Medical imaging in an integrated anatomy curriculum

In view of the fact that medical imaging skills play a central, and increasing role in the practice of nearly all clinical specialties, it is surprising that many medical schools do not have a curriculum formally integrating imaging in its own right.

This article describes the experience of Sydney Medical School who introduced an integrated imaging course into the anatomy curriculum in the first two years of a four-year graduate-entry program and summarizes the reactions of the students. Incorporating imaging into the anatomy teaching early in the curriculum has the potential to improve students’ confidence in understanding imaging modalities and their relevance to clinical anatomy.

Medical Imaging – Why, When and How Should We Teach It to Medical Students?

Increasingly, medical practitioners are expected to be proficient in the basic interpretation of medical images, including X-rays, CT and ultrasound scans. Medical students are expected to gain basic imaging skills before entry into residency programs. A survey of 99 residency program directors in the United States found the vast majority considered basic radiology skills to be essential for medical graduates [1]. Specifically, skills considered essential by over 90% of respondents included a systematic approach to interpreting chest and abdominal X-rays, the ability to recognize common abnormal findings on chest and abdominal X-rays and the ability to choose the most appropriate radiologic study.

These essential skills should be taught in the undergraduate/preclinical setting in order for the medical graduates to meet these expectations.

Despite basic medical imaging skills being considered essential in almost every clinical specialty, many medical schools do not have a defined, longitudinally integrated medical imaging curriculum. Medical imaging is often integrated with other core clinical disciplines. As medical imaging relies heavily on knowledge of anatomical structures, anatomy is considered to be an appropriate discipline to teach these skills.

Integrating medical imaging into anatomy teaching has many benefits. Students exposed to radiology early in a medical curriculum are more likely to report an interest in radiology disciplines and to consider radiology as a career[2]. Students exposed to imaging also show improved understanding of relationships between anatomical structures, an ability to recognize anatomical structures on medical images and confidence in interpreting X-rays, MRI, CT and ultrasound images. Including radiology and ultrasound into the anatomy curriculum has been shown to improve student performance in anatomy and/or imaging [3-5].

Medical imaging components, including ultrasound, CT, MRI and online radiology modules, have been successfully integrated into anatomy curricula by a number of medical schools.

Some schools developed programs that over several weeks integrated a combination of cadaveric specimens, X-rays, ultrasound, CT and MRI scans into anatomy [6, 7]. However, there is a substantial difference between medical schools in the amount and type of imaging taught. A recent review described considerable variation in how medical imaging is integrated into anatomy. Some schools only provide medical imaging materials to students on request [8]. A more uniform approach is needed to achieve consistent educational outcomes, as many medical students still find interpretation of medical images challenging.

Sydney Medical School – Case Study on Integrating Medical Imaging into Anatomy Curriculum

Sydney Medical School made a decision to integrate medical imaging into the anatomy curriculum following a program review. Detailed descriptions of the program and its new imaging component have been published previ-
The program focused on introducing imaging techniques, developing understanding of basic interpretation of medical images and improving student confidence in their ability to understand three-dimensional anatomy. X-rays, MRI, CT, ultrasound images, endoscopy and laparoscopy videos were introduced to the program.

Medical imaging was integrated into the first two years of the four-year graduate-entry program. Because the program was based around problem-based learning (PBL), all teaching of clinical sciences was arranged around PBL cases. Medical imaging components were mapped to PBL cases within the new anatomy curriculum. Students were taught all relevant regional anatomy before medical imaging components were introduced for the same region.

**MEDICAL IMAGING COMPONENTS**

The imaging curriculum consisted of:

1. Nine specialist radiology lectures delivered at the end of each relevant anatomy block by radiologists and a vascular surgeon.

2. Normal radiologic anatomy delivered by anatomy staff. Each anatomy practical session included a station where students identified anatomical structures on X-rays, MRI and CT scans. This provided a basic introduction to imaging.

3. Radiologists and radiology registrars delivered four cross-sectional imaging practical sessions. These sessions aimed to improve understanding of imaging modalities and student confidence in basic interpretation of MRI and CT scans.

4. Sonographers and a vascular surgeon delivered three ultrasound practical sessions. These sessions included one hands-on ultrasound session using a human volunteer.

5. Annotated endoscopy and laparoscopy videos were developed with a gastrointestinal surgeon. They included directional labels and a voice-over description of anatomical structures.

6. Medical imaging assessment was included into the anatomy practical summative assessment.

**STUDENT EXPERIENCE WITH THE NEW MEDICAL IMAGING CURRICULUM – HOW CAN IT BE IMPROVED?**

We prioritized evaluating student experience with the new curriculum because it affects motivation to learn and student engagement. We were also interested if the students’ experience with the new curriculum was affected by their prior exposure to anatomy. We evaluated three consecutive cohorts to ensure the findings were not cohort-specific.

