



In Light of COVID-19 Crisis: Proposed Guidelines for the “New Norm” of Anatomy Teaching

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General Note



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ABSTRACT

The recent COVID-19 has impacted all the human activities around the globe, and medical education was no exception. During this time, e-learning and technology-enhanced learning has gained more attention. Since the crisis shows evidence of lasting for more than expected, it is necessary to prepare guidelines that accommodate and adapt to the situation, especially in anatomy teaching, in which replacing working in the lab by virtual cadavers is still a field of active debate among anatomists. Thus the aim of this guide is not to appraise the educational modalities; instead, we embrace all of them and provide a brief description of each one with proposed guidelines and useful tips. This guide will shed light on the administrative, educational and infection control measures to be taken, including all teaching modalities in anatomy: students' learning by performing a dissection, and learning based on prosected cadavers, bones, plastinated specimens, plastic models and students' learning using virtual cadavers/specimens. Thus, it does not only serve the educationists, but its scope extends to all the personnel whether they are administrative staff, technicians, workers, or anatomy teachers, this guide also serves medical students undergoing anatomy teaching. The guide comprises two levels; the first one is concerned about teaching anatomy at the level of demonstrating the anatomical structures, while the second level is concerned about the assessment issues.

Keywords: COVID-19, Anatomy teaching, Infection control measures, Anatomy laboratories, Dissection, Prosected cadavers, Plastinated specimens, Plastination, Plastic models, Virtual cadavers

1. INTRODUCTION

The recent COVID-19 pandemic has impacted all the human activities around the globe, due to its high spreading potentiality from person-to-person and the public health threat that posed all sectors, medical education was no exception. During this time, e-learning and technology-enhanced learning have gained more attention. Since the crisis shows evidence of lasting for more than expected, it is necessary to prepare guidelines that accommodate and adapt to the situation, especially in anatomy teaching, in which replacing working in the lab by virtual cadavers is still a field of active debate among anatomists. Thus the aim of this guide is not to appraise the educational modalities; instead, we embrace all of them and provide a brief description of each one with proposed guidelines and useful tips.

This guide will shed light on the administrative, educational, and infection control measures to be taken. Thus, it does not only serve the educationists, but its scope extends to all the personnel whether they are administrative staff, technicians, workers or anatomy teachers, this guide also serves medical students undergoing anatomy teaching.

The guide comprises two levels; the first one is concerned about teaching anatomy at the level of demonstrating the anatomical structures, while the second level is concerned about the assessment issues.

Guidelines related to administrative issues

The first step is to formulate a strategic plan that considers the expected changes in the curriculum, modifications in the ways of teaching and assessment, as well as compensation of the missed sessions during the crises. The plan should also address issues related to the financial and logistic impacts of the implementation of infection control measures.

Issues regarding the communications between different parts and sectors within the college and in-between the departments (academic and administrative) must be addressed; it is recommended to gather a team with suitable means and logistics for this matter. Engagement of the stakeholders is a crucial step to be taken; this includes the students.

Guidelines according to learning situations

Teaching anatomy can be categorized into five categories: students' learning by performing a dissection, students' learning based on prosected cadavers, students' learning based on bones and plastinated specimens, students' learning based on plastic models and students' learning using virtual cadavers/specimens.

We have arranged the guidelines according to the most common learning situations in anatomy. It is not our purpose neither the scope of this work comparing those modalities or favoring one on another. Instead, we embrace them all and provide suggested guidelines for each one of them, our reasoning in this matter is to guide all, or at least most of learning situations in anatomy.

2. STUDENTS' LEARNING BY PERFORMING DISSECTION

Educational value

Dissection by the students as a mean for learning anatomy is a more than 400 years tradition. It augments deep learning, active participation, and enhancing skills related to medical professionalism such as working in a team and dealing with stress. However, there is a debate regarding the worth of dissection by the student; this debate is mostly driven by the low number of available cadavers concerning the number of students, besides the downsizing of anatomy in the new curricula (M. Estai & S. Bunt, 2016).

