

Using ultrasound to teach anatomy – a novel, effective and evidence-based approach

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For the medical student or trainee anaesthetist, participating in a theatre list with an anaesthetic consultant is an opportunity with great potential for learning. But, have you ever considered teaching anatomy using ultrasound? In this paper we aim to give suggestions, based upon sound theory, for a novel way of teaching anatomy.

Do anaesthetists need to teach anatomy?

Few would disagree that good anatomical knowledge is essential for any doctor. This is formalised for the undergraduate curriculum by the General Medical Council, in their guide 'Tomorrow's Doctors', which states that the medical graduate should be able to: 'Explain normal human structure and functions.'¹

Anatomy is also of great importance to anaesthetic trainees, both in terms of safe provision of care, and to aid successful passage through both primary and final FRCA exams. There have been sizeable changes, both in the amount of time devoted and the approaches employed, to teaching this subject across medical schools in recent years.^{2,3} Some fear this has led to a drop in standards of knowledge, describing its teaching as being in a 'crisis'.⁴ This is a concern echoed by junior doctors, with a survey of graduates from the University of Nottingham in 2007 demonstrating that 44.2% felt they had not received sufficient teaching in anatomy.⁵ To compensate, more innovative and efficient methods have been developed, including the use of pre-dissected

or plastinated cadavers, computer packages, life models and radiology.⁶ A survey of UK medical schools, taken back in 2002, found that all 21 of those responding utilised radiology to some extent in their anatomy programme.⁷ This facilitates integration of anatomy throughout the curriculum, adding a clinical overlay to the material.⁸

Why use ultrasound?

There are a number of potential benefits in the use of ultrasound, both in terms of familiarisation with a piece of technology which is of growing importance within medicine, and in development of a deeper understanding of functional anatomy.

Ultrasound skills: Due to advances in technology, the ultrasound machine has successfully colonised numerous medical specialties. NICE guidelines on central line insertion,⁹ the increased utilisation of ultrasound for regional anaesthesia, and the developing field of critical care echocardiography¹⁰ mean that anaesthetists are near the forefront of this revolution. This interest has led to the Royal College of Radiologists producing guidance for allied specialties for their training in ultrasound: this describes three levels of competence and the need for continued supervision and practice of skills.¹¹ Exposure to this technology at an undergraduate or early training level, with the ability to align textbook knowledge to identified sono-anatomy, is likely to become increasingly important in the future of safe patient care.

Effective Learning: Adult learning theory suggests there are a range of important motivators that influence how effective teaching interventions will be – so called 'andragogical assumptions'.¹² These include the ability to utilise past experiences and knowledge to build upon current learning, and the recognition of applicability of the learning to real-life situations – easier to appreciate when using modern technology than from an aged textbook.

The spiral curriculum is a structure commonly applied to modern medical curricula.¹³ Its strength relies upon the re-visitation of topics throughout training, adding layers of complexity to previously learned material. Ultrasound images allow consolidation of previously learned knowledge, appreciation of the integration of various anatomical systems (for example, relationships between blood vessels and nerves), and development of an appreciation of sono-anatomy.

The practical, task-based nature of ultrasound allows knowledge of anatomy to be acquired in a different format. This can stimulate the formation of episodic memory, which is linked more closely to personal experiences than to factual learning.¹⁴ This is not a new concept for anaesthetists, as it is one of the theories underpinning the educational benefits of simulation¹⁵ – a technique that the speciality has embraced. Students can develop episodic memory with ultrasound use by recollection of methods employed to visualise or identify certain tissues, emphasising the inter-relationship of various structures with surface anatomy.

The dynamic nature of ultrasound allows demonstration of movement and integration of structures within a living body, with visualisation of certain physiological phenomena – for example, the changing calibre of major veins throughout the respiratory cycle.¹⁶

Can it work?

There are numerous papers published reporting use of this technique. They have mainly focused on the undergraduate curriculum, and a variety of approaches have been employed.^{17,18,19,20,21} Some have used expert scanners to demonstrate images,¹⁹ but others have allowed students to perform their own scans following a brief introduction to the technology.^{17,21} When using the latter approach, and in conjunction with visual aids in the form of line diagrams and cross-sectional images, Swamy et al showed that over 75% of second-year medical students felt confident in identifying muscle, blood-vessels and bone.¹⁷ Most of the studies have simply used student feedback as their end-point, however specific evidence relating to learning outcomes is also starting to appear. Two separate articles have compared students taught cardiac anatomy with either ultrasound or cadaver specimens.^{19,21} Both studies were able to demonstrate a marked improvement in objective test scores of learning after the teaching sessions. These studies have shown that ultrasound is at least as effective as cadaver based teaching.

How can you make it work?

