Teaching and Learning of Anatomy in the 21st Century: Direction and the Strategies

Pallab K. Ganguly*

College of Medicine, Alfaisal University, Riyadh, Kingdom of Saudi Arabia

Abstract: It has been shown earlier that simply covering the material within anatomy objectives with didactic lectures followed by dissection may fail to produce long lasting understanding of the subject. The students are also unable to appreciate the importance of clinical anatomy integrated within various medical disciplines. A medical school may look at restructuring medical curriculum with an anatomy resource centre which can have a pivotal influence on self-directed learning. In order to prepare an innovative resource centre for teachers and teaching, care must be taken so that a student must achieve sufficient knowledge, skill and attitude when given a problem-solving exercise. Based on a theme of learning objectives, the resource centre must be equipped with plastinated cadaveric specimens (or routine cadaveric dissection/prosection). Such gross structural relationships are made more meaningful by the use of living anatomy such as conventional radiographs, CT, MRI, ultrasound, laporoscopic videos and surface anatomy. Simultaneous presence of microscopic anatomy (histology) can help to understand cell biology and molecular medicine in great detail. Sometimes it is also necessary to use plastic models to overcome the complexity of the structures such as perineum and joints. Web-based computer sites can supplement the effort and to achieve what we often call 'self-directed assessment skill'. Once the students are aware of the normal structures, they can be challenged with abnormal structures or tissues. An anatomy resource centre thus, can be integrated with various disciplines. However, it is felt that an efficient clinical anatomy curriculum can only lead to the success in developing an innovative anatomy resource centre for teachers and students.

A. INTRODUCTION

Although it is generally agreed that anatomy is the language of medicine, the 21st century medical curriculum has often shown to reduce the hours dedicated towards anatomy education. A medical school therefore should re-evaluate its own curriculum in terms of what the students need to learn. Since anatomy is exposed to the students at the outset of a curriculum [1], medical schools therefore should be careful in planning students-directed anatomy objectives and how they are going to be delivered. This is particularly important as the current pressure to reduce the hours devoted to learning anatomy may even complicate the entire planning [2,3]. In addition, in the presence of an increasing array of technical disciplines the concept of traditional anatomy has been regularly challenged. The students must be exposed to various state-of-the-art modalities so that the future physicians will appreciate the logic behind understanding living and clinical anatomy. Although the current article will address these issues, at the outset the objectives of such an approach must be clearly understood. First, the exponential growth of medical knowledge creates enormous problem for designing the medical school curriculum [4]. Second, most of the medical schools have reduced the hours necessary for anatomy education [2,3]. Third, the traditional lecture-based anatomy teaching has been shown to have a very little effect on learners looking for lasting understanding [4]. Simply covering the subject may not be ideal for developing attitudes on problem solving exercises. Fourth, it has been reported that learning in a small group environment enhances the knowledge and understanding the subject [5]. Fifth, teaching in an integrated way using various modalities available is considered ideal as it mimics examining common clinical cases [6]. Finally, faced with more anatomy in less time available for teaching, we must make a judgment to develop a place where we can provide more instructional technology that makes the most efficient learning [7]. Accordingly, an understanding of an effective teaching-learning outcome based on a solid ground of clinical anatomy course is necessary and has a pivotal influence on anatomy resource centre that this article will address.

B. THE INTEGRATED RESOURCE CENTRE

The question obviously arises as to how best can we teach anatomy? Can we teach anatomy in a lecture hall effectively? How are we going to arrange learning objectives? Do we need a place where we can effectively integrate anatomy with various other disciplines? What will be an ideal place for teachers and teaching? In designing an anatomy resource centre, the principles of three curricular models may be considered: traditional, integrated problem-based and system-oriented [8]. The entire resource centre thus may be divided into specific areas for dissection, prosection, audiovisual, radiographs/holograms, cross-sectional anatomy, self-directed learning, ultrasound, embryology, molecular medicine, pathological specimens, computers and demonstration. Although histology slides and CDs should be available within a module system, a separate area for histology equipped with video monitors may be also available to the teachers and the students. Since molecular cell biology has just earned its reputation as an authoritative and exciting area, effort must be made to integrate the subject in the over-

*Address correspondence to this author at the Professor of Anatomy, College of Medicine, Alfaisal University, Riyadh, Kingdom of Saudi Arabia; E-mail: pganguly@alfaisal.edu

