Developing a Hybrid Four-Prong Approach to Anatomical Education During the COVID-19 Pandemic

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Abstract

During COVID-19, the anatomy faculty and students at Schulich School of Medicine and Dentistry observed strengths and weaknesses in their transition to online learning. A “four-prong” approach to teaching anatomy was developed. Asynchronous content modules were tailored to specific learning objectives, virtual labs were implemented to work through case-based applications, “live from the lab” review sessions provided the opportunity for interaction and integration, and finally, limited face-to-face laboratory sessions provided an opportunity for supervised consolidation with cadaveric specimens. Our approach may be used by other institutions to enhance anatomical education and student engagement.

Keywords Anatomy · COVID-19 · Live-streamed reviews · Undergraduate medical education · Laboratory dissection

Introduction

Anatomy is a foundation of medical school curricula. Anatomical knowledge is fundamental for the development of clinical skills such as physical examination, the formation and communication of a diagnosis, and for surgical disciplines [1]. At the undergraduate medical education (UME) level, anatomy is typically taught in didactic and laboratory sessions, using cadaveric dissections and prosections. The use of human cadavers allows students to gain practical manual skills, experience human variation [2, 3], master discipline vocabulary, develop appropriate attitudes toward death [3], and develop professional competencies including teamwork and develop stress and time management

strategies [4]. Additionally, Azer and Eizenberg found that pre-clerkship medical students felt that laboratory dissection helped them better understand and recall anatomical structures, gain a deeper understanding of the material through a three-dimensional perspective, and develop a respectful attitude toward the human body [5]. Fundamentally, laboratory learning also allows for enhanced engagement with course material [5, 6].

Previous studies have shown that both students and professional anatomists prefer practical learning methods to traditional didactic teaching [7, 8], though both methods may have a place in a blended multimodal approach [9]. Two beneficial aspects of a team-based gross anatomy laboratory dissection are the provision of feedback and the opportunity for interaction [10]. The importance of providing learners with feedback, especially in a clinical learning environment, has been well-established and has been shown to improve student confidence, motivation, and clinical skills [11]. In fact, Whelan et al. demonstrated that a main disadvantage of independent anatomy learning in UME was a lack of feedback from tutors [12]. Likewise, the laboratory environment also provides an opportunity for learners to provide feedback to their instructors. This allows instructors to gauge the learner’s comprehension of specific concepts and instructors have reported improved interpersonal skills and teaching satisfaction resulting from these interactions [13]. Learner-to-learner feedback, an innate and vital component of groupwork is yet another valuable benefit of

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laboratory-based learning [14]. Aside from the provision of feedback, the opportunity for meaningful interaction is an important aspect of the gross anatomy laboratory. Interactions with peers, instructors, and the donor specimens, the latter involving hands-on exploration of human anatomy using cadavers and prosections, are three examples of interactivity which help to enhance student learning [11]. In summary, the gross anatomy laboratory environment is a valuable component of the anatomical education of medical students due to myriad of factors: the opportunities for feedback (instructor-to-learner, learner-to-instructor, and learner-to-learner), the interactive nature of anatomy laboratory sessions (with instructors, peers, and the donor specimens), the ability to explore human variation and three-dimensional relationships, and the development of various professional skills, including time management and teamwork.

The COVID-19 pandemic has disrupted the traditional delivery of anatomical education and institutions have been required to rapidly adapt curricular delivery. Several academic institutions have documented this disruption and outlined the ways that their curricula have adapted thus far [15–20]. Online learning in the form of video conferencing [18] as well as digitized cadaveric and 3D virtual anatomy platforms [17] are examples of synchronous and asynchronous online learning formats commonly implemented. The timeline of the COVID-19 pandemic means that curricular changes have been fast-paced with minimal opportunity for preparation, so long-term evaluation of these methods in the context of COVID-19 remains to be seen.

