Individual learning processes are complex and depend on a wide variety of factors, such as institutional preferences, the arrangements in place for teaching, and the caseload over time. The learning process is a multidimensional function with a wide intra- and inter-individual skill acquisition. Typical regional anaesthetic procedures such as performance of epidural, spinal, or plexus anaesthesia and manual skills such as arterial line insertion or tracheal intubation have a variety of learning curves. Regional anaesthetic procedures are significantly more difficult to learn than the basic manual skills necessary for a general anaesthetic [1].

Ultrasound-guided regional anaesthesia is expanding both as a clinical tool and for research purposes and, therefore, requires an analysis of the educational concepts governing its use. The use of ultrasound by anaesthesiologists has dramatically increased over the last few years, as evidenced by the number of published articles, workshops and educational events dedicated to this new technique. Ultrasound is used for anatomical evaluation and to facilitate the performance of both neuraxial and peripheral nerve blocks. Preliminary data suggest that ultrasound can improve block success rate and decrease complications. The reason for the success of ultrasound-guidance for regional anaesthesia is the technical development of high frequency transducers, portable hand-held ultrasound machines and associated needles with improved visibility. The development of ultrasound hardware and software has been faster than the development of the educational concepts associated with its use; consequently standardised national and international recommendations for ultrasound use have been missing. In April 2010 a joint committee from the American Society of Regional Anesthesia and Pain Medicine and the European Society of Regional Anaesthesia and Pain Therapy published recommendations for education and training in ultrasound-guided regional anaesthesia [2]. The committee was established to advise institutions on recommendations for the scope of practice and the teaching curriculum. These recommendations specifically define the ten common tasks associated with performance of an ultrasound-guided nerve block, the core competencies and skill sets associated with this new technique, a training practice pathway for postgraduate anaesthesiologists, and a residency-based training pathway. The ten tasks summarise all the necessary steps when performing an ultrasound-guided nerve block.

1. Visualise key landmark structures including blood vessels, muscles, fascia, and bone.

Appropriate anatomical knowledge is an important prerequisite for performance of regional anaesthesia. Ultrasound-guidance for regional anaesthesia requires application of knowledge of anatomical structures. For each nerve block there are typical anatomical landmarks that are completely different from the external landmarks used for an equivalent nerve stimulator based technique. For example in the supraclavicular region of the brachial plexus important landmarks when using ultrasound are the first rib (Figure 1, white arrows), the pleura (blue arrows) and the subclavian artery (red circle).
2. Identify the nerves or plexus on short-axis imaging.

Nerves can be identified in short-axis or long-axis. Figure 2 shows the median nerve in a short-axis (A) and a long axis view (B). Ultrasound-guided blocks are generally performed with short axis (transverse or cross-sectional) imaging of nerves for several reasons. The identification of peripheral nerves is easier compared with the long-axis view. Even if the transducer moves slightly the nerve can be identified if the ultrasound beam is still perpendicular to the nerve. The visibility of fascial structures that surround nerves is better and, most important, it is possible to visualise the circumferential distribution of local anaesthetic around the target nerve.

3. Confirm normal anatomy and recognise anatomical variation(s).

Anatomical anomalies could potentially restrict the distribution of local anaesthetic solution. For example, anatomical variations described in the interscalene groove may, in part, explain failure of surface landmark–based approaches to the brachial plexus block if the anterior scalene muscle serves as a barrier that impedes local anaesthesia [3]. Ultrasound is able to detect these variations, allowing the tip of the needle to be redirected to the target, and the spread of local anaesthetic observed.

4. Plan a needle approach that avoids unnecessary tissue trauma.

There are two different nerve block techniques under ultrasound guidance [4]. Using the out-of-plane (OOP) technique the needle crosses the plane of imaging near the target. With this approach, the target has to be centred within the field of view and the depth noted. Visualisation of the needle tip can be challenging; sliding and tilting of the transducer is as important as small-volume test injections for visualisation of adequate local anaesthetic distribution.

Using the in-plane (IP) technique the needle is inserted within the very thin plane of imaging to visualise the entire shaft and tip. The target should be placed on the side of the imaging field of view away from the approaching needle. If the needle cannot be visualised it
should not be advanced. Tilting the transducer brings the needle exactly back in the middle of the ultrasound beam and decreases the risk of harm to the patient.

