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(Accepted for publication June 3, 2008.)

Anesthesiology 2008; 109:752-3

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In Ultrasound-guided Interscalene Block, Do We Know Where the Epineurium Is?

To the Editor:—The case report by Koff *et al.*¹ illustrates that ultrasound guidance of peripheral nerve blockade will not eliminate the potential for nerve injury. The role of underlying nerve pathology, even if asymptomatic, is highlighted, and the accompanying editorial provides an excellent summary of the many factors that may impact nerve integrity in the perioperative period.²

One issue that bears additional discussion is intraneural (intraepineurial) injection. Many regionalists avoid this to the extent possible, for fear of injuring fascicles during needle insertion or injection, which may or may not produce symptoms³ and which may or may not be visible on ultrasound.⁴ Limited data provide evidence that intraepineurial injection may be safe,⁵ but these data are far from conclusive.

At the level of interscalene block, distinguishing the epineurium of individual nerves with ultrasonography, or even the separation or grouping of nerve elements, is difficult. The article by Moayeri *et al.*⁶ in the same issue of *ANESTHESIOLOGY* shows why this is so. The epineurium in the gross anatomy cross sections appears to be immediately adjacent to the fascial lining the interscalene groove, and barely distinguishable from it. On ultrasound, the largest nerve fascicles at interscalene levels appear as round or oval hypoechoic nodules, usually tightly embraced by the scalene muscles, with a small amount of nonneural tissue apparent between the muscle and nerve. Whether this tissue consists of the fascial lining of the muscle, frequently characterized as the “sheath” of the brachial plexus, or the epineurium of the roots or trunks, or a combination of both is unclear on ultrasound images. It is likely that, as we scan the interscalene region, we visualize fascicles grouped in ways that we cannot discern, and that moving the needle between what we perceive as roots may well result in piercing the inapparent epineurium. Because injectate frequently issues forth from a perforated nerve during injection,⁷ this would not necessarily be apparent on ultrasound imaging. Likewise, the characteristic swelling of the nerve, expected during intraneural injection,^{5,7} would be difficult to appreciate because the actual boundaries of the nerve are not apparent to us. What we perceive as expansion of the groove may, indeed, represent swelling of the nerve due to intraepineurial injection.

A study of the images in the article by Moayeri *et al.* makes another point clear. Although nerve trunks and roots of the plexus become oligofascicular as we proceed proximally,⁸ they do not appear to be monofascicular at the level of interscalene block. We probably can see only the largest fascicles. The ultrasound image from the case report by Koff *et al.* shows only three, large fascicles, considered to be the C5, C6, and C7 nerve roots. However, the cross-sectional images provided by Moayeri *et al.* show no less than 14 fascicles at the interscalene level, many of which appear to be too small to appreciate with standard bedside ultrasound imaging units. Comparisons of ultrasound imaging and histologic sections reveal that only a portion of fascicles in peripheral nerves may be seen on ultrasound imaging.⁴ In my experience, the image provided by Koff *et al.* is quite characteristic of ultrasound imaging in the interscalene region. My concern is that we may not be able to appreciate the boundary of the nerve elements (epineurium) and some of the contents (small fascicles).

The interscalene region differs from many other sites of peripheral nerve blockade. Because the fascial lining of the scalene muscles

tightly invests the neural elements, as illustrated and exploited by Winnie when he described the interscalene block,⁹ local anesthetic solution injected within the “groove” appears to be rather constrained. Although solution injected here may move both proximally and distally, and frequently escapes from the “sheath,”¹⁰ it nevertheless appears to stay very much approximated to the nerves on both ultrasound and radiographic contrast studies.^{9,10} The situation differs from a peripheral nerve coursing its way distally through an extremity, surrounded by adipose tissue or various muscle layers, but without a well-defined and constraining fascial envelope. The sciatic nerve in the popliteal fossa, or subgluteal space, for example, has little to “hold” the injected local anesthetic near it, and injection at one spot frequently fails to surround the nerve, leading to the possibility of partial or inadequate nerve blockade. In this setting, efforts to create a “halo” of local anesthetic surrounding the nerve seem appropriate. However, this is probably not necessary at interscalene levels. Before the use of ultrasound for guidance of interscalene block, peripheral nerve stimulation was used without direct visualization, and most authors recommended a single injection of local anesthetic when the motor stimulation was refined to a 0.2- to 0.5-mA range. Reported success rates with this technique were high.^{9,11} If one single injection, without visualization, led to such efficacy, it is unclear why multiple injections would be necessary when ultrasound is used. An injection “in the groove,” *i.e.*, limited by the scalene muscles and their investing fascia, has a high likelihood of success.

