REVIEW ARTICLE

Regional Anesthesia for Upper Limb Surgery: A Narrative Review

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Regional anesthesia is an expanding subspecialty and is gaining increasing popularity due to its significant benefits over general anesthesia if appropriately accomplished, which includes superior intraoperative pain control, attenuation of the surgical stress response, minimal systemic impairment, lower incidence of postoperative nausea and vomiting, excellent localized postoperative analgesia, and decreased hospital cost and stay. Needle conduction guide toward the targets always has a great importance. The most commonly used local anesthetics include lidocaine, ropivacaine, bupivacaine, and mepivacaine. The type of local anesthetic, the concentration, the volume administered, and the location of the block will affect the onset, duration and depth /type of block. Due to ineffectivity of neuraxial block in upper limbs, upper extremity blocks may be considered as the sole substitute or supersede method of anesthesia for upper limb surgeries.

keywords: **regional anesthesia, upper limb, local anesthetics**

The techniques of regional anesthesia were developed early in the history of anesthesia. The American surgeons William Stuart Halsted and Hall described the injection of cocaine into peripheral sites, including the ulnar, musculocutaneous, supratrochlear, and infraorbital nerves, for minor surgical procedures in the 1880s. Braun also presented the term conduction anesthesia in his 1905 textbook on local anesthesia, which described techniques for every region of the body [2]. These techniques have been a mainstay of the anesthesiologist's armament from that time. Recognizing that upper extremity regional blockade considered as the most frequently use of peripheral nerve blocks in most anesthesiologists' practice, in 2001, the American Society of Regional Anesthesia and Pain Medicine (ASRA) assumed a critical review of all available English-language publications relevant to this topic. The resulting wide source document was produced into a comprehensive review article that was published in 2002; both the source and the review documents will be updated approximately every 5 years [3]. From identifying anatomical landmarks and/or paresthesia-seeking techniques described by Winnie in the mid-twentieth century, to the popularization of the nerve stimulator, to the introduction of ultrasound guidance, anesthesiologists and their patients have more advantages from technology's evolution [4]. Ultrasound guidance further increases the success rate particularly, when used in combination with nerve stimulation, it provides, as of today, the highest degree of safety and success. In March-April 2016 the subject of regional anesthesia and pain medicine, Neal et al, also provided an executive summary of "Evidence-Based Medicine Assessment of Ultrasound-Guided Regional Anesthesia". They determined that there is high-level evidence supporting ultrasound guidance, contributing to superior characteristics with selected blocks, although absolute variances with the comparator technique, e.g. nerve stimulation, are often relatively minor, especially for upper extremity blocks [5]. However, for surgery on the upper extremity, regional anesthesia has gained popularity during recent years, probably depending on the increase in ultrasound availability [6].

Brachial Plexus Anatomy

The brachial plexus is formed by the combination of the anterior primary divisions of the fifth through the eighth cervical nerves and the first thoracic nerves (C5 – T1). Contributions from C4 and T2 are often fewer or absent [4]. As the brachial plexus travels from proximal to distal, it transitions from five roots to three trunks to six divisions to three cords and ends as five branches, which are the major terminal nerves of the brachial plexus [7]. The three trunks formed between the anterior and middle scalene muscles are termed superior, middle, and inferior according to their vertical location. As the trunks pass over the lateral border of the first rib and under the clavicle, each trunk distributes into anterior and posterior divisions. As the brachial plexus protrudes below the clavicle, the fibers combine again to form three cords which are termed according to their connection to the axillary artery: lateral, medial, and posterior. At the lateral border of the pectoralis minor muscle, each cord ends as a large branch before ending as a major terminal nerve. The lateral cord ends as the lateral branch of the median nerve and terminates as for the

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musculocutaneous nerve, the medial cord ends as the medial branch of the median nerve and ends as the ulnar nerve, and the posterior cord gives off the axillary nerve and ends as the radial nerve. A local anesthetic may be injected at any point along the brachial plexus, depending on the needed block effects [4].

