Traditionally, the goal of peripheral nerve blockade (PNB) has been to deposit local anesthetic as close as possible to the nerve to ensure a successful block. It was once widely taught that needle–nerve contact was necessary for a reliable block (eg, “no paresthesia, no anesthesia”). However, it has become apparent that needle puncture, intraneural injection, and even simple contact of the nerve with the needle are potentially hazardous and can lead to histologic and clinical nerve injury.¹⁴ This recognition has resulted in a paradigm shift during needle placement from “as close as possible” to “close enough, but not too close.”⁵ This article reviews the monitors that are currently available to provide information about the relationship between the needle and the nerve during nerve block procedures.

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Nerve Stimulation

Electrical stimulation has been used for decades as a method for localizing nerves during PNB. Several clinical and animal studies have demonstrated that the distance from the nerve and the intensity of motor response are poorly correlated. That is, a needle tip can be placed intraneurally yet provoke no motor response. However, data consistently show that the presence of a motor response at a very low current (such as <0.2 mA) during PNB is highly specific for needle-nerve contact or intraneural needle placement and is associated with histologic injury. In other words, the absence of a motor response is not necessarily reassuring, but if a response is obtained at less than 0.2 mA, the needle likely is either intraneural or engaged in the epineurium and should be withdrawn (Figure 1). As such, we believe the value of nerve stimulation lies less in localization and more in ensuring the absence of a motor response during PNB.

Ultrasound

The introduction of ultrasound revolutionized the practice of regional anesthesia, allowing practitioners to visualize in real time the nerve and the needle as it approaches the target, as well as the spread of local anesthetic in a space or plane adjacent to the target. Despite its potential as a visual aid, successful use of ultrasound depends largely on the skill of the practitioner. Proficiency requires training, as well as good hand-eye coordination and 3-dimensional spatial reasoning.

Needle visualization is critical for safety; an in-plane approach to the femoral nerve has been shown to result in less needle-nerve contact than an out-of-plane approach (Figures 2 and 3). Observing the spread of local anesthetic during injection may help clinicians determine the proximity of the needle to the nerve. If the needle is close to the nerve, but not inside it, local anesthetic will be seen spreading around the nerve or within a sheath (Figure 4). However, intraneural injection may be visualized as swelling of the nerve itself.

Injection Pressure

Opening pressure (OP) is the pressure in the needle–tubing–syringe system immediately before the initiation of flow. It is independent of the dimensions of the syringe or needle, and is equal from the needle tip to the plunger. Once flow begins, however, pressure at the needle tip will vary based on factors including syringe/needle length and diameter, and compliance of the tubing. An OP greater than 20 psi during the injection of local anesthetic has been associated with intrafascicular injection and neurologic injury. Moreover, an inability to generate flow with a pressure of less than 15 psi was 97% sensitive for needle-nerve contact in a study of PNBs. As such, it is recommended that high-pressure injection be avoided.

Assessing OP by “hand feel” is both subjective and unreliable. Two objective methods for measuring injection pressure are the “compressed air injection technique” and commercially available in-line pressure manometers (BSmart, B.Braun Medical; Figures 5-7). Injection pressure monitoring is sensitive for detecting contact between the needle and nerve, and for intrafascicular placement of the needle tip. Yet it lacks specificity, as there are many other causes of high injection pressure, such as a blocked needle.

Conclusion

Three objective monitors can help regional anesthesiologists avoid intraneural injection. However, none is perfect: Ultrasound depends on the ability of the user; nerve stimulation is specific but not particularly sensitive; and injection pressure monitoring is sensitive but not specific. Because of the limitations of each of these monitors, we recommend that they be used simultaneously during PNBs to provide the most comprehensive protection possible against neurologic injury (Figure 8). We feel that approach is analogous to the simultaneous use of pulse oximetry, electrocardiography, and blood pressure and other routine monitoring during the administration of general anesthesia to avoid complications.

Figure 1. The use of electrical nerve stimulation to prevent needle–nerve contact and/or intraneural injection.

(A) Median nerve motor response with a “high” (0.48 mA) current intensity. (B) With the same needle position, the motor response is absent with a current intensity less than 0.2 mA, suggesting—but not proving—the needle tip is extraneural.
Figure 2. In-plane needle insertion.
The needle is directed from the lateral aspect of the transducer, in the same plane as the ultrasound beam. In the corresponding sonographic image in a phantom, the needle is seen approaching the target (*).

Figure 3. Out-of-plane needle insertion.
The needle approaches the beam at right angles. Therefore, only the small slice that crosses the beam is visible as a bright dot. (The asterisk marks the target.)

Figure 4. The spread of local anesthetic between the tibial (TN) and common peroneal (CPN) branches of the sciatic nerve.
Note that the structure of each component nerve is intact and the outer epineurium (dotted lines) has not been violated.

Figure 5. Compressed air injection technique.
A 20-mL syringe is filled with 10 mL of injectate and 10 mL of air. According to Boyle’s law, a compression of the gas by half of its original volume will double the pressure in the system (ie, increase the pressure at the needle tip by 1 atmosphere, or roughly 15 psi). Maintaining the gas bubble at greater than half of its original volume should therefore prevent injection pressures of greater than 15 psi.
References