Koff *et al.* note that they were careful to avoid penetrating the epineurium during the interscalene block. However, they also relate that the needle was moved to three separate sites to completely surround the three nerve roots with local anesthetic solution. Given the anatomical particulars described above, inserting the needle repeatedly around large fascicles within trunks or roots to ascertain that each is completely surrounded by local anesthetic may require repeated intraepineurial injections. I do not wish to criticize this practice by the authors, because I have done the same out of concern that I had not adequately “covered” the roots or trunks with local anesthetic. Further, any relation of the block technique to nerve injury in this case report is unclear. However, to avert injury to small, inapparent fascicles and to avoid repeated intraneural injections, it is probably safest to minimize needle manipulations and injections in the interscalene region.

As noted in the editorial by Hebl,² we cannot control all of the elements of nerve injury in the perioperative period and will never eliminate them. But the number of needle “sticks,” or insertions, in the vicinity of nerves is best held to the minimum that will be efficacious. One injection of local anesthetic solution into the interscalene groove, guided by ultrasound, should be highly successful in providing adequate blockade of the superior and middle trunks. Confirmation of local anesthetic solution surrounding the nerves need not occur at the level of local anesthetic injection: Examination of the supraclavicular area after a single site of interscalene injection usually shows highlighting of the superior elements of the plexus, evidence that solution freely moves distally, and amply bathes this portion of the plexus, as necessary for a successful interscalene block.⁹

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(Accepted for publication June 3, 2008.)

Anesthesiology 2008; 109:753

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In Reply:—We deeply appreciate the interest that our case report has generated. We did not anticipate, however, that the use of ultrasound would have been at the center of the discussion. Our case report stands out independently from the actual mechanism of nerve localization.¹ The academic purpose of reporting this unfortunate clinical experience is to educate anesthesiologists about the possible existence of a peripheral neuropathy in the setting of a presumed isolated central nervous system disease.²⁻⁵

With respect to ultrasound and neural imaging, referring to Dr. Rosenblatt's letter, we completely agree that the sonographic anatomy of the brachial plexus is complex and that there are distinct limitations regarding the ability to resolve intimate tissue layers. We commend Dr. Swenson's extensive experience with successful and safe ultrasound-guided peripheral nerve blocks. At Dartmouth-Hitchcock Medical Center (Lebanon, New Hampshire), we also have a long safety record in performing ultrasound-guided peripheral nerve blocks. Since 2002, we have tracked more than 5,000 ultrasound-guided peripheral nerve blocks in an institutional review board-approved regional anesthesia database. This case report represents the first serious adverse event.

We agree with Dr. Baumgarten; this is why the case report mentioned the importance of discussing individual patient risk to offer an informed consent for this patient and all patients, despite the fact that we are unable to predict outcome with absolute certainty. We would like to clarify several aspects of the described procedure. Most importantly, standard safety precautions were maintained in terms of light sedation, monitoring patient response, and assessment of resistance to injection as mentioned by Dr. Baumgarten. We typically inject (even when using the in-plane approach) 1-2 ml of local anesthetic to help identify the needle tip as it is being advanced. When the needle tip is deemed to be in the correct location, we then inject another 1-2 ml of local anesthetic. If the local anesthetic seems malpositioned (e.g., within the sternocleidomastoid muscle), we then alter the needle location and retest. We consider this to be a common and standard ultrasound practice. It should be emphasized that all parties involved at our hospital agree with Drs. Chelly and Borgeat *et al.* in that this catastrophic injury involving the entire brachial plexus would be near impossible to achieve with a root-level block. This is why it is critically important to consider the contribution of the underlying peripheral neuropathy, which may have predisposed this patient to the development of brachial neuritis. Although we cannot prove that our patient had preexisting peripheral neuropathy, this concept is important in the anesthetic care of the patient with multiple sclerosis, as discussed in the letter of Dr. Borgeat *et al.* Other causes of postoperative nerve injury to consider when evaluating a patient include intraoperative surgical stretch injury; positioning injury, as mentioned in our case

report and by Dr. Borgeat *et al.*; and, as suggested by Dr. Sia, Dr. Hebl's concept of the "double-crush" phenomena.⁶

We must clarify, as mentioned by Dr. Orebaugh, that two of the three "repositions" were the result of the situation mentioned in the previous paragraph: The needle tip was malpositioned in the sternocleidomastoid muscle. Therefore, the text should have stated three "attempts" rather than three "repositions." All clinicians reading this report can sympathize with the false-positive rate of nerve stimulation in which a great motor response occurs, but a suboptimal block results. This most likely occurs secondary to fascial or tissue planes that are being tented but not punctured by the needle tip. This is why many practitioners argue the need to dynamically assess the spread of local anesthetic and make necessary adjustments, as mentioned by Dr. Orebaugh. As such, we strongly recommend that future research should be directed toward defining the morphologic appearance of "successful and safe" *versus* "dangerous or ineffective" spreads of local anesthetic.

Ultrasound-guided regional anesthesia is an evolving technique that has received significant attention during the past decade. In the absence of evidence-based medicine, opinions regarding "best practice" should not distract us from dealing with issues such as considering the risk-benefit of a regional technique in a patient with a complex neurologic disease that may not be completely described in current anesthesia textbooks and the published literature.

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(Accepted for publication June 3, 2008.)