Suggested guidelines

Anatomists are advised to adopt new strategies to eliminate the chance of spreading COVID-19 infection. The measures can be categorized as following: before the session, during the session, and after that. However, these measures cannot be executed unless advocacy and proper preparations among teachers, technical staff, and students are done.

Before the session, the measures start from the cadavers themselves, since they could be a source of infection, and testing the cadavers for COVID-19 is financially inefficient. Thus, the first line of defence is to avoid bringing new cadavers (Brassett et al., 2020). If bringing new cadavers is inevitable, it is advisable to test for COVID-s19 if it is feasible, however, considering that new and untested cadavers are brought, precautions regarding contacting the cadaver or the specimens must be implemented.

As for measures taken during the session, besides the usually known measures of wearing masks and following social distance standards, minimizing the duration of attending the session is essential. This reduction can be achieved by proper preparation of the students through putting more effort into learning the dissection techniques and the expected anatomical variations, through manual books and videos. The use of dissection videos as a tool of teaching has to gain more attention; however, it is considered as supplementary material. Incorporating videos in the "new norm" practical sessions will be much more critical, although it is considered as a passive learning tool (Langfield, Colthorpe, & Ainscough, 2018); integrating it in preparatory tutorials will be reflected on the effective use of time for dissection. This reduction in time will be used to increase the number of sessions needed after also reducing the number of students for each session. The use of pens and papers or notes during the session shall be prohibited. Thus, it is required to record the session and send it to the students as compensation.

After the session, proper disposal of gloves, masks, and other gears and tools is particularly essential. Other measures include changing the stations alternatively, i.e., dividing the stations into two groups, a group of students studies and utilizes some of the stations leaving the other stations empty. In contrast, the next group of the students when they come into the lab, they can start on other stations, leaving the previous ones empty.

3. STUDENTS' LEARNING BASED ON PROSECTED CADAVERS, PLASTINATED SPECIMENS, AND PLASTIC MODELS

Educational value

Gross anatomy teaching faces many challenges, and there is a shortage of cadavers due to insufficient donated bodies for educational purposes (Halou et al., 2013). The lack of body donation, reduced course hours, and difficulty hiring anatomy faculty lead to worldwide curricular reforms that in turn lead to a trend of reducing the teacher-student ratio (Pan, Chan, Yan, & Yang, 2020). This teacher-student ratio resulted in a reduction in both the gross anatomy teaching hours and its context. This also leads to a serious review of how anatomy is taught. Considering this context, education in anatomy had a significant shift toward the use of alternative modes of teaching such as prosected plastinated specimens, plastic models and, living and virtual anatomy (Mogali et al., 2018). The plastic models are successfully used, and now expanding due to their easy accessibility and educational effectiveness (Khot, Quinlan, Norman, & Wainman, 2013). There are current debates if the plastic model can be used alone or in combination with other teaching modalities. Considering the low-cost, easy accessibility and easy to handle with no need for maintaining services,

plastic models provide an alternative learning method for anatomy. It allows students to work in a small group during the laboratory sessions, which improves and promote engagement and communication skills (Mitrousias et al., 2020).

Furthermore, teaching gross anatomy using plastic models enhances spatial and long-retention knowledge acquisition, which makes this modality a valued teaching method (Yammine & Violato, 2016). Interestingly, students were reported to appreciate the use of plastic models as a useful adjunct to cadavers or plastinated specimens (Mogali et al., 2018). Even more, students in the plastic model group scored higher than dissection students and virtual dissection students (Lombardi, Hicks, Thompson, & Marbach-Ad, 2014).

Suggested guidelines: prosected cadavers and plastinated specimens

This section aims to provide interim guidance about the suggested measures in laboratories equipped with plastinated specimens. To eliminate the chance of spreading COVID-19 infection, teaching on plastinated specimens considered one of the alternatives for small group teaching. We will try in this section also to make a risk assessment for contaminated surfaces and objects and represent the necessary precautions that should be adopted by the medical schools in this period.

