Single point injection Ultrasound-guided Infraclavicular block: Where to Inject?

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Abstract

According to literature the brachial plexus block is the most frequently performed peripheral regional anaesthesia technique. A variety of different locations and approaches have been published.

The infraclavicular block (ICB) is one way to block the brachial plexus. It is an underused but effective technique. A variety of different approaches have already been published. The optimal approach and site of injection is still subject of debate. They can be divided in medial and lateral infraclavicular approaches and the more recently described retroclavicular approach. This review article provides an overview of the current state of affairs regarding the ICB as well as some practical tips and tricks.

Keywords: Infraclavicular block, ultrasound, needle approach, single injection point

Introduction

According to literature the brachial plexus block is the most frequent performed peripheral regional anaesthesia technique [1-6]. A variety of different locations and approaches have been published. The choice of approach is often determined by surgical indication. One of the described brachial plexus approaches is the infraclavicular brachial plexus block (ICB). The ICB is indicated for mid-humeral to distal upper limb surgery. The optimal approach and site is still subject of debate. This review article provides an overview of the current state of affairs regarding the ICB as well as some practical tips and tricks anno 2017.

History

Bazy first described the ICB in 1917. [7] He placed a needle below the clavicle, in an "anaesthetic line" drawn between the anterior tubercle of the sixth cervical vertebra and the coracoid process [7].

In 1973 Raj et al. described a more medial needle approach [8]. The needle was pointed in a lateral direction and thereby directed outside the thoracic cage, which made the feared pneumothorax less likely. However, some disadvantages made this approach less popular, including a higher risk of vascular puncture, the low acceptance for most patients due to multiple attempts and the necessity to place the arm in abduction [9]. Moreover, due to the more lateral approach, the musculocutaneous and axillary nerve were inconsistently blocked [9].

The introduction of ultrasound has not only facilitated but also improved success rate of the ICB [10-12].

A Cochrane review published in 2013,presentedpositive outcome characteristics in favour of the ICB including a decrease in tourniquet pain, more frequent blockade of the musculocutaneous nerve (compared to a single shot axillary block) and a reduction in block performance time (compared to a multi-injection axillary block and mid-humeral blocks) [6]. Multiple papers have highlighted the ICBas an easy to learn, effective and underused regional anaesthesia technique of the upper limb [6,13].

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Anatomy

The nerves responsible for the innervation of the upper limb arise from the ventral rami of the C5-T1 spinal nerves (with some possible contributions of C4 and T2). The brachial plexus can be subdivided in roots, trunks, divisions, cords and terminal nerves(Fig. 1). When performing an ICB, the cords are approached. Three separate cords are identified; the medial, lateral and posterior cord.

The prevertebral fascia extends distally and surrounds the brachial plexus. This fascia forms the axillary sheath that also contains the axillary artery and vein [14,15].

The pectoral muscles form the anterior border of the infraclavicular fossa. The second and third rib forms the medial border together with the intercostal muscles. The humerus forms the lateral border. Cranially it is sealed by the clavicle and coracoid process.

As shown in figure 2,in the medial part, the cords are likely to be posterior to the artery. More laterally, at the coracoid level, there is more variation in cord location [16].

The musculocutaneous nerve separates relatively early from the lateral cord and diverges out of the sheath [17]. Macfarlane et al. described that in 50% of the patients the musculocutaneous and axillary nerve leave the sheath before the coracoid process [18]. This finding explains the significant incidence of block failures with a more lateral approach.

The posterior cord generally lies between the medial and lateral cord. This cord is, therefore, seen as the central position of the

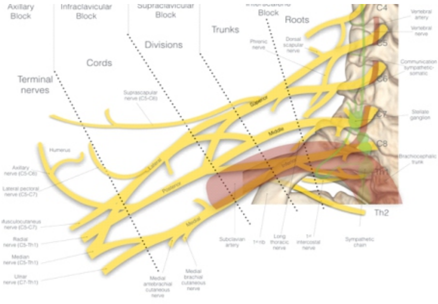


Figure 1: Brachial plexus anatomy.

