Avoiding intra-neural injections in peripheral nerve blocks

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In spite of the many published guidelines and expert opinions aimed at improving safety in regional anesthesia, fundamental research in this area continues to be necessary. Finding new techniques or applying different ways of working with established techniques remains a priority. Many suggestions for avoiding intra-neural injections during ultrasound-assisted PNB have been published in the anesthetic literature e.g. low current nerve stimulation, use of echogenic short bevel needles and/or the use of a pressure monitoring device. None of these techniques avoid intra-neural injections with certainty, even when used together. They only reduce the risk of piercing the epineurium and injecting into the fascicles.
At the same time, other researchers have looked at intentional intra-neural injections and have shown that these punctures do not invariably lead to nerve lesions. However, it is beyond question that an anesthetist would wish to cause nerve damage with functional deficit following PNB, even if most are transient. Multicenter studies and retrospective analyses have been published showing a comparable incidence of nerve lesions before the era of US, when nerve stimulation was widely in use. In the case of this rare complication, the difficulty of proving which technique might be the safer is mainly a methodological and statistical one. It is ethically unacceptable, even if previous studies have been performed on a limited number of patients, to propose large scale prospective randomized controlled trials in which intentional sub-epineural puncture and injection is compared to non-intra-neural injections. Multicenter studies trying to deal with the difficulty of recruitment, and especially retrospective analyses, are complicated by the problem of methodological variability and data acquisition. Furthermore, retrospective studies frequently review data collected over an extended time period, during which there are often concurrent changes to equipment and practice. This implies that the acquired data is not entirely comparable and only limited conclusions can be drawn. Also, adverse events during regional anesthesia are not always published. This leads to an undoubted under-reporting of complications. At this time, there are no clear guidelines on how and to where an adverse event should be reported. The literature, therefore, provides only a limited insight into the real incidence of nerve lesions with functional deficit, the duration of deficits and the mechanism by which they arise e.g. consequence of direct needle trauma and/or injection by the anesthetist or other causes during surgery. Unfortunately, we are unable to measure and show any statistically significant effect of a change in technique or method. In order to reduce the risk of sub-epineural injection, low current stimulation and pressure monitoring have been studied - especially in brachial plexus blockade, where there is a higher reported incidence of nerve lesions. In our clinical practice, common sense and practical experience made us try a tangential approach to peripheral nerves because we hypothesized that this might reduce the risks of sub-epineural injection. In order to investigate this, we simulated accidental intra-neural advancement of the needle in cadavers, using two different approaches i.e. tangential vs direct. The main difficulty in this study was objective evaluation of the results. We attempted to resolve this by filming the blocks and asking blinded experts to evaluate these recordings for sub-epineural injection. We then examined the concordance between these assessments and pathological microscopic examination of the specimens. The overall outcome of these evaluations indicated a moderate to almost perfect inter-observer agreement, according to the Landis and Koch classification. As a consequence of this, the tangential needle approach has now been added to the safety algorithm, along with US visualization, low current stimulation and pressure monitoring in an effort to reduce sub-epineural positioning of the needle tip and subsequent intra-neural injection. It seems that simulation of ultrasound-guided techniques on cadavers may be a useful solution circumventing the ethical problems of “real-world practice”. Furthermore, sufficient statistical power can more easily be achieved in these studies as multiple needle passes and injections are possible in the same specimen. The principle limitations of these studies, however, are the limited availability of human cadavers, the restrictive cost of obtaining cadavers for

training and the inability to perform a functional evaluation of the punctured nerve. Although animal studies may offer an alternative solution, ethical considerations and clinical relevance remain controversial issues. In the future, high resolution US-machines might help to perfectly distinguish the limits of the nerve (epineurium) and the different fascicles, but for the time being this is not currently the case. Karmakar et al. were able to define, using a high-resolution machine, the boundaries of the sciatic para-neural sheath i.e. the epineurium, and the epimysium, which surrounds the muscle compartment. This paper demonstrates the difficulty of distinguishing different layers when using currently available conventional, low resolution US machines – even in the thickest nerve of the human body. Whenever clinicians have the ability to visualize all the different layers in a nerve structure, they will be more readily able to detect post-puncture structural nerve lesions.

As previously indicated, direct intra-neural injection of local anesthetic does not invariably result in nerve lesions. Why? Seemingly, when looking at the histology of a nerve, the fascicular structure needs to be disrupted by the introduction of the needle and/or the subsequent injection, in order to cause a direct damage to axons. With the current use of short bevel needles, it seems difficult to perforate the quite firm and resistant perineurium. In addition, more proximal brachial plexus nerves tend to be more solid due to the presence of more axons concentrated in larger fascicles. Further distally in the plexus, the fascicles tend to be more dispersed in connective tissue, making it less probable that they will be directly contacted with the needle. However, damage of the extrinsic blood vessels present in the connective tissue surrounding the fascicles might lead to hematoma formation, or bleeding, both of which may result in nerve ischemia. Local anesthetics and their adjuvants might also decrease blood flow in these vessels, either by compression or by direct vasoconstrictive effects. This might be deleterious in a nerve with a pre-existing disturbed microcirculation, e.g. diabetic neuropathy. In conclusion: avoiding intra-neural injections seems to be an important safety recommendation, accidental intra-neural injection may not necessarily lead to lesions, and intentional intra-neural injection is certainly not necessary for clinical efficacy.

Reference

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