**Evolution of Practical Anatomy Course in the Covid-19 Quarantine Era**

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Practice points:

* Due to pandemic restrictions, the anatomy staff reviewed and restructured one remaining module of the anatomy course. This restructuring allowed us to evaluate and compare practical and theoretical anatomy online teaching framework to traditional in person instruction.
* This comparison was performed in a two tiered fashion. We were able to compare this group of students' performance on this module with their performance on previous modules which were taught in the traditional full in person structure, as well as comparing this groups' performance on this module to previous groups of students performance on this module when taught in the traditional structure.
* While most students preferred conventional teaching, the advantages and disadvantages of the online method were expressed and can be used for future course improvement.
* Given the results and student feedback, future combinations of online and conventional anatomy teaching appear preferable.

ABSTRACT:

The Covid-19 pandemic necessitated an educational revolution - transitioning to online-teaching. While most courses continued online, replacing the usual classroom activities with online instruction, cadaveric dissections, a core element of medical education, were jeopardized. This paper documents our institution’s attempt to overcome the challenge of distance practical anatomy teaching. The resultant module’s effectiveness, and its objective and subjective impact on the learning experience are evaluated.

Methods: During March and April of 2020, our 2nd year medical students participated “Zoom” only based anatomy instruction for the “limbs” portion of their course. Theoretical frontal lectures were delivered by "Zoom", cadaveric dissection groups were created with identical sized groups compared to previous modules and virtual laboratories were delivered via "Zoom". After the course, all students completed an anonymous questionnaire to evaluate the online module compared with past conventionally taught modules. Additionally, students’ grades were compared to their own grades on other modules completed during the pre-COVID-19 academic year and respective grades of previous classes on this specific module.

Results: While most students preferred the conventional method, some identified benefits in the online method. There was no difference between individuals’ grades in the theoretical exam and the mean grade in previous theoretical exams.

Conclusion: While under optimal conditions cadaveric dissection is key in anatomy teaching, our online method was sufficient during this time and with adjustments should be considered a valuable resource in the future.

**Keywords:** Gross anatomy education, medical education; Covid-19; cadaver dissections; remote learning.

**INTRODUCTION:**

In March 2020, the World Health Organization (WHO) announced Covid-19 a global pandemic (WHO Covid-19: situation report 51, 2020). To limit its spread, countries enforced varying levels of quarantine restrictions, the strictest of which were “stay at home” mandates (Waldrop, 2020; Wolf, 2020). Educational institutions, medical schools included, were focused on converting to online education. Indeed, medical schools rapidly changed their pre-clinical instruction methods, including anatomy instruction, to online-only options (Brassett et al, 2020; Evans et al., 2020; Franchi et al., 2020; Hanad et al., 2020; Pather et al., 2020; Yuen et al., 2020).

The Medical School for International Health (MSIH) at Ben-Gurion University of the Negev (BGU) immediately halted lectures and converted all pre-clinical courses to online-learning via “Zoom” (Zoom Video Communications Inc. San Jose, CA) and "Modular Object-Oriented Dynamic Learning Environment" (Moodle) (Moodle HQ, Perth, Australia). These modalities were already well-established distance teaching, learning and communication tools (Cole and Foster, 2007; Archibald et al., 2019; Srinivasan, 2020). The online-teaching platform was appropriate for most pre-clinical courses, enabling an easy transition for most traditional lectures, group discussions, and problem-based learning, including theoretical anatomy lectures. However, the anatomy staff at BGU were skeptical that online lectures could adequately replace the cadaveric dissections.

Ideally, during practical dissection laboratories, students would have a tangible, three-dimensional experience enabling them to develop accurate perception of spatial relationships between body parts and anatomical areas (Arora and Sharma, 2011). Due to the restrictions, the dissection laboratory closed and delivering such an experience, considered core in anatomy learning (Bergman, 2015), was impossible. The timing of the "shelter-in-place" pandemic restrictions challenged our school, like many others (Evans et al., 2020; Franchi, 2020; Longhurst et al., 2020; Ravi, 2020; Srinivasan, 2020; Theoret and Ming, 2020), to reinvent itself in many ways including learning to teach cadaveric anatomy online.