Regarding teaching macroscopic anatomy depends on preserved human bodies; one of the preservation procedures is called the plastination. Plastination was invented in 1977 by a German scientist named Gunther von Hagens, it is also called known as polymer impregnation can be defined as an art or science of long term of the perishable body or tissue preservation (Alsharif et al., 2017). It is an essential means of teaching the practical sessions of anatomy because the specimens are dry, odourless, handleable (Dawson, James, & Williams, 1990). Their use is not restricted to the dissection room but can be used in any lecture room or museum; thus, it is useful for small group teaching (Riederer, 2014).

Many techniques in recent years are utilized for teaching anatomical science, such as Silicone plastination, which considered the most common type of plastination. It is suitable for the preservation of the body, organs, or even the histological slice (Sargon & Tatar, 2014). In this technique water and lipids substituted by a curable polymer, so the plastic polymer and the preserved tissues are the susceptible items to be touch frequently by students. In the epoxy plastination technique, the procedure depends on E12 to create 2-5 mm durable sectional slices similar to the CT and MRI images (Sora, 2007), it can also be used for the microscopic level to preserve tissues. In this technique, the specimens covered by glass, so the glass is the susceptible item to be touch frequently by students. In polyester plastination, the dry specimens of this technique like the same as described in the earlier procedure, where the body fluids and lipids replace by curable polyester resins, commonly the (P40) (Ezhilarasan, Jetanthi, & Muthuvel Vijayan, 2017). So the Polyester resins and the preserved tissues are the susceptible items to be touch frequently by students. Note: Polyester resins generally used in fibreglass industries.

We suggest the following new measures strategies are adopted to eliminate the chance of spreading COVID-19 infection. As in the previous section, the measures can be categorized as following: before, during, and after the session.

Measures before the section comprise performing hand hygiene for both teachers and students, students and the instructor should wear face masks, getting into the lab must be restricted, and the lab to unnecessary visitors is better to be prohibited.

Measures during the session include adherence to hand washing hygiene by the staff and students (WHO, 2020). Providing hand sanitizing stations within the lab premises (particularly at the entrance) and close to high contact areas should be installed, physical distancing measures between students should be placed when feasible.

After the session, measures taken must consider the methods used in preparing the plastination specimens, as well as the susceptible surfaces commonly touched by students. We have put together recommendations regarding using the plastinated specimens in the faculty of medicine to eliminate the chance of spreading COVID-19 infection, represented in the necessity of using a disinfectant spray. The anatomy museum should mop with a phenolic disinfectant or disinfectant with a 1% sodium hypochlorite after each session. The cleaning process begins by clean up from cleaner surfaces then switches to dirty (the most contact) surfaces after each session, at the end of the cleaning process, carefully clean the equipment used for the cleaning. Students and staff should discard masks and gloves in a designated container before washing hands with soap and water. Do not forget to disinfect all dissection equipment (Forceps, probe, scissors, and needle) after use and before using it in the next sessions.

Suggested guidelines: plastic models and 3D printed models

In response to the COVID-19 pandemic, physical distancing has lead to more restrictions. Also, another challenge that faces anatomy education is that some institutes have denied bringing cadavers at the pandemic period (Singal, Bansal, & Chaudhary, 2020). Thus, the use of accurate anatomical plastic models during and after COVID-19 time seems to be one of the alternatives. First, we have to classify the models according to their form, since part of them has the ability to changes with time, and the others are incredibly fragile models that require infiltration to increase strength (Fredieu, Kerbo, Herron, Klatte, & Cooke, 2015). Accordingly, if

the use of plastic model prefers during this pandemic, we have to consider the safety, storage requirements, and maintenance as well as we have to know how to keep them safe of contamination or being a source of infection.

Plastic models that are solid polymers 3D anatomical model are highly recommended because it is safe, stable and does not require any particular way of handling except for the usual guidelines of dealing with rigid plastic during COVID-19 time which includes cleaning and disinfecting.

