Ultrasound guidance is now the standard of care for peripheral regional anaesthesia, and central venous access. A basic understanding of physics is required to optimise image acquisition and needle guidance.

Ultrasound (US) is sound energy greater >20,000KHz with most commercial US systems operating in the 2MHz- 18MHz range. US waves are generated by piezo electric crystals which act as both transmitters and receivers of the sound wave. Application of a voltage to the crystal causes a conformational change generating a mechanical vibration and in turn a sound wave. Conversely when the same crystal is subjected to the mechanical vibration of a soundwave a voltage is produced - the magnitude of which is proportional to the magnitude of the returned soundwave. Image generation is dependent on the pulse echo technique – the time taken for a soundwave to travel to an object and return is measured. Multiplying this by the tissue conduction velocity (average 1540 ms⁻¹) and dividing by 2 gives the distance to travel through muscle to the target. The most popular technique is in-plane (IP) where the whole length of the needle may be visualised, or out of plane (OOP) where only the needle tip is visible. The choice of IP or OOP guidance is dependent on operator experience and preference, puncture site access and the local anatomy at the block site. There is limited evidence in the literature to recommend one technique based on complications and outcome 1,2, although limited evidence suggests OOP approaches can be marginally more comfortable for the patient, largely related to a reduced distance to travel through muscle to the target. The most popular guidance technique in clinical practice is the short axis in-plane technique.

The angle of insonation to the target structure is crucial to the quality of the image generated, and the ability to depict both the target structure and the needle. The needle orientation may be in-plane (IP) where the whole length of the needle may be visualised, or out of plane (OOP) where only the needle tip is visible. The choice of IP or OOP guidance is dependent on operator experience and preference, puncture site access and the local anatomy at the block site. There is limited evidence in the literature to recommend one technique based on complications and outcome 1,2, although limited evidence suggests OOP approaches can be marginally more comfortable for the patient, largely related to a reduced distance to travel through muscle to the target. The most popular guidance technique in clinical practice is the short axis in-plane technique.

Several basic scanning techniques are routinely performed to optimise the ultrasound image, summarised by the acronym PART. Pressure (P) ensures good skin contact between the probe and the skin, and by compressing the soft tissues reduces the depth. This in turn makes structures not only more accessible but also reduces beam attenuation. Alignment (A) is the physical act of moving the transducer to ensure that the area of interest is in the field of view. Rotation (R) of the probe is used to generate a true short axis view of the target structure. Tilt (T) is the act of tilting the probe, thus changing the angle of insonation to maximise the reflected ultrasound energy.

The choice of needle insertion point is crucial to the ability to generate a good image on the screen. For IP imaging needle insertion immediately adjacent to the probe allows a high range of needle motion but generates steep angles which reduce reflection to the probe. A more lateral insertion reduces the needle angle relative to the probe and produces the highest signal return, with the optimal point for visualisation being when the needle is parallel to the probe head. This position may be impossible to achieve in practice due to constraints of the block site, and presence of other anatomical structures in the needle path. Additionally, very lateral needle insertions generate a degree of tethering from the tissues above which may restrict needle redirection. As the needle is advanced care should be taken to ensure the tip remains in
Abstracts

view at all times - lateral tilt of the probe and rotation may be required during scanning to achieve this.

OOP imaging requires the operator to dynamically tilt the probe to maintain the angle of insonation relative to the needle tip as the needle is advanced. The operator should follow the tip as it is advanced to avoid misidentifying a cross section of the shaft as the tip. The manoeuvres to achieve this may in turn compromise the view of the target nerve. Accurate needle tip tracking can be challenging, especially for novices, and secondary methods of tip localisation may be helpful. These include following movement of the surrounding tissues as the needle is advanced, the hydrolocalisation technique and the use of peripheral nerve stimulation. Hydrolocalisation refers to the injection of small quantities (0.5–1ml) of liquid as the needle is advanced to help locate the needle tip.3

Before needle insertion the operator should choose an appropriate site that will maximise the chance of success – this is not just dependent on the clinical indication, but also the influence of the patient’s body habitus and individual anatomy on signal return. The ability to place the probe footprint at the intended block site and obtain good conduction may be limited in frail, cachectic patients or by wound dressings. Obesity may make the working depth unfeasible and degrade image quality. Tissue oedema may generate unacceptable artefact.

