Needle and Transducer Manipulation: The Art of Ultrasound-guided Regional Anaesthesia

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INTRODUCTION

Successful regional anaesthesia can be summed up by the axiom “The right drug, in the right dose, in the right place”.1 The process of getting the drug to the right place has evolved from the routine elicitation of paraesthesia, to the use of peripheral nerve stimulation, and most recently, ultrasound (US) guidance. US guidance has revolutionised regional anaesthesia (or more specifically, peripheral nerve blockade [PNB]) because it is now possible to directly visualise nerves and their surrounding structures, the advancing needle, and the spread of local anaesthetic during injection. Yet even as the popularity of US-guided PNB grows, several reports have emerged of inadvertent neural or vascular puncture.2-5 Most of these can be ascribed to failure to fully appreciate the location of the needle tip during performance of the block. The objective of this article is to discuss the elements of needle and transducer handling that contributes to successful needle tip localisation during US-guided PNB.

VISUALISE NEEDLE, ULTRASOUND BEAM AND TISSUE INTERACTION IN THREE DIMENSIONS

It is important to appreciate that guiding the needle to the target involves manipulating the needle in three-dimensions, whereas the US image at any point in time is two-dimensional. Successful localisation of the needle tip is greatly aided by the ability to process the series of two-dimensional images acquired during scanning, into a three-dimensional mental image of how the needle, US beam and anatomical structures interact. With this image in the “mind’s eye” it is easier to interpret changes in visibility of the needle tip as it advances toward the target, and to know which transducer movements are required to optimise the view.

MAXIMISE NEEDLE VISIBILITY

The difficulties with ultrasonographic needle visibility have been covered in detail in another review.6 Most of the currently-available block needles were not designed specifically for use with ultrasound, and their smooth metallic surfaces function as specular reflectors, which mean that at steep trajectories, more of the ultrasound waves are reflected away from the transducer rather than towards it, resulting in poor visibility (Figs 1A and B).7 A shallow needle trajectory is therefore recommended where possible. Visibility is also improved by using larger-gauge needles; however this must be weighed against the greater tissue trauma, and possibly greater patient discomfort, associated with their use.

A common error when advancing the needle in-plane with the ultrasound beam is to mistake a portion of the shaft for the needle tip (Fig. 2). This can be avoided by ensuring that the needle bevel is face-up towards the transducer. In this orientation, the needle tip has a characteristic “double-echo” appearance that distinguishes it from the shaft and makes it easier to locate.
With the increasing popularity of US-guided PNB, manufacturers are now producing specialised echogenic needles (Fig. 1C). Most of these achieve their increased visibility by changing the surface of the shaft (texturing, dimpling, etc) to increase scatter of ultrasound waves back towards the transducer. Our expectation is that these will prove useful for the novice practitioner and when performing blocks that involve deep targets and steep needle trajectories.

**OPTIMISE NEEDLE-BEAM ALIGNMENT**

**Ergonomics**

Ergonomics contributes to good needle-beam alignment and visibility in two ways. Firstly, it minimises operator fatigue, which has been shown to be a common shortcoming amongst novices. Secondly, it improves the operator’s ability to control and coordinate the manipulation of both the transducer and needle whilst simultaneously looking away at the US screen. The patient should be elevated to a height that does not require the operator to bend over. The operator’s hands should be braced on the patient for support; this also steadies the transducer, which might otherwise slip in the gel on the patient’s skin. The US screen should also be placed in a location where it is visible without the operator having to turn their head or torso away from the patient, i.e. direct line-of-sight (Fig. 3). This last factor has been shown to have an impact on the accuracy of needle-to-target guidance.⁸
**Transducer Movement**

Needle visualisation in the in-plane approach requires alignment of the US beam with the shaft and tip of the needle. Novices often fail to appreciate that the diameter of a typical 22-gauge block needle is approximately 0.7 mm and that the width of the ultrasound beam is also measured in millimeters. Fine, controlled movements of the transducer are therefore essential for alignment.

The three basic transducer movements are sliding, tilting and rotating. Sliding the transducer across the needle is the most useful manoeuvre for aligning the US beam and the needle tip in both the in-plane and out-of-plane approach. Tilting is a less precise method of moving the US beam as the arc subtended by a given angle of tilt will vary with depth. Rotation is necessary in the in-plane approach if the needle and beam are tangential to each other rather than in line. It is also recommended that only the transducer be moved when trying to align it with the needle. Moving the needle when its tip is not visualised increases the risk of inadvertent tissue injury, whilst simultaneously moving the needle and transducer makes alignment more challenging.

**USE INDIRECT INDICATORS OF NEEDLE TIP LOCATION**

Despite the strategies outlined above, the operator will still often encounter difficulty in directly visualising the needle tip. However, the location of the needle tip can still be accurately determined by using several indirect indicators.