Another important mode of transmission of COVID-19 may be spread from contact with contaminated surfaces or objects (Cinar et al., 2020). Studies suggest that the COVID-19 virus could remain on surfaces for hours or even days and, therefore, regular environmental cleaning is recommended with a disinfectant (Ramesh, Siddaiah, & Joseph, 2020).

The materials used to construct anatomical models include acrylonitrile, butadiene, styrene, polylactic acid, ferrous and nonferrous metals, ceramic, and elastic polymers. The materials are differ depending on the specific application of the printed object (hard, soft, opaque, and transparent components). Regarding the 3 D printed anatomical models for education, the essential parameters are resolution, safety, and stability. The stability of models depends upon the material used; some printed models are stable, while others change in flexibility and opacity with time. In terms of safety, some of these materials are skin sensitive. In contrast, others emit fumes and ultrafine particles (Fredieu et al., 2015). Considering this issue detergents and disinfectants may cause significant changes and reactions that would be harmful to the students or staff (Paroli)Accordingly, choosing of appropriate cleaning and disinfection agents are highly recommended.

4. STUDENTS' LEARNING BASED ON BONES

Educational value

Bones are considered as an essential part of the anatomy education curriculum (Ajayi, Edjomariogwe, & Iselaiye, 2016) and play an indispensable role in promoting anatomy comprehension. All the students in medical schools receive instruction and experience through the teaching of anatomy courses by engaging the cognitive learning process (Bloom, 1956). However, the skeleton provides a realistic approach for studying the names and positions of the bones, and the movements take place in the joints. Also, it visually linked to muscle action in the body (Greene, Smith, Pendergraft, Raub, & Arns, 1993).

Suggested guidelines

From the previous description, it can be concluded that the bones are considered as one of the educational methods or tools that frequently touched and transferred among students, they can even borrow and take them to their classrooms, libraries, and even their homes and dormitories. Thus, the bones can be classified as one of the factors that may contribute to the transmission of COVID-19 infection.

We will try in this section to summaries the procedures of bone preservation for academic purposes because we believe that knowledge of the steps will help to generate the strategies for eliminating the possibility of the infection spreading.

The preservation technique described by (HABIB & Ali, 2019), it is established with the boiling of bones in water with washing powder that will help to remove the remaining tissues and keep the shapes, rigidity, and density of bones. The second step is full cleaning of individual bone after boiling and separate the articulated bones from their joints precisely to preserve all topographic features, and that occurs by treating them with the Hydrogen Peroxide solution (H₂O₂). The third step is drying: by exposing the bones to sunlight or dried in the shade on a cotton cloth. Finally, the bones painted with a thin solution of wood polish (Aggarwal, Gupta, Goyal, & Kaur, 2016).

E-learning and Virtual Cadavers

Demonstrating the body structures through dissecting the body is a fundamental part of teaching anatomy. Over the past decades, many approaches were used to increase the effectiveness of anatomy teaching. However, there is an escalating debate about abandoning the old school way and weather the new ways are good enough substitute in the short-term as well as long-term memory retention. Recently, due to the restrictions caused by the current COVID-19 pandemic, the necessity has increased to find alternatives that provide the required safety measurements with minimizing the effect in achieving better anatomy education.

Many revolutionary tools and techniques could be used to enhance the teaching of anatomy (Mohamed Estai & Stuart Bunt, 2016); in the following sections, we will cover some of these tools:

E-learning

In the light of current COVID 19 events; there is global shifting toward e-learning education and resources as a safe method during the current restriction period. In E-learning; the computers and Internet technologies are used to deliver knowledge and enhance

the performance (Ruiz, Mintzer, & Leipzig, 2006). E-learning provides high-quality visualizations with up-to-date information to meet the all students' educational needs (Choules, 2007). It also has excellent communication and follows up a system with assessment tools where the students can access the courses' resources at any time (Jastrow & Hollinderbäumer, 2004).