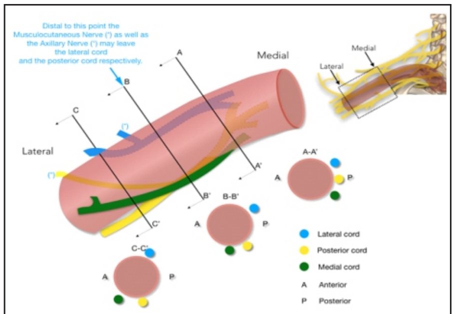


Figure 2: : Infraclavicular region anatomy; positions of cords relative to the axillary artery.

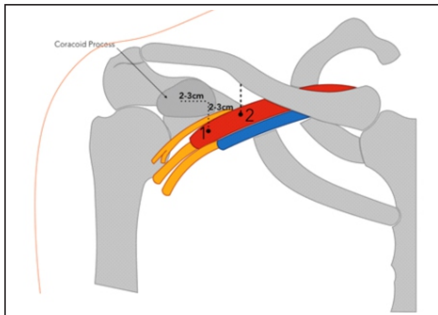


Figure 3: Insertion point and needle direction: 1. Perpendicular to the skin towards axillary artery. 2. 45° to the skin directed lateral andinfero-posterior towards the brachial artery.

brachial plexus at this level. The other cords, which are variable in location and move deeper as they travel distally, are described as the peripheral cords [19,20].

Many variants have been described. There are cases in which all cords lie lateral to the axillary artery or cases of fusion of the three cords to a single cord lying lateral to the axillary artery [21].

Block performance

1) Technique with a peripheral nerve stimulator

The coracoid approach is the most popular technique because it is easy to perform and has a low risk for pneumothorax [22]. The coracoid process is the primary landmark and is easily palpated, even in obese patients [23]. The patient is placed in supine position with the head turned to the ipsilateral side. The arm is placed in 90-110° abduction with external rotation of the shoulder. This position moves the brachial plexus towards the surface of the skin and away from the pleura [6,20,22,24]. In those patients who cannot move the arm due to malfunction or pain, many studies point out that it is possible to keep the arm adducted. While this is the case, Bigeleisen et al. state that abduction of the arm allows a more favourable brachial plexus position in terms of safety and accessibility [24]. Different techniques have been described. The needle is inserted perpendicular to the skin, 2 cm medial and 2-3 cm inferior to the coracoid process and directed to the axillary artery. Others perform a mid to 2/3 lateral infraclavicular approach, at an angle of 45° to the skin directed to the brachial artery (Fig. 3) [23]. The needle is advanced until an adequate motor response is obtained. The current of the nerve stimulator is set initially at 1mA until the desired response is achieved and then decreased to between 0.3 and 0.5mA. The needle is advanced until the response returns and at this point, 25-40 ml of local anaesthetic (LA) is injected. A high volume of LA is necessary for an adequate success rate and a multiple injection technique increases success. The importance of the nerve stimulation has been emphasized in a few papers. Stimulation of the posterior cord increases success rates of the block [25]. Distal muscle stimulation is more difficult to achieve, however, according to literature, this will result in a higher block success [23]. Stimulation of the proximal muscles (biceps, pectoralis, triceps) has a low success rate (44%) [26]. When the musculocutaneous nerve is stimulated, the success rate decreases as this nerve may have already left the sheath [22].

2) Ultrasound guided approach

<u>Scanning and sonoanatomy</u>

The infraclavicular region has a simple sonoanatomy when looking in a sagittal plane. The axillary artery, pleura and second rib, are easily identified, but not all structures (cords, cephalic vein, thoraco-acromial artery and its acromial branch) are as easy to find with ultrasound(Fig 4). The patient is placed in a supine position with the thorax elevated to 30° . The head is turned to the contralateral side and the arm can be in abduction or adduction (in abduction, the clavicle moves cephalad, making structures more visible). The ultrasound machine is placed in direct line of sight and a sterile high-frequency (12–18 MHz) probe is used to scan the infraclavicular region.