A pre-block scan should be performed to delineate the sonoanatomy and provide a tactical overview of where best to insert the needle, allowing for the variables previously mentioned. Common potential hazards lying in the needle path should be looked for and excluded. These include the dorsal scapular and long thoracic nerves, one of which may lie in the path of an IP interscalene approach in up to 83% of cases4, the transverse cervical and dorsal scapular arteries which may complicate supravacular block5 and proximal branches of the femoral artery affecting femoral nerve block6. Reducing probe pressure, and the use of colour doppler may help reveal previously unseen vascular hazards. The operator should also be aware of the many artefacts that may affect the ultrasound image and how to mitigate them.7

Prior to needle insertion the operator should consider the needle end point, as this will influence needle trajectory and insertion point. Selecting an insertion point incompatible with good needle visualisation is a common novice error.8 The target area should be placed in the centre of the screen as this is where most US systems focus the beam and where lateral resolution will be optimal. Historically there has been a tendency to place the needle tip as close as possible to the target nerve whilst staying perineural. Increasingly there is a realisation that we may overestimate our ability to accurately determine the needle tip and such close placement may increase the risk of intraneural injection. Acceptable success rates can be achieved by choosing an end point further from the nerve.9 Increasing use is also being made of falcine planes and sheaths that may help channel the local anaesthetic around the nerve. A hydrodissection technique can help push structures out of the way and also localise the needle tip. The needle should be angled tangentially aiming towards the poles of the target nerve – this will help minimise the risk of intraneural injection.10 The needle should never be advanced without visualising the tip – failure to observe this rule is one of the most common mistakes made by novices.8 Nerves are commonly enveloped in the fascia of the surrounding muscles and when this is breached the image should be re-optimised to ensure that the nerve is not tethered on the needle.

Ergonomics can help ensure needling success – the optimum arrangement has been shown to be with the screen directly ahead of the operator11 and with both the probe and needling hand in-line with the screen.12

Technical advances to both the needle and the ultrasound machine can help improve needle visualisation. Echogenic needles with laser etching present many more reflective faces perpendicular to the ultrasound beam, increasing needle visibility at steeper insertion angles13 and consequently reduce procedural time. Some manufacturers offer proprietary software algorithms and beam steering technology to enhance needle visualisation at steeper needle angles. Add on needle guidance positioning solutions comprising external electromagnetic-emitting devices coupled with sensors in the needle also exist. Whilst technology can make needle guidance easier it does not relinquish the operator of the need to follow good basic principles.

REFERENCES


A58
51-year-old male patient presented with multiple rib, tibial and scaphoid fractures due to fall from tractor and planned for external fixation. He was 180 cm tall, weighed 120 kg, had a history of obstructive sleep apnea (OSA) and 60 pack-year of smoking. He wasn’t operated before, not on any medications, not allergic to drug and didn’t use cpap or oral device for osas.

He was found conscious, pulse rate(PR) 88/min, blood pressure(BP) 160/80mmHg and SpO2 94. Airway investigation revealed mallampati score 3, mouth opening 4cm, thyromental distance 6cm and neck circumference 52cm. He had 6 score in El-Ganzouri airway difficulty score, 35 points in Ariscat score and 6 points in Stop-Bang score. His high scores implied he could suffer from pulmonary complications perioperatively and we might encounter difficulties with his airway protection. To avoid such problems, infraclavicular block with 20 ml of prilocain 2%+bupivacain 0.5% and spinal anesthesia with 1.8 ml of 0.5% hyperbaric bupivacain were performed for his tibial and scaphoid fractures while avoiding sedatives and opioids. Surgery lasted 130 minutes uneventfully and without any complaints from patient who was sent to orthopedics ward.