In practice, to assess student experience, we conducted surveys consisting of a combination of 5-point Likert scale and open response questions. The surveys also asked students to rate their level of prior exposure to anatomy based on the description provided. A detailed description of the method and statistical analysis was published previously [9]. We reviewed components of the medical imaging curriculum that were poorly received by the students. As student opinion is not always in line with best teaching practice that supports learning, changes to the curriculum were only made if they were evidence-based.

Over three quarters of students who responded to the survey classified themselves either as beginners or near beginners in anatomy. Between 90%-92% of students were satisfied with the overall quality of teaching. This suggested a good overall student experience with the new curriculum.

The students rated cross-sectional imaging practical sessions consistently higher than imaging lectures. The main lecture criticisms included repetition/overlap, including less content or making lectures slower paced and less complex. Students with less prior anatomy experience wanted more complex and interactive material included in lectures: “More interactive learning, more case scenarios and real clinical studies”. A review of imaging lecture content in response to students’ comments revealed the need to simplify and scaffold content to reduce its complexity. In response, interactive introductory radiology sessions were...
developed. These sessions were taught by a radiographer and focused on basic concepts, for example systematic interpretation of X-rays.

Between 72-77% of students believed cross-sectional imaging sessions helped them better understand the imaging modalities of CT, MRI and ultrasound. Between 76-84% of students thought these practical sessions helped them understand spatial relationships between the structures of thorax, head and neck and 71-77% believed they helped reinforce the location and relationships of abdominal viscera. Between 69-80% of students agreed ultrasound sessions were helpful in understanding abdominal and vascular ultrasound. 72% of students thought endoscopy and laparoscopy movies were useful in relating practical session material to clinical practice. Most students thought radiology and ultrasound practical sessions were good and wanted more of them. Overwhelmingly, tutors were named as the most useful resource. Students with low prior anatomy experience wanted more imaging quizzes: “the imaging [practical] sessions – should have had quizzes”. Students with high prior anatomy experience wanted ultrasound to be taught as part of clinical skills rather than anatomy: “Ultrasound might be better taught as patient doctor tutorials on clinical days”. To improve ultrasound sessions, we developed a series of notes and questions to support ultrasound activities, which were made available to students online. Use of an ultrasound dummy with pathological organs was also introduced to ultrasound sessions in addition to using volunteer models.

**LIKELY FUTURE DEVELOPMENTS**

More and more medical schools are incorporating imaging into their anatomy curriculum. More of them, including our program, introduce medical students to multiple imaging modalities during their anatomy studies. Given the increased reliance on imaging for diagnosis and treatment and its relevance to anatomy, it is likely that use of imaging in anatomy laboratories will continue to increase. A big challenge will be to work on development of a standardised curriculum for medical imaging. This curriculum will need to begin in pre-clinical years and continue into more advanced clinical stages of medical programs. While developing such a curriculum will be a challenge, it will provide consistency in imaging training. It will also provide medical students with an opportunity to build on the imaging skills acquired in pre-clinical years and apply these skills in clinical practice.

**CONCLUSION**

The longitudinal integration of medical imaging into the anatomy teaching early in the curriculum may improve students’ confidence in understanding imaging modalities and their relevance to clinical anatomy. Medical imaging is likely to remain in the medical curriculum, given its increased use in medical practice and expectations that students graduate with basic radiology skills.

**REFERENCES**


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**Book review**

**Vascular Imaging of the Central Nervous System: Physical Principles, Clinical Applications and Emerging Techniques**

_by Joana Ramalho, Mauricio Castillo_

Published by Springer 2014 432 pp € 133.30 hardbook; € 109.99 e-book

The first book-length reference to thoroughly describe diagnostic and therapeutic advances in the development of vascular radiology over the last decade

The last ten years has seen vascular imaging of the central nervous system (CNS) evolve from fairly crude, invasive procedures to more advanced imaging methods that are safer, faster, and more precise—with computed tomographic (CT) and magnetic resonance (MR) imaging methods playing a special role in these advances.

Vascular Imaging of the Central Nervous System is the first full-length reference text that shows radiologists—especially neuroradiologists—how to optimize the use of the many techniques available in order to increase the sensitivity and specificity of vascular imaging, thereby improving the diagnosis and treatment of individual patients. Each chapter is formatted carefully and divided into two essential parts: The first part describes the physical principles underlying each imaging technique, along potential associated artifacts and pitfalls; the second part addresses clinical applications and novel applications of each method.

There is a strong focus on the clinical application of each modality or technique in CNS radiology.