ultrasound, the scalene muscles appear beneath the sternocleidomastoid, and the hyperechoic, round-to-oval brachial plexus roots (typically C5, C6, and C7) are visualized between them. The needle is advanced from lateral to medial using an in-plane technique (Fig. 2). Typically, 10–15 mL of 0.5% ropivacaine, levobupivacaine, or bupivacaine is injected. Using higher volumes may increase lower trunk spread but also raises the risk of complications. The block is most effective in the C5–C6 dermatomes, providing anesthesia to the shoulder region and affecting muscles such as the deltoid, supraspinatus, biceps, and pectoralis major.

The most common and clinically important complication of the interscalene block is hemidiaphragmatic paralysis due to inadvertent phrenic nerve (C3–C5) blockade, which can occur in up to 100% of patients. This may cause severe respiratory distress in patients with COPD, obesity, or restrictive lung disease. Other complications include recurrent laryngeal nerve blockade (causing hoarseness), Horner syndrome due to sympathetic chain involvement, intravascular injection, neurotoxicity, and, rarely, epidural or subarachnoid spread.^[12] To reduce risks, low anesthetic volumes, frequent aspiration, and cessation of injection upon resistance are recommended. USG guidance is highly effective in minimizing these complications.

Supraclavicular Block

The supraclavicular block anesthetizes the brachial plexus at the trunk level (C5–T1) and is often referred to as the “spinal anesthesia of the arm.” Because the trunks are tightly clustered at this level, a single injection can provide dense anesthesia of the entire upper extremity. It is particularly suited for surgeries up to the proximal elbow, including arteriovenous (AV) fistula creation, humeral fracture fixation, and elbow arthroplasty. However, complete blockade of the ulnar nerve (C8–T1) is not always achieved.^[13]

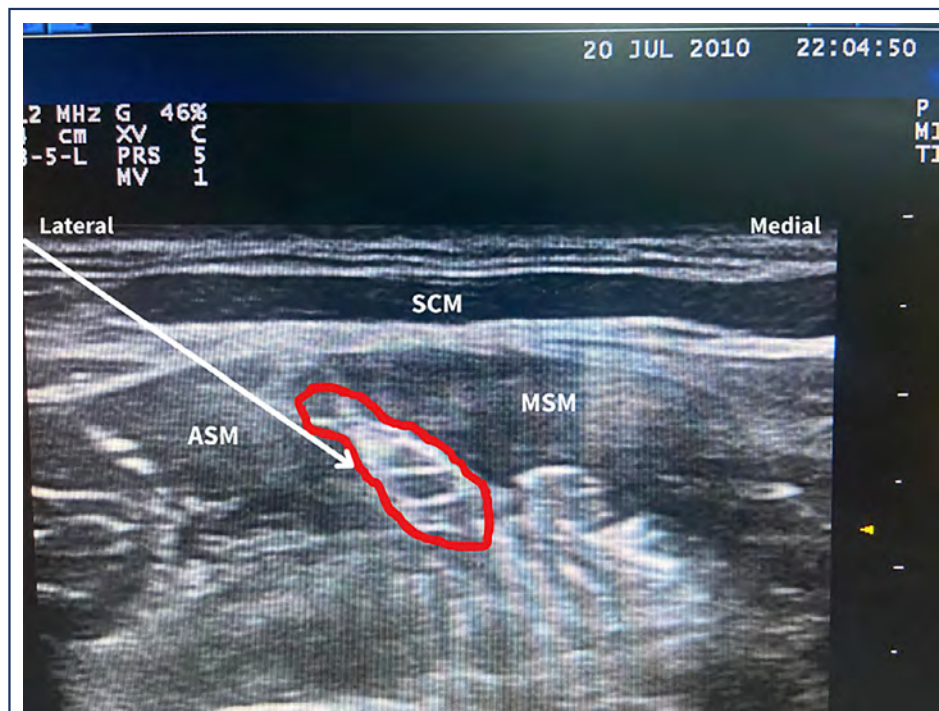


Figure 2. Ultrasound image of Interscalene block. The white arrow indicates the path of the block needle. The red line indicates the brachial plexus between the scalene muscles

SCM: Sternocleidomastoid muscle; ASM: Anterior scalene muscle; MSM: Middle scalene muscle

For USG-guided supraclavicular block, the patient is placed supine with the head turned contralaterally. A high-frequency linear probe is positioned just above the clavicle, beneath the scalene triangle (Fig. 3). On ultrasound, the brachial plexus appears as a hyperechoic “bunch of grapes” lateral to the subclavian artery. The needle is advanced from lateral to medial using an in-plane technique (Fig. 4), and 20–30 mL of 0.5% ropivacaine, levobupivacaine, or bupivacaine is administered. This block effectively covers most C5–T1 dermatomes, providing both sensory and motor blockade to the arm, forearm, and hand.

The most feared complication is pneumothorax, as the brachial plexus lies adjacent to the parietal pleura at this level. Over-advancement of the needle may puncture the pleura. The subclavian artery and vein are also nearby, creating risks of intravascular injection, hematoma, and neurotoxicity.^[14] These complications are significantly reduced with USG guidance. Other possible risks include bradycardia-hypotension, Horner syndrome, and occasional phrenic nerve involvement. Thus, careful anatomical identification, use of low anesthetic volumes, and frequent aspiration are essential.