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all theme. A module of a resource centre is defined here as a set of materials contained in a learning carrel and addressing a particular set of integrated objectives [6,9,10]. Each module is centred on a theme of a specific unit or a system explaining various concepts. These modules and the arrangements of the carrels have pivotal influence on the resource centre and constitute the ideal place for teachers and teaching including self-directed learning. A typical carrel (module) should have labelled plastinated specimens/prosections, radiographs/CT/MRI to show the same area of interest, models/charts to simplify the structural arrangements, case studies with questions and answers to strengthen the concepts of functional and clinical anatomy and histology/pathological specimens to identify the abnormalities of the specific area/organ. Computer-assisted materials, videocassettes (such as laporoscopy), ultrasound and a structured program of living anatomy in the clinical professional skills curriculum facilitate such an arrangement. For detail of the arrangement of an anatomy resource centre, the readers are referred to Ganguly *et al.* [6].

C. THE METHODS AND THE MODALITIES

The 21st century technology in medical education has changed every facet of our life and also holds a significant promise in education of health professionals of present and future thereby revolutionizing medical training. Digital technology has added a new dimension in teaching anatomy. The anatomy resource centre provides various modalities that prove to be a gateway for acquiring all the essential skills in anatomy from multiple perspectives.

Web-Based Learning: Living Anatomy

Living anatomy is defined as the anatomy revealed on living humans, is gaining importance in modern anatomy education, and has even been considered to replace cadaver-based anatomy study. It is important to introduce the modalities through which living anatomy can be studied and explore the feasibility of using them to replace cadaver-based anatomy. We believe that the study of anatomy *via* the three main modalities of living anatomy, namely surface anatomy, medical imaging and surgical procedures, rely on a foundation of sound knowledge of the three-dimensional anatomy.

(a) Surface Anatomy

Surface anatomy has become increasingly important in anatomy education in the recent decades. The main reason is that surface anatomy forms the obvious connection between basic gross anatomy and clinical practice, because it is the basis of physical examination. Also included under surface anatomy are the projection technique and body painting. Both use the body surface as the medium for presentation of images of the internal anatomy. They use either commercially available images or hand painted images to enhance students' learning of surface anatomy.

(b) Medical Imaging

The most powerful tool available nowadays for the study of living anatomy is no doubt the medical imaging technologies, such as X-ray, CT, MRI, and ultrasound. Their primary purpose is to reveal anatomy, normal and pathological, in patients. The use of these medical images in the teaching of anatomy is a by-product of these medical imaging technologies. Radiographs, CT, MRI, ultrasound, laparoscope, plastinated specimens, models, charts, histological slides, bones, dissection, web based CD packages, diagrams and case studies with relevant questions and answers are the wide range of available facilities in the anatomy resource centre. These facilities represent diverse content areas and utilize a variety of learning strategies. These new systems promise to make broad-based training experiences available for students at all levels. Medical students could acquire proficiency and gain confidence in the ability to perform a wide variety of techniques long before they need to use them clinically. Labeled X-ray, MRI, and CT images help students become familiar with the appearance of key anatomical structures as seen through different medical imaging techniques.

(c) Surgical

Programs related to electronic learning and virtual simulations allow the students to rehearse and refine basic operative procedures, using an unlimited pool of virtual patients manifesting a wide range of anatomic and pathologic variations. Simulated encounters, in combination models and dissection could increase the depth and breadth of students' exposure to medical problems and enhance the acquisition of clinical skills. Laporoscopic video/e-learning facility also provides an amalgamation of the principles that are applied to the structures both in the dead and live scenario. Students obtain the working knowledge and also get ready to what they really have to look for when it comes to health care problems. With the integrated teaching methodology in medicine, the anatomy resource centre thus can have a pivotal influence on the integration of various subjects throughout the curriculum.

Integration

Both **i**ntra-departmental and inter-departmental integration are necessary. Thus horizontal as well vertical integrated system of learning brings a thorough understanding of the subject or the topic. However in order to achieve this goal any system can be approached in a dynamic way. For example, one of the important concepts the students are likely to encounter in cardiovascular system is "cardiac contractility". The cardiovascular learning station will contain the models of the heart, specimens of various parts of heart, normal and abnormal radiographs of heart, labeled plastinated specimens, CT scans of heart showing various positions of heart and its structural relationship with other vital organs in the mediastinum, histological slides to study the features of cardiac cells, diagrams /charts to emphasize the physiology of excitation-contraction coupling, charts to pinpoint the neural control and embryological aspect of cardiac development and its anomalies and how they interfere with the normal position and contractility of heart, CD highlighting the congestive heart failure with audio visual images and question charts with answers for self study [6]. Thus this anatomy resource centre plays a major role in the integration of the basic sciences, clinical sciences and self directed learning throughout the curriculum.