Patients with OSA are at increased risk of perioperative morbidity and mortality because of potential difficulty in maintaining a patent airway. Patients have increased perioperative risk from OSA and are prone to respiratory and airway problems if opioids, sedatives and inhaled anesthetics are used. RA for a difficult airway patient helps avoiding difficulty of awake fiberoptic intubation and bypasses the question of when and where to extubate the patient. RA is recommended in patients with OSA and/or potentially difficult airways who present for surgery.

REFERENCES

Peripheral nerve blocks’ effectiveness is limited by pain outlasting the analgesic duration of the nerve block. Different approaches have been used to counter this limitation, for example insertion of catheters for continuous infusion, increasing the total dose of the local anesthetic or administering adjuvants.

A well-functioning catheter is an effective method for increasing analgesic duration, but placing catheters are relatively more time-consuming, require more expertise, and may not be suitable in an outpatient setting. Furthermore, catheters are limited in their effect by catheter migration away from the nerve, dislodgement, and leakage. Consequently, attempts to increase the duration of single-injection peripheral nerve blocks are warranted.

Local anesthetic volume and concentration
It is a common perception that higher concentrations of local anesthetics will increase the duration of nerve blocks, but the relationship between concentration and duration is not straightforward. Earlier studies showed no connection between local anesthetic dose and duration.1–4 Then, in connection with the development of ultrasound-guided techniques, and dose-finding studies focusing on ‘how low can you go’, evidence started to emerge showing decreased duration with decreased doses.5–9 Although the evidence between the previous and more recent studies may seem contradictory, the explanation seems to be that the relationship between local anesthetic dose and duration is not linear. In two studies by Nader et al10 and Jaeger et al11, duration of nerve block following a wide range of volumes and concentrations was studied in a non-clinical setting. These studies demonstrated that administration of very low volumes or concentrations of local anesthetics reduced the effectiveness of the nerve block by reducing success rate and duration. In contrast, as long as a minimal effective dose of local anesthetics was used, ensuring a high success rate, there was nothing gained in duration by a simple increase in concentration or volume.

Adjuvants Dexmethasone, dexmedetomidine, clonidine and fentanyl have all been shown to prolong sensory and motor block duration, as well as increasing the time to first analgesia.12 Among these adjuvants, dexmethasone seems to be the most effective.12–13

α2-adrenergic agonists Clonidine prolongs sensory and motor block, and increases the time to first analgesia compared with placebo, but to a lesser degree than dexmedetomidine.12, 14–15 Recent meta-analyses have shown that compared with placebo, dexmedetomidine prolonged a brachial plexus block by 292 minutes (95% CI: 245 to 329) and clonidine by 176 minutes (95% CI: 118 to 205). In the studies directly comparing the two α2-agonists, dexmedetomidine prolonged analgesia by approximately three hours.10 Of note, both α2-agonists were associated with a concurrent fourfold increase in the relative risk for hypotension, in addition, dexmedetomidine also increased the relative risk for bradycardia requiring medical intervention by a fourfold.14

Dexmethasone Dexmethasone increases time to first request of analgesics by 8.7 hours (95% CI: 6.6 to 10.8) compared with placebo.12 In comparison, the meta-analyses comparing the two α2-agonists to placebo have shown that dexmedetomidine prolongs analgesia by about five hours and clonidine by about three hours.12, 14 A recent systematic review by Albrecht et al13 only retrieved one study directly comparing dexmethasone to dexmedetomidine, reporting that dexmethasone prolongs analgesic duration by about 2 hours. Because of the scarcity of direct comparisons, Albrecht et al performed an indirect comparison between perineural dexmethasone and perineural dexmedetomidine, finding that dexmethasone significantly prolongs the duration of analgesia by a mean difference of 148 minutes (95% CI: 37 to 259 minutes).13 The result of the indirect comparison was thus similar to the results of the direct comparison.

Furthermore, dexmethasone was associated with a lower rate of intraoperative hypotension and postoperative sedation, compared to dexmedetomidine.13 The high effectiveness and low rate of side-effects suggests that dexmethasone may be the most favorable adjuvant.