Local Anesthetics and Dosages

Nowadays the most commonly used local anesthetics are lidocaine, ropivacaine, bupivacaine, and mepivacaine [8], but for more information, readers can be referred to another reference, because this subject is beyond the capacity of this study. However, to perform anesthesia for surgical procedures a higher concentration should be chosen than for blocks in the treatment of acute/chronic pain. For the continuous infusion of local anesthetics in catheter procedures, lower concentrations are to be used. The chosen concentrations are to be adjusted to the maximum single dose. The addition of adrenaline to some local anesthetics leads to a higher maximum dosage threshold. In using a mixture of various local anesthetics, it should be noted there is a chance an occurrence of toxicity thus requiring a relative change of the maximum single or daily dosage. About the recommended dosage for the individual procedures, a difference is made between nerve stimulation and ultrasound with recommendations adjusted according to the technique used. With ultrasound guided technique, the injected volume is less of significance than the observed spread along the nerve, which usually can be achieved with few milliliters [9].

Approaches for Brachial Plexus Block

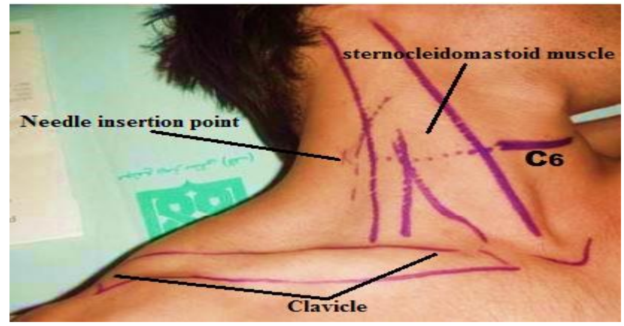
Blockade of the brachial plexus (C5-T1) at several locations from the roots to the terminal branches is indicated for surgical anesthesia of the upper extremity and shoulder, so we have 4 types of brachial plexus block (Figure 2): Interscalene for shoulder and proximal humerus surgical procedures; and Supraclavicular, Infraclavicular, and Axillary for surgeries distal to the mid-humerus [4].

Interscalene block (trunks block)

The clinical application of inter-scalene brachial plexus block is indicated for procedures involving the shoulder and upper arm [4]. Also, there are contraindications including, local infection, severe coagulopathy, local anesthetic allergy, contralateral paresis of the phrenic and/or recurrent laryngeal nerve, relative: pronounced COPD, and patient's refusal.

Nerve stimulator technique: Put the patient supine with the head rotated toward the nonoperative side. Find the cricoid cartilage, which indicates the C6 level. Palpate the lateral border of the sternocleidomastoid muscle (SCM), and move your fingers laterally into the inter-scalene groove (between the anterior and middle scalene muscles). Certify that the clavicular head of the sternocleidomastoid muscle, rather than the more medial sternal head, is being palpated. The external jugular vein often passes the border of the sternocleidomastoid muscle at this point. The first needle insertion should be posterior to the vessel. Initial needle insertion (at the level of C6) is indicated by an "X" (Figure. 1). A 22- to 25-gauge, 5-cm, insulated needle [10]. A current of 0.8-0.9 mA, at a pulse frequency of 1 Hz and pulse duration of 0.1 m sec (100 micro sec) [11].

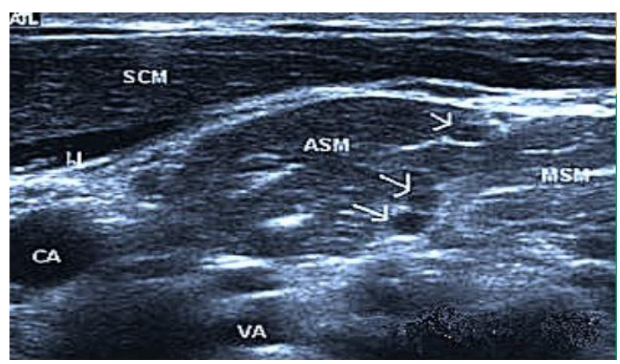
Figure 1- Needle insertion point "X" for interscalene block. (With permission from author) [1].



Ultrasound technique: The area is best visualized by placing the probe obliquely across the anterior and middle scalene muscles at the level of C5-C6. In this case, the sternocleidomastoid muscle (SCM) is seen in the upper part of the image and scalene muscles below it. The roots of the nerve are visible as three to five hypoechoic rings between two muscles (anterior and middle scalene muscles). A slightly deeper vertical artery (Vertebral) adjacent to the transverse spine of the vertebrae is also visible. The carotid artery and internal jugular vein in the internal part of the brachial plexus are also seen (Figure 2) [12]. A 2.5 cm or 5 cm, 22-G, insulated needle is frequently used.