Apart from enhancing the learning process, the anatomy resource centre also provides a great opportunity to incorporate a) peer assisted learning b) small group discussions.

Peer Assisted Learning

Currently at Alfaisal University we utilize the services of the teaching assistants (TAs), who are students with honor grade. This has proved to be extremely beneficial and have yielded excellent student understanding. The students here get an opportunity to listen to the Professors in the lecture hall and then the same topic is learned in a lab environment with display of plastinated specimens, cadavers and radiographic imaging materials. During this process the TAs go to each small group and assist the learning process. It is felt that the TAs play a significant role in this teaching/learning process because the students feel more comfortable to approach their peers for clarification of doubts. They may not have any inhibition to approach the TAs as many times they want. The border-line students in particular can get excellent opportunity through peer assisted learning.

Small Group Sessions

Small group discussions can be very well practiced within large lecture halls and the discussions can be monitored and supervised by the faculty members. Small group learning session should be encouraged as this allows and encourages the students to share the information among their peers and also to search for clinical correlation of the topic. This allows the students to actively participate in the process of learning and removes the traditional student/ teacher barrier. Small group teaching has been widely and successfully applied in anatomy teaching [6, 11-14].

At Alfaisal University, gross anatomy is taught through lectures and lab studies. There are two laboratory sessions per week, and each lasts for 2 hrs, for a total of 4 hrs of laboratory time per week. Students are divided into smaller groups, each composed of around ten to twelve students. Each small group is assigned to one of the four stations in the lab at the beginning of each lab session. Each small group is given 20 min for each station, after which each group moves to the next station. At the end of the session, each group will have moved through all four stations. The materials used at each station include the following: radiological materials (plain X-ray, CT, MRI, ultrasound, angiogram etc); plastic anatomy models; plastinated specimens; articulated skeletons or isolated bones and clinical scenarios to be tackled by the students.

At the beginning of each lab session, the resource person spends about 45 min demonstrating the themes on the materials at each station. To assist the demonstration, a video camera is used for capturing images of the materials and a projector and LCD monitor are used for displaying the whole demonstration. After the lab demonstration, each small group is assigned to one station and is usually given 20 min to examine the materials at that station. The students have to accomplish some specific tasks, outlined by the resource person during the lab demonstration. The students are encouraged to accomplish the tasks by themselves, without assistance from the resource person. They can refer to their class notes, textbooks, and atlases and also discuss the tasks within their groups. Students are encouraged to revisit the stations once the lab session is over.

If students are unable to complete the assigned tasks on their own, assistance is available from the resource person and another professor, who are present throughout the lab session. The students are asked the reasons for their failure to accomplish the tasks, and how much they have accomplished. Guidance is then provided to help them to accomplish the tasks [5]. The small group discussion also significantly improves the communication skills among the students.

Communication Skills

Since communication with the patient is the key in elucidating the proper history and symptoms (which in turn becomes a basis for a preliminary diagnosis), medical education has always stressed upon the importance of communication skills in medical students. The medical curriculum in many places have realised the importance of the current changes and have incorporated many simulated sessions with standardized patients to enhance the students' communication skills. By practicing small group discussions in the class particularly in professional skill course, we encourage more student-to-student interaction, which primarily helps them to develop the basic communication skills and the important skill to work within a team. By encouraging the students to discuss within small groups, we are encouraging the students to constructively criticize each other, which in turn offer scope for professional improvement (self assessment). This is only possible when the students work among themselves and will unlikely to be true in the traditional approach as the students more often do not want to disagree with the professors in a didactic lecturing environment.

Hands on Experience

With all the modalities available in the anatomy resource centre students can get a good amount of hands on experience that will help understand and retain the acquired knowledge. Since, physicians encounter anatomy in their everyday clinical practice through living anatomy, it is therefore essential to teach students anatomy in these contexts right from the beginning. It is a widely held view that dissection gives students a 3D view of human anatomy and reinforces knowledge acquired in lectures [15, 16]. At Alfaisal University, the students are also engaged in dissection on a weekly basis. The students enjoy dissection and can strengthen their knowledge using a real human body (cadaver).