Many of these changes have already been examined and reported. To date, many of the articles published examine the implications on educational staff (Cheng et al., 2021; Jones, 2020; Pather et al., 2020). Jones et al. have also concerned themselves with ethical issues which may arise should this teaching method continue post-pandemic (Jones, 2020).

A small number of published studies examined reactions of students to such changes (Cuschieri et al., 2020); but to the best of our knowledge none of them compared students’ performance to conventional methods of instruction.

To best replicate the dissection experience while maintaining the safety of students and faculty, the staff surveyed relevant literature regarding supplemental anatomy teaching methods. A commonly described method to enhance anatomy teaching is using videos and animated programs. While it is widely researched (Attardi et al., 2015; Attardi et al., 2016; Attardy et al., 2018; Grosser et al., 2019) its impact on students’ accomplishments, knowledge acquisition and preferences are still debated. Some authors claim these strategies have positive impact on student satisfaction and grades, (Dev et al, 2006; Topping, 2014; Choi-Lundberg et al., 2016; Ozer et al., 2017), while others found them equivalent to traditional strategies (Saxena et al., 2008; Mahmud et al., 2011). Furthermore, some studies were conducted on non-dissection-based courses, and others supplemented traditional courses with videos or animated programs.

To the best of our knowledge no study was conducted comparing online-only delivery, including dissections, to the traditional classroom delivery, especially within the same cohort.

We hypothesized that online anatomy teaching to be equal to or not inferior to the traditional dissection-based method.

This article describes our efforts to overcome the challenge of remote-only practical anatomy teaching and its impact on students’ learning experience objectively, by comparing inter and intra group performance, and subjectively, from students’ feedback.

**MATERIALS AND METHODS**

**Context:**

The MSIH program at BGU is a 4-year international program recognized by the ECFMG. Its curriculum modeled after an American four-year medical school curriculum. Each class comprises of 24-30 students, many of whom graduated from US undergraduate institutions, 50% of whom completed a B.Sc. Minimum MCAT score for admission is 504. While class characteristics vary, on average, the student body is 50% female.

The gross anatomy course is taught during the 2nd year, in 4 modules (thorax, abdomen and pelvis, head and neck, limbs). All modules traditionally include frontal conceptual/ theoretical lectures and practical cadaveric dissections. Lectures are delivered by anatomy instructors from the faculty of Ben Gurion university. Practical laboratory groups (up to 8 students) are instructed by teaching assistants (TAs). Students are requested to review structures before cadaveric lab using the assigned course book (Netter, 2011), and then participate in relevant dissections. Dissections are performed according to Grant's dissector book (Tank, 2012).

For the 2019-2020 academic year, the first three modules -thorax, abdomen and pelvis, head and neck - were taught traditionally.

**Online Anatomy experience**

Once restrictions were issued, the staff had to convert the remaining module -limbs- to remote-learning. As a basic principle, their goal was minimizing changes while maintaining the course’s style, depth of instruction and attention to detail. Accordingly, the same lecturers, number of practical and theoretical hours, dissection groups and instructors from the other modules remained.

As with other pre-clinical courses, theoretical lectures previously delivered as frontal were taught online using “Zoom”, with existing presentations. Most students attended the “Zoom” lectures and virtual dissections from Israel while several returned abroad (mostly to the US).

Regarding the module’s dissection component, the class was divided into two groups, each assigned to a teacher assistant (TA), and participated in “Zoom” lessons. This allowed personal attention and a convenient platform for participation, especially due to time-zone gaps (Israel is GMT+2, 7 hours ahead of US Eastern).

Medical students’ recommended learning goals and milestones in anatomy have been described by the Anatomical Society of Great Britain (Smith et al., 2016) and were considered in adapting our module to distance-learning. Furthermore, adaptation was done according to the needs assessment and instructional objectives steps in Kern’s 6-step curriculum development model (Sweet et al., 2015).