Infraclavicular Block

The infraclavicular block targets the brachial plexus at the fascicular level (lateral, posterior, and medial). At this level, the fascicles are arranged clockwise around the axillary artery: the lateral fascicle lies superolateral, the posterior fascicle posterior, and the medial fascicle inferomedial. This block is suitable for elbow, forearm, and hand surgeries and is especially preferred when long-term analgesia is desired through catheter placement.^[15]

For USG-guided infraclavicular block, the patient lies supine with the arm abducted 90° and the head turned contralaterally. A linear or convex probe is placed just below the clavicle, inferomedial to the coracoid process (Fig. 5). On ultrasound, the axillary artery appears as a circular anechoic structure centrally, with the fascicles visible as hyperechoic structures surrounding it (Fig. 6). The needle is advanced from lateral to medial in-plane, and 20–30 mL of 0.25–0.5% ropivacaine, bupivacaine, or levobupivacaine is injected. Because the block covers all terminal branches from C5–T1, it provides a dense motor-sensory block of the hand, forearm, and elbow.



Figure 3. Probe position for supraclavicular block

Advantages include a lower risk of pleural injury compared to supraclavicular block, a flatter anatomy that facilitates catheter placement, less interference from shoulder movements, and reduced risk of diaphragmatic paralysis. Potential complications include vascular puncture, hematoma, and, rarely, pneumothorax. If USG imaging is suboptimal, nerve stimulator support is advised. The infraclavicular block is less affected by anatomical variations and is particularly advantageous in obese patients. When performed correctly, it offers an effective, safe, and long-lasting block, making it a preferred modern technique.

Axillary Block

The axillary block targets the brachial plexus at the level of the terminal branches: median, ulnar, radial, and musculocutaneous nerves. It is especially useful for surgeries of the forearm, wrist, and hand, including tendon repairs. The block carries minimal risk of phrenic nerve involvement, diaphragmatic paralysis, or pneumothorax, making it a safe alternative for patients with pulmonary compromise or coagulation disorders.^[16]

For USG-guided axillary block, the patient is placed supine with the arm abducted 90°. A linear probe is positioned in the axilla between the coracobrachialis and biceps brachii muscles. On ultrasound, the axillary artery appears as a round anechoic structure centrally, with nerves distributed around it: the median nerve anteromedial, the ulnar nerve inferior, the radial nerve posterior, and the musculocutaneous nerve lateral, often within the coracobrachialis (Fig. 7). Fractional injections are made for each nerve, totaling 20–30 mL of 0.25–0.5% ropivacaine, bupivacaine, or levobupivacaine. The musculocutaneous nerve must be separately targeted as it lies outside the main sheath.

The axillary block has a low complication rate and is well-suited for catheter placement. Its superficial location and relative distance from major vessels add to its safety. However, because the intercostobrachial nerve (T2) lies outside the brachial plexus at this level, tourniquet pain cannot be prevented with this block alone, requiring additional skin infiltration if necessary. Other potential complications include intravascular injection, hematoma, infection, and rare nerve injury. These risks can be minimized with careful needle advancement under USG guidance, frequent aspiration, and avoidance of high-pressure injection.

