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## The Utilisation of Radiology for the Teaching of Anatomy in Canadian Medical Schools

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### Abstract

**Objective:** To determine the utilisation of diagnostic imaging (radiology) as a department and/or imaging medium in the teaching of anatomy at the Canadian undergraduate medical education level.

**Methods:** The study objectives were achieved through the use of a questionnaire and a literature review. The anatomy department head at each English-based Canadian Medical School was contacted, and the individual most responsible for anatomy teaching in the medical school curriculum was identified. This individual was subsequently asked to complete a questionnaire that evaluated the involvement of radiology for anatomy teaching in their curriculum.

**Results:** The use and integration of radiology is a common practice in the teaching of anatomy in Canadian undergraduate medicine. Although the methods and extent of its use varied among institutions, every English-based Canadian medical school, except one, was using diagnostic imaging material in their instruction of anatomy. Furthermore, half of the institutions had a radiologist as a faculty member of their anatomy department to help teach and to use imaging to its full potential.

**Discussion:** This audit of anatomy departments suggests that diagnostic imaging has an important role to play in anatomy teaching in Canadian English-speaking medical schools.

### Résumé

**Objectif :** Déterminer quelle est l'utilisation faite de l'imagerie diagnostique (radiologie) comme département ou comme mode d'imagerie dans l'enseignement de l'anatomie aux étudiants canadiens de premier cycle en médecine.

**Méthodes :** Les objectifs de l'étude ont été atteints grâce à un questionnaire et une analyse des articles publiés. Le chef du département d'anatomie de chacune des écoles de médecine canadiennes anglophones a été joint et la personne chargée de l'enseignement de l'anatomie dans le programme d'études en médecine identifiée. On a ensuite demandé à cette personne de remplir un questionnaire qui visait à évaluer la place qu'occupait la radiologie dans l'enseignement de l'anatomie au sein du programme d'études.

**Résultats :** La radiologie est communément intégrée à l'enseignement de l'anatomie aux étudiants canadiens de premier cycle en médecine. Bien que les méthodes et l'importance de son utilisation varient d'un établissement à l'autre, toutes les écoles de médecine canadiennes anglophones, sauf une, utilisaient l'imagerie diagnostique dans l'enseignement de l'anatomie. En outre, la moitié des établissements comptaient, au sein de leur département d'anatomie, un professeur radiologiste chargé de contribuer à l'enseignement, de façon à pleinement exploiter l'utilisation de l'imagerie.

**Thèse :** Cette analyse des départements d'anatomie suggère que l'imagerie diagnostique joue un rôle important dans l'enseignement de l'anatomie dans les écoles de médecine canadiennes anglophones.

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*Key Words:* Medical school; Anatomy; Education; Curriculum; Diagnostic radiology

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Diagnostic imaging (radiology) personnel are trained to assess anatomy and derangements of anatomy on images acquired via modern imaging modalities. It seems fitting then that radiology should play a significant role in anatomy teaching. Although the importance of anatomy teaching remains undisputed, the debate concerning how best to provide this teaching is ongoing. With the advent of novel imaging modalities and techniques, the role that radiology should play in undergraduate medical education also has come into question.

This debate has been further fueled by the shift in medical curricula around the world from the traditional, didactic, basic science foundation to more clinically oriented, problem-based teaching methodologies. This transformation first started in the early 1990s when the United Kingdom General Medical Council first issued a statement recommending the shift away from traditional teaching methods, which included highlighting the importance of integration of clinically-based teaching and problem-based learning (PBL) into undergraduate medical education [1], which indirectly led to a reduction in the amount of didactic anatomy teaching and anatomic dissection time in favor of more clinical, peer-led, problem-based learning and self-directed independent learning activities [2]. In addition, it seems that a gap has formed between what clinicians deem to be relevant and what is thought to be relevant by undergraduate medical educators, which has led to the concern that physicians are graduating with diminished anatomic knowledge [2]. The idea that curriculum evolution is the only reason for the change in anatomic teaching in medicine would be too simplistic. Other influences have been proposed as to why this shift has taken place. For example, the high cost associated with cadaver use [3], an increased focus on research, the increasing number of medical students admitted yearly, compounded by the reduced number of qualified anatomists and staff available to teach anatomy, to name a few [4–7].