To optimize virtual learning, established elements of effective online pedagogy should be incorporated [21, 22]. These elements include emphasizing feedback, establishing social connections, and using a range of technologies [19]. Online tools such as virtual dissection simulators and online anatomy software have served to supplement traditional modes of content delivery [23–26]. However, these online tools do not address all the benefits of face-to-face laboratories [23], and the current circumstances may limit access to quality virtual simulators and software. Other online-specific challenges have been noted from faculty and student perspectives. For example, faculty have had to address challenges including the lack of student interaction, an issue amplified by the anonymity afforded in an online environment [17]. Likewise, students have faced limited access to optimal learning environments and reduced engagement with peers, instructors, and course material [19]. However, despite many challenges, the transition to online learning due to the COVID-19 pandemic provides educators the opportunity to evaluate the way anatomy is taught. Educators can ensure that the limitations of online anatomical education are addressed and that the benefits of laboratory-based anatomy teaching are maintained both during the current pandemic and there after [16]. A blended

learning approach where multiple modalities are implemented may be an effective way to address the limitations and challenges of online learning [18].

Description

The Schulich School of Medicine and Dentistry at Western University has a 4-year undergraduate medical program. The anatomy curriculum is delivered in the first 2 years of study in an integrated systems-based format using a blended learning model. The content is delivered asynchronously via online modules, which include interactive knowledge checks, and the content is applied and explored in self-directed anatomy laboratories. The laboratory setting has one teaching assistant (TA) for every two dissection tables, and the dissection tables have approximately six students per table. Students are expected to work through a dissection manual while dissecting or looking at prosections, depending on the area of study.

We will first describe the conditions leading up to development of the four-pronged approach. During the beginning of the COVID-19 crisis in March 2020, the students were in their gastroenterology block and the genitourinary block remained. The anatomy content was already being delivered via asynchronous interactive online modules, so that aspect remained unchanged. To replace the laboratory component, the anatomy professor chose to implement virtual dissection software to maintain the self-directed exploratory nature of the laboratories, using the original laboratory manuals. Dissection videos were also linked to allow students to visualize harder-to-conceptualize structures. Soon after implementation of the virtual dissection software, limitations arose. The anatomy professor struggled to visualize all the necessary structures and felt that the software was limited by only having 2D key views. There was minimal guidance while working with the software, and a lack of interactivity and feedback. Virtual dissection software also limited the appreciation of 3D spatial relationships and human variation normally present.

To address these concerns, the anatomy professor implemented live anatomy reviews. With the help of student leaders, questions and review topics were collected from the class via a Google document ahead of the live sessions. During the live sessions, the instructor talked through anatomical concepts using the pre-collected questions as a guide while illustrating the concepts with the relevant specimens on camera. The Google document allowed the anatomy professor to prepare the most appropriate specimens ahead of time. The anatomy lab reviews were live-streamed via ZOOM [27]. This platform enabled the camera to view both the specimens and the professor and allowed students to ask questions during the demonstration. Importantly, when using ZOOM, necessary security measures were taken to ensure adequate privacy to the donor specimens and the anatomy laboratory. Medical students in the anatomy

course had to agree to a professional statement in order to receive the ZOOM link and password. Once students provided the password, they were then added to a waiting room and a TA took attendance to ensure all students were enrolled in the program before allowing them into the meeting. Once the session began, the meeting was locked down, preventing individuals from joining the meeting to maintain security for our learners and donors. During the session, a TA monitored the chat function and alerted the professor to any students who had their hand up while the professor was busy demonstrating and unable to look at the screen. During the sessions, the professor aimed to present the specimens in a dignified manner and ensured that no personal identifiers were visible. Two live anatomy reviews were held: one after the gastroenterology block content and one after the genitourinary block content.

Prior to the COVID-19 crisis, the assessment was a traditional bell-ringer style exam with application-type questions. During the COVID-19 crisis, it was decided that the advantages of this type of exam, such as students being able to demonstrate their knowledge of structure identification and understanding of spatial relationships in the 3D space of the cadaver, could not be replicated in an online format with 2D anatomical pictures. Thus, the assessment was changed to a group assignment. The group assignment consisted of four different cases. Each laboratory dissection group was assigned one case. Each group was required to create a multimedia presentation of the case demonstrating the related anatomy of the symptoms, assessment, treatment, and management. Each group was also responsible for submitting a one-page handout to highlight the related anatomical content for their fellow classmates. After submission of the project, each group was asked to peer-grade three other group assignments that covered the other three cases, so that each group had exposure to all four case assignments.