Sometimes it is possible to reach several individual nerves by one needle insertion (for example in the axillary region). In spite of the fact that there is no evidence favouring any particular ultrasound technique it is important to plan an appropriate approach for each block procedure to avoid unnecessary tissue trauma.

5. Maintain an aseptic technique with respect to the ultrasound equipment.

The ultrasound transducer should be placed in a sterile sheath after applying gel between the transducer and inside of the sheath, avoiding any wrinkling or trapped air that could impede full contact (Figure 3). For catheter insertion techniques, it is important to place both the transducer and its cable inside a sterile sheath to guarantee complete sterility. In our department we use an adhesive transparent dressing to cover the probe for a single-shot block.

6. Follow the needle with real-time visualisation as it advances toward the target.

Real-time visualisation has various advantages. The tip of the needle, the target nerve, important landmarks and adjacent structures can be identified. Furthermore, anatomical variations can be detected, and the user has the option to reposition the needle in case there is inadequate spread of local anaesthetic.

7. Consider a secondary confirmation technique, such as nerve stimulation.

Dr Peter Marhofer has observed 'With little reservation, it is anticipated that ultrasound-guided regional anaesthesia will become the gold standard for performance of regional anaesthesia' [5]. Ultrasound can only be regarded as the gold standard if the user feels comfortable with the equipment. For teaching purposes, or if a student does not feel confident identifying nerves with ultrasound alone, it is possible (and recommended) to combine both ultrasound and nerve stimulation techniques although muscle twitches can make the ultrasound image more difficult to interpret.

Combining both techniques sometimes illustrates an interesting paradox. Occasionally even a perfect nerve stimulation technique that has generated a good twitch response can produce a delayed block or no block at all. If ultrasound is combined simultaneously with
a nerve stimulator technique it may identify the presence of septae (Figure 4; white line) within the neurovascular sheath that influence
the pattern of local anaesthetic spread [6] (blue field), whereas the current originating from the tip of the stimulation needle still reaches
the nerve (red arrow).

Figure 4

Local anaesthetic spread influenced by septae

8. When the needle tip is presumed to be in the correct position, inject a small volume of a test solution. If the solution
is not observed during this test injection, conclude that the needle tip is intravascular or out of the imaging plane.

Repeated incremental injections of small volumes of a local anaesthetic solution (0.5-1 ml), the so called hydro-localisation technique,
has been shown to be a simple technique with a relatively short learning process. This makes it possible to provide efficient placement of
local anaesthetic using an ultrasound-guided axillary block in an out-of-plane approach [7].

9. Make adjustments to the needle position if unintended spread of local anaesthetic is observed. The visualisation
of local anaesthetic deposition should occur through the entirety of the injection to avoid an intravascular injection.

Intravascular injection is still possible with ultrasound-guidance [8]. Pressure applied to the ultrasound transducer can occlude veins
making negative aspiration of blood unreliable as a means of excluding intravascular needle tip placement. Therefore, it is important to
aspirate without external transducer pressure and to inject a small volume of test solution.

10. Maintain traditional safety measures including the presence of resuscitation equipment, frequent aspiration,
intravascular test doses, standard monitoring, patient response, and assessment of injection characteristics.

Buying an ultrasound machine with a high frequency transducer does not guarantee improved patient safety. Equipment that is fit-for-
purpose is a prerequisite; however even with appropriately trained anaesthesiologists complications can occur. Safety measures should
be the same for regional anaesthesia techniques performed with or without ultrasound guidance.

The use of ultrasound requires a variety of skills associated with different aspects of the procedures. The Joint Committee of the
American Society of Regional Anesthesia and Pain Medicine and the European Society of Regional Anaesthesia and Pain divides these
skills into four categories: an understanding of the way the ultrasound machine works, image optimisation, image interpretation, and ob-
servation of needle insertion and injection of the local anaesthetic. A skill set has been defined for each of these categories and is listed
in their recommendations for education and training in ultrasound-guided regional anesthesia. [2].
Acquisition of skill sets associated with ultrasound-guided regional anaesthesia can be achieved in several ways. Many of these various skills are described in a six-step teaching model (see Figure 5) [9].