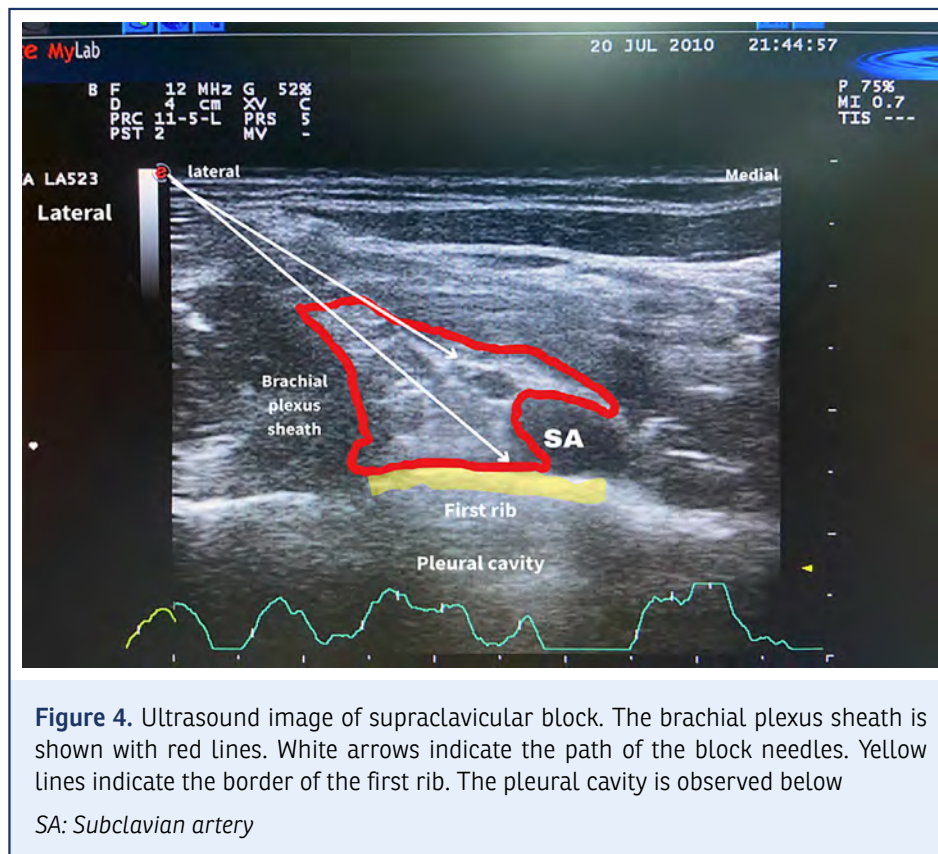
DISTAL NERVE BLOCKS

Distal nerve blocks are versatile techniques used in surgeries at the wrist and hand level, providing sensory blockade while preserving motor function. Their utility extends to minimally invasive tendon surgeries, carpal tunnel decompressions, postoperative pain control, and anesthesia for procedures involving the thenar region. At this level, the terminal branches of the brachial plexus—including the median, ulnar, radial, musculocutaneous, and medial antebrachial cutaneous nerves—are located superficially, making them accessible for blockade.

These blocks are especially advantageous in patients where motor preservation is desirable, such as cases requiring early postoperative hand physiotherapy.^[17]

Median Nerve Block

The median nerve arises from the lateral and medial cords of the brachial plexus, travels through the volar forearm, and enters the hand via the carpal tunnel. The block is typically performed at mid-forearm (distal to the pronator teres) or just proximal to the carpal tunnel. On ultrasound, the median nerve appears as a hypoechoic oval structure between the flexor digitorum superficialis and profundus muscles, medial to the radial artery. Clinically, this block is preferred for procedures involving the palmar thumb, index, and middle fingers.^[17]



Ulnar Nerve Block

The ulnar nerve originates from the medial cord of the brachial plexus, courses medially to the brachial artery, and passes through the groove between the olecranon and medial epicondyle at the elbow. It then travels along the medial forearm and enters the hand via Guyon's canal. USG-guided blockade is commonly performed in the distal third of the forearm, deep to the flexor carpi ulnaris muscle, where the nerve appears hypoechoic and oval, medial to the ulnar artery.

It is especially effective for procedures involving the palmar and dorsal aspects of the fourth and fifth fingers, as well as the ulnar wrist region. Motor involvement is minimal, affecting intrinsic hand muscles only mildly—an advantage for outpatient procedures.^[18]

Distal block applications under USG guidance are easy because the nerves are superficial and their relations with vascular structures can be visualized. The median nerve is located between the palmaris longus and flexor carpi radialis tendons at the wrist level, medial to the radial artery. The ulnar nerve is observed medial to the flexor carpi ulnaris tendon at the wrist, right next to the ulnar artery. The radial nerve mostly courses as a superficial branch on the dorsal surface, lateral to the radius, and is blocked by subcutaneous injection.

Distal nerve blocks offer a promising future with their ability to reduce opioid requirements. In general, injection of 5–8 mL of 0.25% bupivacaine or ropivacaine around the nerve is sufficient. In distal blocks, ensure circumferential spread without direct contact with the nerve. Additionally, a single injection surrounding the nerve is preferred over multiple injections. The most significant advantage of distal nerve blocks is that they provide analgesia while preserving motor function. In this way, they are preferred especially in cases where hand functions need to be monitored post-operatively. There is also no risk of serious complications specific to proximal blocks, such as diaphragmatic paralysis, pneumothorax, or vascular injury. Complications are usually pain at the injection site, hematoma, infection, and, very rarely, nerve irritation. Frequent aspiration should be performed before injection, and high-pressure injection should be avoided. Distal nerve blocks have been shown to reduce opioid requirements and increase patient satisfaction, especially in hand surgery.^[19]

Radial Nerve Block

The radial nerve originates from the posterior cord (C5–T1) and initially accompanies the axillary artery. It travels posterior to the humerus in the spiral groove, crosses toward the



Figure 5. Probe position for infraclavicular block

lateral epicondyle, and divides in the antecubital fossa into a superficial sensory branch and a deep motor branch.^[20]

Blockade can be performed at multiple levels—proximal, at the elbow, or distally. When performed proximal to the elbow, the needle is inserted ~4 cm above the lateral epicondyle, between the brachialis and brachioradialis muscles. Common anesthetic regimens include 5–10 mL of 0.25–0.5% bupivacaine, 5–15 mL of 0.2–0.5% ropivacaine, or 5–10 mL of 1% lidocaine. Ropivacaine is often favored in hand surgery due to its prolonged sensory effect with minimal motor block.

USG guidance allows precise deposition with smaller volumes, maximizing efficacy while minimizing systemic toxicity risk.^[21] Radial nerve blocks are useful in distal radius fractures, extensor tendon repairs, and wrist surgeries.

General Principles of Distal Blocks

- On USG, the median nerve lies between the palmaris longus and flexor carpi radialis tendons at the wrist, medial to the radial artery.