Dissection discussions were conducted using the course book “Atlas of Human Anatomy” (Netter, 2011) and a book containing photographic dissections “Color Atlas of Anatomy: A Photographic Study of the Human Body” (Rohen et al, 1993). Instead of dissecting according to Gray’s Anatomy, the class reviewed pictures of professional dissections from the books (Figure 1). Additionally, the TAs reviewed, in real-time “Zoom” sessions, open-access online dissection videos provided by the University of Wisconsin (UW, 2015) previously confirmed to satisfy the requirements of the Anatomical Society of Great Britain. Table 1 compares properties of the practical module before and after Covid-19.

**Module Assessment**

Due to the above changes, students who had already experienced traditional anatomy learning in three previous modules, had to adapt to a new method for their final module. Since such modifications may alter student’s reaction and satisfaction and affect learning, an evaluation model reflecting both levels were required. Kirkpatrick’s model (Panchenko, 2013) which allows assessing students’ reaction to the new format (Kirkpatrick’s first level) as well as evaluating the learning process (Kirkpatrick’s second level) was used.

**Performance Outcomes of Online Module**

Knowledge acquisition in the first three modules, and in previous academic years for all modules, was evaluated by theoretical and practical “spotter” exams. The theoretical exam included 60 multiple-choice questions (two per academic hour) and graded between 0 to 100, 65 being the passing grade. The spotter exam was typically held in the dissection room, using cadavers dissected during the course as “stations”. There were 25 stations, each of which contained three pins on anatomical structures for the students to identify by full name as in the course book, yielding a total of 75 structures. Correct answers were calculated out of 100, 55 being the passing grade.

For the online module, the theoretical exam was identical to previous years.

However, the practical exam differed. The online spotter exam contained 25 stations, each with 1-3 pictures (from the photographic dissection book) with arrows pointing to structures to be identified (Figure 2). The total number of structures and grading method were similar to the traditional exam.

Students participated in both exams using “Moodle” while being proctor-supervised via “Zoom”.

**Self-Report Assessment of Online vs. Conventional module**

To assess students’ reaction and satisfaction (first level of Kirkpatrick’s model) with the new module compared to previous traditional modules, students completed an anonymous questionnaire (Appendix 1) approved by our Institutional Review Board (16-2020). To diminish comparison bias, the questionnaire had students first evaluate the online module before answering the same questions about the previous modules.

The questionnaire was divided into three sections:

1) *General Module Assessment*: module quality was assessed by designated measures developed by researchers, used to assess both online and conventional modules separately. It included seven self-reportable questions on a five-point Likert Scale, focused on the following: teaching quality, understanding level, contribution to theoretical knowledge, value in test preparation and memorization, and overall satisfaction (Figure 3).

2) *Preferred Module Method*: Participants were asked to indicate their preferred teaching method for five learning aspects (e.g., ability to concentrate). For each, students chose the method they felt was superior (Figure 4). In an open-ended section, students were encouraged explain their choice.

3) *Qualitative Assessment of the Module*: text boxes allowed students to express their views on the method and comment on issues not otherwise addressed. Students were asked about advantages and disadvantages of the online method, and how they anticipate it should be integrated in future modules.

The anonymous questionnaire was sent after the final exam, but before grades were published. This was intended to reflect students’ opinion more accurately on the module without their own numeric grades potentially affecting survey responses (Appendix 2).

As mentioned, all students previously completed three other, conventionally taught, portions of the anatomy course. This allowed students to serve as an internal control group to evaluate satisfaction and opinion on the quality of the modified module’s remote instruction and learning.

**Data Analysis**

Data was analyzed using SPSS V.26.

*Analyzing performance:* To analyze students’ performance in the online module, first we compared it to their performances in the previous conventionally taught modules of the same academic year. Additionally, we compared the online class’s performance on the limbs module to the two previous classes’ performance on that module.

More specifically, performance in the online module’s exams were compared respectively to the same year theoretical and practical performances in the conventional modules, by two repeated measures ANOVA models: one for theoretical and one for practical exams.

In addition, comparisons between students’ outcomes in the online limbs module and those of two previous classes in the limbs module (i.e., 2019, 2018), were tested by linear regression models. Each model tested the predicting effect of ‘academic year’ (calculated as two dummy variables comparing 2020 to the previous years) on student’s performance in each exam.

Differences in age, gender, and admission test scores from all three academic years were controlled for each of the regression and ANOVA models.