The rapid adjustments to the curriculum in this initial semester was effectively a test pilot and would later help cement the four-pronged approach to learning anatomy in the following fall semester. Important to note, in-person laboratory sessions were initially completely cancelled in the March 2020 spring semester, but subsequently approved for limited small groups donning PPE the following fall 2020 semester. The sessions occurred approximately once every few months to limit exposure. Thus, we were able to incorporate traditionally taught, albeit smaller group in-person laboratory sessions into our four-pronged approach.

Discussion

The Four-Pronged Approach

The COVID-19 pandemic has provided an opportunity for the development of novel online resources and online

teaching modalities. In this unprecedented time, it is unknown how long anatomy will require a virtual delivery. Reviewing the strengths and weakness of the delivery of anatomy this past year, we have developed a novel hybrid anatomy curriculum that aims to curtail weaknesses and capitalize on strengths. Our curriculum utilizes a student-centric blended learning approach with four methodologies, or “prongs”: (1) asynchronous content delivery via online modules; (2) application of content via synchronous TA-led video-conference tutorials (virtual laboratories, or vLabs); (3) live anatomy lab reviews; (4) periodic in-person sessions in the anatomy lab when regulations permit. These four prongs increase opportunities for students to interact with faculty and receive feedback while learning.

First, asynchronous modules are used to deliver course content in preparation for in-person laboratory sessions. Modules are updated to focus on key learning objectives and broken into “mini-lectures” with embedded knowledge checks, which allow for feedback and promote engagement. Furthermore, modules conclude with customized lab demonstration videos created by the anatomy instructor to allow visualization of specimens and summarize asynchronous content.

Next, the vLabs increase opportunities for feedback and interactivity. During vLabs, students work in small groups under the guidance of a teaching assistant (TA) to explore case-based application questions. Cases are created to align with asynchronous modules and allow students the opportunity to apply anatomical knowledge in clinical scenarios. In these virtual groups, students interact and exchange feedback with both peers and TAs. Importantly, this also allows TAs to assess student comprehension of asynchronous content.

Third, “live from the lab” reviews are used to consolidate and integrate asynchronous module content and vLab clinical cases. During these sessions, the anatomy and clinical faculty video-conference students from the anatomy lab. Instructors use case-based clinical applications to review anatomical and clinical principles and answer outstanding questions. Importantly, 3D spatial relationships and normal human variation are emphasized through real time manipulation of specimens. These reviews also provide the opportunity for valuable reciprocal feedback between instructors and students.

Finally, several face-to-face laboratories are scheduled at strategic intervals throughout the term. Sessions are held in small groups to respect reduced building capacity. Personal protective equipment is donned, and distancing protocols outlined by public health are followed. Face-to-face laboratories are an opportunity for students to interact with specimens and discuss content in small groups with an instructor. These sessions provide a valuable opportunity for supervised consolidation and review with cadaveric specimens.

This four-pronged approach to anatomical education addresses the challenges encountered during the initial rapid transition to online learning. While not a complete replacement for the anatomy lab, it aims to ensure that each student will have the opportunity to learn the anatomical course content in a manner that allows for self-directed learning and interaction with course content, instructors, and peers. The development of this hybrid curriculum has been a huge opportunity for Western University to innovate its curriculum and adapt to its students' needs.

Strengths and Weaknesses

Strengths and weaknesses to Schulich UME's four-pronged approach will now be discussed. We will focus the discussion on the online live teaching components the most because those are the newest adaptations that need to be evaluated. Pertinent strengths include tailored content, the use of an engaging and interactive platform, the development of 3D spatial awareness and exposure to human variations, and the opportunity for independent student feedback through metacognitive processes. Weaknesses identified include the limited provision of meaningful feedback and interactivity.

Strengths

It has been well-established that using cadavers to teach anatomy is beneficial to learners as it increases interactivity in the learning environment, allows for meaningful feedback to occur, and encourages exploration of human variation and spatial relationships [5, 10, 11]. Though the current circumstances do not permit conventional cadaveric teaching in person, many of the advantages of gross anatomy lab teaching were achieved using video-conference-based cadaveric teaching through live anatomy lab reviews. There were four major strengths of our implementation of live anatomy lab reviews: tailored content, the use of an engaging and interactive platform, the development of 3D spatial awareness and exposure to human variations, and the opportunity for independent student feedback through metacognitive processes.

