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INVITED COMMENTARY

Ultrasound-guided vascular access

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This Invited Commentary accompanies the following article:
Lamperti M, Biasucci DG, Pittiruti M, *et al.* European Society of Anaesthesiology guidelines on perioperative use of ultrasound for vascular access (PERSEUS vascular access). *Eur J Anaesthesiol* 2020; **37**:344–376.

In the current issue of the *European Journal of Anaesthesiology*, a comprehensive guideline sets out the evidence base and recommendations for ultrasound-guided vascular access.[1] It is long, and perhaps best used by reading the summaries and then entering the sections of interest for more detail, rather than trying to read it in its entirety.

The guideline gives strong support for ultrasound guidance for all routes of access including where a superficial vessel under the skin cannot be directly visualised or palpated. There are very few properly conducted studies showing that appropriately used ultrasound does not improve efficacy and safety. In the writer's centre ultrasound is used for almost all central venous access procedures, is increasingly used for femoral arterial access, and commonly used for peripheral venous and arterial access in the more challenging case. It is debatable whether ultrasound will become routine for peripheral access, and whether other technologies, like near infrared imaging, could replace ultrasound.

Throughout the guideline it is emphasised that, apart from the internal jugular vein, there is a lack of strong evidence from randomised trials for most aspects of vascular access in adults and children. This lack of evidence also applies to training. It may be generally accepted that if the technology works at one site of vascular access, it is very likely to prove effective at other sites, where the vessel cannot be easily visualised or palpated directly. There is potential for a very wide range of permutations of techniques at the different sites.

Useful comparisons can be made with the introduction of other perioperative technologies, such as, pulse oximetry, and capnography, which are now used routinely in well resourced hospitals to improve safety, despite a lack of level 1 evidence of benefit. It is accepted that further trials against historical techniques, is neither ethical nor well tolerated. Older generations will recall initial discussions about capnography ('why is it needed when I saw the endotracheal tube in the larynx'), and pulse oximetry ('I can see when a patient is cyanosed'). Similar caveats may apply to ultrasound guidance; it may be neither ethical, practical nor necessary to conduct controlled trials for every route of access in every group of patients.

In its early years, ultrasound use was only in the context of large machines restricted for use in the X-ray department. An alternative was to use a fluoroscopy-guided needle technique; using bone landmarks or injection of X-ray contrast upstream to provide a contrast-enhanced vessel. Then small portable ultrasound devices with limited resolution became available, typically bought by charitable funds. Initially, these machines were generally used for difficult/failed central line procedures and then some began to use them routinely, especially for long-term venous access procedures.[2] These latter procedures often failed with landmark techniques because of blocked central veins. Despite enthusiasm from early adopters of ultrasound, there was a lack of evidence for, and widespread resistance to their routine use, and the writer never won a pro con debate at conferences. In the UK, it has taken at least 15 years to implement national guidance,[3] but disagreement continues. A snapshot of contemporary opinion is provided in a UK anaesthetic newsletter.[4]

In well resourced countries, today's generation of practitioners use ultrasound routinely and have not been exposed to the difficulties and dangers of landmark techniques, which, consequently, leads to issues with teaching and retention of landmark skills. The latter may still be needed in emergencies, in out-of-hospital

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procedures, and in low-resource countries.[5] Nevertheless, in the UK, in a medicolegal setting, it is now difficult to defend complications, which could have been avoided by the use of ultrasound.

Ultrasound enables the use of puncture sites away from the traditional landmark-guided sites. These sites offer potential advantages beyond the actual needle access. Good examples include the use of a more lateral approach to the axillary vein rather than a subclavian site, peripherally inserted central catheters (PICC/midline) in the mid upper arm away from the elbow flexure, mid forearm radial artery cannulation away from the wrist flexure and superficial femoral artery/vein puncture more distal than the groin.

Ideally, operators should have ultrasound skills to enable well tolerated cannulation at all commonly used sites (e.g. peripheral, upper arm, neck, subclavian, femoral) to allow an optimal choice for each patient, indication and device. Evidence is starting to accumulate to guide the choice of access sites; for example, for long-term venous access a more central route of access may be favourable in terms of infection and thrombosis compared with PICC placement.[6]

The guidelines do not comment on standards and specifications of ultrasound devices and related equipment.[1] Modern machines offer high resolution suitable for all types of commonly performed vascular access, nerve blocks and other relatively superficial procedures. However, linear higher frequency (e.g. 7–13 MHz) probes typically used, are not suitable for imaging of the heart and intrathoracic structures, for example, for catheter tip location and pericardial imaging. A separate lower frequency curvilinear probe (echocardiography type) is needed, which may be unavailable outside ICUs and specialist cardiac theatres/imaging suites.