*Analyzing the self-report questionnaire:* First, to test differences in the General Module Assessment of the online and conventional modules, we conducted paired-samples t-tests using Cohen’s d for measuring effect size. Then, to test Preferred module method, the preference rates for online versus conventional module for each learning aspect were compared. Finally, answers in the Qualitative Assessmentpart were analyzed and themes identified using Braun and Clarke’s framework (Braun and Clarke, 2006). Frequencies of answers relating to themes compiled to formulate a general description.

**RESULTS:**

All (n=24) students completed the questionnaire in full. 55% were male, and the mean age was 25.6.

The results of a repeated-measurements ANOVA comparing students’ grades in the theoretical limbs exam to their mean grades in other modules theoretical exams, revealed no significant difference (F(1,17)=1.67, p>.1). A second repeated-measurements ANOVA done on respective practical exams grades, showed similar results; namely, no significant difference between students’ grade in the online practical exam and mean grade in the conventional practical exams (F(1,17)=2.10, p>.1). These suggest there are no differences between the students’ performances (practical and theoretical) in the online module compared with conventional modules in the same year.

Finally, we compared students’ performances in the online module to those of previous classes on that module (i.e., taught in 2019, 2018). Figure 5 shows grades in the practical and theoretical limbs exams and mean grades in the other anatomical exams throughout 2018, 2019, and 2020. The results of a regression model on the grades of the limbs theoretical exam by academic year show the grades in 2020 were not significantly different from those in 2019 and 2018. Additionally, a similar regression model on the practicalexam showed the grades in 2020 were significantly lower than 2019’s but not significantly different from 2018’s grades in this module (Table 2).

**Self-Report Assessment of Online vs. Conventional Modules**

General Module Assessment showed high internal consistency in both online and conventional modules’ assessment scales (Cronbach’s α=.89, Cronbach’s α=.95, respectively). Paired-sample t-tests showed significant differences between online and conventional modules evaluations demonstrating lower scores for the online module, across all seven items (Figure 3).

To measure the overall difference between the methods, seven items reflecting aspects of the modules were averaged and compared with the means. The mean evaluations of the online module (M*=*3.39) was lower than that of the conventional module (*M=*4.25), significantly so (T(23)=-.40, p<.01, Cohen's d = 1.050).

Students reported superior clarity of larger anatomical structures (Q3) and 3D perception (Q4) during in-person dissections (83% and ~91% respectively). Under the comment section, students reported that seeing and touching cadavers is deemed irreplaceable for visualization. However, in evaluating the online method, students did comment on enhanced ability to see smaller structures, which are often difficult to visualize. This point is also applicable to the dissection textbooks which can be displayed by the anatomy instructor in a more organized fashion online, compared to a crowded dissection laboratory.

Finally, students were asked to hypothetically select a preferred method for hypothetical additional modules. Most, 87%, chose the conventional method, while 13% chose the online method.

Additional student comments are mentioned and discussed in the Discussion section.

*Preferred module method included*- five preference questions with space for explanation for each. Students’ preference for each question are described in Figure 4. According to students, the laboratory learning environment enhanced students’ abilities to concentrate. Most students (Q1, ~87%) claimed they were able to better concentrate during in-person dissections. Students claimed laboratory attendance promoted active participation and that tactile learning engaged them for longer. A minority of students (13%) claimed that online-learning better enabled concentration, as they were able to review the virtual dissection and easing their anxiety and apprehension about “missing” something. They felt this improved their learning experience. Regarding time-utilization (Q2), ~66% thought conventional dissections were more efficient in use of allocated time and resulted in improved recall of material meaning. Namely they needed less time to review the material. 33% claimed to have better time-utilization in the online dissections, by not having to prepare and find structures. Structures were “cut and ready”, and less time was spent on activities deemed external to learning.

*Qualitative Assessment of the Module-*A majority of students (79%) provided extensive answers to this section. Analysis of this section yielded five major themes (listed from most cited to least): spatial 3D competence; review opportunities of virtual dissections; available virtual dissections; time-utilization and efficiency; cadaver preservation and learning environment. The most valuable responses are quoted verbatim under Table 3.