A high frequency (8-15 MHz) linear probe is very suitable [11].

Figure 2- ASM&MSM, anterior and middle scalene muscles; SCM, sternocleidomastoid; CA, carotid artery; VA, vertebral artery; IJ, internal jugular vein; THREE ARROW, brachial plexus nerve roots in in cross-section. (With permission from author) [1].



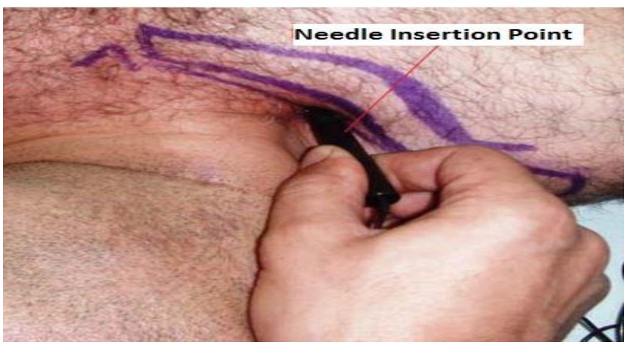
Dosage of local anesthetics: for anesthesia (US/NS) 4–10/10–30 ml; analgesia (US/NS) 5/20 ml; continuous 2–6 ml/h [9].

Supraclavicular block (divisions block)

Indications for the supraclavicular block are surgeries on the elbow, forearm, and hand [13]. Severe chronic airways disease is considered as a contraindication [14].

Nerve stimulator technique: The patient is placed in the semi-sitting position, the ipsilateral shoulder down and the head rotated to the opposite side. A parasagittal (parallel to the midline) plane at this level determines the "dangerous" region, where the risk of pneumothorax is high and a lateral region which is not dangerous. There is a narrow "window of chance" to perform the supra-clavicular block over the clavicle since the trunks are short and run in a very steep direction caudally towards the clavicle. It should be performed at enough space from the insertion of the sternocleidomastoid muscle on the clavicle to be safely away from the pleural dome, but not so far that may cause trunks and the plexus to be lost totally. This distance called “the safety edge”. And in adults, it is about (2.5 cm) that parallels to the width of the anesthesiologist’s thumb [11]. Palpate the posterior edge of the sternocleidomastoid muscle at the C6 level and move your fingers laterally above the anterior scalene muscle until they identify the inter-scalene groove (the groove may be difficult to identify under the C6 level). Then roll your fingers laterally down the inter-scalene groove until they are about one centimeter from the mid-clavicle. This place is the initial advancing site for the needle (Figure 3). A 5cm, 22-G, insulated needle is used [10].

Figure 3- Needle insertion above clavicular. (With permission from author) [1].



Ultrasound technique: The use of ultrasound for the supraclavicular block allows the practitioner to see the brachial plexus structures, as well as the subclavian artery and pleura, just below the first rib. The inherent safety of this technique requires continuous visualization of the needle tip during needle advancement and, if performed correctly, greatly improves the safety of this block [2]. The coronal oblique plane gives the best transverse view of the brachial plexus. Position the probe on the neck directly over the clavicle in the supraclavicular fossa [10]. Scanning usually started medially, over the sternocleidomastoid muscle, right above the clavicle. The probe is then slid laterally towards the midpoint of the clavicle. At this level the anterior and middle scalene muscles can be visualized; a cross section of the subclavian artery is seen above the first rib (Figure 4). A high frequency (8-15 MHz) is used [11].

Figure 4- ASM; MSM, anterior and middle scalene muscles; (SA) the subclavian artery is seen above the first rib. RIB 1. (With permission from author) [1].

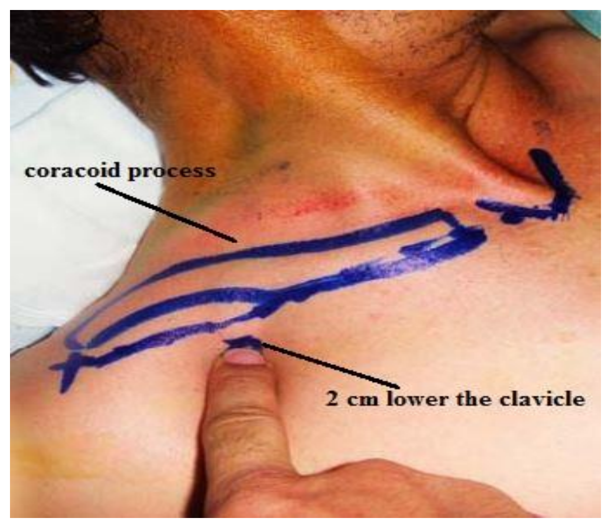
Dosage of local anesthetics: for anesthesia (US) 15–30 ml; analgesia (US) 10 ml. continuous 4–6 ml/h [9].

