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"I would have everie man write what he knowes and no more."—Montaigne

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Editorial I

Ultrasound-guided nerve blocks

The ideal in the practice of regional anaesthesia would be the ability to deliver precisely to the target nerve exactly the right dose of local anaesthetic without incurring any risk of damage to the nerve or its related structures. Currently, we aim to achieve this by using needles and catheters, guided mostly by knowledge of anatomy supplemented by electrical nerve stimulation or the elicitation of paraesthesiae. Knowledge of anatomy takes the needle to the general area of the nerve and helps avoid other structures. The specific nerve location technique allows a close approach, hopefully without the risk of nerve damage. Unfortunately, this is essentially a blind process, but modern imaging techniques might be used to overcome this. Ultrasound-aided nerve blocks have been reported in the anaesthetic literature since 1978, with an increase in interest from the mid-1990s, probably as a result of improvements in ultrasound equipment. One such study appears in this issue of the journal, and implies that there is a case for routine use of ultrasound in regional anaesthesia.[1] We consider whether this is correct.

Most of the studies of ultrasound in regional anaesthetic practice have looked at one or more of the various approaches to the brachial plexus, some using ultrasound to identify and mark the skin over blood vessels and others using it to guide the needle or catheter to the nerve. Ultrasound has also been used to visualize the spread of local anaesthetic from a catheter and to validate currently used landmarks. In 1978, La Grange and colleagues[2] reported the use of a Doppler ultrasound device to aid identification of the subclavian artery and vein before brachial plexus block by the supraclavicular approach in 61 patients. Their success rate was 98% and there were no complications. Other authors[3 4] used Doppler ultrasound to identify and mark the location of the axillary artery for brachial plexus block in patients whose axillary artery was impalpable. In 1988, Vaghadia and Jenkins[5] described the use of Doppler ultrasound in three patients for intercostal nerve block. Again, Doppler ultrasound was used to identify the relevant arteries before marking the skin for injection. The authors felt that the advantage was location of the ribs by a less painful and a more accurate method (in obese patients) than palpation.

In 1989, Ting and Sivagnanaratnam[6] used ultrasound to confirm placement of a cannula in the axillary sheath and to demonstrate the spread of local anaesthetic in 10 patients for forearm or hand surgery. The cannulae were placed without ultrasound guidance by palpation of the artery and feeling for a click on entering the sheath. In this small study, the block was successful in all subjects and no paraesthesiae or vascular punctures occurred. A larger study, involving 40 patients, was performed by Kapral and colleagues,[7] who used ultrasound to guide placement of cannulae within the brachial plexus sheath and to confirm the spread of local anaesthetic in both axillary and supraclavicular approaches. Spread of anaesthetic was also confirmed radiographically. Again, all the blocks were performed without damage to vessels or nerves (although there was no mention of long-term damage) or, especially, the pleura. Satisfactory block was achieved in all but one patient in each group of 20. Despite correct placement of the cannulae within the sheath in each group, only 75% of the patients in the axillary group achieved satisfactory blockade of the musculocutaneous nerve. The authors commented that the advantages of ultrasound guidance were that it showed directly the effect of over-abduction of the humerus, which compresses the axillary vessels and could interfere with the proximal spread of the anaesthetic, and that it allowed 'relatively small volumes of local anaesthetics' to be used. Güzeldemir and Üstünsöz[8] in 1995 described the placement of a catheter under ultrasound guidance for continuous axillary brachial plexus blockade in one patient, confirming the location by digital subtraction radiography.

Two ultrasound studies of the brachial plexus were reported in radiology journals in 1998. Sheppard and colleagues,[9] while not specifically describing ultrasound for nerve blocks, evaluated the ability of ultrasound to visualize components of the brachial plexus, using MRI as a guide to background anatomy. They described the plexus nerves as having a hypoechoic appearance, with thin hyperechoic rims which were tubular on longitudinal scans and oval to round on transverse scans. They also felt that colour Doppler was essential to prevent the confusion of nerves with small blood vessels. Yang and colleagues[10] looked at the anatomy of the brachial plexus under ultrasound and subsequently used it to guide the placement of catheters for interscalene and supraclavicular blocks (16 and four patients respectively) before arm surgery.

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Radiography and computed tomography (CT) were then used to confirm catheter placement and the spread of contrast material before injection of 1% lidocaine 30 ml with epinephrine 1:200 000. Surgery commenced 20 min later. Despite x-ray and CT confirmation of correct catheter placement in all patients, the success rate was only 60% for surgery, although the postoperative analgesia rate was 100%.

Ootaki and colleagues[11] reported a study using ultrasound guidance for infraclavicular block in 60 patients as anaesthesia for upper limb surgery. Their success rate was 95%, meaning that all but three patients underwent surgery with no further anaesthetic or analgesic. None of the patients required a general anaesthetic. Their success rate was similar to that reported in larger studies by Raj and colleagues[12] and Kilkaand colleagues,[13] and there were no complications other than paraesthesiae in three patients. The advantage of ultrasound in avoiding pneumothorax was apparent, because Ootaki and colleagues were able to see the needle, pleura and lung and to place the needle accurately either side of the subclavian artery for local anaesthetic injection. The brachial plexus was not stated as having been identified in this study.

Greher and colleagues[1] have added to our knowledge of anatomy in relation to nerve blocks by using ultrasound to identify the brachial plexus in the infraclavicular region in order to assess the accuracy of existing landmarks used for infraclavicular vertical plexus block. It is of interest and importance that their study indicates that these landmarks are not ideal in all sizes of patient, and may decrease the margin of safety by allowing the close approach of a needle to the pleura and vessels. Their recommendation is that ultrasound guidance be used when performing this block or that their modification of the anatomical landmarks be used if ultrasound is not available.