Spatial 3D competence, opportunity to re-watch virtual dissections and available virtual dissections were the most common and were mentioned about in 20% of answers. Other themes were less common and mentioned in less than 10% of answers.

**DISCUSSION:**

In this study, we showed that students’ performance did not differ significantly between online and traditional modules and between years; with the exception of the practical exam grades in 2019 and 2020. Students’ responses delineated benefits and disadvantages of the online method. Based on responses, most students preferred conventional modules over the online module. Note that students already completed the other modules of the course conventionally and had had to adapt to a different learning experience under stressful circumstances induced by the ongoing Covid-19 pandemic. We logically posit that upon facing new experiences students might naturally prefer the familiar “safe” mode. This may partially explain dissatisfaction and difference between the methods.

The advantage of the online method is on-demand viewing anytime and from anyplace. While some students remained in their university residences, others were scattered globally across various time-zones. However, all could access and complete the course. Students referred to this positively in the questionnaire’s open-ended sections, especially compared to the in person cadaveric lab which is locked and requires permission for access. This may be utilized for future improvements, including guest lectures and more.

Another reported advantage of online learning is the option to revisit recordings and enhance repetitive learning. Though most institutions allow “self-study” for dissections, it is often not guided by a tutor, is performed on an already dissected cadaver, and does not necessarily focus on key issues. Recordings and replay of dissections are perfect remedies for these shortcomings.

Also, online-learning utilizes higher-quality dissection books and videos, which are difficult to replicate in real-life, as was previously addressed (McLachlan et al., 2004). As noted, delicate anatomy, which dissections struggle to preserve, was better demonstrated using the online material. Structures appeared clearer with enhanced detail resulting from better vantage points and resolution. Moreover, using such resources saved preparation time, promoting more efficient time management.

However, frontal dissections advantages were also addressed by many students. Even the highest-definition 3D is inferior to reality. Tactile learning facilitates concentration and understanding relationships between structures, tissues and movement-induced anatomical changes. Students’ ability to dissect and find structures is one facet that ingrains anatomical landmarks and verbiage. Also, dissections have traditionally conveyed a “hidden” curriculum, with students reporting a transformative experience, where donated cadavers are referred to as their “first patient.” This is often formative and credited with learning how to relate to future patients respectfully (Hafferty and Finn, 2015).

As mentioned, there was no statistically significant difference between the theoretical grades of both methods. Ostensibly, deficiencies in practical knowledge would have negatively affected students’ performance on the theoretical exam. We believe the lack of significant difference suggests virtual dissections equally prepared students to the theoretical portions. The difference in the practical exam grades may also be attributed to challenges acclimating to a new method. Specifically, for the practical exam we switched from the traditional spotter exam on a 3D cadaver to a computerized, two-dimensional picture-based test. This alone could have resulted in worse performance. While our distance-learning course adhered to Anatomical Society’s guidelines (Smith et al., 2016), the level of understanding, internalization and long-term recall of material requires further study.

Limitations: The study has several limitations. Firstly, our evaluation based only on the first two levels of Kirkpatrick’s model. Though common (Yardley and Dornan, 2012), further research is needed for higher levels, considering behavioral and method change in a larger context. Secondly, the students had to rapidly adjust to a different learning experience concurrent with the additional stresses and anxiety of this unprecedented crisis. This surely affected their attention, resources, and ability to accommodate to this change. In future research evaluating online anatomy laboratories, allowing students to acclimate and adjust many of the reported deficiencies may minimize subjectively reported deficiencies. Given the lack of statistical difference in theoretical knowledge acquisition, this online model may be more educationally acceptable.

**CONCLUSIONS:**

While we recognize there are always tradeoffs when we must adapt, our experience is that online practical anatomy teaching can effectively substitute for traditional methods when needed, as during the current crisis. However, traditional in-person dissections are still preferred especially for students who already experienced traditional dissections. We believe an evolution of practical anatomy learning necessitates incorporation of both methods to result in an improved experience. This may include enhanced preparation with online resources before dissections and/or recording dissections so that they can be revisited. We feel this combination may optimize learning and time-utilization while maintaining benefits of the traditional experience.

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