First, the ability to use live anatomy lab reviews enabled the professor to tailor content to Schulich's UME curriculum. It enabled constructive alignment with the institutional curriculum objectives. This facilitated the transition from in-person to online laboratories. It increased the continuity for students while allowing the professor to align content across the employed teaching modalities (asynchronous interactive modules, virtual dissection software, and live lab reviews). We found that the addition of live anatomy lab reviews facilitated the customization of content beyond what was previously achieved through online virtual dissections or videos created by other institutions. Additionally, student leaders were able to elicit feedback from peers on behalf of

the professor to determine what they wanted to review prior to the live session. This allowed the professor to tailor the content not only to the curricular goals, but to student needs.

Second, the live anatomy lab reviews provided an engaging and interactive platform during a period of exclusively online learning. Students were able to communicate directly with the professor by speaking through the microphone or using the chat box function while different anatomical concepts were being explained. This was a method to increase learner engagement through instructor-to-student interactivity beyond what other online modalities (such as asynchronous dissection videos and virtual dissection software) permitted. To enhance interaction further, during the second review session, the anatomy professor requested that students turn on their own cameras to help simulate an in-person teaching environment. Approximately one third of the class obliged. With the cameras on, this session had significantly more instructor-to-student interaction compared to previous sessions without cameras. This change enabled the professor to garner immediate feedback based on facial expressions and body language. The face-to-face interaction allowed the professor to adapt the session based on perceived engagement and clarify points that seemed to require more explanation based on student reactions.

Third, live anatomy lab reviews allowed for student exposure to human variation and the opportunity to develop improved spatial awareness of the human body. The anatomy professor was able to use multiple specimens during the lab review and show variation among them. For example, variation in supernumerary renal vessels and the presence of an accessory inferior epigastric vein were shown. To aid students in understanding spatial relationships within the body, the anatomy professor was able to discuss where fluid would collect in the abdominal cavity and identify important spaces that are difficult to visualize when studying from 2D images.

Last, live anatomy lab reviews provided the opportunity for independent student feedback through metacognitive processes. A vast amount of research has shown the value of metacognition in academic learning, with benefits such as the opportunity for personal awareness and the fostering of independent learning [28]. Students who demonstrated metacognitive strategies, such as monitoring their learning, reflecting on their mistakes, and planning their learning task, exhibit better exam performance and gain a deeper understanding of the material [29]. Flavell demonstrated that metacognitive knowledge is composed of three categories: person variables, task variables, and strategy variables [30]. Specifically, person variable is when an individual can recognize their own strengths and weaknesses with regards to their learning. Live anatomy lab reviews provided students with opportunities to reflect on the material that they understood and wrestle with the material with which they struggled - the lab reviews facilitated these metacognitive processes. In summary, strengths of the live

anatomy lab reviews include the opportunity to tailor content with the use of an interactive platform, the opportunity for instructor-to-learner and learner-to-content interactivity, the opportunity to develop spatial awareness and explore normal human variation, and the opportunity to engage in metacognitive feedback processes.

Weaknesses

Although there were many advantages to the implementation of live anatomy lab reviews, two major weaknesses of the live anatomy lab reviews remained: limited interactivity and limited feedback.

While live anatomy lab reviews introduced some instructor-to-student interaction during a time of predominantly asynchronous independent learning, opportunities remained limited. There also remained a lack of interactivity between students and the content (specifically the donor specimens), and students and their peers. As mentioned previously, we tried to amplify instructor-to-student interaction by asking students to turn on their cameras during the second review session. As only one third of the class obliged, two thirds of the class did not benefit from the same level of interaction. The student authors of the current paper felt that by turning their cameras on, they were more engaged with the material and the instructor. The fact that two thirds of the class potentially did not benefit from this perceived level of engagement remains a limitation of our approach. Additionally, though live anatomy lab reviews aimed to mitigate the lack of interactivity with donor specimens by using a video-conferencing platform, student interaction with anatomical specimens remained limited; students themselves were unable to perform cadaveric dissection or interact with dissections. Students were thus unable to actively explore the anatomical relationships and human variations at their own pace. As previously discussed, student interactivity with specimens is an essential component of an anatomy laboratory experience. Not only do students and instructors prefer practical, interactive teaching methods [7, 8], but they also gain a deeper understanding of anatomical concepts when they can interact with the specimens [5, 6]. Nonetheless, while the students were not able to explore the specimens themselves, they did have the opportunity to ask content-related questions to the anatomy professor and watch as the professor worked with the specimens in real time. Finally, student-to-peer interactions were also limited during these sessions. Since students could not easily talk amongst themselves or collaborate during these live anatomy lab reviews, peer interactivity was eliminated. Therefore, though live anatomy lab review sessions provided some interactivity with the instructor and exposure to specimens, interactivity with the instructor, specimens, and peers remained limited and a pertinent weakness.