Diagnostic images are simply depictions of anatomy, and the interpretation of these images requires a solid understanding of anatomy and its normal variants. Diagnostic imaging has the ability to exquisitely display anatomy in 2 dimensions. The emergence of picture archiving and communication systems (PACS) and software capable of complex image postprocessing now allows instructors to display 2-dimensional (2D) and 3-dimensional (3D) digital images for the purpose of anatomy teaching. This has led some undergraduate medical faculties to involve imaging modalities and radiology department personnel in their anatomy teaching in light of increasing curriculum pressures [2,8–11]. This has aided in narrowing the gap between basic anatomy and clinically relevant anatomy, which many believe has been lacking [12]. Furthermore, the inclusion of imaging anatomy has been shown to be advantageous for students in their future careers [13], and this approach has already been implemented in medical schools around the world, including Germany [14,15], Brazil [13], England [16], and Turkey [17]. It has also sparked many studies that concern interinstitutional reviews of anatomy teaching

processes for best practices in Ireland, the United Kingdom, and the United States [4,18]. A recent review of the use of computed tomographic (CT) imaging of cadavers juxtaposed with cadaveric dissection by Lufner et al [19], further enforces the utility of the integration of radiology into anatomy teaching by deploying the appropriate hardware and software to deal with the DICOM-based images generated by modern CT scanners. The investigators reinforce the previously mentioned strengths of this strategy, but they also demonstrate improved performance on objective evaluation tools applied to the anatomy curriculum [19].

The current Canadian status, however, has not yet been subject to a review, and, therefore, we surveyed the 14 Canadian, English-based medical schools and canvassed the medical literature for current practices, the context, and the methods by which universities have approached the use of radiology in anatomy teaching.

## Materials and Methods

The study was carried out in the Department of Medical Imaging at the Royal University Hospital. We designed and deployed a questionnaire that used an online survey program. The survey questions were created after a review of the literature and presentation of the proposed survey to a group of medical students and radiologists for modification and revision. The Web site for this survey was also used to collect, display, and tabulate the survey responses.

Anatomy department heads were asked to identify the person responsible for delivering the anatomy curriculum to medical students at their institutions. The person identified was invited to participate in our survey. Once the identified individual had agreed to participate in our survey, an e-mail was directing the person to the Web site that hosted our survey. Survey responses were compiled and analysed by us.

We acknowledge that there are inherent limitations of the survey format in that it curtails the discussion of a topic to selected and focused questions, and does not facilitate a broader discussion of the topic in question. The limited number of individuals involved in the response to our survey were only familiar with the delivery of anatomy teaching and may not have had an in-depth understanding of the medical school curriculum as a whole. In addition, data were not acquired from all medical schools, which potentially limited the breadth of our knowledge of the current status of radiology involvement across Canada as a whole.

## Results

The overall response rate to the survey was 92.9% of those invited to participate (13/14). Survey responses were received from the following: University of British Columbia, University of Alberta, University of Calgary, University of Saskatchewan, University of Manitoba, University of Western Ontario, McMaster University, University of Northern Ontario, University of Toronto, University of Ottawa, McGill University, Dalhousie University, and

Memorial University. A summary of responses to key questions is provided below.