High resolution allows imaging of equally important adjacent at-risk structures; arteries, veins, nerves, pleura and others. In central venous access, it is generally more important to avoid collateral damage rather than cannulate the vein at the first attempt. Older small screen, low resolution devices are still in use in many centres; these will not adequately show needle tip position, thrombus, nerve bundles, or arterial branches. Ultrasound images, which may be diagnostic as well interventional, are not being saved in any reliable retrievable archive in most centres, which is not acceptable by radiology standards.

Needle visualisation is important, with a large number of aids available. These include: disposable and nondisposable needle guides, ultrasound beam adjustors, echo tip needles and automatic aspiration devices. Although these have plausible advantages, they have not entered main steam practice, and all add to the cost of procedures. A major advantage of ultrasound is that, beyond the initial purchase and ongoing maintenance and training costs, there is little additional cost per procedure apart from sterile gel and protective sleeves (often too short for optimal sterility). There are studies citing cost effectiveness assessed by a number of measures, including; complications, operator and theatre time and waste of expensive disposable equipment.

Training is well covered in the guideline.[1] Ultrasound guidance requires significant skills, which some find easier to acquire than others. The learning curve may be long to achieve expert skills, and operators still need other skills to complete all procedural steps. There are various scoring systems to predict the difficulty of peripheral venous access and these could be refined further for central access. The variable anatomy of veins and arteries is less well recognised outside of vascular or reconstructive surgery. Common variations include high bifurcation of the radial and ulnar arteries in the upper arm with corresponding variance in brachial veins, dominance of one internal jugular vein on the left or right, arterial branches in front of the axillary artery (thoracoacromial trunk) or behind internal jugular vein (thyrocervical trunk).

Some limitations are discussed below.

Gaining vessel access: Ultrasound guidance and operator skills are not the only variables to determine success. Small collapsible mobile target vessels, or thickened vessel walls or perivascular sheaths with vulnerable arteries (main trunk or branches) or nerves (either in front or behind) may be difficult to access safely with the standard needles provided in kits. Many vascular access needles are relatively blunt, and this varies between kits and manufacturers. First pass safe access may be helped with smaller bore, sharper tipped, 20-gauge needles with finer more flexible guidewires, a small dilator and introducer sheath. The latter is designed to pass a standard 0.038″ guidewire, which is then used to complete the procedure. So-called 'micro-type' kits are available, but similar needles, guidewires and catheters can be found in arterial line sets and radial artery access kits (6 Fr) as used by cardiologists for coronary interventions. Soft flexible nitonol tipped guidewires are very helpful in more challenging cases for initial access and central positioning. The use of multiple serial dilators (e.g. 6, 8, 10 and 12 Fr) rather than trying to insert one large dilator (e.g. 12 Fr), improves safety and reduces discomfort, particularly if there is scarring from previous access or injury.

Catheter tip guidance and confirmation: The guideline strongly supports of the use of ultrasound for catheter tip position confirmation when other techniques like ECG, electromagnetic or X-ray guidance are not available.[1] Whilst such techniques are now well described, and work for enthusiasts and experts in the trial situation, their true practicality is still uncertain and in development. This may reflect practical sterility issues for a single-handed

operator, lack of cardiac type imaging skills or appropriate machines and probes.

Recognition and management of complications: Ultrasound is excellent for recognition of pleural or pericardial collections, once they occur, but, usually, it will not demonstrate the site of central vessel damage. Ultrasound does not usually allow the path of misplaced central catheters to be accurately determined, nor can it predict whether it is safe to remove them.[7,8]

In the case of actual or suspected complications, I would encourage early use of ultrasound to identify pleural and pericardial complications, but not rely on it to guide management of misplaced catheters, bleeding or other problems. The catheter point of entry, course and exit from the circulation, need to be identified to guide further management.

Definitive diagnostic imaging needs computed tomography (CT) angiography or fluoroscopy with injection of contrast down the catheter to verify its position in the venous system, mediastinum, arterial tree, pleura or pericardium. Urgent referral to the appropriate specialty is vital for favourable outcomes, for example, cardiovascular surgery, cardiology or interventional radiology.

Ultrasound guidance for vascular access is now well established. Future investigations should seek to further refine equipment, training and procedures to maximise patient benefits.

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