Hopefully you have been persuaded of the benefits of this approach – but how can you deliver this in a busy theatre list? Many anaesthetists will use ultrasound to perform some kind of intervention as a matter of course. We propose that this is an opportunity to provide teaching on some aspect of anatomy – you do not need to be actually teaching how to perform the procedure. Being creative with when and how you use

teaching opportunities is the key to maximising learning in the workplace. This expands the potential teaching repertoire on offer. For example, when performing an advanced procedure, e.g. ultrasound-guided brachial plexus block, with a junior trainee, the learning is about anatomy and not the block itself. In contrast, when performing a basic procedure, e.g. ultrasound-guided internal jugular central line, the learning for the trainee who has mastered this skill can be upon some wider aspect of neck anatomy. This is described in more detail below. Which areas to scan depends upon the expertise of the anaesthetist and the opportunities available in the list. However, there are papers published describing successful sessions on cardiac,¹⁹ neck,¹⁸ and upper and lower limb^{17,18} anatomy.

Pre-theatre: If you are lucky enough to know who will be accompanying you on your list, then you can direct them towards some resources to help maximise their experience. The Society of Ultrasound in Medical Education²² has a website (www.susme.org) which features a number of short online lectures covering ultrasound physics and basic scans. Traditional anatomy books can be consulted to refresh knowledge of the area to be scanned. This technique of preloading with knowledge and allowing the face-to-face time to focus on sense-making and putting into practice has been widely described as ‘flipping the classroom,’ and is very efficient.²³

Theatre: One important principle is the need to tailor the session to your audience. It is important to challenge your learners, but only to a manageable point.²⁴ So for students and more junior trainees, it may be more appropriate to perform the scanning yourself in order to demonstrate the relevant structures. Once some ultrasound skills have been obtained, there will be increased benefit for the trainees to do the scanning themselves, under supervision.

As previously described, it is not necessary to provide teaching on the actual procedure that is being performed, but rather this can form a framework to instruct on some aspect related to the procedure that is appropriate to the trainee’s level. To illustrate this, we have suggested a variety of techniques that could be used with students or trainees of different grades when a patient is scheduled to have an inter-scalene block.

Medical student: An introduction to the basic principles of ultrasound, such as probe selection and techniques to improve obtained images, e.g. depth, gain, probe pressure. This can lead to identification of different tissue types – muscle, artery, vein. A demonstration of the anatomy of the carotid sheath and its relations can then follow.

CT1/2 trainee: Refinement of ultrasound technique, including colour/flow doppler, can be introduced. The trainee can be encouraged to perform parts of the scan, exploring the musculature of the neck, in particular the sternocleidomastoid and scalene muscles. The relations of various important nervous structures, such as the cervical and brachial plexi, can be demonstrated. Alternatively, the anatomy of the thyroid and trachea can be explored, noting the proximity of the thyroid to important neck structures.

ST3+ trainee: More senior trainees should be encouraged to perform the scans themselves from beginning to end. The roots and trunks of the brachial plexus and its relations can be identified, following it from the neck down towards the supra-clavicular plane. The position of the trunks in relation to the subclavian artery can be compared to the cords and the axillary artery. The infra-clavicular region can also be scanned, demonstrating the pectoralis muscles, the axillary artery and vein, the ribs

and pleura. This can lead to discussion of ultrasound-guided subclavian central line insertion.

The teaching intervention does not have to last long. Giving the trainee the opportunity to repeat the scans after the intervention can be useful – this could either be upon themselves or each other. They can also scan subsequent patients on the list, looking to identify the same structures on different patients: this develops an appreciation of the inter-individual variation, and allows conceptualisation and consolidation of learning. Supplementing this with other anatomical resources aids in identifying structures.¹⁷ These resources could be textbooks, wall posters or online anatomy packages. Some of these require a subscription, such as anatomyTV (www.anatomy.tv), but others are free (www.innerbody.com).

Consent/ethical issues

Most patients accept that training is an integral part of hospital care, so verbal consent for the session is likely to be sufficient. If healthy volunteers are to be used (for example if trainees are to scan themselves or each other after the initial session), then there are guidelines published by the British Medical Ultrasound Society²⁵ which can be helpful (www.bmus.org). They have also developed a consent form which volunteers can sign. They recommend that there should be a process to follow up on any incidentally discovered abnormalities – this is usually via the GP. It has been suggested that the likelihood of discovery of minor abnormalities such as benign cysts, or even a pregnancy, is higher if the abdomen or pelvis is scanned. For this reason, these areas may be best avoided when scanning volunteers.¹⁶

Conclusion

With ever reducing time for training, we need to think creatively about opportunities for learning and think carefully about the way we teach, in order that we maximise every occasion. Ultrasound provides a modern and clinically relevant modality for teaching a traditional core element of medical knowledge, which is of key relevance to students and anaesthetic trainees alike. This has great scope for use as an engaging and informative form of teaching in theatre.

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