Upper Limb Nerve and Regional Blocks in Hand and Shoulder Surgeries
(Narrative Review Article)

Abstract
The brachial plexus block is a regional anesthesia technique primarily used for upper limb surgeries. This method involves injecting local anesthetics near the brachial plexus, a network of nerves that innervate the arm, temporarily blocking sensation and motor function in the affected area. It serves as an alternative or adjunct to general anesthesia, particularly benefiting patients with significant comorbidities or those at risk of complications associated with general anesthesia. Regional anesthesia plays a crucial role in orthopedic and outpatient anesthesia advancements by providing both intraoperative anesthesia and postoperative analgesia. Furthermore, with the advent of ultrasound technology, newer upper limb block techniques have been introduced for targeted anesthesia. These various approaches allow anesthesiologists to tailor pain management strategies based on the individual needs of patients and surgical requirements. Continuous improvements in ultrasound technology have enhanced the safety and efficacy of these blocks, making regional anesthesia a standard technique for pain management in upper limb surgeries.
Keywords: Nerve block, Regional block, Upper limb, Hand and shoulder surgeries.

Accepted: 39 days before printing

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Introduction

Annually, over 22 million orthopedic surgeries are performed worldwide. Upper limb orthopedic surgeries account for more than half of the total surgeries performed each year and are associated with severe postoperative pain that requires multifaceted anesthesia[1]. Postoperative inflammation and pain in upper limb surgeries lead to reduced range of motion in the affected joint, increased mechanical pain, and delayed recovery. Interestingly, around 15 to 20 percent of patients report lower functional levels in daily activities after upper limb orthopedic surgery compared to their preoperative state[2,3].
Over the past twenty-five years, peripheral nerve blocks have become increasingly common for managing intraoperative pain in upper limb surgeries. Several factors have contributed to the growing acceptance and use of these peripheral nerve blocks, including increased awareness, pain measurement in patients, and greater emphasis on reducing hospital stay durations and associated costs[4,5]. Regional anesthesia (RA) for the upper limb has become a crucial component in pain management for hand and shoulder surgeries. These techniques are fundamentally based on brachial plexus blocks and their terminal branches, providing effective anesthesia while minimizing the risks associated with general anesthesia[6]. For over a century, brachial plexus blocks have been an essential tool in regional anesthesia. Providing anesthesia for surgery and postoperative analgesia for the entire upper limb is closely linked to advancements in orthopedic and outpatient anesthesia. Moreover, with the advent of ultrasound, new methods for anesthesia of various upper limb regions have been reported[3].
The advantages of RA, such as improved postoperative pain management, reduced opioid usage post-surgery, and faster recovery time, have led to widespread acceptance of various types of peripheral and regional nerve blocks[7].

RA can generally be divided into two categories: neuroaxial anesthesia (spinal, epidural, and combined spinal-epidural (CSE)) and peripheral nerve blocks (upper and lower limb blocks)[8]. Among brachial plexus blocks, the intrascalene block is the most commonly used for shoulder surgery. Other brachial plexus nerve blocks used for upper limb orthopedic surgeries include the supraclavicular block, infraclavicular block, and axillary plexus block. Several practical and theoretical aspects of regional nerve blocks need to be considered to optimize their beneficial effects and minimize the risk of complications[7]. This review article aims to address the types of regional blocks and their indications based on previous studies. In this narrative review, articles that included keywords such as brachial plexus nerve blocks, hand and shoulder surgeries, upper limb surgeries, intrascalene block, supraclavicular block, infraclavicular block, and axillary block in their titles or abstracts were reviewed. The articles were in English and were not restricted by publication date, resulting in 54 articles being included for review.

