

Volume and Dose of Local Anesthetic Necessary to Block the Axillary Brachial Plexus Using Ultrasound Guidance

IN this issue of ANESTHESIOLOGY, O'Donnell and Iohom report a successful block of the brachial plexus at the axilla with as little as 1 ml of 2% lidocaine per nerve.[1] Their findings are at odds with the conventional experience in which axillary brachial plexus block has been typically associated with a variable success rate ranging from 50% to 100%, even when substantially larger volumes of local anesthetics are used.[2,3] Before the introduction of electrolocalization and/or ultrasound guidance, blind injection of the local anesthetic around the axillary artery (transarterial technique) was the predominant method used to block the axillary brachial plexus. Failures or incomplete blocks were thought to be caused by imprecise needle placement or septation of the brachial plexus sheath, leading to malposition of the local anesthetic.[4,5] In 1961, De Jong showed that success of the axillary perivascular technique depends on the injection of a sufficient volume of local anesthetic and recommended that 42 ml of local anesthetic was necessary to fill the axillary brachial plexus sheath.[6] To increase the success rate, larger volumes of local anesthetic, as much as 80 ml in some reports, have been used, with techniques using multiple injections.[6,7] Only few investigators reported the ability of small aliquots of local anesthetic (*e.g.*, 5 ml/nerve) to result in successful block.[8]

So, can ultrasound guidance increase the efficacy and decrease the 15% volumes of local anesthetic necessary to accomplish a successful block? According to Casati *et al.*, there is no significant difference in block success rate or speed of onset between ultrasound and multistimulation techniques when 20 ml of 0.75% ropivacaine are used.[9] Lo and colleagues concluded that the volume used to block the axillary brachial plexus was smaller by a mere (7 ml) with ultrasound as compared to transarterial or nerve stimulation techniques (40 ml *vs.* 47 ml).[10] In the study by Chan and colleagues, ultrasound guidance improved the success rate of axillary brachial plexus block, but it still resulted in a 17% failure rate using 42 ml of 2% lidocaine and 0.5% bupivacaine.[11] These recent studies were all contributed by leading groups in the application of ultrasound for regional anesthesia, and yet, even with substantially greater volumes and doses of local anesthetic, none reported as fast and reliable blockade as the current report.[1] So, how does one explain the spectacular results of O'Donnell and Iohom with as little as 1 ml/nerve of 2% lidocaine? One possibility is that their results are related to an über-precise deposition of local anesthetic by an anesthesiologist and ultrasonographer extraordinaire. Perhaps these were intraneural injections of local anesthetics for which only miniscule amounts of injectate are necessary to accomplish blockade? Or, are their results overly optimistic due to a type-I error because of the small sample size in their up and down design? The research of yesteryear was largely concerned with identifying volumes of local anesthetic and techniques to "fill" the axillary brachial plexus sheath to "capacity." Could it be, as O'Donnell and Iohom imply, that a less conventional, opposite direction – enhancing the precision and determining the *lowest* amount of local anesthetic necessary for blockade – is the future?

Our inability to provide a definitive answer to these questions stems from the unpredictability of the placement and disposition of local anesthetic. It is this factor that has traditionally hampered our efforts to define the relationship among dose, volume, and concentration of the local anesthetic to reliability, quality, and duration of the blockade. The effects of these variables with application of local anesthetics have largely been studied in laboratories on isolated nerves by measuring compound action potentials or on single nerve fibers using voltage clamp techniques.[12] Many of these studies bare little relevance to clinical practice because multilayered ensheathments of peripheral nerves in patients impede the diffusion of drugs into the ion channels. Furthermore, there is a significant variability in the nerve/connective tissue ratio, not only among the nerves, but also at different locations along the same nerve.[13] Such anatomic variability may help explain why a higher concentration of local anesthetic is required to block the sciatic nerve in the popliteal fossa than at the subgluteal fold.[14] When applied directly to ion channels, the concentration of local anesthetics necessary to cause conduction block is small compared to those used clinically.[15] Therefore, it would seem ideal if the means used to localize nerves allowed for precise administration of local anesthetics on the inner side of connective tissues without risking mechanical or injection injury to the axons. If so, should intraneural but extrafascicular injections, at least for large peripheral nerves (*i.e.*, sciatic nerve), become a preferable method of performing blocks in the future? (Personal verbal communication, Xavier Sala-Blanch, M.D.,

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Although this view may initially seem overreaching, it is not completely detached from reality, provided continuing advances in electrophysiologic (new modes of nerve stimulation), anatomic (ultrasonography), and hydrostatic (pressure) monitoring during application of nerve blocks prove beneficial clinically. In defense of such heretic prediction, there is mounting evidence that intraneural injections may occur more commonly than previously thought without imminently leading to neurologic injury.[16,17]

Perhaps the most important question, however, is whether the results of O'Donnell and Iohom are reproducible and ultimately applicable to everyday clinical practice? A recent study of 520 ultrasound-guided nerve blocks by anesthesia residents resulted in a success rate of 93.6% and four complications.[18] A video analysis of these blocks identified as many as 398 performance errors. Intriguingly, despite ultrasound guidance, most errors were failure to visualize the needle and the maldistribution of local anesthetic. This data casts doubts as to whether the ultrasound guidance alone will prove to be a panacea for challenges in peripheral nerve blockade. Whatever the answers, the provocative nature of the report by Drs. O'Donnell and Iohom is welcome because it will add fuel to the ongoing efforts to define the role and limits of ultrasound-guidance in regional anesthesia.

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