According to literature, ultrasound-guidance in combination with neurostimulation is superior to

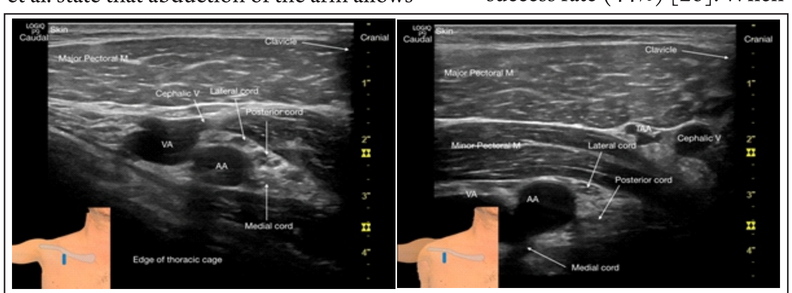


Figure 4A: Sono-anatomy medial infraclavicular region (arm in abduction). **4B:** Sono-anatomy lateral infraclavicular region (arm in adduction or abduction).

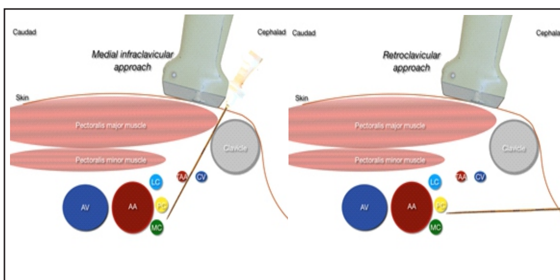
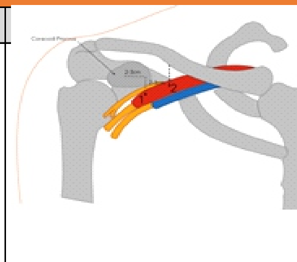
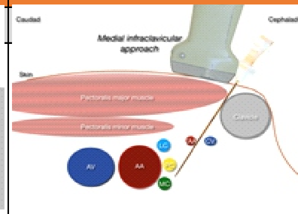
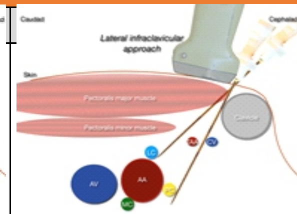
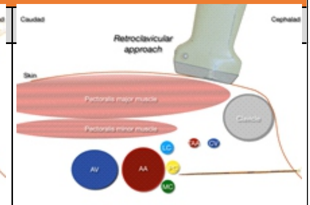


Figure 5A: Different in plane approaches of the medial infraclavicular region with single injection point. A. Medial infraclavicular. B. RAPTIR. (AV: Axillary vein, AA: Axillary artery, TAA: Acromial branch of thoracoacromial artery, CV: Cephalic vein, LC: Lateral cord, PC: Posterior cord, MC: Medial cord)

Table 1: Characteristics of different approaches with and without ultrasound.
(AV: Axillary vein, AA: Axillary artery, TAA: Acromial branch of thoracoacromial artery, CV: Cephalic vein, LC: Lateral cord, PC: Posterior cord, MC: Medial cord)