Brachial Plexus Anatomy

A thorough understanding of brachial plexus anatomy is essential for effective peripheral nerve blocks in the upper limb. The primary neural and cutaneous innervation of the upper limb originates from the brachial plexus. This plexus is formed by the ventral rami of five spinal nerves (C5–T1), which merge to create trunks, divisions, cords, and terminal branches. The nerve roots combine to form the upper (C5–C6), middle (C7), and lower (C8–T1) trunks. These trunks divide into six divisions, which further merge into three cords: lateral, posterior, and medial. The major nerves supplying the upper limb arise from these cords, including the musculocutaneous, axillary, median, ulnar, and radial nerves. Some sensory nerves of the shoulder and upper arm originate outside the brachial plexus[8]. The brachial plexus is typically divided into roots, trunks, divisions, cords, and terminal branches, which include:

- **Roots:** C5, C6, C7, C8, T1
- **Trunks:** Upper (C5–C6), Middle (C7), Lower (C8–T1)
- **Cords:** Lateral, Posterior, Medial
- **Terminal Branches:** Musculocutaneous, Axillary, Median, Ulnar, Radial

Understanding this anatomy is crucial for performing effective nerve blocks[9] (Figure 1).

Types of Brachial Plexus Blocks

The four types of brachial plexus blocks include the Interscalene Block, used for shoulder and proximal humerus surgeries; the Supraclavicular Block, Infraclavicular Block, and Axillary Plexus Block, which are used for procedures involving the distal to mid-arm region[9,11].

Interscalene Block

This block targets the roots of the brachial plexus in the intrascalene groove and is particularly effective for shoulder surgeries. The needle is inserted between the anterior and middle scalene muscles with 20-30 milliliters of local anesthetic [9,12] (Figure 2). The intrascalene block provides surgical anesthesia or numbness for the upper limb from the outer clavicle to the shoulder joint and proximal humerus[11,13]. Potential complications include Horner's syndrome and diaphragm paralysis due to the proximity to the phrenic nerve[9]. Intrascalene blocks are contraindicated in some pulmonary and cardiac diseases. Obesity may be a relative contraindication, as respiratory failure could result from diaphragm paralysis[14,15]. Therefore, absolute contraindications include local infection, severe coagulopathy, allergy to local anesthetics, paralysis of the contralateral phrenic nerve, and relative contraindications include COPD and patient refusal.

Supraclavicular Block

The supraclavicular block provides surgical anesthesia or numbness from the middle of the humerus to the fingertips[16,17]. For performing the supraclavicular block, the needle is directed from above the clavicle toward the brachial plexus. The patient is positioned supine, and the head is turned toward the opposite side to elevate the affected side. Once the patient is properly positioned, the needle insertion point is identified by palpating the neck muscles and the clavicle. The needle is then advanced into the tissue, and after confirming the proper position of the needle tip, the injection is performed[12,18] (Figure 3). Supraclavicular blocks should be used with caution in patients with impaired

pulmonary capacity, as the pneumothorax that may result can significantly worsen their respiratory status. An example of such a relative contraindication is known pneumonia on the opposite side[3].

Infraclavicular Block

This block provides surgical anesthesia or numbness from the middle of the humerus to the fingertips[19]. Performed beneath the clavicle, this block is particularly beneficial for surgeries on the distal arm and forearm, offering a broader coverage of the distal brachial plexus compared to supraclavicular blocks. For performing an infraclavicular block, the patient is positioned supine, and after ensuring the proper positioning, the needle insertion point is located by palpating the clavicle. The needle is then advanced into the tissue, and once the needle tip's position is confirmed, the injection is performed[20,21] (Figure 4). This technique is also useful for the placement of a continuous catheter and long-term infusion. Apart from absolute contraindications such as infection at or near the insertion site or coagulopathy, there are no specific contraindications for this block. Coagulopathy is a relative contraindication and should be evaluated based on the risk-to-benefit ratio[22]. The risk of pneumothorax exists due to the needle's direction toward the apex of the lung, especially with medial approaches to the block[23].

Axillary Plexus Block

The Axillary Plexus Block is a regional anesthesia technique primarily used for distal upper limb surgeries, including those of the forearm, wrist, and hand. It is favored for its simplicity and effectiveness in providing anesthesia while minimizing complications compared to other methods[8,24]. This block provides analgesia or surgical anesthesia from the mid-humerus to the fingertips[25,26]. However, axillary blocks should not be performed if the needle pathway cannot be visualized among vascular structures[24,27] (Figure 5).

