Brachial Plexus Block: "Best" Approach and "Best" Evoked Response—Where Are We?

Practitioners and investigators alike continue the search for one of the "Holy Grails" of regional anesthesia: the ideal brachial plexus block. Such a block would be ideal if it produced rapid, complete, and consistent anesthesia of the arm, forearm, and hand; led to secure catheter placement; and was nearly free of side effects or complications. The approach could be performed with the arm and head in any position and could be performed by a single injection of local anesthetic (LA). Of all approaches to brachial plexus block, infraclavicular block (ICB) is a strong contender (see below), but its success by single-injection technique remains controversial. In this issue, Rodríguez et al.[1] have asked whether a distal evoked motor response is best for single injection ICB. Although the authors have shown improved distribution of anesthesia with a distal, median nerve stimulation rather than a proximal, musculocutaneous nerve stimulation, their overall rate of complete sensory anesthesia at 20 minutes was only 19%. A higher percentage of patients in this group (68%) ultimately underwent surgery without supplementation, but this success rate is still clinically unacceptable.

Why Might ICB Be Close to Ideal?

The ICB, specifically the paracoracoid technique, has many features of an ideal approach. The arm and head can be in any position, and catheter placement is secure. ICB should not result in phrenic block, recurrent laryngeal block, pneumothorax, or impairment of pulmonary function.[2]

Why Is Single Injection Important?

In theory, single injection is simpler, faster to perform, and should cause less tissue and vascular trauma and pain compared with multiple injection. In addition, two theoretical questions raised with multiple-injection techniques are avoided with single injection. (1) Is the risk of nerve injury from continued needle passes after the first LA injection higher with a multiple-injection technique? (2) Is the appropriate threshold current for injection on a subsequent motor response increased by the first LA injection? Furthermore, the application of brachial plexus block to a catheter technique typically requires a single injection as the standard approach.

Is Single Injection Successful for ICB?

In case reports and prior reported series of ICB, the endpoint of distal response was shown to have a higher success rate than did LA injection on a proximal response. Rodríguez et al.[1] have performed an appropriate study and conclude that single injection ICB is not successful when a single, distal response is used to infer correct needle position. What differentiates this study from those before, showing greater than 90% success with similar volumes of LA injected on a distal response? In this study, testing was performed by a blinded observer, and the definition of success was quite stringent: complete anesthesia and paralysis below

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Table 1. Infraclavicular Block Success, Distal to the Elbow, with Single-Injection on a Distal Response

Author	n	Design	Observer Blinding	LA Type	LA Volume (mL)	Endpoint	5N Block 20 min	5N Block 30 min
Borgeat[5]	118	S	No	R	40–50	AL	—	97%
Gaertner[9]	40	RCT	Yes	BL	30	AS	40%	—
Jandard[16]	100	S	No	M	40	AS	<70%*	89%
Deleuze[8]	50	RCT	No	R	40	AS	85%†	90%
Desroches[4]	75	S	No	M	40	AL	—	100%‡
Rodríguez[1]	60	RCT	Yes	M	40	AS	<37%*	—

NOTE. 5N Block, 5 nerve block consisting of the median, ulnar, radial, musculocutaneous, and medial antebrachial cutaneous nerves.

Abbreviations: AL, analgesia; AS, anesthesia; BL, mixture of 0.5% bupivacaine and 2% lidocaine; LA, local anesthetics; M, 1.5% mepivacaine; R, 0.6%–0.75% ropivacaine; RCT, randomized controlled trial; S, series.

*Lowest individual nerve block success.

†Approximated from figure.

‡Duration of testing not specified.

the shoulder at 20 minutes. Previous authors have tested longer intervals (30 minutes), used only sensory block below the elbow as an endpoint (5-nerve block as described in Table 1) and used analgesia rather than anesthesia to define success. Also, the use of nonblinded observers may have introduced bias in these studies (see Table 1). Indeed, if less-strict criteria for success are applied to the results obtained by Rodriguez et al.,[1] the rate of sensory analgesia or anesthesia of individual nerves below the elbow with distal stimulation improves from 74% to 95%, even at 20 minutes. The imprecise definition of a "distal response" (see below) used by many authors makes comparison of these studies even more difficult.

Based on the results of Rodríguez et al.,[1] one must conclude that complete surgical anesthesia, even with distal stimulation, cannot be achieved predictably within 20 minutes of single-injection ICB, especially if all branches to the arm are needed for surgery.

Distal Versus Proximal—Can We Really Tell Where We Are With ICB?