- The ulnar nerve is medial to the flexor carpi ulnaris tendon at the wrist, adjacent to the ulnar artery.
- The radial nerve is subcutaneous on the dorsum, lateral to the radius, and blocked with a superficial injection.

Typically, 5–8 mL of 0.25% bupivacaine or ropivacaine suffices. Circumferential spread around the nerve is essential, avoiding direct needle–nerve contact. A single perineural injection is generally preferred over multiple punctures.

Key advantages include preserved motor function, absence of major complications seen with proximal blocks (e.g., diaphragmatic paralysis, pneumothorax), and reduced opioid requirements, all of which enhance postoperative recovery and patient satisfaction.^[19]

COMPLICATIONS OF PERIPHERAL NERVE BLOCKS

Local Anesthetic Systemic Toxicity (LAST)

LAST is a rare but life-threatening complication caused by inadvertent intravascular injection or excessive systemic absorption. Symptoms can appear within seconds or be delayed up to 30 minutes. Neurological signs (dizziness, confusion, perioral tingling, tinnitus) typically precede cardiovascular collapse. If untreated, seizures, coma, and cardiovascular instability may occur.^[22]

Management requires immediate recognition and initiation of intravenous lipid emulsion (Intralipid) therapy, along with supportive care. Bolus and infusion regimens are weight-based, and escalation may be required in refractory cases.^[23,24] To reduce risk, the lowest effective dose should always be used, especially when multiple block sites are anesthetized.

Hematoma

Accidental vascular puncture during USG-guided blocks may lead to hematoma, particularly in patients with coagulopathies. Most resolve with compression; surgical intervention is rarely needed.

Nerve Injury

Although rare, nerve injuries may occur, most being transient (days to months). Permanent injury is reported in only 0.015–0.09% of cases.^[25,26] Intraneural or intrafascicular injection is the main cause. To prevent injury:

- Stop injection if paresthesia or high resistance is encountered.
- Confirm perineural spread with USG.

Risk is higher in patients with pre-existing neuropathies (e.g., diabetes). Symptoms include pain, paresthesia, or sensory–

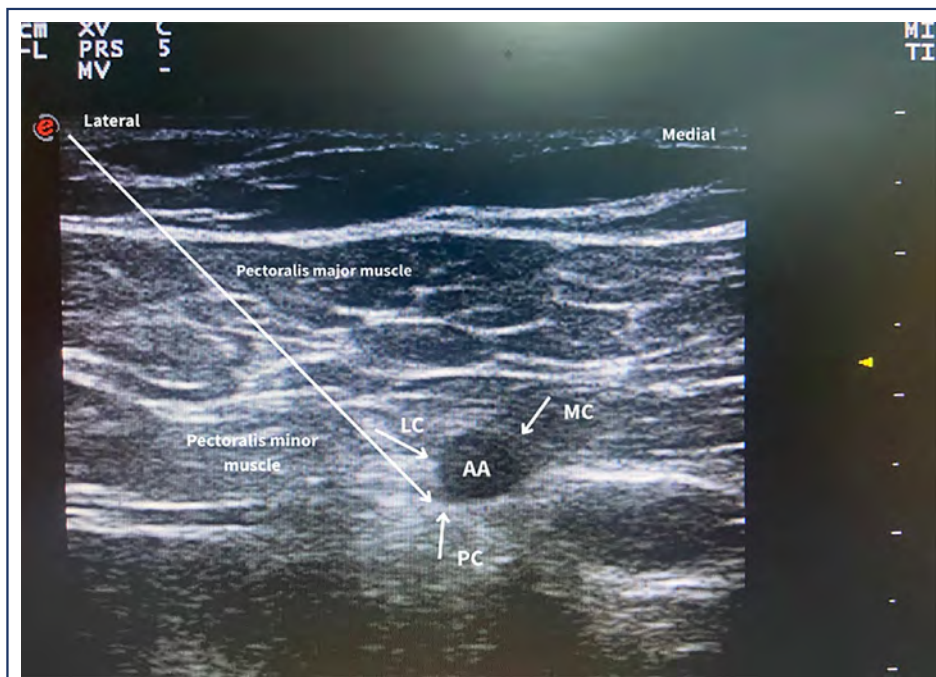


Figure 6. Ultrasound image of infraclavicular block. The white lines indicates needle trajectory. More than one injection may be required to block all three cords