The second major weakness of live anatomy lab reviews was that they did not provide the same opportunity for direct feedback as is provided in the laboratory environment; particularly, feedback from instructor-to-learner and learner-to-learner. It has been demonstrated that a lack of feedback from instructors is a major disadvantage of independent learning [12]. This was exemplified during our transition to online education when all learning was shifted to asynchronous independent learning. Although the live anatomy lab reviews allowed for some positive interaction and feedback as discussed previously (specifically learner-to-instructor feedback), the large group format limited the amount of meaningful feedback that the professor could provide to each individual student. Additionally, this format prohibited learner-to-learner feedback, as students were not in the anatomy lab to work through challenges within their student teams. To mitigate these two perceived weaknesses, the change in assessment format to the clinical anatomy group assignment aimed to provide an alternative opportunity for students to collaborate and provide peer feedback. The creation of the group assignment thus attempted to supplement the lack of student-to-peer interactivity and learner-to-learner feedback in the live anatomy lab reviews.

Conclusion

Access to face-to-face cadaveric anatomy laboratories remains a valuable component of any anatomy curriculum. It allows students to develop a deep understanding of anatomical structures. It contributes to the development of numerous professional competencies, allows students to interact with course content, and provides an opportunity for meaningful feedback from instructors and other students. Due to the COVID-19 pandemic, traditional laboratory-based anatomical education was forced to transition to online learning. In the place of laboratory teaching, Schulich UME continued to provide asynchronous interactive online modules to deliver course content. Modules were further supplemented with asynchronous virtual dissection software and dissection videos. To address student concerns, live anatomy lab reviews using videoconferencing were implemented. These reviews increased student engagement and provided an environment in which students could interact with the anatomy instructor in real time. They also provided an opportunity for students to develop a deeper understanding of spatial relationships and an appreciation for normal human variation through a digital platform. Noting the strengths and weaknesses of the online transition, Schulich UME officially developed a four-pronged approach to learning anatomy: asynchronous content delivery via online modules, application of content via synchronous TA-led video-conference tutorials, live anatomy lab reviews, and occasional face-to-face sessions when permitted. Schulich UME anatomy will continue to

implement this approach until the pandemic subsides. Our proposed methods optimize student engagement by enhancing interactivity for students and instructors, and provide opportunities for meaningful feedback in a small group setting. These methods will address gaps perceived during the initial change over to online learning. We suggest that this approach, developed in response to the COVID-19 pandemic, could be implemented by other institutions to facilitate the transition to online learning while retaining a high-quality anatomy curriculum.

Take Home Messages:

- Schulich UME has developed a hybrid four-pronged approach to teaching anatomy that facilitates engagement and maximizes opportunities for learner feedback. It is currently being used during this pandemic and can be used in any future emergency situations.
- The four prongs include various styles of teaching: asynchronous online modules, TA-led video-conference tutorials, live laboratory reviews, and periodic in-person sessions in the anatomy lab when regulations permit.
- Strengths of this hybrid approach include: tailored content and the opportunity to interact with the professor, experiencing anatomy in 3D, and being able to engage in metacognitive processes.
- Weaknesses of this hybrid approach include: suboptimal opportunity for feedback and student interaction.
- Access to in-person cadaveric anatomy laboratories remains a valuable component of any anatomy curriculum and is still incorporated in our four-pronged approach in a limited capacity.

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Declarations

Conflict of Interest The authors declare no competing interests.

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