With the use of nerve stimulation in general, needle position is routinely inferred from elicited motor response. With ICB in particular, much is made of distal versus proximal stimulation.[3,4] The terms "proximal," "distal," and even "median" stimulation are not specific enough to anatomically identify needle position with respect to the brachial plexus at the cord level applicable to ICB. Needle localization is important for making an educated readjustment to locate the desired response or an alternative response. Although needle localization by motor response is straightforward at the level of the terminal branches of the plexus, such as during axillary or forearm blocks, it is more challenging at the infraclavicular brachial plexus for at least three reasons: anatomic variability, proximal branches to the arm, and dual-cord contribution to the median nerve.

The brachial plexus has its greatest complexity and variability at the infraclavicular region, where at least 13 branches are found. The derivation of the cords, their interconnections, and the manner in which terminal branches arise are not constant.[6] For example, the musculocutaneous nerve has an anomalous origin or connection to the median nerve in 11%, and a connection carrying C7 fibers from the lateral cord to the ulnar nerve occurs in 42% of anatomic specimens.[5,6] The lateral root of the median nerve may pass posterior to the axillary artery, and the axillary and radial nerves may arise directly from the divisions such that a true posterior cord is not present. Although the musculocutaneous and axillary nerves usually arise distal to the coracoid, these nerves may branch early and potentially be found some distance from the cords. Similarly, the nerve to the long head of the triceps may arise from the axillary nerve,[7] and injection on a triceps response may again be distant from the plexus. These anatomic variations could explain incomplete success in producing anesthesia of axillary or musculocutaneous nerves from ICB, even when distal anesthesia is successful,[8,9] and vice versa.

Even with textbook anatomy, other nerve branches leave the cords and innervate the upper arm musculature, such as the subscapular nerve to teres major (internal rotation of the arm) and thoracodorsal nerve to the latissimus (adduction of the arm). Misinterpreting these movements as plexus stimulation would lead to LA deposition outside the target area of the cords and to inconsistent anesthesia.

Even identifying distal flexion responses as the target response may not be specific enough to locate a needle because of the dual contribution to the median nerve from both medial and lateral cords. Although distal extensor finger or wrist responses are unequivocally from posterior cord or radial nerve stimulation, wrist flexion can be achieved by needle stimulation in four different positions in the plexus: the lateral cord or lateral root of the median nerve (flexor carpi radialis and palmaris longus) and the medial cord or medial root of the median nerve (flexor carpi ulnaris and flexor digitorum sublimus).

Classic studies of fiber topography of the median nerve by Sunderland[10] identify pronator teres fibers and flexor carpi radialis in the lateral root, and nerves to the flexor digitorum profundus, flexor pollicis longus, and intrinsic thenar muscles in the medial root. Nerve-injury studies also suggest that median fibers to the finger flexors are most likely found in the medial cord and medial root of the median nerve.[11] Neonatal brachial plexus injury to the C8-T1 roots (Klumpke's paralysis), although rare, produces paralysis of the hand.[12] In summary, with the most common plexus anatomy, one can conclude that finger or wrist extension is the result of posterior cord stimulation, finger flexion most likely identifies medial cord or medial root to the median nerve stimulation, but wrist flexion may result from either medial or lateral cord stimulation or stimulation to the medial or lateral median nerve roots.

Even if careful characterization of motor response can locate the needle medial, lateral, or posterior to the axillary artery, whether one particular location should be targeted for best LA spread is not clear. Rodríguez et al.[1] postulated that because the medial cord is middepth, it might be the best site for injection, but they did not separate blocks using median-type stimulation into medial or lateral cord responses. After stimulation of a single cord, injected LA must spread to encircle the axillary artery to reach the other cords, which requires enough volume and time to occur, if the LA ever does reach the other cords. The concept of a dense sheath surrounding the plexus in the infraclavicular region has been challenged,[3] and although AP radiographs show proximal spread of dye to the clavicle from infraclavicular injection,[13] this action does not confirm circumferential spread around the vessel.

Conclusion

The ICB is an attractive approach to brachial plexus block for procedures below the shoulder, but Rodríguez et al.[1] have shown that rapid, complete anesthesia by single-injection ICB remains an elusive goal. The latency of single-injection ICB should lead the practitioner to choose multiple stimulation if onset within 20 minutes is needed. Knowledge of the neuroanatomy of this site and more sophisticated analysis of the type of motor stimulation elicited should be goals of future studies of ICB. For example, combined nerve stimulation and ultrasound may help elucidate and confirm the neuroanatomy of the cords and track the initial spread of local anesthetic after injection at a single cord. Authors have described improved ICB success (90% to 95%) with ultrasound-guided techniques[14,15] as an important new development in improving the clinical usefulness of ICB. Perhaps with further study, we can finally identify "where we are" when we perform ICB.

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