PC: Posterior cord; MC: Middle cord; LC: Lateral cord; AA: Axillary artery

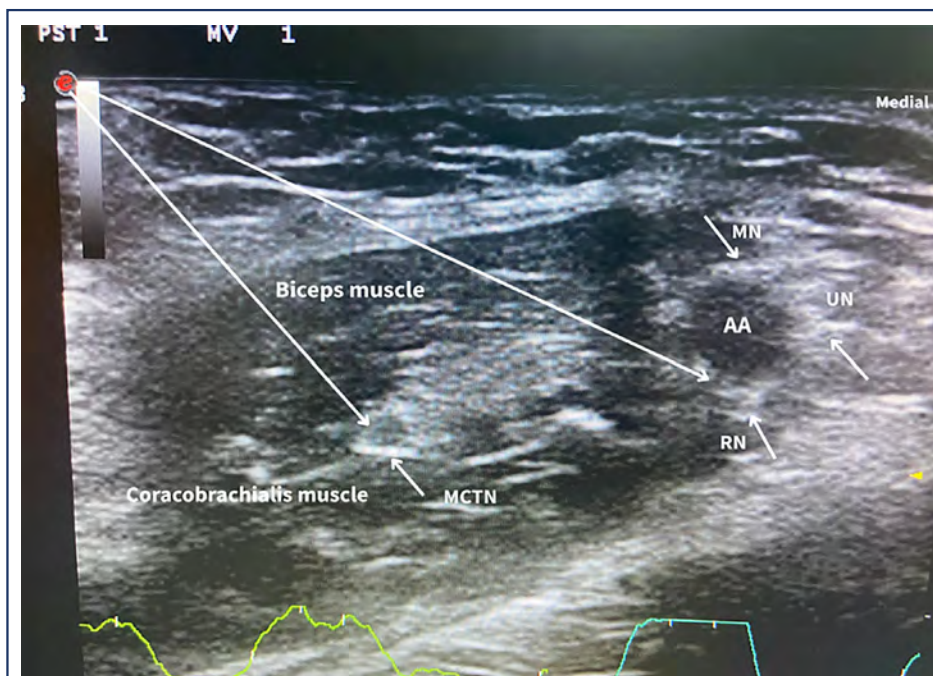


Figure 7. Ultrasound image of axillary block. The white lines indicates needle trajectory

AA: Axillary artery; MCTN: Musculocutaneous nerve; RN: Radial nerve; MN: Median nerve; UN: Ulnar nerve

motor deficits, which usually resolve within six months. Persistent cases require further evaluation.^[27]

Phrenic Nerve Paralysis

Nearly all interscalene blocks cause ipsilateral diaphragmatic paralysis, reducing vital capacity by ~25%. This is usually tolerated in healthy patients but may cause respiratory distress in those with COPD, obesity, or bilateral blockades.^[28]

Pneumothorax

Most often associated with supraclavicular blocks, pneumothorax results from needle puncture of the pleura. Clinical signs include sudden dyspnea, chest pain, and hypoxemia. USG guidance has significantly reduced its incidence.^[29]

Horner Syndrome

Horner syndrome (ptosis, miosis, enophthalmos, anhidrosis) occurs due to anesthetic spread to the cervical sympathetic chain, especially after interscalene blocks. Reported incidence exceeds 50% in some series. It is typically benign and transient but may alarm patients.^[30,31]

Total Spinal and Epidural Spread

Accidental subarachnoid injection may cause total spinal anesthesia, leading to apnea, hypotension, bradycardia, and loss of consciousness. Epidural spread produces milder but clinically significant bilateral block and hypotension.^[32]

Block Failure

Failure may occur even in experienced hands if anesthetic is deposited outside the neurovascular sheath. Obesity (BMI >25) increases failure rates due to obscured landmarks.^[26] Modern USG techniques, adjuvants, and improved training have improved success rates and reduced procedure time.^[33-35]

Patients should be counseled preoperatively regarding possible block failure and alternative analgesic options.

Infection

The risk of infection following a single-dose peripheral nerve block (PNB) is negligible. However, it is increased in certain patient populations, including hospitalized patients, trauma patients, immunocompromised individuals, males, and those not receiving antibiotic prophylaxis. Failure to follow infection-prevention guidelines may result in serious complications. Removing the catheter within 48–72 hours after placement for continuous blocks significantly reduces the risk of infection and prevents these potential consequences.

Allergic Reaction

Most adverse reactions to local anesthetics are non-allergic in nature. Nevertheless, mild allergic manifestations such as erythema or rash may occur, and in rare cases, severe reactions can progress to anaphylaxis. Medications and resuscitation equipment for symptomatic management should always be readily available in settings where PNBs are performed.

DISCUSSION

USG-guided PNBs are widely employed for intraoperative anesthesia and postoperative analgesia in orthopedic upper extremity surgeries. Each block carries distinct advantages, disadvantages, and potential complications (Table 1). Compared with traditional nerve stimulator techniques, USG-guided PNBs have been shown to increase success rates and reduce the need for supplemental analgesics or sedatives. For example, in rotator cuff surgeries, the rate of conversion to general anesthesia was significantly lower with USG-guided interscalene blocks than with nerve stimulator-guided procedures (0.5% vs. 6.7%, $p < 0.001$).^[36]

The supraclavicular block provides rapid onset and homogeneous anesthesia of the distal upper extremity. However, pneumothorax remains a risk, even with USG guidance. More than half of the pneumothorax cases reported in the literature are associated with this block, highlighting the need for caution in patients with underlying pulmonary disease.^[30] Additionally, the volume of local anesthetic appears to influence the incidence of phrenic nerve-related diaphragmatic paralysis; higher volumes are linked with greater paralysis, prompting recommendations for low-to-medium volumes for safety.^[33]

The infraclavicular block is advantageous for providing long-term analgesia in forearm and hand surgeries due to its homogeneous blockade of distal branches and ease of catheter placement. Compared with the supraclavicular block, it significantly prolongs motor block duration and shortens time to surgery.^[37] Moreover, the costoclavicular approach to the infraclavicular block has been shown to markedly reduce the incidence of hemidiaphragmatic paralysis and better preserve postoperative pulmonary function.^[38] Infraclavicular blocks are also associated with a lower risk of Horner syndrome compared with supraclavicular blocks.^[39]

By contrast, the axillary block minimizes the risk of pneumothorax and diaphragmatic paralysis due to its superficial anatomical location and distance from the pleura and phrenic nerve. It is therefore considered a particularly safe option for hand and wrist procedures.