Infraclavicular block (cords block)

This type of block can provide anesthesia of a large part of the upper limb including the elbow, particularly if achieved proximally near the apex of the axilla [2]. Contraindications for infraclavicular block involve thorax deformity, foreign bodies in the needle insertion area (e.g. pacemaker), and clavicular malunion [9].

Nerve stimulator technique: The patient is placed semi-seated with the ipsilateral shoulder down. The arm is slightly abducted, to bring the neurovascular bundle away from the thoracic cavity and reduce the occurrence of pneumothorax. As the neurovascular bundle follows the arm its relationship to the coracoid process is pretty more maintained. The coracoid process is identified by palpation in the level of the deltopectoral groove (connection between the middle third with the lateral third of the clavicle), about 2 cm lower the clavicle, and marked on the skin (Figure 5). It is possible to use 10cm, 21-G insulated needle [11].

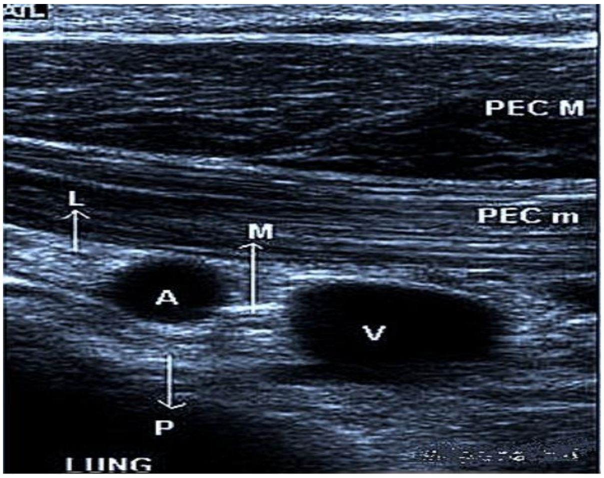
Figure 5- Two cm caudal and two cm medial. (With permission from author) [1].



Ultrasound technique: When using ultrasound in the infraclavicular area it may have two main approaches, a proximal one just under the clavicle and a more distal one at the level of the coracoid process. Put the probe in an oblique mode in the mid pectoral region. This probe rotation is needed to obtain a better cross section of the neurovascular bundle, which is traveling diagonally in the infraclavicular region. In parasagittal level, immediately near the coracoid process on the medial side, the best images obtained are possible. In this way, a transverse view of the brachial plexus, adjacent to the axillary artery it will be obtained. The cords are hyperechoic in this area. The medial cord is located between the axillary artery and axillary vein and it is not always visible as shown in (Figure 6). A 5cm, 22-Gauge, insulated needle can be used. A lower frequency linear probe is usually used, in the range of 4-7 MHz [11].

Figure 6- pectoralis major (PEC M) and Pectoralis minor (PEC m) is located distally to this US section. The axillary vein (V) is the most medial, and axillary artery (A) The most lateral surrounded by three cords (L)

lateral, (P) posterior, (M) medial. (With permission from author) [1].



Dosage of local anesthetics: for anesthesia (US/NS) 20–30/30–50 ml; analgesia (US/NS) 10–20/20–30 ml, continuous 4–6 ml/h [9].

Axillary plexus block (terminal branches)

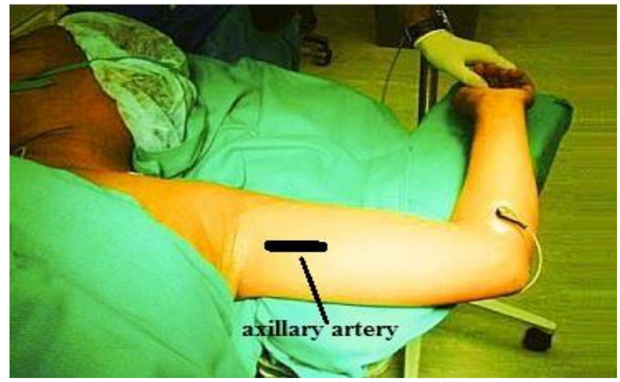
The indications for this block include operations to the forearm and hand. Elbow surgeries are also performed successfully using the axillary block [15]. The axillary block is inappropriate for surgical operations on the upper arm or shoulder, and all the patients must be able to abduct the arm to perform the block [2]. However, there are few contraindications to this block such as local infection, neuropathy, and risk of bleeding. Because the axilla is extremely vascularized, there is a high risk of local anesthetic infusion into the small veins traumatized by needle insertion [4].

