Axillary Brachial

Neurostimulation Technique

Alain Borgeat, M.D.
Department of Anesthesiology
Balgrist University Hospital
Zurich, Switzerland

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Colin McCartney, F.R.C.A.

The brachial plexus can be effectively blocked at three different locations: 1) at the level of the trunks, the interscalene block; 2) at the level of the cords, the infraclavicular block; or 3) at the level of the terminal nerves, the axillary block. These three blocks are completely different since the nerve surroundings are not comparable. If the trunks at the interscalene level are confined within a space practically free of connective tissue, the more distal we go along the brachial plexus, the more connective tissue will be encountered.

Anatomical consideration is a key issue when dealing with the technique chosen to block the brachial plexus at the axillary level. In the 1970s and 1980s, the anatomic basis for performing axillary block was the belief that the nerves and vessels were enclosed by a tubular sheath into which local anesthetic solution is injected. This sheath served to confine the injected drug so that structures contained within the sheath were surrounded by local anesthetic.[1,2] This design, however, was too simple and does not actually correspond to the clinical reality. By using a combination of anatomic dissection, histologic preparations and X-rays made after injection of contrast media, Thompson and Rorie showed that the connective tissue forming the

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Anahi Perlas, M.D., F.R.C.P.C.
Assistant Professor
University of Toronto
Ontario, Canada

The axillary approach is a popular technique used to provide regional anesthesia of the brachial plexus. At the axillary level, the neurovascular bundle is very superficial (within 1-2 cm of the skin in most patients). This approach may offer a greater degree of safety in comparison to other brachial plexus approaches, as it is far from the neuroaxis and the pleura as well as major vessels of the neck. The neural structures in the axilla, however, are not the brachial plexus itself but rather the major terminal nerves. This means that the median, ulnar, radial and musculocutaneous nerves all need to be anesthetized to provide surgical anesthesia of the entire forearm and hand. This is not always easily accomplished with traditional "blind" techniques as it is well established that the neural sheath in the axilla often has multiple compartments, and local anesthetic solution may not spread equally to all nerves.[1] The musculocutaneous nerve in particular needs to be blocked separately since it leaves the neurovascular bundle high in the axilla and moves distally in a plane between the biceps and coracobrachialis muscle.[2]

These two anatomic facts help to explain why, when using nerve stimulation, it is necessary to elicit multiple responses and block each nerve individually to achieve consistent anesthesia of the entire upper extremity.[3] It also has been shown

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"neurovascular sheath" extends inward, forming septa between components of the plexus.[3] The authors concluded that the sheath is a multicompartmented structure formed by the thin connective tissue sheath, the surrounding plexus and the septa that extend inward from the sheath. Moreover, Thompson and Rorie emphasized the fact that a fascial compartment is created for each nerve, and this compartment serves to define the anatomic limits of that nerve. The description of these compartments has clinical implications since it may explain some block failure.

These findings were confirmed by Partridge et al.[4] The authors dissected the brachial plexus of cadavers and found that the sheath consists of multiple layers of thin connective tissue surrounding the various elements of the neurovascular bundle. Interestingly they demonstrated that these septa are not always complete, forming in some cases small bubble-like pockets when solution is injected. They were able to show that despite the presence of septa, single injections of methylene blue into the axillary sheath resulted in immediate dye staining of median, radial and ulnar nerves. These observations demonstrated the presence of possible connections between compartments. The clinical implication of this study is important since it may explain the high success rate of single-shot injection. Most importantly the author showed that the location of individual components of the neurovascular bundle within the sheath is quite variable. In 75 percent of the cases, the positions of the nerves with respect to the axillary artery correspond to those described previously.[5,6] In 13 percent, however, the radial nerve lay anterior to the artery and adjacent to the ulnar nerve. In 6 percent, all three nerves lay anterior to the axillary artery. In an additional 6 percent, the axillary vein lay outside the axillary sheath altogether. The clinical implication of these findings is great since normal anatomical position of the nerves at this level will only be encountered in approximately 75 percent of the patients.

Finally, a more recent anatomical study confirmed that septa from the deep surface of the axillary sheath create compartments for individual nerves and showed that they are relatively impermeable to solutions in physiologic conditions.[7] The authors also were able to demonstrate in this investigation that when the septa are stretched by the pressure created by the injected volume, bubble-like defects result from tears of the septa, which allow flow of the injection material to other compartments, although this did not happen in every specimen.

