electively by a haematologist before any surgery or invasive procedure.

- Patients with acute illnesses such as sepsis or conditions that can be associated with a coagulopathy such as chronic liver disease.
- Patients on some anticoagulants. As anticoagulants, but not necessarily antiplatelet drugs, are stopped before operation for elective surgery, coagulation testing should only be required for emergency surgery. When surgery is performed on anticoagulated patients, appropriate testing can be useful in excluding over-anticoagulation at the time of surgery.

**Conflict of interest**

The authors have declared no conflicts of interest related to this editorial. Dr D.R. Spahn has provided a full declaration of interests that was published in *Br J Anaesth* 2010; 105: 103–5, doi: 10.1093/bja/aeq166.

**References**


**EDITORIAL II**

**Nerve location in regional anaesthesia: finding what lies beneath the skin**

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Regional anaesthesia always works—provided you put the right dose of the right drug in the right place. Thus began a 2005 editorial in this journal by Drs Denny and Harrop-Griffiths in which they emphasized that the secret to successful regional anaesthesia has always been, and will always be, the accurate placement of local anaesthetic drugs in the correct anatomical location. Within a year of the Czech-born Austrian ophthalmologist Carl Koller's first description of the use of cocaine for regional anaesthesia of the eye in 1884, the American surgeon William Stewart Halsted described a decidedly surgical approach to getting local anaesthetic solution to exactly the right place: he dissected out the fifth cervical nerve root and injected cocaine directly into it. In 1912, the German surgeon Georg Clemens Perthes was the first to describe the location of nerves by passing electrical current through a needle inserted intact skin. His prescient work was not developed further at that time, not least because of his own description of the technique as ‘far from being perfect’. The 1960s saw a resurgence of interest in electrical nerve stimulation as a way of identifying the location of nerves during regional anaesthesia. Greenblatt and Denson’s 1962 publication on this subject led to a wave of interest that culminated in the development of small and reliable nerve stimulators that allowed this technique to become the ‘gold standard’ for the performance of most peripheral nerve blocks by the 1980s.

The idea of locating nerves by percutaneous stimulation using commercially available nerve stimulators was raised in a 1993 publication that was followed by others that supported its use for nerve location in regional anaesthesia. One idea mooted was that a more accurate placement of a block needle could be achieved with the use of a jig-like, purpose-built device that would pass the needle alongside—or even through—the tip of the stimulating electrode that had identified the likely position of the nerve by evoking characteristic muscle contractions. Although the results of these studies were outwardly encouraging, little was done to verify that the ability to elicit provoked muscle contractions from a target nerve with low currents with a stimulating electrode placed on the skin implied that the electrode was directly over the nerve, that is, few asked the question whether the ease of electrical stimulation translated to anatomical proximity, and in particular whether a low current threshold for provoking contractions implied that the nerve was superficial.

The study reported by Wegener and colleagues in this issue of British Journal of Anaesthesia sheds some light on the relationship between percutaneous electrode guidance and the anatomical reality that lies beneath the skin, and which can be revealed by modern ultrasound imaging devices. The authors used a transparent film perforated in a grid-like fashion and placed over the interscalene groove of volunteers. A pen-shaped electrode was used to stimulate the underlying nerves through the perforations and the threshold currents needed to provoke muscle contractions were measured. Using high-resolution ultrasound imaging, the depth of the most superficial nerve structure in the area, usually the fifth cervical nerve root (C5), and the distances between this structure and the stimulating points were measured. Correlations between the stimulation thresholds and both the depth and distance from the stimulating points were then calculated. The results of this study are predictable and intuitively correct, but nonetheless valuable. In only 10% of recordings did the skin location at which the stimulating current was the lowest match identically to the skin location that was anatomically closest to the nerve supplying the muscles that were seen to contract. The electrical properties of different biological tissues vary widely, and therefore the ‘electrical anatomy’ beneath the stimulating electrode is likely to differ markedly from the real or ultrasonographic anatomy. The authors correctly conclude that percutaneous electrical nerve stimulation is not a reliable clinical technique for nerve location.

Wegener and colleagues studied only one anatomical region, but their choice of the skin overlying interscalene groove was both logical and supportive. The C5 nerve root in the area of the posterior interscalene groove is usually a very superficial structure and its localization with percutaneous electrical stimulation should be relatively easy. However, even in this area, with little tissue lying between the stimulating electrode and the target nerve, the ability to ‘map’ nerves accurately with percutaneous stimulation is considerably poorer than with ultrasound. It is reasonable to presume that in other anatomical regions, where the nerves lie deeper and where more tissue of greater variety lies between the electrode and the target nerve, the correlation will be poorer.

