Modern approaches to teaching and learning anatomy

The view that new doctors have inadequate knowledge of anatomy is not supported by the evidence, argues **John Collins**, but greater effort is needed to capitalise on the learning potential of new technologies

Recent reports from the United Kingdom[1] and Australia[2] claim the teaching and learning of anatomy in universities is in crisis. This is attributed to less time being allocated to the subject and decreased opportunities to dissect cadavers. Although everyone would agree anatomy is important, few lament the move away from endless hours of cadaver dissection and didactic lectures. Efficient use of new technology and teaching methods should allow better teaching and understanding.

Is anatomy teaching in crisis?

The evidence most frequently quoted for the so called crisis is Raftery's assertion that there has been a "vast increase in claims associated with the lack of anatomical knowledge."[3] This claim was based on the finding that "damage to underlying structures" was the commonest reason for settlements of claims relating to general and vascular surgery.[4] Lack of knowledge of anatomy is but one cause of such intra-operative errors, albeit an important one. And many of the errors are likely to have been made by surgeons who graduated before changes in the teaching of anatomy. A reduced focus on learning and assessment of anatomy in some postgraduate surgical training programmes has been reported[3 5] and may be important.

Successful teaching and learning in anatomy

The curriculum, teaching, and assessment must encourage the learning of clinically meaningful anatomy

- Prosected cadaver specimens, life models, radiological images, and telescopic views of the living body maximise learning
- Cadaver dissection should be reserved for those contemplating a surgical career
- Departments of anatomy must form closer links or integration with those in surgery or radiology
- All clinical teachers must take greater responsibility for sequential teaching of anatomy across the continuum of learning

Media coverage of the introduction of newer methods for teaching and learning anatomy has tended to focus on the negative, with little if any discussion of the value of cadaver dissection.[6] Last year, the *Australian* reported, "Less than four in ten medical students agreed they will know enough anatomy to become competent doctors."[2] This was based on responses from students to a survey conducted by the Australian Medical Students' Association.[7] However, half of respondents had not started the clinical component of their course[7] and were therefore not well placed to judge the level of anatomy required by a medical graduate.

Challenges of teaching anatomy

Those responsible for courses in anatomy face daunting challenges. Confronted with a dwindling number of tutors and reduced teaching time, they must deliver new curriculums to an expanding and increasingly diverse student population through a more learner centred approach. This is taking place at a time of changing models of delivering education and rapidly expanding instructional tools such as new imaging and telescopic views of the living body that are easily accessible on CD-ROMs and web based resources. The challenge is even more formidable given the dearth of empirically tested evidence related to the learning, assimilation, and application of knowledge of anatomy.[8]

Learning, assimilation, and recall

The real objective of learning anatomy is to integrate an understanding of normal function with recognition of normal structure. This provides the foundation that will help students to develop the logic, inference, and problem solving needed to diagnose and manage patients.

Anatomy must be taught and learnt within a context that is clinically meaningful and related to the competencies required by new medical graduates so that students understand its relevance to their future practice.[9] Assessment must similarly focus on tasks that resemble realistic clinical problems and reward integration and application.[10] Unfortunately, assessments often centre on factual recall of isolated fragments of information, which encourages superficial learning with subsequent poor retention and application to medical problems.[10]

Methods of teaching and learning

Although an understanding of anatomy is fundamental for clinical practice, many other topics compete for a place in the curriculum. The time allocated to anatomy in medical school is unlikely to increase, and the focus must therefore move to the curriculum and methods used for its teaching and learning. The time honoured learning of gross anatomy through the visual and tactile experience of cadaver dissection, supplemented by lectures and tutorials has been added to by other methods. These include problem based learning and the use of prosected cadaver specimens, life models, radiological images, and laparoscopic views of the living body and interactive multimedia packages.[11 12] Today's students are used to receiving information through new technology and can readily make use

of multimedia resources. So how can we ensure doctors have an adequate knowledge of anatomy?

The curriculum

The introduction of new disciplines into undergraduate teaching led to a reduction in the anatomy curriculum.[13] This reduction made it vital to identify which aspects of anatomy every newly qualified doctor practitioner should know. A new core syllabus in anatomy for all doctors developed on behalf of the Anatomical Society of Great Britain and Ireland attempts to set the standard required for safe and effective clinical practice.[14] Similarly, specialty colleges such as surgery are moving to a generic core curriculum for all of their trainees, with the addition of more detailed anatomy when required for individual specialties.[15]

Cadaver dissection

Dissecting cadavers helps gain an understanding of the three dimensional structure of the human body through self discovery and observations. It also helps to develop the spatial reasoning skills necessary to understand and interpret imaging data.[16] However, dissection of cadavers is expensive, time consuming, and emotionally disturbing for some students.[17] Furthermore, the preserved tissues don't always provide an accurate impression of the living body. The role of dissection in developing dexterity skills[18] is limited and has been superseded by the more versatile environment of skills laboratories.