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that the location of individual nerves with respect to the axillary artery is highly variable, making nerve-seeking with nerve stimulation more challenging.[4]

When a nerve stimulator is being used, the endpoint of motor response is lost for that particular nerve once the injection of local anesthetic is begun and may be significantly attenuated for the remaining nerves. Even more important, once the injection of local anesthetic starts, there is no way to know how it is spreading except to wait for the effect of the block to set in. When using ultrasonography, it is common to see — after 1 or 2 mL — a spread of local anesthetic solution outside the nerve "sheath," despite what seemed to be a perfectly adequate motor response to nerve stimulation. It is possible, then, to reposition the needle to ensure correct spread of the local anesthetic. When all that is available is the motor response, the practitioner cannot appreciate where the local anesthetic solution is spreading, and all one can do is await the results of the block. It is common, therefore, with traditional "blind" techniques to obtain a partial block when using the axillary approach to the point that some textbooks warn to be prepared to perform "rescue blocks."[5]

The last decade has seen a tremendous growth in the use of real-time imaging to guide peripheral nerve blockade in a search for more successful and safer procedures.[6,7] In particular, real-time ultrasonography is being used increasingly throughout the world as a means of guiding peripheral nerve blocks, including the axillary approach to the brachial plexus. In our experience, the advantages offered by this technique for axillary block include the ability to:

1. Consistently and accurately locate each individual nerve, including the musculocutaneous nerve.
2. Guide the blocking needle toward each target nerve. As the neurovascular bundle is very superficial in this location, the axillary approach is especially suited for an "in-line" technique in which the needle is advanced within the path of the ultrasound beam, visualizing the entire needle shaft [Figure 1, next page].
3. Avoid unintended vascular punctures.
4. Recognize unintended intraneural injection early and correct the needle position before further local anesthetic solution is injected.[8]
5. Assess the spread of local anesthetic solution around each target nerve [Figure 2, next page].

This can be accomplished in a timely manner and while maintaining sterility. Furthermore the introduction

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The lessons from these studies are that the anatomy at this level is variable, and the possible interconnections between the compartments are unpredictable. This explains the various success rates found in the literature when dealing with one or multiple injections. It is generally accepted that multiple stimulation technique is superior to single injection. Several authors have confirmed the superiority of multiple stimulation-guided techniques,[8-10] emphasizing the need for a precise guided-target technique when performing axillary block.

Each specific surgery of the distal upper extremity — the main indication for the axillary block — will involve the distribution of one, two or more peripheral nerves to a different extent (e.g., median nerve for decompression of the carpal tunnel). Therefore, in order to provide "a la carte" block, the neurostimulation technique is the only one available that permits the targeting of one specific nerve with certainty. This is a main advantage since the anesthesiologist can titrate the concentration and the dose of the local anesthetic to provide an anesthetic block for the nerve(s) mainly concerned by surgery and an analgesic dose for the other. Again, neurostimulation is the only currently available technique that allows the anesthesiologist to be sure where the drug is exactly deposited. The use of the perineural catheter has become the gold-standard for postoperative analgesia in orthopedics.[11,12] — this also is true for the axillary catheter. In this context, Rodriguez et al. have nicely demonstrated that, in addition to the musculocutaneous nerve, radial nerve stimulation produced more extensive anesthesia of the upper limb than did, for example, the ulnar.[13] Thus the radial nerve is the one that should be targeted for the placement of the perineural catheter. Indeed there is no other way to be sure of targeting the right nerve than with neurostimulation. One of the most feared complications of perineural catheter, except neuropathy, is the occurrence of infection. Among the groups familiar with the neurostimulation technique, the incidence of infection is very low.[14,15] The use of ultrasonography probe seriously complicated the procedure and raised some doubts concerning strict aseptic technique.

Detractors of the neurostimulation technique declare that ultrasonography will increase the success rate and lower the incidence of complications. This is not true, or at least not proven. No study to date has proven that ultrasonography is better or worse than neuro-stimula-

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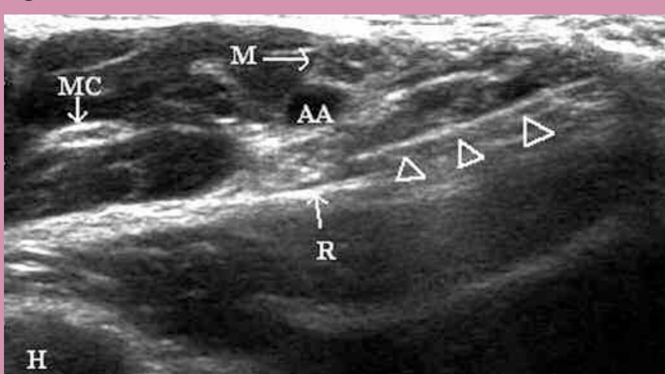
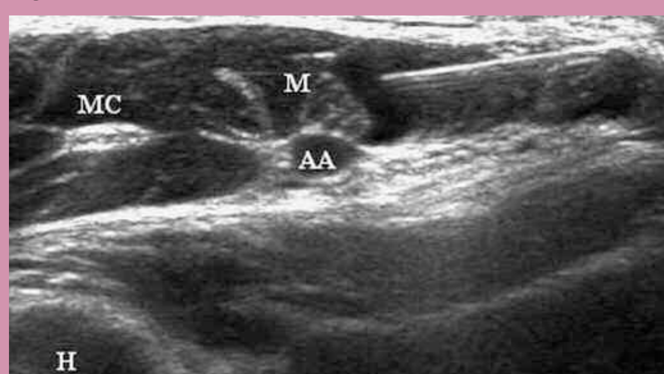
of image guidance does not necessarily mean that nerve stimulation has to be phased out completely. In fact image and motor response are two quite different endpoints that can be used well in combination. While image guidance gives us anatomic information, the motor response gives us functional information about the nerve in question. The combination of the two techniques may,