Online learning and Curriculum delivery

Many online applications and learning platforms provide good alternate during the pandemic time. They could be used for all activities, including student's performance throughout the course and material delivery. Many other tools could also be used for presentations and online meetings (Taha, Abdalla, Wadi, & Khalafalla, 2020)

These are some recommended platforms (Taha et al., 2020):

- **Blackboard Collaborate:** <https://help.blackboard.com/Collaborate/Ultra>
- **Zoom:** <https://zoom.us/>
- **Skype:** <https://www.skype.com/>
- **Moodle:** <https://moodle.org>
- **Slack:** <https://slack.com/>
- **Go webex:** <https://www.webex.com/>
- **Join me:** <https://www.join.me/>
- **Team viewer:** <https://www.teamviewer.com/>
- **Schoology:** <https://www.schoology.com/>
- **Microsoft team viewer:** <https://www.teamviewer.com/>
- **Google suite:** <https://gsuite.google.com/products/meet/>

Medical imaging

It is a valuable tool that uses integrated images of different radiological modalities to teach anatomy and clinical anatomy (Grignon, Oldrini, & Walter, 2016). It provides in vivo visualization of anatomy and pathological processes (Sugand, Abrahams, & Khurana, 2010). Though it does not provide enough substitute to the traditional anatomy, it could be used safely during this time as a hybrid with the other teaching tools for better understanding and retention (Chowdhury, Wilson, & Oeppen, 2008; Sugand et al., 2010).

Virtual Anatomy system

Technology has changed how people use and interact with educational materials. Many tools have been developed and currently provide a good source of learning. They have enhanced the students' learning outcomes (Moro, Stromberga, & Raikos, 2017). Most importantly, these tools could be used and to help to deliver the learning objectives with minimal risk of getting infected by the current pandemic. These tools include podcasts, screencasts, and software available on computers and mobile devices (Green, Pinder-Grover, & Millunchick, 2012; Molnar, 2017; Moro et al., 2017; Scalise et al., 2011).

Virtual reality devices

Virtual reality provides a virtual environment where artificially sensory stimuli replace all direct sensory stimuli; the interaction is like real objects. However, full VR is technologically challenging and has not yet been implemented (Luursema, Vorstenbosch, & Kooloos, 2017).

Use of tabs and anatomy software

The tablet technology can present anatomical information and it is clinical correlations in the most appropriate manner. It also contains a range of media from instructional videos to an interactive quiz. Many useful anatomy apps are available now (Gondim et al., 2018; Lewis, Burnett, Tunstall, & Abrahams, 2014; Motsinger, 2020).

Applications for 2D

Some anatomy software has properties that their images could be projected onto a volunteer, and he/she could be rotated while rotating the internal structures. This technique is also good at indicating clinically relevant transverse views (McMenamin et al., 2018), however, distancing and COVID 19 protection measurements should be considered.

Anatmage Table

Anatmage table is a revolutionary virtual 3D anatomy table that provides detailed, accurate, and dissectible structures. It also offers a wide variety of options; rich anatomy contents, high-quality radiological work station, interactive segmentation, and full annotation, clinical cases and 3D prints <https://www.anatmage.com/table/>.

5. GENERAL GUIDELINES RELATED TO INFECTION CONTROL MEASURES

Attention must be paid to other infection control measures such as ventilation and air exchange, disinfecting doors handles, seating stools, and students' lockers. Installation of sensors at doors for automatic closing and opening as well as sensors on handwashing devices is recommended. Also provision of supplies for cough etiquette and respiratory hygiene, like no-touch receptacles, tissues, and 60-95% alcohol-based hand sanitizers is needed at the entrance of the venue. Moreover, physical distance (at least 6 feet) and mask-wearing are also recommended for students and staff during laboratory or theoretical lessons, in order to prevent the spread of respiratory secretions during talking, sneezing, or coughing

Students used to bring some manual textbooks or electronic devices that help them to study during the anatomy sessions in the laboratories or dissection room, bringing such items should be prohibited to eliminate the spread of the infection. Instead, prerecorded videos can be provided before each session to help students study and prepare for the session; the session itself can be recorded and sent to them afterwards.