Table 1. Ultrasonography-guided peripheral nerve blocks performed in upper extremity orthopedic surgeries

Block	Clinical application	Target nerves/structures	Advantages	Disadvantages	Complication
Cervical plexus block (superficial/deep)	Neck surgeries, clavicle fractures, adjunct in shoulder surgeries	Superficial: C2–C4 cutaneous branches; Deep: C2–C4 spinal nerve roots	Simple, safe	High risk in deep block, insufficient for shoulder	Phrenic nerve block, diaphragmatic paralysis, vertebral artery puncture, LAST
Interscalene block	Shoulder and upper arm surgeries	C5–C7 brachial plexus roots/trunks	Most effective for shoulder, rapid onset	Often spares C8–T1, short duration	Phrenic nerve paralysis, laryngeal nerve block, Horner syndrome
Suprclavicular block	Elbow, forearm, hand surgeries; sometimes shoulder	Brachial plexus trunks and divisions	Rapid and dense block, wide applicability	Risk of pneumothorax, less effective for shoulder	Pneumothorax, Phrenic nerve paralysis, Horner syndrome, LAST
Infracavicular block	Elbow, forearm, hand surgeries	Brachial plexus cords	Suitable for catheter placement	Technically more difficult, close to vascular structures	Hematoma, pneumothorax, LAST
Axillary block	Forearm and hand surgeries	Median, ulnar, radial, musculocutaneous nerves	Safe, no risk of pneumothorax	Additional injection may be needed for musculocutaneous nerve	Hematoma, infection, LAST
Median nerve block	Palmar surface of the hand, 2 nd –3 rd finger surgeries	Median nerve (forearm/hand)	Localized, targeted analgesia	Limited area, often requires combination	Nerve injury, LAST
Ulnar nerve block	Ulnar side of hand, 4 th –5 th finger surgeries	Ulnar nerve (elbow/wrist)	Sufficient for specific surgery	Limited scope, requires precise localization	Nerve injury, paresthesia, LAST
Radial nerve block	Dorsal hand, thumb surgeries	Radial nerve (elbow/wrist)	Sufficient for specific surgery, safe	Does not provide full hand analgesia, often requires combination	Nerve injury, hematoma, LAST

LAST: Local anesthetic systemic toxicity

This narrative review has several limitations. First, although studies from specific databases and within a defined time frame were screened, explicit inclusion and exclusion criteria were not applied. Second, unlike systematic reviews or meta-analyses, this review does not provide pooled quantitative outcomes. Finally, the narrative design may have led to the unintentional omission of relevant studies or disproportionate emphasis on certain findings.

CONCLUSION

With advances in ultrasonographic imaging and the increasing popularity of regional anesthesia, particularly brachial plexus nerve blocks, the use of these techniques in orthopedic upper extremity surgery has expanded considerably. USG-guided PNBs provide precise and targeted anesthesia and analgesia, reduce systemic opioid requirements, and help prevent opioid-related complications. Optimal outcomes are achieved when block selection is tailored to the patient and procedure and performed by experienced practitioners.

Disclosures

Conflict of Interest Statement: The authors declare no conflicts of interest. All authors have approved the final version of the manuscript.

Funding: The authors declared that this study received no financial support.

Use of AI for Writing Assistance: Artificial intelligence-supported technologies (e.g., ChatGPT) were not used in writing the article.

Author Contributions: Concept – K.A., A.S.Ş.; Design – K.A.; Supervision – K.A., A.S.Ş.; Funding – K.A.; Data collection and/or processing – K.A., A.S.Ş.; Data analysis and/or interpretation – K.A., A.S.Ş.; Literature search – K.A.; Writing – K.A.; Critical review – K.A., A.S.Ş.

Peer-review: Externally peer-reviewed.