Figure 1



Sonogram of the axillary area. M = median nerve, R = radial nerve, MC = musculocutaneous nerve, AA = axillary artery, H = humerus. Arrows show the needle shaft with the needle tip in proximity to the radial nerve.

Figure 2



Sonogram of the axillary area during local anesthetic injection. M = median nerve, MC = musculocutaneous nerve, AA = axillary artery, H = humerus. Notice the needle tip in proximity to but not touching the median nerve that is being surrounded by local anesthetic solution, which appears anechoic ("black") in the figure.

tion. The success rate of blocks among groups that can master correctly neurostimulation is high, between 95 percent and 97 percent,[11,12] and the incidence of complications, such as neuropathy or infection, is very low (repeated axillary block does not increase the risk of persistent paresthesia).[14-16] In this context, it will be extremely difficult to have an adequately powered study that will be able to show the advantages of ultrasonography over neurostimulation. The technological improvements of neurostimulation, including new settings for duration and frequency of electrical impulse, allow a quick localization and a soft approach of the nerve. New insulated needles also permit better precision for the correct placement of the needle tip. Additionally the neurostimulation needle is becoming thinner and thinner and therefore less painful for the patient. On the other hand, when using ultrasonography, needles tend to become larger and larger — more painful for the patient — because the tip of the small needle is often difficult to visualize.[17]

To summarize, neurostimulation is, in 2006, a well established, inexpensive and safe technique that is associated with a high success rate. There is still much to learn and to understand with respect to its best utilization. In the context of axillary block, the anatomical particularities of the nerves at this level favor the use of a technique that allows precise targeting of selected nerve(s) that need to be anesthetized according to the type of scheduled surgery. Ultrasonography cannot fulfill these requirements. Moreover neurostimulation is a wonderful teaching tool. Within two minutes, one can demonstrate the triple innervation of the thumb: abduction, radial nerve, adduction, ulnar nerve; and opposition, median nerve. No resident will forget such a picture. Neurostimulation is unique in that it allows one to visualize the direct relation between anatomy and physiology. This is much more representative than some hyper-hypoechogenic holes in a foggy background! Ultrasonography is a descriptive technique, neurostimulation is an analytical one.

In conclusion, one has to remember that well-controlled trials of the use of devices are essential for what is new and exciting. New technology is only better if patients' outcome is improved. This information will place regional anesthesia on a firm foundation of scientific knowledge. None of these considerations have been confirmed with the use of ultrasonography.

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in fact, be quite appropriate for the axillary approach as several nerves need to be blocked.

For all the reasons above, real-time ultrasound guidance offers significant advantages for the performance of axillary brachial plexus block over the more traditional technique of nerve stimulation as the sole endpoint. Still a relatively new technique, randomized, controlled trials are under way to determine if the use of ultrasonography indeed results in better quality blocks, and this data should be available in the near future. Until publication of these studies, some preliminary small investigations have had encouraging results for other brachial plexus approaches.[9,10]

At our institution, the use of ultrasound guidance has been a major enhancement to our busy regional anesthesia practice. There is little question that it has improved our confidence as well as the quality and safety of our blocks. It also has influenced our practice in ways we did not anticipate just a few years ago. Every block performed under ultrasound guidance is a lesson in applied anatomy. This has allowed us to appreciate anatomic constants as well as anatomic variations among patients. It has shifted our approach from performing a technique based on standard textbook anatomy to performing it based on the specific anatomic characteristics of each patient. It also has shifted our approach from inserting the needle into the right place to ensuring that local anesthetic solution spreads in the right place, something we were not able to appreciate in our daily practice with older methods.

In summary, ultrasound guidance — with or without the concomitant use of nerve stimulation — is a greatly superior technique for the performance of axillary brachial plexus blocks than nerve stimulation alone. I expect that the use of this technique will continue to grow in the years to come.

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