CLASSIC		ULTRASOUND		
Approach				
Landmark	CoracoidprocessandClavicle	Deltopectoralgroove	Coracoidprocess	Clavicle
Puncture	Puncture site: 1) 2-3 cm inferior to the clavicle and 2 cm medial to the coracoid process or 2) 1-2cm below mid-clavicular. Needle directed1) perpendicular to the skin towards the axillary artery or 2) laterally and infero-posteriorly towards the brachial artery.	Puncture site: Inferior to clavicle. In plane approach. Needle tip: Inferior to the posterior cord. Since the cords are close to each other, one single injection is usually sufficient.	Puncture site: Inferior tothe clavicle. In plane approach. Needle tip:Inferior to the posterior cord. Due to the anterior position of the lateral and medial cords, repositioning of the needle tip closer to the lateral cord is more likely to result in a successful block.	Puncture site: Superior and posterior to the clavicle. In plane approach. Needle tip:inferior to the posterior cord. If the spread to lateral cord is insufficient, it may be necessary to reposition the needle closer to this cord.
Position	Supine	Supine	Supine	Supine
Arm	Abduction 90-110°	Abduction 90-110°	Abduction 90-110° or adduction	Adduction
Neuro-stimulation	Yes	Yes (low current)	Yes (low current)	Yes (low current)
Ultrasound probe		Inferior of clavicle. Close to lateral edge of thoracic cage.	Inferior of clavicle/coracoid process	Inferior to the clavicle
Needle visualization		Poor to good (depending of the angle)	Poor (deep block, mostly steep angle)	Best albeit blind zone

neurostimulation guidance alone [10-12]. Maximum visibility of the cords is achieved when the ultrasound probe is placed caudal to the clavicle, close to the thoracic wall, with the axillary artery in a short axis view (Fig. 4A). However, moving the probe towards the axilla may make the cords less identifiable as they move around the artery and penetrate deeper (Fig. 4B) [20]. Actually, there is no need to identify all cords as a large volume of LA may be injected in the sheath, which will provide a block of the brachial plexus by diffusion [14].

Lateral versus medial approach

In the literature, a distinction is made between single and multiple injection techniques and a medial versus lateral approach. The multiple or triple technique refers to the three different cords localized and anesthetized separately. In this review, we focus on the single point injection. Bowens et al. investigated the difference between a single LA injection close to the posterior cord relative to a more peripheral single injection (medial or lateral cord) [19]. The first method had a success rate of 99%, while the success rate was 92% in the lateral cord approach and 84% in the medial cord approach. Furthermore, injection close to the posterior cord will reduce the procedural time [27-29]. LA spread resulting in a U-shaped distribution around the artery will result in a complete sensory block in more than 90% [11,29,30].

Placing the transducer in the parasagittal plane inferior to the clavicle just lateral to the thoracic cage (Fig. 2 A-A'), will result in an image of the axillary artery and vein with the hyperechoic cords cranial to the artery(Fig. 4).As the needle has to pass through the pectoralis muscles, a LA infiltration of the skin and muscles is advisable to improve patient comfort during block performance. After an in-plane insertion of the needle (postero-caudal direction),the lateral cord will usually be encountered first. This lateral cord will ensure elbow or finger flexion when stimulated by neurostimulation. The posterior cord is located deep to the lateral cord and superficial to the medial cord. With stimulation, finger stimulation and/or wrist extension will occur. As stated above, a single injection posterior to this cord will have a high success rate [19,20,27,28]. When the US-probeis moved laterally, the cords will separate as showed in Fig. 2, making the block performance more complicated and resulting in a higher risk of vascular puncture [24]. Moreover, it is important to realize that in 50% of cases the musculocutaneous nerve and axillary nerve will not be blocked as they diverge out of the fascia when moving laterally [17] (Fig. 2).

When compared, a more medial approach will result in less tourniquet pain (97%versus 83% in a more lateral approach),more favorable brachial plexus position (92% versus 83%) and a faster onset (9 minutes versus 13 minutes) [24]. The disadvantage of this infraclavicular needle approach is the steep angle of insertion, making needle visualization challenging.