Figure 5

1. Knowledge of anatomy
2. Basic knowledge of ultrasound & equipment
3. Hands-on workshop with test persons
4. Phantom workshop
5. Cadaver workshop
6. Ultrasound-guided block with the help of an instructor

A knowledge of anatomy (Step 1) is the basis for image interpretation as described above. It is necessary to have a basic understanding of ultrasound and be familiar with ultrasound equipment in order to optimise image quality and interpret the ultrasound image (Step 2) [10]. Furthermore, awareness of acoustic, anatomical, optical or other artefacts [11] is required. Basic science and clinical knowledge can be taught and maintained in a number of ways, such as journal or textbook study, interactive studies, self-evaluation programmes, and problem-based case discussions. Manual skills and image optimisation can be taught in hands-on workshops with volunteer subjects (Step 3). As needle insertion and injection is not possible in these volunteers it is necessary to complete this educational element with a phantom workshop (Step 4). Simulation is an accepted part of training, assessment, and research in aviation, nuclear power, and the military. In contrast little work has been done in setting standards for simulation in anaesthesia [12]. Tuition in ultrasound-guided core-needle biopsy of the breast using a turkey-breast phantom improved technique, accuracy, and confidence of students training in diagnostic radiology [13]. A few years later it was shown that anaesthesiology residents, with little or no previous ultrasound experience, could rapidly learn and improve speed and accuracy in performing a simulated interventional ultrasound procedure by using this teaching model [14]. Figure 6 shows such a teaching model used in our department for regular resident training. Apart from commercially available phantoms, new inexpensive models of varying complexity are available to assist ultrasound-guided needle-to-target localisation learning [15-17].

Figure 6

Phantom training: chicken breast with embedded olive. (OS - olive stone, FP - fruit pulp, Arrows - needle in an in-plane-alignment)
Cadaver workshops (Step 5) permit combination of steps 3 and 4 because not only can the anatomy of the upper and lower extremity be visualised [18, 19] but needle and test injections can be performed.

Patient simulation is widely used in clinical education. The key aims are to improve the student’s competence and confidence, improve patient safety and reduce errors. Understanding its benefits, range of uses and limitations will help clinical teachers optimise the learning process. We have learned a lot about improving patient safety and education concepts from specialty-specific critical incident reporting systems. Sites and colleagues studied a total of 398 errors occurring during ultrasound guided regional anaesthesia and linked these to performance observed to compromise the procedures by using detailed video analyses [20]. Important errors were detected in 43.7% of these cases, for example, the needle was not visualised while being advanced, which is an important patient safety consideration. Using these results he was able to recommend important educational targets for future training and simulation programmes.

Performing an ultrasound-guided block with the help of an instructor (Step 6) completes the education concept. This six-step teaching model is not evidence-based, but summarises ideas from years of teaching experience.

The Joint Committee defines two different pathways to obtain training in ultrasound-guided regional anaesthesia: a residency-based pathway and a practice pathway. The training programme should use a curriculum enabling the resident to understand device operation, image optimisation and interpretation and needle insertion techniques. Physicians who have completed their formal anaesthesiology training should participate in educational events including both didactic and hands-on experience. Practising scanning techniques is as important as using simulators and phantoms similar to the six-step model. Furthermore, incorporation of ultrasound based techniques within existing regional anaesthetic practice is recommended. Maintenance of a documentary record of blocks performed and their associated success and complications is recommended for both groups.

With increasing adoption of regional anaesthesia techniques, especially ultrasound-guided procedures, there is a need for more research based information governing successful learning processes and validated education concepts. The guidelines will be reviewed on a periodic basis by the Joint Committee and modified if necessary.

Key learning points

• Regional anaesthetic procedures are significantly more difficult to learn than the basic manual skills necessary for administration of general anaesthesia.
• Ultrasound can be used for anatomical evaluation and to facilitate the performance of both neuraxial and peripheral nerve blocks. This is an expanding field stimulating both clinical and research interest.
• The development of ultrasound hardware and software has proceeded faster than the development of educational concepts underpinning the use of this new technique.
• The ASRA/ESRA joint committee recommendations summarise all the steps necessary to perform an ultrasound-guided nerve block.
• With the increasing tendency towards adoption of regional anaesthesia techniques, especially ultrasound-guided procedures there is a definitive need for more information and research governing the process of successful learning such techniques and the validated educational principles supporting them.

References