Dissection of cadavers is of value principally for those contemplating a career in surgery. Anatomical dissection is not a primary learning method because pupils must know in advance what to look for in order to achieve the greatest benefit.

Prosected cadaver tissue

Prosected cadavers provide learners with pre-dissected material. They maximise the increasingly scarce resource of cadavers and teachers and make more time available for teaching, learning, and revision. Wet prosected tissue enables the learner to explore, visualise, and understand the inter-relations of anatomical structures. Plastinated prosected material is more robust and can be handled safely and stored at room temperature, but the rigidity of the tissues limits its use to visualisation.

Life models

The use of life models in the study of the living body has been neglected in teaching and assessment. Living anatomy enables the learner to see structures move and function,[17 19] particularly in the musculoskeletal system, and to become familiar with important surface landmarks. It also provides students with the opportunity to observe, examine, and interact with a living person.

Radiological imaging

Imaging techniques such as computed tomography, magnetic resonance imaging, positron emission tomography, and ultrasonography have provided fresh opportunities to present anatomy to medical students and graduates. Cross sectional and functional imaging show three dimensional anatomical relations as well as help students to understand physiology. Real time techniques can show processes such as the beating heart. Because images can be recorded and stored digitally, they can be analysed in detail during teaching.

Computed tomography and magnetic resonance imaging offer unique teaching opportunites. Multidetector computed tomography provides clear anatomical detail in the axial and reconstructed sagittal and coronal planes. The images can be manipulated to remove irrelevant tissues such as bone, allowing detailed study of particular organs and their relations to the vascular anatomy. This application of advanced imaging is the modern equivalent of traditional anatomical dissection. Magnetic resonance imaging provides clear images of different intracranial structures and of muscles, tendons, ligaments, cartilages, and nerves that are not available by other means. It can also be used to study brain function and cerebral blood flow. Positron emission tomography has opened up new methods of studying functional anatomy at a molecular level.

"The real objective of learning anatomy is to integrate an understanding of normal function with recognition of normal structure"

Telescopic views of internal living anatomy obtained during diagnostic and therapeutic procedures, including minimally invasive surgery, provide a realistic and effective teaching and learning opportunity. For example, they can provide live views of the structures in the peritoneal cavity or knee joint and internal views of the viscera.

Comparison of outcomes between different methods

Support for dissection as the pre-eminent teaching and learning method is based more on emotive arguments than scientific evidence. Descriptive papers and professional opinions are common, but scientific evidence of its superiority is lacking.[20] No difference was found in the level of knowledge of anatomy between those who learned through prosected specimens and those who dissected cadavers.[20] There are no reliable studies on long term retention and recall of anatomical knowledge, and claims that today's graduates know less anatomy than in the past are unsubstantiated.

New approach

Medical education has changed from when newly qualified doctors were allowed to practise unsupervised.[21] Today's focus is on continued learning, and all medical graduates must have further education, training, and assessment before proceeding to independent practice.

It is the responsibility of universities to ensure medical graduates have mastered the fundamental principles and core knowledge of anatomy necessary to start clinical practice (box). Equally, postgraduate medical colleges or education bodies are accountable for making certain that their graduates are proficient in the more detailed anatomy required for a particular specialty.

The undergraduate programme should be principle based (start with general anatomy) and problem directed (incorporate clinical anatomy) to help students develop the capacity to understand and interpret the living anatomy that they will encounter. Prosected cadavers can enhance this learning experience, but dissecting cadavers is beneficial only in specialties requiring more detailed anatomy. Modern radiological imaging and telescopic views of the living body supplemented by

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Bare bones. How much anatomy is enough?

life models provide the most realistic and clinically useful learning methods.

Learning anatomy is facilitated and reinforced by sequential teaching throughout the course. All clinicians, and surgeons and radiologists in particular, should be encouraged to teach anatomy throughout the medical course. Closer links or integration between departments of surgery or radiology with anatomy will help to achieve this and also benefit postgraduate learning.

Further research is required to evaluate the relative merits of different methods for teaching, learning, and assessment of clinically relevant anatomy. Well designed studies comparing different courses would help to replace emotive arguments and anecdotes with much needed scientific evidence.

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