Retroclavicular Approach to the Infraclavicular Region (RAPTIR)

Charbonneau et al. described the retroclavicular block in 2015. This approach, known as RAPTIR (Retroclavicular Approach to the Infraclavicular Region) offers, according to the paper, a quick, safe, and reliable approach for distal arm blocks [5,14,31]. Using this new approach, a success rate of 90% was established (total sensory score of 10/10 at 30 minutes)with a surgical success rate of 96% [5].

The advantage of this approach is

enhanced needle visibility compared with the previously described ultrasound technique [31,32]. The needle is inserted in plane, cranially and posteriorly to the clavicle, in the supraclavicular fossa (Fig. 5). This will result in an almost perpendicular alignment of the ultrasound beam with the needle shaft, making the needle perfectly visible [5,14,31,32]. The needle should be directed towards the posterior wall of the axillary artery deep to the posterior cord [5,33]. A supplementary advantage of this technique is lower pain scores and discomfort. This is because needle penetration of the pectoralis major and minor muscles is avoided and the arm can be held in a resting position alongside the body when abduction of the arm is too painful [5,14,31-33].
RAPTIR is associated with reduced performance time, less paraesthesia during block performance and fewer needle passes than the previously described classic approach.34RAPTIR avoids important vascular structures, including the acromial branch of the thoracoacromial artery and the cephalic vein, both of which lie in the trajectory of the needle in a classical infraclavicular approach and are therefore at risk of needle trauma (Fig. 5) [14,33,34].
The lateral cord is located at the cephaloanterior aspect of the axillary artery and lies on the needle trajectory of the classic infraclavicular block. RAPTIR causes less needle trauma to this cord [14,33,34].
Sutton et al. noted that achieving a U-shaped spread of LA under the axillary artery often failed to reach the lateral cord [33]. The explanation lies in the tendency to push the needle under the axillary artery when using RAPTIR. A solution for this problem is to withdraw the needle and redirect it anteriorly to deposit LA at the lateral cord. This manoeuvre eliminates the delay for a complete block [33]. Criticism of the RAPTIR approach exists; anatomical variability of the clavicle may decrease space for needling and thus increase patient discomfort [35].
While needle visualization is improved by a perpendicular trajectory, the acoustic shadow produced by the clavicle results in a blind zone. This means that this approach may be technically challenging [36].

Indications: Surgery of the hand, forearm and elbow are the main indications for ICB [21]. Anaesthesia of the arm from dital to a mid-humeral level can be expected with an ICB. The supraclavicular nerve (C3-C4), innervating the upper part of the shoulder joint, will not be anaesthetized by this technique since it escapes from the plexus at the interscalene-supraclavicular level. In some cases, when T2 forms an intercostobrachial nerve (and is not a part of the brachial plexus), the medial brachial cutaneous nerve (T2), innervating the medial part of the skin of the upper arm, will not be anaesthetized.
When a catheter for long-term analgesia is required, the infraclavicular approach is superior to the axillary approach as catheter dislocation is less frequent and the risk of infection is lower [9,21].
An important advantage of the ICB is that patients don't necessarily have to move their arm to receive a brachial plexus block. With the arm in abduction the different structures are more clearly visualised, however unlike the axillary plexus approach, arm abduction is not mandatory. Therefore in compromised patients, e.g. humeral fracture, an ICB might be more practical. On the contrary, performing an ICB in obese patients can be challenging as the landmarks are more difficult to identify.

Drugs and volume

The neurovascular bundle in the infraclavicular region is very compliant, thus it is possible to inject a large volume of LA solution up to 30-40 mL [9].
Ultrasound-guided infraclavicular brachial plexus block via a coracoid approach can reduce the volume of LA mixture [37]. A dose of 18 ml provides a good analgesic effect and does not seem to affect the onset ofthe anaesthetic block [37].
Many types of LA can be used for anaesthesia or analgesia. We refer to other articles for more information about this topic [36-38].

Complications: Complications are extremely rare and this explains the difficulty to obtain reliable data about incidences [39]. Retrospective studies estimate an incidence of 0.5-1.0% [39]. For major complications, like permanent nerve damage, a 1.5/10000 (0.015%) incidence has been reported [39]. The incidence of transient neurologic lesions might be as high as 8-10% [39,40].