REFERENCES

- Héroux J, Bessette PO, Belley-Côté E, Lamarche D, Échavé P, Loignon MJ, et al. Functional recovery with peripheral nerve block versus general anesthesia for upper limb surgery: a systematic review. *BMC Anesthesiol* 2023;23:91. [\[CrossRef\]](#)
- Huaguo Y, Kang S, Hu L, Zhou H. Advancing pain management for extremity trauma: the evolution of ultrasound-guided nerve blocks for patients in the supine position in trauma centers. *Eur J Trauma Emerg Surg* 2024;50:1381–90. [\[CrossRef\]](#)
- Mariano ER, Loland VJ, Sandhu NS, Bishop ML, Lee DK, Schwartz AK, et al. Comparative efficacy of ultrasound-guided and stimulating popliteal-sciatic perineural catheters for postoperative analgesia. *Can J Anaesth* 2010;57:919–26. [\[CrossRef\]](#)
- Nijs K, Van Rossum M, Ory JP, Pierson M, De Wachter G, Callebaut I, et al. Ultrasound-guided axillary brachial plexus block versus distal peripheral forearm nerve block for hand and wrist surgery: a randomised controlled trial. *Br J Anaesth* 2023;131:e20–2. [\[CrossRef\]](#)
- Nijs K, Hertogen P, Buelens S, Coppens M, Teunkens A, Jalil H, et al. Axillary brachial plexus block compared with other regional anesthesia techniques in distal upper limb surgery: A systematic review and meta-analysis. *J Clin Med* 2024;13:3185. [\[CrossRef\]](#)
- Suárez Medrano D, Díaz Jara J, López Ramírez M, Espinoza Vargas, D. Review of the brachial plexus anatomy and its evaluation by imaging. *Austral J Imag* 2024;30:59–70. [\[CrossRef\]](#)
- Li Q, Chen X, Han J, Xie Y, Gu C. Comparing C3, 4, and 5 nerve root block and interscalene with intermediate cervical plexus block in diaphragmatic motion for clavicle surgery. *Sci Rep* 2025;15:289. [\[CrossRef\]](#)
- Herring AA, Stone MB, Frenkel O, Chipman A, Nagdev AD. The ultrasound-guided superficial cervical plexus block for anesthesia and analgesia in emergency care settings. *Am J Emerg Med* 2012;30:1263–7. [\[CrossRef\]](#)
- Ho B, De Paoli M. Use of ultrasound-guided superficial cervical plexus block for pain management in the emergency department. *J Emerg Med* 2018;55:87–95. [\[CrossRef\]](#)
- Opperer M, Kaufmann R, Meissnitzer M, Enzmann FK, Dinges C, Hitzl W, et al. Depth of cervical plexus block and phrenic nerve blockade: a randomized trial. *Reg Anesth Pain Med* 2022;47:205–11. [\[CrossRef\]](#)
- Zhao Y, Qin S, Yang X, Gao C, Yuan X, Li T, et al. Comparison of the anesthesia effect of ultrasound-guided middle and low interscalene brachial plexus block: a randomized, controlled, non-inferiority trial. *BMC Anesthesiol* 2023;23:1. [\[CrossRef\]](#)
- Lim YC, Koo ZK, Ho VW, Chang SS, Manohara S, Tong QJ. Randomized, controlled trial comparing respiratory and analgesic effects of interscalene, anterior suprascapular, and posterior suprascapular nerve blocks for arthroscopic shoulder surgery. *Korean J Anesthesiol* 2020;73:408–16. [\[CrossRef\]](#)
- Luo Q, Liu H, Deng L, Nong L, Li H, Cai Y, et al. Effects of double vs triple injection on block dynamics for ultrasound-guided intertruncal approach to the supraclavicular brachial plexus block in patients undergoing upper limb arteriovenous access surgery: study protocol for a double-blinded, randomized controlled trial. *Trials* 2022;23:295. [\[CrossRef\]](#)
- Singh SK, Katyal S, Kumar A, Kumar P. Massive hemothorax: A rare complication after supraclavicular brachial plexus block. *Anesth Essays Res* 2014;8:410–2. [\[CrossRef\]](#)
- Govender S, Möhr D, Tshabalala Z, van Schoor A. A review of the anatomy and a step-by-step visual guide to performing an ultrasound-guided supraclavicular brachial plexus block. *SAJAA* 2019;25:17–22. [\[CrossRef\]](#)
- Koo CH, Hwang I, Shin HJ, Ryu JH. Hemidiaphragmatic paralysis after costoclavicular approach versus other brachial plexus blocks in upper limb surgery: a meta-analysis. *Korean J Anesthesiol* 2023;76:442–50. [\[CrossRef\]](#)
- Jalil H, Polfliet F, Nijs K, Bruckers L, De Wachter G, Callebaut I, et al. Efficacy of ultrasound-guided forearm nerve block versus forearm intravenous regional anaesthesia in patients undergoing carpal tunnel release: A randomized controlled trial. *PLoS One* 2021;16:e0246863. [\[CrossRef\]](#)
- Haley CB, Beauchesne AR, Fox JC, Nelson AM. Block time: A multispecialty systematic review of efficacy and safety of ultrasound-guided upper extremity nerve blocks. *West J Emerg Med* 2023;24:774–85. [\[CrossRef\]](#)
- Knopp BW, Eng E, Esmaeili E. Pain management and opioid use with long-acting peripheral nerve blocks for hand surgery: A descriptive study. *Anesth Pain Med* 2023;13:e139454. [\[CrossRef\]](#)