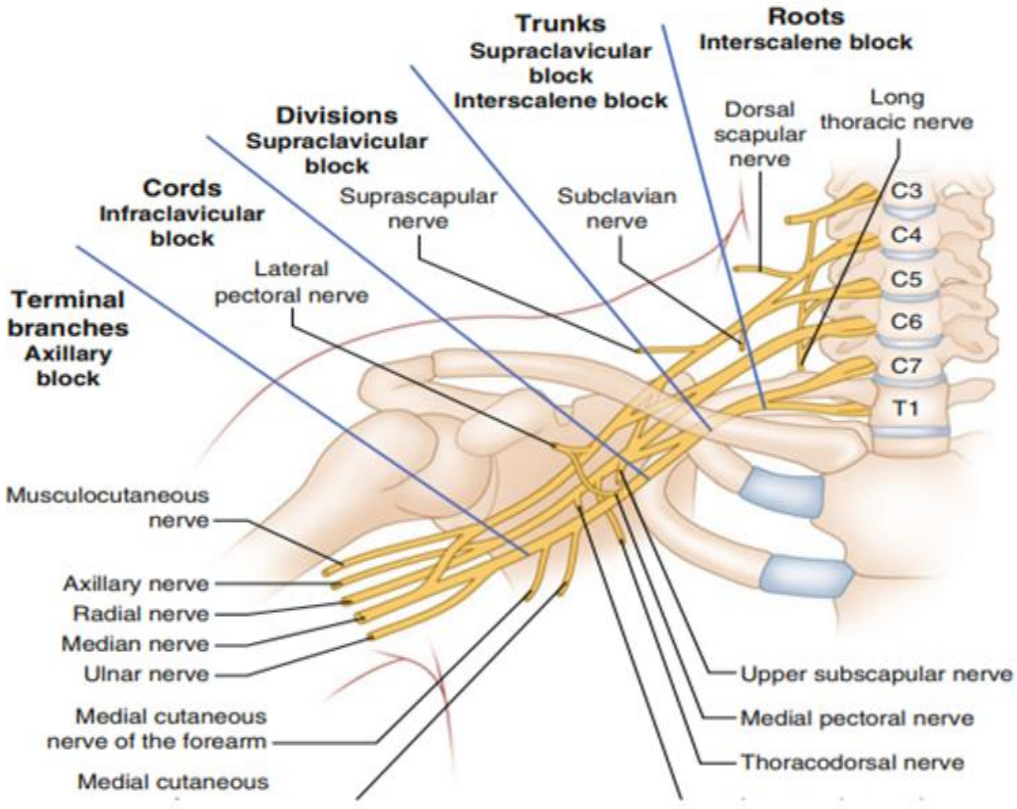

Figure 1: Anatomy of the Brachial Plexus[10]: {Roots of the Interscalene Block; Long Thoracic Nerve; Dorsal Scapular Nerve; Upper Subscapular Nerve; Medial Pectoral Nerve; Thoracodorsal Nerve. Trunks of the Supraclavicular-Interscalene Block; Subclavian Nerve; Divisions of the Supraclavicular Block; Suprascapular Nerve; Cords of the Infraclavicular Block; Lateral Pectoral Nerve; Terminal Branches of the Axillary Block; Musculocutaneous Nerve; Axillary Nerve; Radial Nerve; Median Nerve; Ulnar Nerve; Medial Cutaneous Nerve of the Forearm; Cutaneous Nerve.}