1. Is there anatomy instruction included in the undergraduate medical curriculum? If not, how is anatomy learned in undergraduate medicine at your institution? Please specify. All sites that responded indicated that anatomy was included as a dedicated course in the undergraduate curriculum.
2. Which of the following teaching methods are used for anatomy instruction in undergraduate medicine? Select all that apply. The responding sites used a combination of didactic lecturing (13/13), cadaveric dissection (9/13), self-directed student independent learning (SDL) methods (11/13), and PBL (9/13) to teach anatomy. Computer-based learning of anatomy was used at 6 of 13 sites.
3. In which year(s) does anatomy instruction take place? Select all that apply. Anatomy instruction occurred early in the undergraduate medical program in Canada, primarily in the first year (13/13), with the majority of curricula, including some anatomy instruction in the second year (9/13) as well; only one site (1/13) included it in third-year undergraduate medicine.
4. How many hours of anatomy teaching do medical students receive in their undergraduate training before clerkship? The amount of anatomy instruction offered varied substantially. The least amount of anatomy offered was between 40 and 60 hours at one site, however, the majority of schools offered in excess of 100 hours of anatomy instruction.
5. Which of the following anatomy teaching methods would you consider most important for a medical student's learning? Please rank the following in order of most important to least important. Cadaveric dissection was considered to be the most important anatomy teaching method by 8 of 13 sites, whereas 6 of 13 sites considered computer-based anatomy learning to be least important. Didactic presentations were considered to be the second most important method of learning anatomy closely followed by SDL and PBL methodologies.
6. Is radiology used to teach anatomy in undergraduate medicine? Twelve of 13 respondents indicated that radiology was used in their anatomy teaching. The one site that did not include radiology responded that they did think it would be useful and that the instructors would be capable of using and teaching diagnostic imaging to supplement their anatomy instruction.
7. In which instructional format is radiology being used to teach anatomy? Select all that apply. The manner in which this teaching was deployed varied considerably. The majority used radiology in combination with didactic lecturing (9/10), but it was used during other learning opportunities, including clinical PBL cases (6/10), SDL (5/10), and dissection laboratory (3/10), and during computer-based learning sessions (4/10).
8. Is there a specific anatomy textbook that is suggested? If so, which? The majority of respondents (80%) indicated that they did recommend a specific anatomy textbook for students. Most Canadian medical schools suggested that students might find some or all one of the following references of value: *Atlas of Human Anatomy* [20], *Essential Clinical Anatomy* [21], or *Gray's Anatomy* [22].
9. Is there a specific radiology textbook that is suggested for use in anatomy? Ten percent of respondents stated that they recommended a radiology textbook.
10. Is there a specific anatomy online resource (Internet, intranet, etc.) that is recommended for students? If so, which? A slight majority of medical schools (60%) recommended or offered a specific online anatomy resource for their students. These consisted of a variety of in-house programs, made specifically by and for their respective medical school.
11. Is there a computer-based program (CD-ROM, DVD, computer software, etc.) for anatomy that students have access to for student self-directed independent learning? The majority of responding Canadian medical schools (80%) provide a computer-based program for their students as a supplement for anatomy learning.
12. What percentage of the anatomy instruction offered is supplemented by using radiology? Although most sites use diagnostic images to teach anatomy, the extent of its use is variable: 40% of the sites that responded indicated that radiology was used in 20% or fewer of anatomy instruction offered, 40% of sites indicated that radiology was used in 20%-30% of instruction, and 20% of responding sites used radiology as much as 40%-50% of the time in anatomy instruction.
13. What radiology modalities were used to teach anatomy? Select all that apply. The radiology modalities adopted for anatomy instruction were diverse, with most Canadian medical schools using a combination of 4 or 5 different modalities, including radiographs, CT, magnetic resonance imaging (MRI), angiography, and ultrasound (US). The 3 most commonly used modalities were radiographs (100%), CT (90%), and MRI (90%). Interestingly, at 1 site, the students were provided enhanced anatomy teaching that uses real-time US displayed on large viewing monitors in their gross anatomy laboratory. Students at this site could also attend US clinics to gain a better understanding of the anatomy depicted by US and how it can be related to 3D body structure.
14. In your opinion, what radiology modalities are most useful in anatomy instruction/learning anatomy? Please rank the following in order of most useful to least useful. When asked which imaging modalities were most useful in anatomy instruction, respondents considered plain radiographs to be most important, followed closely by CT and MRI. US was considered slightly less useful than MRI, and angiographic images were deemed least useful.
15. Is there a specific anatomy faculty member who is a certified radiologist? Surprisingly, 50% of the schools responding indicated that there was a certified radiologist as a faculty member of the department of anatomy.

16. Are any other personnel from the department of radiology involved in the teaching of anatomy? If so, please estimate the number of hours that each of these radiology department personnel is allocated to teach anatomy to medical students. This question was directed at the those schools that did not have a radiologist on staff in the department of anatomy to determine whether there was any other diagnostic imaging personnel that helped in the anatomy instruction. The respondents indicated that 90% have a member of the department of radiology (the majority of the time this was either a radiologist, resident, or both) involved in the anatomy teaching. Of the schools in which a radiologist is teaching anatomy, a third of the sites indicated that radiologists were allotted more than 10 hours of anatomy teaching, another third of the sites responded as radiologists being allotted 8–10 hours, and the other third being allotted under 4 hours of anatomy teaching time.
17. What teaching methods are the radiology department personnel using to teach anatomy in undergraduate medical education? Select all that apply. Radiology-based anatomy instruction provided by imaging personnel was through a combination of methodologies, with the majority using didactic lectures (88.9%). Other less frequently used methods included case-based PBL and supplementation to cadaveric dissection, 44.4% and 22.2%, respectively.

A summary of some of the key findings is presented in Table 1.

## Discussion

Radiology images are simply 2D depictions of anatomy, and the interpretation of images requires a solid understanding of anatomy and its normal variants. Every English-based Canadian medical school polled, except one, indicated

Table 1  
Summary of key findings

Event	Response	No. respondents	%
Survey response rate		13/14	92.9
Most important anatomy teaching tool	Cadaveric dissection	8/13	61.5
Radiology used to teach anatomy		12/13	92.3
Most commonly used imaging modalities	Radiographs		100
	CT		90
	MRI		90
Most useful imaging modality	Radiographs		
Most common teaching technique used by radiologists to teach anatomy	Didactic lecture		88.9
Percentage of anatomy departments with a radiologist as a faculty member		6/12	50

CT = computed tomography; MRI = magnetic resonance imaging.

that radiology was incorporated into the instruction of anatomy. The majority of respondents (80%) indicated that radiology modalities were being used for 30% or fewer of the anatomy instruction provided.