By incorporating virtual anatomy lab, students can try to enhance their learning process by utilizing the available online tools that represent their understanding or focus on a particular area of study. It is possible that students can achieve a 3D understanding by working extensively with living bodies say for example by using portable ultrasound equipment to visualize structures in the living body and also in conjunction with a suitable software package where there is a facility to view projection of color images on the surface of the body, which can be dissected away layer by layer; by use of color transverse sections and by extensive use of imaging. These modalities allow the student to get prepared to encounter the real world scenario from the day one of medical school. Living anatomy can also be studied through consented peer examination, supported by life models. Undoubtedly modern 3D imaging methods give better views of the internal structures of individual living patients during medical procedures that can be superior to those observed during dissection. It may be pointed out that cadavers may

also present a number of disadvantages such as color, smell, texture and cannot be palpated or auscultated as in a real life [17].

Innovations

Anatomy department may use a number of digital video cameras and associated software for video links between the computers of faculty and students. These cameras should be able to take pictures in high resolution colour and send them to the students over the intranet. This technological advance presents a number of new opportunities: the tutor can speak in one window, drawing the student's attention to a graphic in another. This is particularly useful in a visual subject such as anatomy. Students would be able to contact resource persons for seminars without having to gather in one site and this is a great advantage particularly if the interaction is needed from a distance.

There is no doubt that in the 21st century, students are becoming completely dependent upon the world wide web (www) for acquiring information and to seek additional resources. As medical educators, we have to modify our attitude towards the whole process of teaching basic medical sciences including anatomy. The entire world of medical education is moving towards the direction of applied way of teaching and learning so as to provide the students the clinical importance of the basic topics they learn in the medical curriculum. The provision of self-learning and assessment facilities needs to be backed up with professional facilitation and support. The department of anatomy is becoming more involved in use of the world wide web for dissemination of teaching and research material [7].

Accordingly, the anatomy departments may have to modify its www page for interactive access of its teaching programmes. Using the hypertext linking facilities of www pages, links should point to files on our file server of study guides, lecture notes and handouts, past exams, references and even house keeping matters such as timetables, and requests for information. The process already exists in many Institutes across the world. Alfaisal University has also established MOODLE system to accomplish these goals.

It would be extremely useful to have software copies of Autodesk Animator Pro., Digimorph, Multimedia Explorer and a number of other virtual anatomy software packages for graphic manipulation. With these tools we can add animated sequences, transformations (the "morphing" of an embryological structure into the adult structure for example), even short video segments. With the addition of plug-ins it is now also possible to share macromedia presentations including sound and video over the Internet. The coming decade will undoubtedly see more opportunities in this direction.

D. THE ASSESSMENT SYSTEM: TEACHING LEARNING OUTCOME

Since anatomy is standing right at the entrance of the bridge leading from college life to professional school, we have the unique opportunity to challenge these individuals in ways that they have never been challenged. The learning in anatomy resource centre differs from a regular lab system with regard to the accumulation of achieved knowledge. Instead of successively ordered topics, the student must learn to integrate the fundamentals of anatomy with various related topics and also with the recent developments in the field of anatomy.

Assessment system has pivotal influence on student's education and therefore it is necessary to match the assessment to the learning process. The purpose of assessment is to understand the quality of student learning and this is achieved through incorporating standard and different tools of testing through out the curriculum. These tools of testing allow space to assess the various domains of learning, i.e. knowledge, skills and logical reasoning (6,14). The role of assessment is fundamental to learning and should motivate students and give them a feeling of achievement at the end of a study period; provide diagnostics of students' strengths and weaknesses by providing feedback to students and staff.

The assessment system in the anatomy resource centre should therefore be continuous and rigorous, involve all the objectives of the curriculum, involve all the modalities available within the anatomy resource centre and should be self directed.

Continuous Assessment and Formative/Summative Examination

Assessment works best when it is ongoing, not episodic. The point is to monitor progress toward intended goals in a spirit of continuous improvement. Assessment is most effective when it reflects an understanding of learning as multidimensional, integrated, and revealed in performance over time. In that way continuous assessment encourages consistent and effective learning throughout the course and can be conducted in myriad ways such as online quizzes, lab worksheets, group projects, homework assignments, lecture quizzes, classroom participations, mid-term test, and practice sessions.