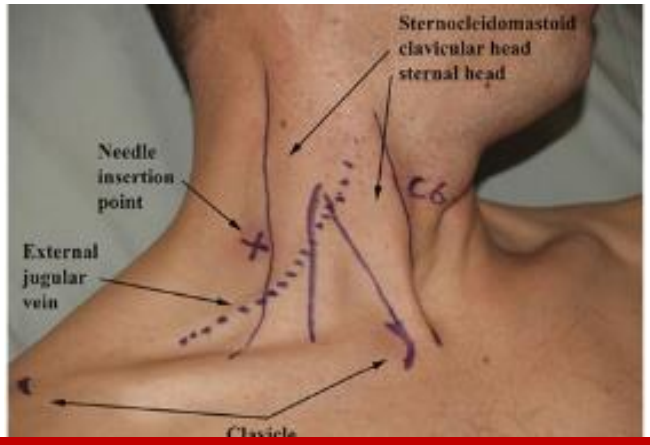

Figure 2: Needle Insertion Site ("X") for Interscalene Block[12]: {Sternocleidomastoid Clavicular Bead; Sternal Head; Needle Insertion Point; External Jugular Vein.}

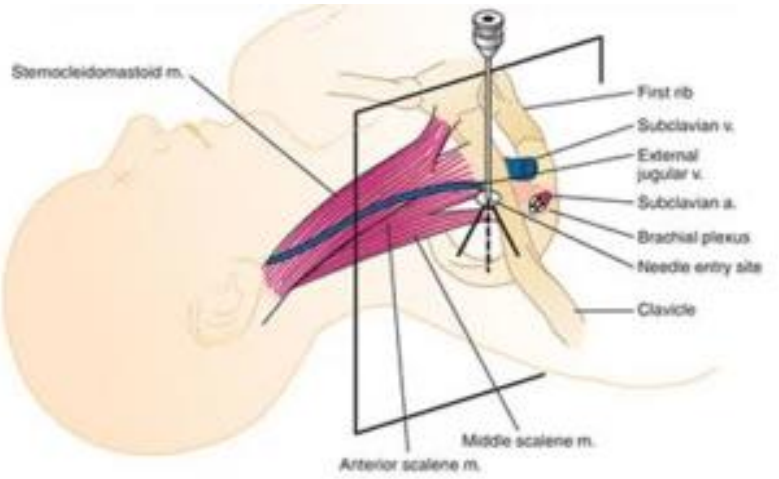

Figure 3: Supraclavicular Block Site[18]: {Right to left, top to bottom: Subclavian Vein (Subclavian v.); External Jugular Vein (External jugular v.); Subclavian Artery (Subclavian a.); Brachial Plexus; Needle Entry Site; Clavicle; Medial Scalene Muscle; Anterior Scalene Muscle.}

Figure 4. Infraclavicular Block Site[21]: (Vertical approach: Needle insertion and orientation) The infraclavicular block is performed in the subclavian fossa, which is surrounded by the pectoralis major and minor muscles, the clavicle, and the humerus. This technique typically requires 30–40 mL of local anesthetic for effective anesthesia

