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Ultrasound-Guided Perineural Catheter Insertion: Three Approaches, but Little Illuminating Data

Brian M. Ilfeld, MD, MS^{*,*}, Michael J. Fredrickson, MD^{†,†}, and Edward R. Mariano, MD, MAS^{††,††}

^{*}Departments of Anesthesiology, University of California San Diego, San Diego, California [†]University of Auckland, Auckland, New Zealand ^{††}Departments of Anesthesiology, University of California San Diego, San Diego, California

As ultrasound-guided regional anesthesia becomes more popular and practiced, a plethora of research involving this relatively new modality is being published—to the degree that Regional Anesthesia and Pain Medicine recently added an entire ultrasound-related section to every issue.¹ However, the overwhelming majority of these reports involve single-injection peripheral nerve blocks, to the exclusion of perineural catheter insertion.² Unfortunately, data from many of these publications cannot be automatically inferred to perineural catheter placement for multiple reasons. First, while the angle between the long axis of the placement needle and nerve is relatively unimportant for single-injection blocks, it is critical for perineural catheter insertion since catheters tend to exit the needle and traverse past any nerve that is perpendicular to the needle itself.³ Second, a major advantage of ultrasound guidance for single-injection nerve blocks lies in the real-time repositioning of the needle tip to maximize local anesthetic spread, while perineural catheter bolus and/or infusion is analogous to a single-point injection.⁴ Third, unlike needles, flexible perineural catheters rarely remain within a 2-dimensional ultrasound view, making it difficult to observe catheter-tip placement relative to the target nerve.⁵ While it is impossible to include all ultrasound-guided techniques and respective equipment, the purpose of this editorial is to briefly review the major ultrasound-guided catheter-insertion approaches along with their relative potential strengths and weaknesses.

Ultrasound orientation

Before engaging in any discussion involving ultrasound, commonly-accepted vocabulary must be understood. A needle inserted with its length within a two-dimensional ultrasound beam is described as “in plane,” while a needle inserted across a two-dimensional ultrasound

Address for correspondence: Brian M. Ilfeld, MD, MS, Department of Anesthesiology, UCSD Center for Pain Medicine, MC 7651, 9500 Gillman Drive, La Jolla, California, 92037-7651. Telephone: (858) 657-7102; Fax: (603) 258-7782; bilfeld@ucsd.edu.

^{*}Associate Professor In Residence

[†]Clinical Senior Lecturer

^{††}Associate Clinical Professor

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beam is “out of plane.”⁶ A nerve with its long axis within the ultrasound beam is viewed in “long axis,” compared with “short axis” when viewed in cross-section.⁶

Needle In-Plane, Nerve in Short-Axis Approach (Figure 1, Panel A)

For single-injection peripheral nerve blocks, the overwhelming majority of reports describe a short-axis view of the nerve because this view allows for easier identification and differentiation from surrounding structures.⁶ When the long axis of the needle is inserted within the ultrasound plane, the needle tip location can be more-easily identified relative to the target nerve. If the initial local anesthetic bolus is placed through the needle, the spread may be observed and adjustment of the needle tip made, if desired. Unfortunately, when the perineural catheter is inserted past the needle tip, it has the tendency to bypass the nerve given the perpendicular orientation of the block needle and target nerve,³ although there are certain anatomic locations that will often allow a catheter to be passed and remain perineural.^{7;8} Some practitioners have advocated either passing the catheter a minimal distance past the needle tip, or advancing the catheter further initially and then, after needle removal, retracting the catheter such that its orifice(s) lie a minimal distance (<2 cm) past the original needle tip position⁹ (although yet others have suggested this may result in a dislodged catheter tip as the needle is withdrawn over the catheter, especially by trainees). Some advocate using an extremely flexible perineural catheter in an attempt to keep the catheter tip in close proximity to the target nerve if the catheter is inserted more than a minimal distance.¹⁰⁻¹² Still others describe reorienting the needle from an in-plane to a more-parallel trajectory and inserting a stimulating catheter to better monitor catheter tip location.¹³

Proposed benefits include using the same basic technique for both single-injection and perineural catheter placement, simply adding the insertion of a catheter *via* the placement needle/angiocatheter; and its application in nearly all anatomic catheter locations, even for deeper target nerves.¹² If a 17- or 18-gauge needle is used, the needle tip may be more-easily identified and remains within the ultrasound plane due to its rigidity compared with smaller gauge needles (Figure 2).¹⁴ While some have speculated that the use of a large needle is more painful, seven prospective studies reported a median catheter-insertion pain score of 0-2 on a 0-10 numeric rating scale (10=most pain imaginable) when the needle track was first anesthetized with lidocaine *via* a 25-27 gauge needle.^{9;11;12;15-18} In addition, the potential benefits of using a larger needle gauge (fewer needle passes given the relative ease of keeping a rigid, larger-gauge needle in plane; less risk of undesired tissue contact due to misinterpretation of the needle shaft for the needle tip) must be weighed against the potential risks (increased patient discomfort; increased tissue trauma; increased injury if a vessel is punctured).

Disadvantages of this approach include new needle entry sites relative to the nerve compared with more-traditional nerve stimulation modalities which typically use a parallel needle-to-nerve insertion; challenges keeping the needle shaft in-plane¹⁹ difficult needle tip visualization for relatively deep nerves;^{20;21} and, as noted above, the catheter tip may bypass the target nerve given the perpendicular orientation of the needle and nerve.³ If an extremely flexible catheter is used in an attempt to minimize this issue, it is sometimes difficult to thread past the tip of the placement needle.