At Alfaisal University, block exams are conducted at the end of every 6 weeks (formative) in an 18week semester. End-of-semester exam is usually summative in nature. A portion of assessment system is also dedicated to PBL tutorials and is evaluated on a weekly basis. The questions are asked in the form of multiple choice question (MCQ), short answer question (SAQ) and objective-structured practical examination (OSPE). These questions are based on the USMLE format where there is less focus on the direct identification of the structures and more emphasize given to the secondary questions. For example in an OSPE mode, a pointer may be placed in a CT showing left atrium. One can ask the question why may a patient experience difficulty in swallowing in an enlargement of the structure indicated by the pointer. A student not only has to identify the left atrium in a CT but also be able to think that esophagus is a structure that is posteriorly placed and an enlarged left atrium (such as in mitral stenosis) may obstruct it leading to dysphagia. Bones-articulated and non articulated, cadavers: prosected materials, diagnostic images: X-rays, CT, and MRI. plastic models or section of adult human body, digital images on topographic anatomy (including computer assisted program) are generally used for devising the questions. The faculties are assigned as resource person to format these questions. Care is taken to ensure appropriate distribution of questions from various topics keeping it relevant to the learning objectives of the course. Accordingly, a blue-print is developed well before the exam schedule and is distributed to the facul-

ties for development of the questions. For the anatomy lab, each student is given 60 seconds to answer a station and will have to go around all the stations before completing the exam. As per USMLE format, questions are devised either as vignette type or with a clinical scenario followed by 5 choices of answers. Each choice will have no negative correlates or absolutes. Students will have to choose the most appropriate choice and mark it in the scantron sheets. This is then passed through the machine for automatic marking and scoring. The scoring machine also provides a feedback to both the students and the staff in a data analysis sheet. In order to orient the students to the block exams pattern, mock exams are conducted a week before the block exam. These mock exams help students understand their strengths and weaknesses in the topic and focus their preparation for the real exam. Very often the questions are also put in an objective structured clinical examination (OSCE). The short answer questions are mostly related to basic understanding of clinical cases. Following a clinical scenario, the students are asked to answer the basic mechanisms (anatomy, physiology, biochemistry, genetics, molecular medicine, embryology etc.) involved.

This assessment technique allows teachers to examine both what students think they are learning from exams and tests quality of exams. Specifically, this style gives teachers specific student reactions to exams, so that they can make the exams more effective as learning and assessment devices.

Self-Directed Assessment

This is probably the best form in which a student can feel confident in his/her teaching-learning outcome. Therefore, the anatomy resource centre must provide enough facilities to create an environment so that a student can challenge the depth of knowledge, skill and attitude towards problem solving exercises. The anatomy resource centre must be equipped with various facilities as indicated earlier including computer assisted program commercially available.

Students' Feedback on Assessment

In the anatomy resource centre, the clinical approach focuses student's attention on the critical skills of spatial reasoning and the application of structure-function relationships, while freeing student from endless hours of memorization that produces little true learning. However, it is well known that one of the most important resources for sustaining professional development in teaching is getting feedback from students. To understand the student learning in the anatomy resource centre surveys should be conducted in which the feed back should be focused on various aspects such as facilities available in the anatomy resource centre, influence of facilities on learning, effects of integration in anatomy, results of learning 3D and 2D anatomy together and finally the questions (and answers) of the recent exam held.

Although questionnaires are most often used to collect student feedback, they by no means constitute the only method. Student feedback can also be obtained through student representation on staff-student committees, structured group discussions, one to one student interviews, e-mail, bulletin boards, students' diaries and/or log books. For a detailed description of a typical assessment system in a problem-based curriculum the readers are referred to Chakrabarty *et al.* [18].

E. CONCLUSIONS

A sound anatomy curriculum is essential based on the need of the 21st century. Perhaps the time has come when the medical schools across the world can present their anatomy resource centres in a new direction that will bring 21st century technology to the students to make the learning objectives in a more effective manner. The strategies should be clear as the new face of the anatomy resource centre has a pivotal influence on integrated teaching and in relation to students' attention on the critical skill of thinking and assimilating new knowledge rather than presenting details for memorization. Thus the students can use an integrated anatomy resource centre more by spending less time in the traditional didactic anatomy lectures.

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