Regarding the duration of sessions, we suggest it to be as short as possible, to control the spread of infection, and the time in-between sessions must be as long as possible, allowing for air exchange, other measures include changing the stations alternatively as described previously.

The ratio of model/students shall be revised; if the numbers of models increase that will provide a few students with appropriate models, so there will be needs to swap the models between the students which in turn will eliminate the spread of infection.

Controlling the in-and-out traffic to the laboratories is crucial; no getting in and out during the session is preferred, as well as prohibiting the visitors and additional personnel from getting in-and-out the lab at all times. As well, screening tests to everyone should be obligatory by at least checking out their temperature inconsistent with COVID-19 fever range standards.

Minding the situation of infection spread in the city is essential in making decisions relevant to the modality and intensity of the teaching process. Some applications provided by health authorities offer information about the infection spread among residential regions of both staff and students. These applications can be used to relieve some of the staff or students (from highly infected areas) from coming to the laboratories temporarily, rearrangement of the missed educational activities for such students requires flexibility in implementing the curriculum.

It is essential to put informative signs contain advices, instructions, and guidelines, the signs should be numerous and distributed all over the laboratories and venues.

Students' Assessment

As mentioned previously, this guide comprises two levels; the first one is concerned about teaching anatomy at the level of demonstrating the anatomical structures, while the second level is concerned about the assessment issues.

It is vital to consider dividing the students into small groups; consequently, there will be a need for more examination venues and more lengthy examination schedules.

One way to overcome this is by putting more emphasis on formative assessments. Especially for the practical sessions and assessment of practical skills, other modalities include open-book examinations; this can allow for asynchronous online mode and thus overcoming technical and connectivity issues.

We should focus more on programmatic assessment, with more diverse methods and tools, focusing more on low-stakes formative assessments, consideration such as validity, reliability, educational impact, acceptability, and cost can be prioritized using a framework presented by (Wadi, Abdalla, Khalafalla, & Taha, 2020).

The educational impact of the new measures

All the above measures put more burden on the students, teachers, and the educational system as a whole.

The teachers will be involved in their new roles regarding the orientation and training of the students; however, this has its bright side, it will encourage teamwork, leadership, response to the stress and other medical professionalism values.

The vast amount of logistics will burden the educational system await to be implemented. An inclination towards full virtual learning will be noticed; this will impact the experience of real dissection negatively and fuel the everlasting debate about virtual

versus real cadavers among anatomists, this time the student will be part of the debate as well. Implementing the curriculum in these circumstances requires flexibility; we expect that COVID-19 will eventually change the way curricula are developed.

6. CONCLUSION

The aim of this guide is not to appraise any type of the educational modalities; instead, we embrace all of them and provide a brief description of each one with proposed guidelines and useful tips. This guide sheds light on the administrative, educational and infection control measures to be taken, including all teaching modalities in anatomy: students' learning by performing a dissection, and learning based on prosected cadavers, bones, plastinated specimens, plastic models and students' learning using virtual cadavers/specimens. Thus, it does not only serve the educationists, but its scope extends to all the personnel whether they are administrative staff, technicians, workers, or anatomy teachers.

The educational process will be burdened by the logistics involved; anatomy teachers will find themselves playing additional roles in health education. About the future of anatomy teaching and with the debate still stands about whether to teach anatomy in real or virtual cadavers, this pandemic will push further towards virtual cadavers and online teaching. However, the best compromise will be to adopt mixed modalities. Regarding students' assessment, this pandemic will serve the cause of formative assessment well. Programmatic assessment will be more embraced with more diverse methods and tools.

The implementation of these guidelines is subjected to changes according to the developing situation of COVID-19 in terms of further improvements in the management of the pandemic situation and vaccine development. One must also consider the context of the institute regarding the available venues, number of students and staff, and curriculum.

However, these guidelines are also applicable for possible pandemic situations similar to COVID-19, including any future outbreaks that could affect the educational process. Moreover, they are not necessarily confined to anatomy laboratories only but can also be implemented in other laboratories in medical schools.

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All authors contributed equally to this work and they have read and agreed to the final manuscript.

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