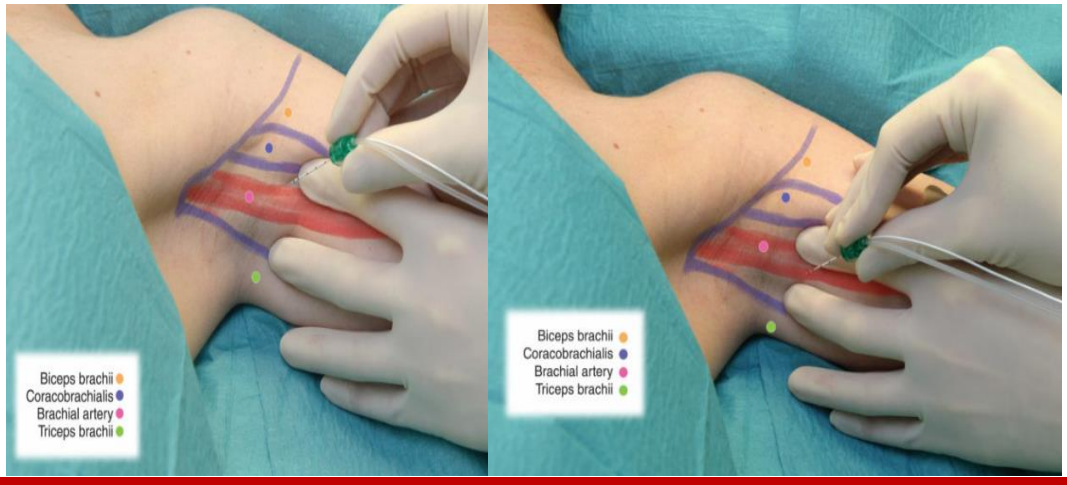

Figure 5: Location of the Axillary Block (Right image: Radial nerve block and left image: Median nerve block)[24]: {From top to bottom: Brachial bypass muscle; Coracobrachialis muscle; Brachial artery; Triceps brachii muscle}.

Discussion and Results

However, these blocks can carry potential risks and complications. A direct injury to the brachial plexus can occur while inserting the needle, leading to temporary or permanent nerve damage, which may result in sensory disturbances or varying degrees of motor loss[28]. In brachial plexus blocks with interscalene or supraclavicular approaches, there is a risk of puncturing the pleura, which could lead to pneumothorax (lung collapse), with the incidence of this complication estimated to range from 1 to 4%. Accidental injection of local anesthetic into blood vessels can cause systemic toxicity, which may manifest as central nervous system symptoms (such as seizures, speech disturbances) or cardiovascular complications[29]. Bleeding at the injection site can lead to hematoma formation, which may compress adjacent nerves and cause ischemic damage[28]. Transient diaphragm paralysis, a common side effect of interscalene blocks due to the proximity to the phrenic nerve, can potentially lead to respiratory complications, especially in patients with underlying lung diseases. Nevertheless, regional blocks have several advantages over general anesthesia, including superior pain control: providing targeted pain relief during and after surgery, reducing systemic effects: minimizing systemic drug exposure, which results in fewer side effects like nausea and vomiting, shorter recovery times: patients often experience faster recovery with less pain post-surgery, and cost efficiency: they may reduce hospital stay durations and associated costs[30]. The brachial plexus block is an effective regional anesthesia technique that offers significant advantages over general anesthesia for upper extremity surgeries. Its various approaches allow for anesthesia tailored to the patient's needs and surgical requirements, making it a valuable tool in modern anesthetic practice. Some contraindications exist, such as active infections at the injection site or known allergies to local anesthetics. Additionally, patients with severe pulmonary or cardiac conditions should be carefully evaluated before undergoing certain types of blocks[11]. A study's results showed that all three blocks—supraclavicular, infraclavicular, and axillary—can be used for upper extremity surgeries with similar anesthesia quality[31].

Interscalene Block

Despite the tendency to use regional anesthesia for orthopedic procedures, there is resistance to the use of interscalene regional blocks for shoulder surgeries due to concerns about block failures and potential complications[32]. However, the interscalene block is effectively used for intraoperative and postoperative pain management in shoulder surgery. A study by Takayama and colleagues showed that interscalene blocks guided by ultrasound performed by specialists for shoulder surgeries are effective and safe, requiring less time and having a high patient acceptance rate[33]. Another study by Bishop and colleagues demonstrated that the interscalene block provides effective anesthesia for most types of shoulder surgeries, including arthroplasty and

fracture stabilization. When administered by a dedicated and skilled anesthesiologist, the success rate is very high, with relatively low complication rates[32]. Results from a study by Beaudet and colleagues indicated that immediate postoperative pain reduction and decreased opioid consumption favored interscalene anesthesia compared to intra-articular anesthesia[34]. Studies have also shown that interscalene blocks, compared to general anesthesia or other pain control methods, result in less pain, reduced opioid consumption, faster recovery, and lower costs in patients undergoing shoulder surgeries[35-42].