Ancillary radiology resources recommended to, and/or provided for, medical students were virtually nonexistent in comparison with those for anatomy. This was surprising in light of a recent audit of first-, second-, and third-year medical students at the University of Saskatchewan that found that 71.4% would use a radiology textbook if one were recommended. The same unpublished survey date revealed that a majority of students, 92.1% and 85.7%, had a similar opinion with regard to online resources and computer-based programs, respectively, for SDL for radiology.

A large number of the medical schools surveyed (90%) have a member of the department of radiology involved in the anatomy teaching. Most of the time, this person was either a radiologist or a radiology resident. Surprisingly, 50% of the surveyed departments have a certified radiologist as a faculty member of the department of anatomy. Having a trained radiologist on staff represents a powerful learning tool for students, because it allows for anatomy learning while bridging the gap between a clinical specialty and basic medical science. It is obviously easier to incorporate imaging studies into anatomy if there is someone on staff who is specifically trained in radiology, one who understands how the imaging can be used to its fullest potential. In a study by Erkonen et al [18], as well as in subsequent studies, it has been stated that, if radiologists do not formally teach radiology to students, then nonradiologists will [23]. This, in combination with the expressed need for radiology to assume a central role as a teaching tool throughout undergraduate medicine, supports our notion of radiologists helping to teach anatomy [24].

It is also very promising to see the integration of a clinical department into the undergraduate medical curriculum, because this is probably in the best interest of the medical student. The Radiological Society of North America established an ad hoc committee on anatomy instruction to investigate the role of radiology in teaching anatomy. The committee surveyed 100 academic radiology departments across the United States and found that, although 76 indicated that the department was involved in anatomy teaching, this was only for an average of 21 hours per year [10]. Another survey of radiology clerkship directors revealed that 9% of programs directed a gross anatomy course, and 20% taught some portion of an anatomy course [1]. Therefore, although radiology is incorporated into anatomy teaching, there is still room for improvement with respect to the extent of its involvement.

Mitchell and Williams [4] determined that, although most departments used computer-based learning for presenting medical images, the amount of imaging material available and dedicated specifically to anatomy learning was quite limited. Another possible benefit of the radiology-anatomy collaboration could be the creation of a dedicated radiology-anatomy repository that could be used to highlight anatomy teaching and be retrieved for future learning.

The manner in which radiology is being used in the instruction of anatomy varied considerably. We noted that almost every site used some combination of didactic lectures, utilisation of cadaveric specimens, clinical PBL, and SDL. Although a large number of medical schools use computer-based learning for anatomy (80%), only 66% of the schools that offered computer-based learning for anatomy also offered medical imaging in a similar format. This seemed counterintuitive to us because the use of imaging in medicine today is almost completely digital, and images are stored in large databases related to PACS. It would seem only natural that computer-based learning and the use of images from PACS for anatomy teaching would go hand-in-hand. Having said this, it was encouraging to learn that anatomy is being offered through a wide variety of different media. For example, some schools have created podcasts, self-directed quizzes for self-evaluation, and clinical cases integrated into anatomy objectives, and offer videos to students to help them learn anatomy. Moreover, one school has started using US machines in the gross anatomy laboratory for anatomy teaching and also provides their students with the opportunity to attend US clinics for patient imaging [11], which allows for basic science and clinical imaging integration.

It was also encouraging to see that so many different imaging modalities were being used in anatomy teaching and that students were made aware of them at such an early stage in their education. The incorporation of the widely varied imaging modalities is of benefit to those in their early years of medical school, because it helps them develop a fundamental understanding of how the different imaging technologies are able to depict different anatomic structures. It also gives students insight into the appropriateness of specific imaging technologies based upon the anatomy, or derangement thereof, that they are seeking to highlight [13]. Further advancements in image postprocessing applications will also inevitably benefit anatomy students as their use becomes more widespread and applicable. For example, the use of 3D technologies was not prevalent in our survey but have been proven to be valuable for anatomy education and clinical skill development [25].

There is no doubt that anatomy is one of the foundational pillars on which a medical student builds his or her knowledge. Over the past decade or so, this foundation has undergone a shift from a traditional didactic style of instruction to a more interactive one that involves PBL, clinical cases, computer-based learning, and SDL. Whether it is because of this teaching evolution or a combination of other influences, more and more medical schools have been incorporating radiology into their undergraduate curricula. Although radiology has been integrated into an array of different undergraduate medical courses [2,4,5], it has been most commonly used to teach anatomy in undergraduate medicine [7].

We believe that the combination of the many different imaging technologies available, associated with traditional, didactic, and cadaveric learning, is a highly effective way to teach anatomy. We are encouraged that so many of the Canadian medical schools surveyed currently incorporate radiology into their anatomy teaching. We hope that this trend will continue and that the departments involved will

develop dedicated imaging software and hardware processes to enhance anatomy teaching in the age of digital medicine.

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