Anatomic considerations before the axillary block:

1. The neurovascular bundle is multicompartmental [16].
2. The axillary artery is the most important landmark.
3. Although present the anatomic variations usually, the median nerve is found superior to the artery, the ulnar nerve is inferior, and the radial nerve is posterior and slightly lateral.
4. At this level, the musculocutaneous nerve has already left the sheath and lies with the coracobrachialis muscle [2].

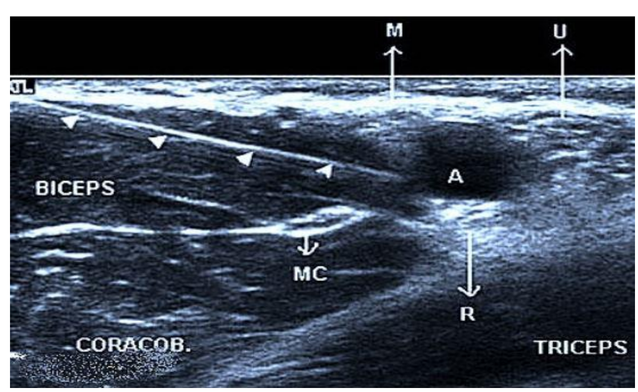
Nerve stimulator technique: The patient must be placed in supine position and the arm is abducted to about 80-90 degrees and the elbow is a little elevated to 20-30 degrees. The biceps muscle is found by visualization and/or palpation. The coracobrachialis muscle is found directly below it. While biceps are very movable the coracobrachialis is palpated as a thick poorly mobile mass. The pulsation of the axillary artery is identified proximately below the coracobrachialis. The arm position is in abduction with a small pad under the elbow and the trajectory of the axillary artery marked (Figure 7) [11]. A 25-gauge, 2-cm needle is recommended.

Figure 7- the arm is abducted about 80° to 90°, and the axillary artery is marked. (With permission from author) [1].



Ultrasound technique: Ultrasound guidance with visualization of local anesthetic spread around the four nerves (with and without nerve stimulator) decreases block onset time and can decrease the number of needle redirections; however, the rates of success and complications are like the other approaches [17-18]. Ultrasound can also help with the success with smaller volumes of local anesthetic, although the overall duration of sensory and motor block will be markedly decreased [19]. The probe is placed across the neurovascular bundle in the proximal part of the arm at this level the neurovascular bundle of the axilla is commonly very superficial and the terminal nerves can be visualized surrounding the axillary artery. The median nerve is usually superficial (anterior) to the artery, the ulnar nerve is medial and somewhat posterior, and the radial nerve is posterior. Distally in the axilla, the radial nerve appears as hypoechoic and starts shifting more lateral, but it still remains posterior to the artery. The musculocutaneous as hyperechoic is lateral to the artery at all times and it can be traced from its origin in the lateral cord proximally to its location between biceps and coracobrachialis distally. If a single injection is planned it should be made in the proximity of the radial nerve. Individual injections of terminal nerves can be done as needed. An image of the neurovascular bundle of the axilla in cross section is shown in (Figure 8). This is a superficial block for which a 5cm, 22-G, insulated needle suffices. A high frequency (8-15 MHz) linear probe is employed [11].

Figure 8- the axillary artery (A) is seen surrounded by three main nerves, median (M), Ulnar (U) and Radial (R). Also seen is Musculocutaneous nerve (MC), and some muscles. (With permission from author) [1].



Dosage of local anesthetics: for anesthesia (US/NS) 15–30/30–50 ml, analgesia (US/NS) 10–20/20–30 ml, continuous 4–6 ml/h [9].

Supplementary blocks for the axillary block

In order to perform a targeted injection of a specific nerve in the axilla particularly distal peripheral nerve block of the upper limb, it is necessary to know how to block each nerve separately [11]. A supplementary Musculocutaneous, Median, Ulnar, Radial nerve block may be required if anesthesia of the axillary nerve distribution is insufficient [20].