Palhais and colleagues conducted a randomized controlled study and concluded that ultrasound-guided interscalene brachial plexus block with additional facial nerve injection reduces the frequency of hemidiaphragm paralysis and its effect on respiratory function while providing similar anesthesia compared to standard injections[43]. Additionally, a study by Auyong and colleagues showed that when maintaining lung function post shoulder arthroplasty is prioritized, suprascapular blocks may offer a useful alternative to interscalene or supraclavicular approaches[44]. In a study by Mosaffa and colleagues, the efficiency of interscalene blocks with and without combination with SCPB was found to be identical. The interscalene block is an alternative local anesthesia method for clavicle fractures. Therefore, the interscalene block alone is as effective as when combined with SCPB[45]. In another study by Mosaffa and colleagues, it was shown that the modified interscalene block is a suitable technique for forearm and wrist surgeries, and unlike conventional methods, it does not carry the risk of pneumothorax[46].

Supraclavicular Block

The supraclavicular block is a highly effective regional anesthesia technique for upper extremity orthopedic surgeries. Its advantages include a high success rate, reduced risk of complications, effective postoperative pain management, and avoidance of complications related to general anesthesia. As ultrasound technology continues to advance, its application is likely to improve further, enhancing its beneficial outcomes for patients undergoing orthopedic surgeries[18,47]. A meta-analysis by Muir and colleagues showed that infraclavicular blocks had a higher success rate than supraclavicular blocks in orthopedic surgeries[20].

Meanwhile, another meta-analysis by Sun and colleagues demonstrated that the supraclavicular block is an effective and safe pain control technique, offering an alternative to interscalene blocks with similar pain control, less morphine use, and fewer complications during shoulder arthroscopy, especially for patients with severe chronic obstructive pulmonary disease, obstructive sleep apnea, and obesity. Given the potential biases in meta-analysis studies, clinical trials with adequate power and better design, including long-term follow-up, are required to reach a firmer conclusion[48]. In a study by Auyong and colleagues, it was shown that the anterior suprascapular block, but not the supraclavicular block, did not offer superior anesthesia compared to the interscalene approach for large shoulder arthroscopy surgeries, while preserving lung function best with the anterior suprascapular block[49]. A study by Karaman and colleagues reported that the supraclavicular block was as effective as the interscalene block in reducing postoperative pain and quality of recovery for shoulder arthroscopy surgeries[50].

Infraclavicular Block

In a study by Sarkar and colleagues, it was demonstrated that the infraclavicular block provides a similar level of surgical anesthesia compared to the supraclavicular block, but with fewer complications and performed in a shorter time[51]. Another study by Zhang and colleagues showed that the infraclavicular block may be superior to the supraclavicular block for controlling anesthesia in upper extremity surgeries[23].

Axillary Plexus Block

The axillary plexus block is a reliable and effective technique for upper extremity anesthesia. It carries a lower risk of complications compared to other brachial plexus methods (e.g., lower risk of pneumothorax), and is suitable for both inpatient and outpatient procedures. Its success rate increases when guided by ultrasound[24,52].

A study by Badiger and colleagues reported that different techniques of axillary block have increased success rates and better block quality[53]. A study by Dabir and colleagues showed that the occurrence and intensity of tourniquet pain were significantly lower when combining the axillary brachial plexus block with subcutaneous lidocaine injection compared to

using the axillary block alone, offering a simple, effective, and safe method to prevent tourniquet pain in the upper arm[54].

Conclusion

In summary, while the brachial plexus block is effective for upper extremity anesthesia and is generally safe, it also carries certain complications that should be discussed with patients before the procedure. Understanding these potential side effects can help make an informed decision about the choice of anesthesia technique for upper extremity surgeries. Regional anesthesia for upper extremity surgeries is, in some cases, a preferred method and, when combined with mild to moderate sedatives, can be considered a good anesthesia technique. The brachial plexus block is a valuable technique in regional anesthesia, improving surgical outcomes while minimizing the risks associated with general anesthesia. Its various approaches allow anesthesiologists to tailor pain management strategies based on the patient's needs and surgical requirements.

Acknowledgements

The author extends gratitude for the consultations provided by the research specialist of the Clinical Research Development Unit at Imam Khomeini Hospital, Urmia University of Medical Sciences.

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