**Tissue Movement**

Small, gentle, repetitive needle movements create corresponding tissue movement at the tip that facilitates localisation. Jiggling the needle in-and-out in a staccato fashion works well for out-of-plane and in-plane approaches; the needle may also be tilted up-and-down in the in-plane approach. The risk of inadvertent puncture of nerves and blood vessels is minimal with these manoeuvres if short-bevelled block needles are used. One limitation is that tissue motion may be transmitted beyond the needle tip as well as along the needle shaft. This may make it difficult to precisely locate the tip, particularly in the out-of-plane needle approach.

**Tactile Feedback**

Practitioners familiar with landmark-guided PNB techniques will appreciate the importance of sensing fascial “clicks” or “pops” in determining needle tip location. Correlation of this tactile feedback with visual cues of needle advancement helps localise needle tip position, particularly with respect to fascial layers.

**Hydrolocation**

Hydrolocation involves rapid injection of a small amount of fluid (0.5 to 1 mL) to confirm needle-tip position by both tissue movement and the appearance of a small anechoic “pocket” (Fig. 4). Further injection of fluid also aids in opening up the space between anatomical structures (hydrodissection), thus creating an obstacle-free path for further needle repositioning. The needle tip is often accentuated as a bright echogenic structure within the dark anechoic pocket of fluid. Either local anaesthetic or 5% dextrose may be used as the injectate. The advantage of using 5% dextrose is that it preserves the motor response to subsequent electrical stimulation. There is also less “wastage” in the event that local anaesthetic is deposited distant from the target nerve.

**IN-PLANE VERSUS OUT-OF-PLANE NEEDLING TECHNIQUES**

**In-plane Needling Technique**

In the in-plane technique, the needle is inserted such that both shaft and tip lie in the same plane with the US beam.
A recommended approach when trying to visualise an in-plane needle is to start by sliding the transducer in a smooth, controlled fashion back-and-forth across the long axis of the needle. Small jiggling movements of the needle as described above will help with localisation. Once the needle is located on the US screen, the view should be optimised to provide the best possible view of the tip (usually recognisable by its double echo) and as much of the shaft as possible. This may involve sliding the transducer in very fine increments, or rotating it to bring the needle perfectly in-line with the beam. Tilting movements in the in-plane technique are only recommended if it is physically impossible to slide the transducer, as it is more difficult to make small incremental changes in beam position. As the needle is advanced, continual changes in transducer position are usually necessary to maintain an optimal view of the needle. If needle tip visibility is lost at any time, needle advancement should be halted until it has been located again, particularly when it is in close proximity to important structures, e.g. nerve, vessel, pleura.

**Out-of-plane Needling Technique**

In the out-of-plane technique, the long axis of the needle is at right angles to the plane of the ultrasound beam, and only its cross-section is visible at any time. The needle tip and shaft have very similar appearances, with the only clue being a more pronounced acoustic shadow deep to the shaft (Fig. 5). The danger here is mistaking a cross-section of the shaft for the tip, which will lie at a greater depth.

When trying to visualise the tip, the transducer should be slid back-and-forth along the long axis of the needle. Rotational and tilting movements are not usually helpful, although as always the operator should be cognisant that if the transducer is tilted to optimise the view of the nerve, this will change the position of the beam with respect to the needle too. Once again, the transducer should not be kept immobile as the needle is advanced; the transducer must be slid in the same direction to track the needle tip and keep it in view. While it can be difficult to directly visualise the needle tip on the US screen, its depth is readily ascertained by indirect indicators such as tissue movement and hydrolocation. These are invaluable aids in the out-of-plane approach and should always be used.
Some thought should be given to the site and angle of needle insertion with respect to the transducer. If the transducer is inserted some distance away from the transducer or in a relatively shallow trajectory, a greater portion of the shaft may potentially be imaged and mistaken for the tip (Fig. 5). It is therefore the author’s preference to insert the needle close to the transducer and at a steep trajectory when using the out-of-plane approach. The only time this is not recommended is if the target is very superficial, in which case the needle tip may not intersect the US beam before it reaches the target.

It would be inappropriate to recommend the exclusive use of either the in-plane or out-of-plane technique. Both have their advantages and limitations, and the choice will depend on the block being performed, on individual patient characteristics, and on the experience of the operator.

CONCLUSION

Successful US-guided PNB can be described in terms of two core competencies; first, “Know what you are looking at” and second, “Know where your needle tip is”. Knowledge of sonoanatomy and the interpretation of US images can be learnt through attending instructional courses, self-study and practice on volunteers. On the other hand, the ability to manipulate needle and transducer, and to accurately localise the needle tip, is very much a technical skill that must be largely acquired in clinical practice.

Hopkins, in a 2007 editorial in the British Journal of Anaesthesia, pointed out that US guidance has “the potential to produce successful nerve block with no complications secondary to needle misplacement in all cases”, and that any failures of efficacy or safety should be ascribed to “operator deficiency rather than a shortcoming of the technique”. While this last statement may not always be true, the inherent limitations of needle visibility can be minimised or compensated for by appropriate needle and transducer handling. Therein lies the art of US-guided regional anaesthesia.

REFERENCES