The results presented by Wegener and colleagues echo those reported by Weintraud and colleagues. They performed ilio-inguinal and ilio-hypogastric nerve blocks using a landmark-based method, and examined the spread of local anaesthetic solution using ultrasound imaging. In only 14% of their cases was the local anaesthetic delivered in an anatomically correct location around the target nerves and between the internal oblique and transverse abdominal muscles. It is of interest that the block failure rate in the study was only 45%, much lower than the rate of 86% that might have been deduced from the ultrasound findings. Thus, administration of local anaesthetic solution in anatomical structures near to nerves can be associated with block success, and this may be particularly so if relatively large volumes of local anaesthetic are used (they used 0.3 ml kg⁻¹). Wegener and colleagues did not proceed to confirm their theoretical findings by giving real blocks, and we can only speculate about the success rate of interscalene brachial plexus blocks guided by percutaneous nerve stimulation. A 100% success rate for interscalene blocks guided in this way has been claimed but the report described only three such blocks.

It is axiomatic that a detailed knowledge of anatomy is a prerequisite for the successful and safe performance of regional anaesthetic techniques. Knowledge of the frequency
and extent of anatomical variation is also useful. The anatomy of the brachial plexus at the posterior interscalene groove is highly variable,\textsuperscript{10} and direct visualization with ultrasound is the only bedside method that can identify these variations. There are no data that indicate to what extent anatomical variations influence individual block success, but experience of a very large number of ultrasound examinations of the upper brachial plexus suggests to us that a large proportion of failed blocks are likely to be due to aberrant anatomy. Accordingly, it seems reasonable to assume that ultrasound imaging during block performance should be associated with higher block success rates.

There is, therefore, evidence that landmark-based techniques are poor locators of nerves, and that percutaneous electrical nerve stimulation is also a poor locator of even superficial nerves. However, high success rates with landmark techniques, and perhaps with techniques guided by percutaneous nerve stimulation, can be achieved. This is probably due to the large volumes of local anaesthetic commonly used before the advent of ultrasound-guided regional anaesthesia which promotes extensive spread of local anaesthetic and thus overcomes the anatomical inaccuracy associated with older nerve location techniques. However, we would argue that the safety of regional anaesthesia is enhanced by the use of the smallest mass of local anaesthetic drug compatible with adequate efficacy and high success rates. Mirroring the success of the manufacturing principles that led to ‘lean manufacturing’,\textsuperscript{11} we would like to suggest the assonantal concept of ‘lean regional anaesthesia’—an approach that seeks to make the drug masses used for nerve blocks as lean as is practicable. Several recent studies have shown that single-nerve blocks and techniques that use multiple-nerve blocks can be safely and effectively achieved with very low volumes of local anaesthetics.\textsuperscript{12–14}

As little as 0.7 ml of local anaesthetic solution need be used for blockade of the ulnar nerve in the forearm.\textsuperscript{12} Even if doses two or three times this volume are used in everyday clinical practice, a significant decrease in the mass of local anaesthetic when compared with volumes given traditionally can be achieved. This is probably due to the large volumes of local anaesthetic commonly used before the advent of ultrasound-guided regional anaesthesia which promotes extensive spread of local anaesthetic and thus overcomes the anatomical inaccuracy associated with older nerve location techniques. However, we would argue that the safety of regional anaesthesia is enhanced by the use of the smallest mass of local anaesthetic drug compatible with adequate efficacy and high success rates. Mirroring the success of the manufacturing principles that led to ‘lean manufacturing’,\textsuperscript{11} we would like to suggest the assonantal concept of ‘lean regional anaesthesia’—an approach that seeks to make the drug masses used for nerve blocks as lean as is practicable. Several recent studies have shown that single-nerve blocks and techniques that use multiple-nerve blocks can be safely and effectively achieved with very low volumes of local anaesthetics.\textsuperscript{12–14}

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Landmark-based techniques make assumptions about the nerves that lie beneath the skin, which we now know are often inaccurate. The study by Wegener and colleagues shows that although percutaneous nerve stimulation was thought to provide a more accurate anatomical assessment of the location of nerves below the skin, it too is frequently inaccurate for even the most superficial of nerves. Ultrasound imaging remains the optimal method for determining the often variable anatomy of nerves and nerve plexuses and, in the opinion of the authors, is likely to be the only realistic way of achieving the ‘lean regional anaesthesia’ that should be associated not only with cost-effectiveness but also with enhanced patient safety.\textsuperscript{15, 16}

Conflict of interest
None declared.

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