1. Musculocutaneous Nerve Block: The musculocutaneous nerve originates from the lateral cord and because of its unclear take off level, it must be blocked first. To perform this block by nerve stimulator technique firstly identify and hold the patient's biceps muscle with one hand and direct the needle with the other in a direction vertical to the main axis of the arm, insert it between biceps and coracobrachialis.

2. Median Nerve Block: The median nerve is more frequently situated anterior to the axillary artery running in the same direction, making it a very superficial block. We can perform this block with nerve stimulator technique, by using the mark of the axillary artery on the skin as a reference, the needle is advanced very peripherally to the skin (shallow angle), in the same direction of the artery. It is better to mark the course of the artery on the skin than to keep the fingers on the pulse to avoid bringing the artery even closer to the skin and increasing the risks for accidental artery puncture [11].

3. Ulnar Nerve Block: The ulnar nerve is situated closely medial to the artery, slightly deeper than the median nerve. It provides sensory innervation to the medial side of the hand. Because the medial brachial and the medial antebrachial cutaneous nerves run along with the ulnar nerve on the medial side of the axillary artery, the ulnar nerve approach is achieved for anesthesia of the medial arm and medial forearm. However, to perform this block by nerve stimulator technique, also the axillary artery has to be marked on the skin this is the main reference, the needle is directed slightly medial to the artery [11].

4. Radial Nerve Block: The radial nerve is most frequently located posterior (deeper) to the axillary artery. It is the largest of the terminal branches of the plexus. Again to achieve this block by using a nerve stimulator technique, the two fingers are used to one hand as "hooks" to slightly shift the artery out of the way in order to reach the radial nerve situated posterior to it. The needle is inserted posteriorly with a 30-degree cephalad orientation [11].

Ultrasound Techniques:

The brachial plexus once again is superficial here so a linear, high frequency (10-15 MHz) the probe is used. The arm is abducted and a pillow is placed under the elbow, as described for the nerve stimulator technique. The probe is placed across the neurovascular bundle to get a cross section image of it. The median nerve is usually seen superficial (anterior) to the artery. The ulnar nerve is medial and somewhat posterior, the radial nerve is posterior. Distally in the axilla, the radial nerve starts shifting more lateral, but it still remains posterior to the artery. The musculocutaneous is lateral to the artery at all times and it can be seen entering the coracobrachialis muscle. If a single injection is planned it should be made in the proximity of the radial nerve. Individual injections of terminal nerves can be done as needed [11].

Dosage of local anesthetics: Anesthesia and analgesia (US/NS) 2/5 ml [9].

Discussion and Results

1. Interscalene block

Recently, the interscalene block is well performed for intraoperative as well as postoperative pain management related to shoulder surgery. In July 2009, Liu et al, performed a prospective, randomized, controlled trial study, they searched for studies of Ultrasound-Guided Group and compared it with Nerve Stimulator Group, and then concluded that the use of ultrasound guidance didn't significantly reduce the incidence or severity of postoperative neurological symptoms after interscalene block for outpatient shoulder arthroscopy when compared with the nerve stimulator method. But they also demonstrated that the use of ultrasound guidance can reduce the number of needles passes and provide a complete motor block at the 5 min assessment [21]. Likewise, Gonano. et al, did a comparison of economic aspects of interscalene brachial plexus blockade and general anesthesia for arthroscopic shoulder surgery, in May 2009. Their conclusion was that the ultra-sonographic-guided ISB is a cost-effective method for arthroscopic shoulder surgery [22]. On the other hand, Peter. et al, achieved Respiratory Impact of Analgesic Strategies for Shoulder Surgery in May 2012, they established some possible strategies that may decrease the high occurrence of the ipsilateral phrenic nerve block in interscalene brachial plexus block, including (1) using low volumes of local anesthetic agents, (2) targeting the brachial plexus at the inferior level in the neck, (3) applying the suprascapular nerve block, (4) applying the combination of a suprascapular and the axillary nerve block, and concluded that the using doses of 10 ml or less of local anesthetic agents, reduce the risk of causing Phrenic Nerve Palsy, but cannot actually avoid it [23]. Faraj. et al, offered the Real Benefits of Single-Shot Interscalene Block, in May 2015, and said in their meta-analysis, that the interscalene block can produce effective analgesia up to 6 hours with motion and 8 hours at rest after a shoulder operation, with no demonstrable advantages thereafter. The interscalene block can also produce the opioid-sparing effect and decrease opioid-related side effects in the first 12 and 24 hours postoperatively. These findings are useful to inform perioperative risk-benefit discussions regarding interscalene block for shoulder surgery [24]. Palhais et al, from Canada, performed a randomized, controlled study in December 2015, and they concluded that the Ultrasound-guided interscalene brachial plexus block with the extra fascial injection decreases the frequency of hemi diaphragmatic paresis and effect on respiratory function whereas providing similar analgesia when compared with a conventional injection [25]. In addition, there is clinical trial study by Benedikt. et al, on 11 January 2017 which explained that the combination of a peripheral nerve block with low-dose ropivacaine and general anesthesia decreased postoperative pain compared with general anesthesia alone for several days after outpatient arthroscopy, it also shortened the time to home discharge [26]. Recently Thiago. et al published an article in February 2017 and introduced their conclusion that the perineural 4 mg dexamethasone was more effective than intravenous in extending the duration of ropivacaine in ultrasound-guided interscalene brachial plexus block [27]. And Esmaeil. et al, from Iran, introduced an article on 13