Lower limb nerve block using ultrasound was investigated in two studies of the 3-in-1 technique by Marhofer and colleagues in 1997 and 1998. In the first,[14] ultrasound guidance was compared with nerve stimulator guidance, and the onset time and quality of the block were assessed in 20 patients in each group. There was no mention of blinding of the assessor to the method used. The onset time of the 3-in-1 block was significantly shorter (16±14 *vs* 27±16 min, $P<0.05$) and quality, on a percentage scale (100% representing uncompromised sensation), was significantly better in the ultrasound group (15±10% of initial value *vs* 27±14% of initial value, $P<0.05$). Sensory block of each nerve (femoral, lateral cutaneous of the thigh and obturator) was assessed, and the results indicated that the ultrasound group achieved a complete 3-in-1 block in 95% of cases compared with 85% in the nerve stimulator group. Interestingly, the femoral nerve could not be identified in three of the patients in the ultrasound group. Two of these patients each had a large fracture haematoma and one of the three patients subsequently had an inadequate block. The blocks were not intended for surgical anaesthesia, but were performed for analgesia before spinal anaesthesia for surgery. In the second of their studies, Marhofer and colleagues[15] investigated whether ultrasound guidance in the 3-in-1 block affected the dose of local anaesthetic required. They compared three groups of 20 patients each: one ultrasound guided group using 0.5% bupivacaine 20 ml, and two nerve stimulator groups using 0.5% bupivacaine 20 ml and 30 ml respectively. The study was identical in other aspects to their previous one, and the overall success rate, as defined by loss of sensation to 30% of the baseline response, was 95% in the ultrasound guided patients and 80% in each of the other groups.

The literature also reports ultrasound-guided/aided/assisted nerve blocks of the coeliac plexus, stellate ganglion, psoas compartment, pudendal nerve, prostatic nerve and others. It is also worth mentioning that ultrasound has been used to assess the depth of the epidural space[16] and to assess the lumbar epidural space during pregnancy.[17] One of the present authors (DGS) has used ultrasound to examine the anterior approach to the sciatic nerve in conjunction with an as yet unpublished MRI study. He found that the sciatic nerve could not be identified, although the femoral vessels close to needle insertion were identifiable, as was the lesser trochanter. The use of ultrasound to avoid structures in conjunction with nerve stimulation to locate the nerve could be appropriate in this block, although this has not been reported.

From all these studies, it appears that ultrasound can be a useful aid whether it is used to locate arteries, to mark the skin for unguided blocks or as a real-time guide of needle or catheter position relative to the nerve or related blood vessels, and can be used to define the spread of local anaesthetic. However, it is interesting to note that, even with the ability to establish that the needle or catheter is close to the nerve, or within its sheath, and then to observe the spread of local anaesthetic, there is no guarantee of an adequate nerve block.

Modern clinical ultrasound equipment typically operates in the 2.5–20 MHz frequency range. The higher the frequency the better the spatial resolution, but at the expense of reduced depth penetration. Lower frequencies provide better depth penetration but at lower spatial resolution. Additional features, such as pulsed-wave and colour Doppler imaging, allow the indentification of vessels and the blood velocities in those vessels. Modern ultrasound equipment is cheaper and more portable and produces better-quality imaging than that used in previous studies. State-of-the-art diagnostic ultrasound equipment has multiple probes and software packages, and costs from £100 000 to £150 000. But a modern portable ultrasound machine, which might be used for regional anaesthesia and peripheral arterial and central venous cannulation, would have a single variable-frequency linear array transducer (5–10 MHz), be the size of a portable defibrillator and cost approximately £15 000.

Should anaesthetists use ultrasound to guide needle insertion in nerve blockade?

The simple answer is 'yes', on the basis of the results of the studies mentioned and, to a certain degree, on common sense. It can be argued that it is better to use the best equipment available to actually identify structures rather than to infer their position from surface anatomy and older nerve location methods. However, the complicated answer is 'it depends'. It depends on what type of nerve block is planned, on what the complications are and on the individual's personal experience. Thus it may be of use in certain blocks for which the complication rate is high or the complications are more serious, such as brachial plexus blocks. It might be considered particularly appropriate when performing nerve blocks in anaesthetized patients, such as children. It could also be of use in other blocks, such as the 3-in-1 block, for which it has been demonstrated that the success rate is higher using ultrasound and that the dose of local anaesthetic required is lower. Teaching and training is another obvious important application of ultrasound in regional anaesthesia.

Could any anaesthetist, with minimal training, use ultrasound to visualize the needle during a nerve block?

In three of the studies described above, one person performed all the blocks, but in the others there was no mention of different researchers performing the blocks. The next stage would be to look at the use of ultrasound by a number of different anaesthetists using modern, affordable and portable equipment in a typical clinical setting.

Is the combination of ultrasound and nerve stimulation the 'dream ticket' for those who practise regional anaesthesia?

It appears that the use of ultrasound can help prevent accidental puncture of blood vessels and the pleura, but that it does not prevent paraesthesiae.[10] The use of a nerve stimulator avoids the need to elicit paraesthesiae and has been claimed to reduce nerve damage, although this is contentious.[18] Certainly, the use of a nerve stimulator does not eliminate the risk of nerve damage. Using ultrasound might help prevent nerve damage, but this hypothesis remains to be tested.

In summary, we have a technique for peripheral nerve identification which is being used increasingly in research and appears to offer better accuracy and safety, but is technology-dependent and expensive. The high cost will limit its immediate general availability, but continued technical development and cost reduction will change this ultimately. Any method that offers even the possibility of improved accuracy in identifying the positions of the nerves we wish to block and of structures we do not wish to damage must continue to be evaluated.

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