Although ultrasound and neurostimulation are broadly used nowadays, intraneural injections still occur. Intraneural injections do not necessarily result in permanent injury [41,42]. Animal studies have revealed that an intrafascicular injection combined with a high injection pressure results in neural injury with deficit. Penetration of the epineurium and injection in the connective tissue surrounding the fascicles will result in a lower injection pressure and will probably not result in permanent neurological dysfunction [39,43,44]. Besides the use of ultrasound, low current stimulation and pressure monitoring, a tangential approach of the cords may reduce the incidence of intraneural injection [45].
A short-bevelled needle will allow the nerves and nerve fascicles to slide or roll away from the needle tip. Less neurological complications will occur when a proper needle is chosen [39].
Vascular puncture may more frequently result in a hematoma compared to other blocks as compression is difficult as the clavicle overlies the plexus.
Pneumothorax is a rare complication. As compared to a supraclavicular block, a larger margin of safety exists between the plexus and pleura, which reduces the risk of pneumothorax [20,24]. This block will seldom interfere with the stellate ganglion or phrenic nerve [22]. LA systemic toxicity (LAST) is an extremely rare complication and since the use of US, the dose of LA has been reduced [39,46].

Conclusion

Ultrasound guided infraclavicular nerve block is a valuable option for anaesthesia of the distal upper limb. A medial approach has a high success rate with a single injection inferior of the posterior cord. The recently described RAPTIR-technique is a potential alternative to the medial approach but may require additional manipulation and redirection of the needle to obtain adequate nerve blockade. Future comparative studies will determine if this results in an increased risk of complications.

Pearls and tips:

- For extensive upper extremity

anaesthesia, an infraclavicular block has several advantages over the interscalene and supraclavicular blocks. A more reliable blockade of the ulnar nerve and fewer adverse events such as diaphragm paralysis, central block, pneumothorax, or Horner's syndrome are seen [14].

Technique of US-scanning: The pectoralis muscles will be the most superficial structures. Move the transducer cephalad to view the edge of the clavicle and lateral to medial and vice versa to find the best image of the artery, vein and cords. The vein will almost always be caudal to the artery and compressible. Changing the applied pressure of the probe may allow improved visualization of the vein.

Abduction of the arm (to 90°) will stretch the pectoralis muscles and enhance the window of the ultrasound image. It will bring the cords closer together and closer to the skin, enhancing nerve visualization.

Mostly a linear high frequency transducer is used. The use of a small curved/convex transducer can be helpful for providing a wider field of view. This may allow more space for needle insertion.

It is important to recognise that the soft tissue-pleura interface is highly echogenic because of the sudden decrease in acoustic impedance [2].

A steep angle of needle insertion results in poor needle visualisation. Moving the transducer or needle to obtain a more perpendicular US-beam relative to the needle will improve this.

- Cords are often hyper-echoic in this region. The lateral cord is usually located cephalad to the artery. The posterior cord is most frequently posterior to the artery and the medial cord caudal.

- The optimal single point injection site of the LA in an ultrasound-guided infraclavicular block is posterior to the axillary artery close to the posterior cord [19,20].

- Macfarlane et al. described that in 50% of patients, the musculocutaneous and axillary nerves leave the sheath proximal to the coracoid process. This finding explains the significant incidence of block failures using a more lateral approach, making the medial approach the better choice [18].

- Stimulation of the posterior cord increases success rates of the block [25]. Distal muscle stimulation is more difficult to achieve, however this will result in a higher rate of block success [23].

- LA distribution resulting in a U-shaped distribution around the artery will result in a complete sensory block in more than 90% [11,29,30].

- RAPTIR provides superior needle visualization because of the almost perpendicular alignment of the ultrasound beam on the needle shaft.

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