April 2017, then concluded that using interscalene brachial plexus block for reduction of anterior shoulder dislocations takes less time to discharge and may make it more possible in conditions mandating faster discharge of the patient. However, since pain scores may be lower using procedure sedation and analgesia, this method may be preferred by many physicians in some other situations [28].

2. Supraclavicular block

Usually, the supraclavicular block is an association with the risk of pneumothorax and also with the occurrence of transient Horner's syndrome. However, the ultrasound-guided technique has assisted its performance, and there is an increasing interest in the block. In 2014, Sadowski et al. published a comprehensive review on its renaissance following the introduction of the ultrasound-guided technique [29]. Gamo et al. presented their experience with the ultrasound-guided supraclavicular block technique in 202 patients [30]. They presented that the block had a rapid practice time (average 4 min), better intraoperative conditions, the mean surgery time of 75 minutes with a range of 6 to 232, and the mean of 437 minutes (range 171 to 992) of postoperative analgesia. The transient Horner's syndrome was detected in 10% of patients. Vaghadia et al. compared ropivacaine and bupivacaine for supraclavicular plexus block performed by paresthesia or nerve stimulation technique in 104 ASA physical status 1–3 patients scheduled for upper limb surgery. Long and effective anesthesia/analgesia was accomplished with ropivacaine 7.5 mg/mL similar to 5 mg/ml bupivacaine without differences between the two groups. The mean duration of analgesia, time to need for rescue analgesia, was 11–12 hours [31].