Needle Out-of-Plane, Nerve in Short Axis Approach (Figure 1, Panel B)

One benefit of this approach is a generally familiar parallel needle-to-nerve trajectory used with traditional nerve stimulation techniques (and also vascular access). In addition, because the needle is parallel to the target nerve, the catheter theoretically may remain in closer proximity to the nerve, even when threaded more than a centimeter past the needle tip.^{9;15}

The main disadvantage of this technique is the relative inability to visualize the advancing needle tip,^{9;22} which some speculate increases the likelihood of unwanted contact with nerves, vessels, peritoneum, pleura, or even meninges²³ (however, others have suggested that the consequent orientation of needle more along the long axis of the target nerve—as opposed to perpendicular—makes nerve penetration very unlikely, especially with a 17- or 18-gauge Tuohy needle). Practitioners often use a combination of tissue movement and “hydro-location” in which fluid is injected and the resulting expansion infers the needle tip location (either with or without color doppler flow).^{22;24} Some have suggested that for superficial catheters (e.g., interscalene and femoral), the consequent “longitudinal” orientation of needle with nerve makes precise visualization of needle tip less critical, as the needle tip tends to remain relatively close to the nerve if the needle tip is advanced beyond the ultrasound beam. However, for deeper nerves, this technique is not as straightforward as guiding the needle tip to a target nerve as in the in-plane technique described above, and may be more difficult to master (and, at times, nearly impossible).^{20;21}

Needle In-Plane and Nerve in Long-Axis Approach (Figure 1, Panel C)

Theoretically, this technique takes the benefits of both previously-described approaches, and harbors few of the limitations. The nerve can be viewed along with the needle shaft/tip, and the catheter monitored as it exits the needle parallel to the target nerve. The problem is in the execution: keeping three structures—the needle, nerve, and catheter—in the ultrasound plane is not only very difficult to learn, but difficult to execute even after mastery.²⁵ Until now, evidence of this technique's difficulties could be found only indirectly in the scarcity of published reports.^{25;26} However, in this issue of *Regional Anesthesia and Pain Medicine*, Wang and colleagues provide data from a well-designed randomized, observer-masked study demonstrating the difficulties of this approach.²⁷ Fifty patients had a femoral perineural catheter placed using ultrasound-guidance with an in-plane needle shaft. Half of the subjects had the nerve imaged in-plane as well (“long axis” view; Figure 1, Panel C), while the remainder had the nerve imaged in cross-section (“short axis” view; Figure 1, Panel A). For the long axis view group, catheters were advanced approximately 7 cm along the femoral nerve; for the short axis view group, catheters were advanced 2 cm past the needle tip, but then withdrawn 2 cm following needle removal leaving the catheter tip at the original needle tip perineural position.

For the long axis treatment group, the investigators had great difficulty in keeping the nerve, needle, and catheter all within the ultrasound plane, and “could not advance the catheters with real-time ultrasonographic visualization in the majority of the patients.”²⁷ They “had to resort to some maneuvers including changing the position and direction of the ultrasound probe, tilting the probe, shaking and mild withdrawal of the catheter, and injecting 2 to 5 mL saline to find the tip of the catheter.”²⁷ Even with these maneuvers, 10% of catheters could not be placed within 30 minutes, and the mean (SD) time for all insertions was 21 (8) min vs. 12 (3) min for the comparison group ($p < 0.01$). A difference of 9 min for placement was not only statistically significant, but clinically significant in many—if not most—*anesthesiology* practices, and combined with the increased variability (SD of 8 vs. 3 min), would often prevent perineural catheter insertion based simply on time constraints. There are additional limitations of the long-axis approach that preclude its use in multiple circumstances. To view the nerve in long axis, the nerve itself must be relatively straight; and there can be only one target nerve as opposed to multiple trunks or cords as found within the brachial plexus. All of these issues combine to make the needle in-plane, nerve in long axis technique the most challenging of the three approaches discussed above. However, this balance may change with advances in catheter and/or ultrasound technology in the future.²⁸

The limited length of an editorial precludes a discussion of multiple additional ultrasound-related issues, such as transducer selection, the concomitant use of nerve stimulation (an important tool in a subset of patients),⁴ and various methods for catheter tip localization.⁵ Although many proponents voice firm opinions based on their personal experience, little clinical data exists comparing aspects of any one placement technique with another. This editorial may-likely trigger a plethora of letters from practitioners sharing their approaches and experiences, and we believe the sharing of information can only benefit the evolution of perineural catheter insertion techniques. However, only by prospectively comparing various approaches will their relative benefits and drawbacks be truly revealed and the science of perineural infusion advanced. To this end we applaud the recent publication by Wang and colleagues,²⁷ and eagerly await the results of additional well-designed, randomized, controlled clinical trials, allowing the transition from an editorial highlighting a lack of answers, to practice guidelines based on prospectively-collected data.

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Figure 1.

Various ultrasound-guided perineural catheter insertion approaches: needle within the ultrasound plane and target nerve in cross-section or “short axis” (Panel A); needle out-of-plane and target nerve in short axis (Panel B); and both the needle and target nerve within the ultrasound plane (Panel C).

Figure 2. Placement needle visualization under ultrasound. A 17 gauge uninsulated Tuohy-type needle (Panel A; FlexTip, Arrow International, Reading, PA); and a 21 gauge insulated B-bevel needle (Panel B; Stimuplex, B. Braun Medical, Bethlehem, PA).