20. Fajardo MR, Rosenberg Z, Christoforou D, Grossman JA. Multiple nerve injuries following repair of a distal biceps tendon rupture--case report and review of the literature. *Bull Hosp Jt Dis* 2013;71:166–9.
21. Bao N, Chen L, Xia Y, Wang Q, Shi K, Papadimos TJ, et al. Effect of ultrasound-guided nerve block with 0.75% ropivacaine at the mid-forearm on the prevalence of moderate to severe pain after hand surgery. *Clin Ther* 2018;40:1014–22. [\[CrossRef\]](#)
22. Vasques F, Behr AU, Weinberg G, Ori C, Di Gregorio G. A review of local anesthetic systemic toxicity cases since publication of the American Society of regional anesthesia recommendations: To whom it may concern. *Reg Anesth Pain Med* 2015;40:698–705. [\[CrossRef\]](#)
23. Gitman M, Fettiplace MR, Weinberg GL, Neal JM, Barrington MJ. Local anesthetic systemic toxicity: A narrative literature review and clinical update on prevention, diagnosis, and management. *Plast Reconstr Surg* 2019;144:783–95. [\[CrossRef\]](#)
24. Neal JM, Neal EJ, Weinberg GL. American Society of Regional Anesthesia and Pain Medicine Local Anesthetic Systemic Toxicity checklist: 2020 version. *Reg Anesth Pain Med* 2021;46:81–2. [\[CrossRef\]](#)
25. Malchow RJ, Gupta RK, Shi Y, Shotwell MS, Jaeger LM, Bowens C. Comprehensive analysis of 13,897 consecutive regional anesthetics at an ambulatory surgery center. *Pain Med* 2018;19:368–84. [\[CrossRef\]](#)
26. Kamel I, Ahmed MF, Sethi A. Regional anesthesia for orthopedic procedures: What orthopedic surgeons need to know. *World J Orthop* 2022;13:11–35. [\[CrossRef\]](#)
27. Verlinde M, Hollmann MW, Stevens MF, Hermanns H, Werdehausen R, Lirk P. Local Anesthetic- Induced Neurotoxicity. *Int J Mol Sci* 2016;17:339. [\[CrossRef\]](#)
28. Campbell AS, Johnson CD, O'Connor S. Impact of peripheral nerve block technique on incidence of phrenic nerve palsy in shoulder surgery. *Anesthesiol Res Pract* 2023;2023:9962595. [\[CrossRef\]](#)
29. Gauss A, Tugtekin I, Georgieff M, Dinse-Lambracht A, Keipke D, Gorsewski G. Incidence of clinically symptomatic pneumothorax in ultrasound-guided infraclavicular and supraclavicular brachial plexus block. *Anaesthesia* 2014;69:327–36. [\[CrossRef\]](#)
30. He LD, Vlassakov KV, Bader AM, Chen YYK. Adverse event reporting in ultrasound-guided brachial plexus blocks: A scoping review. *JCA Adv* 2025;2:100085. [\[CrossRef\]](#)
31. Arslan K, Çetin Arslan H. Horner's syndrome during vaginal delivery with epidural analgesia. *Pain* 2021;33:272–5. [Turkish]
32. Turner FN, Shih RD, Fishman I, Canello DP, Solano JJ. Total spinal anesthesia following an interscalene block treated with intravenous lipid emulsion. *Cureus* 2019;11:e4491. [\[CrossRef\]](#)
33. Yeniocak T, Canbolat N. Retrospective analysis of ultrasound-guided infraclavicular block: Effect of experience of anesthesiologists on volume of local anesthetic administered. *Pain Res Manag* 2019; 2019:4846956. [\[CrossRef\]](#)
34. Küçüksaraç G, Arslan K, Sahin AS. Effect of dexamethasone on postoperative analgesia following the transversus abdominis plane block in gynecological laparotomies. *Cureus* 2024;16:e73814. [\[CrossRef\]](#)
35. Arslan K, Arslan HC, Yıldız ME, Sahin AS. Effects of ultrasonography-guided transversus abdominis plane block on postoperative analgesia, gastrointestinal motility, and mobilization in patients delivering cesarean delivery under spinal anesthesia: A retrospective study. *Duzce Med J* 2023;25:167–17. [\[CrossRef\]](#)
36. Lim JA, Sung SY, Lee JH, Lee SY, Kwak SG, Ryu T, et al. Comparison of ultrasound-guided and nerve stimulator-guided interscalene blocks as a sole anesthesia in shoulder arthroscopic rotator cuff repair: A retrospective study. *Medicine (Baltimore)* 2020;99:e21684. [\[CrossRef\]](#)
37. Zhang G, Hou X, Wang H, Han C, Fan D. Infraclavicular versus supraclavicular nerve block for upper limb surgeries: A meta-analysis. *Medicine (Baltimore)* 2024;103:e40152. [\[CrossRef\]](#)
38. Hong B, Lee S, Oh C, Park S, Rhim H, Jeong K, et al. Hemidiaphragmatic paralysis following costoclavicular versus supraclavicular brachial plexus block: a randomized controlled trial. *Sci Rep* 2021;11:18749. [\[CrossRef\]](#)
39. Zhang L, Pang R, Zhang L. Comparison of ultrasound-guided costoclavicular and supraclavicular brachial plexus block for upper extremity surgery: a propensity score matched retrospective cohort study. *Ann Palliat Med* 2021;10:454–61. [\[CrossRef\]](#)