3. Infraclavicular block

Infraclavicular brachial plexus block is performed at the level of the cords, and provides excellent anesthesia for operations at/distal to the elbow. The upper arm and shoulder are not anesthetized with this type of block. As with other brachial plexus blocks, the intercostobrachial nerve (T2 dermatome) is spared [4]. So to evaluate the efficacy and safety of infraclavicular brachial plexus block compared to another brachial plexus blocks in providing regional anesthesia of the lower arm, Chin. et al. published an article in October 2010, for 15 studies with 1020 participants, of whom 510 received infraclavicular block and 510 received other brachial plexus blocks. And they decided that the infraclavicular block is a safe and easy approach for providing surgical anesthesia of the lower arm. Then they established some benefits for infraclavicular block including the lower likelihood of tourniquet pain during surgery, and more reliable blockade of the musculocutaneous and axillary nerves when compared to a single-injection axillary block [32]. On the same subject, Sun. et al. from the Republic of Korea demonstrated in their meta-analysis on September 29, 2016, that infraclavicular brachial plexus block with multiple injection techniques showed a significantly lower incidence of an incomplete ulnar block than supraclavicular brachial plexus block [33]. On the other hand, on 29 August 2009, Richard. et, al. selected one hundred three hand surgery patients and randomized them to receive either ultrasound-guided (ultrasound group) or dual motor endpoint nerve stimulation (stimulation group) and compared them with the infraclavicular block using 2% lidocaine 15 ml and 0.5% bupivacaine 15 ml with epinephrine. They presented that there was no significant difference in the success rate of ultrasound guidance and dual motor endpoint stimulation for the infraclavicular block [34]. In addition Manuel. et al. compared them in July-August 2009, with seventy patients scheduled for hand or forearm surgery randomly assigned to receive coracoid infraclavicular brachial plexus block using either ultrasound guidance, or nerve stimulation, and reported that the present investigation demonstrates that ultrasound guidance and nerve stimulation provide similar onset time, success rate, and duration of motor blockade for coracoid infraclavicular brachial plexus block, however, ultrasound guidance reduces the time required to perform the block [35]. But Eren et al. said that the ultrasound guidance proved to be more effective in maintenance of successful infraclavicular block than neurostimulator guidance and appears to be a useful tool to reduce the local anesthetic doses to even 70% of those conventionally used. Neurostimulator individually was established to be approximately equivalent to 30% and 50% decreased doses under ultrasound guidance with respect to all measurements in this study [36]. Likewise, in infant's field, Vrushali. et al. published an article in September 2014 and established that the continuous infraclavicular catheters can be exactly and effectively located along the posterior cord exclusively under ultrasound guidance in infants and small children [37]. And Ilker. et al. achieved randomized, double-blinded clinical trial using lower volume of local anesthetic for infraclavicular block under ultrasound guidance with children in December 2016, and supposed that similar block success, postoperative sensory block durations, and pain scores may be obtained in infraclavicular brachial plexus in pediatric patients with lower local anesthetic volumes [38]. Also, Faramarz. et al. from Iran, did a study in February 2015 and confirmed that the volume of the injected anesthetic accelerated the onset of sensory and motor block (infraclavicular block) without affecting the rate of success in our patients [39]. But Prangmalee. et al. compared between costoclavicular and paracoracoid with ultrasound-guided for the infraclavicular block on February 2017, and their result had similar onset times. Furthermore, no intergroup differences were found in terms of performance times and success rates. And they offered that future dose-finding trials are required to explain the minimum effective volume of local anesthetic for costoclavicular infraclavicular blocks [40].

4. Axillary block

Because the location of the axillary block is near the proximal arm, this technique generally has a greater safety profile when compared with other brachial plexus blocks [41]. Likewise, its acceptance has endured because it carries no risk of pneumothorax and can provide an excellent anesthesia and analgesia for elbow or forearm procedure. Newly studies have detected that a multiple injection method is much likely to provide reliably successful blocks [42]. A recent Cochrane review (Chin KJ in 2013) has supported this assertion, and an increasing number of anesthetists are using multiple injection techniques, both with and without a nerve stimulator [43]. Santoshi et al. in their prospective study in March 2017 showed that the identification of all the four nerves produced higher success rate and better quality of the block when compared to single-injection technique. With the availability of ultrasound for nerve site, proponents and enthusiasts were keen to use the axillary technique to the brachial plexus. In addition, the use of ultrasound is associated with a decrease in the time taken to perform the block and has the potential to increase the success rate [44].

To support that, Anil. et als'. study in 2014 and illustrated that the advent of ultrasound technology, there is a marked improvement in the success rate, shorter onset time and reduction in the volume required for the successful block [45]. But Michael et al. did a randomized controlled trial in 2016 that compared the ultrasound versus nerve stimulator for axillary block, and confirmed a difference in the efficacy of axillary brachial plexus block performed by learners when ultrasound guidance was compared with a nerve stimulator technique, and there was sign of similarly improved clinical performance of novices in both groups. These studies, similar to many other publications purporting to show the greater success rates of ultrasound-guided techniques when compared with stimulator techniques, appear to accomplish very modest success rates when using a nerve stimulator to find nerves [46].

Conclusion

Regional anesthesia for upper limb surgeries is a technique of choice in some instances and in combination with mild to moderate sedations can be considered as a good technique of anesthesia, by making a systematized schedule for these techniques may decrease complications of general anesthesia and improve patient satisfaction during perioperative management. Ultrasound introduces a degree of flexibility to the techniques of regional anesthesia that did not exist before. It certainly gives the operator the chance to choose the best needle path based on the anatomy and the ultrasound image obtained, without necessarily having to conform strictly to any particular technique already described. As a method for analgesia, continuous infusion of local anesthetics in combination with general anesthesia can be considered as a proper method of pain control during and after surgeries. As many studies approve this method also is comparable with current pain control systems and could be weighed by them. However regional anesthesia and analgesia can be considered as a routine procedure for anesthetic or analgesic management of upper limb surgeries in the future.

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