The Integrated Clinical Anatomy Program at Alfaisal University: an innovative model of teaching clinically applied functional anatomy in a hybrid curriculum

Ahmed Yaqinuddin, Muhammad Faisal Ikram, Muhammad Zafar, Nivin Sharaf Eldin, Muhammad Atif Mazhar, Sadia Qazi, Aftab Ahmed Shaikh, Akef Obeidat, Khaled Al-Kattan, and Paul Ganguly

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

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Qazi S, Shaikh AA, Obeidat A, Al-Kattan K, Ganguly P. The Integrated Clinical Anatomy Program (ICAP) at Alfaisal University: an innovative model of teaching clinically applied functional anatomy in a hybrid curriculum. Adv Physiol Educ 40: 56–63, 2016; doi:10.1152/advan.00153.2015.—Anatomy has historically been a cornerstone in medical education regardless of specialty. It is essential for physicians to be able to perform a variety of tasks, including performing invasive procedures, examining radiological images, performing a physical examination of a patient, etc. Medical students have to be prepared for such tasks, and we can assist this by changing the way that we educate students in medical schools. Thus, newer medical curricula need to be designed according to needs of future physicians. In this report, we describe a unique program called the Integrated Clinical Anatomy Program (ICAP). The ICAP was developed at the College of Medicine of Alfaisal University in the Kingdom of Saudi Arabia. Here, we describe the unique features of this program, including the structure and facilities of the Anatomy Resource Center. The Anatomy Resource Center plays a pivotal role in engaging the students for faculty-directed structured laboratory sessions as well as peer-assisted uniform student-centered learning. The ICAP has shown great promise, as reflected by early results from a nationwide progress test. Students from all years of the Alfaisal University medical school scored significantly higher than the national average on the anatomy and physiology component of the nationwide progress test examination, with P values of 0.0179 and 0.0015, respectively. We believe that the ICAP can be used as a model for teaching clinically applied functional anatomy to medical students in a hybrid curriculum around the world.

LEARNING HUMAN ANATOMY has remained core to medical education for centuries (25). Both anatomists and clinicians agree that an accurate knowledge of human anatomy is of paramount importance for safe clinical practice (9, 12). Yet, in recent years, there has been a declining trend in the anatomic knowledge of practicing clinicians. Waterston and Stewart (30) demonstrated that clinicians think that anatomy is not adequately taught in medical schools and, thus, the knowledge of graduating students is below the adequate safety level to practice. In this alarming situation, Bergman et al. (4) and Kemeir (16) highlighted key factors that have resulted in this decline in anatomic knowledge among undergraduate medical students.

In Gulf Cooperation Council (GCC) countries and Saudi Arabia, 40% of medical schools follow traditional didactic curricula, whereas the rest have shifted to more innovative problem-based curricula (23). However, there are several concerns regarding the teaching of anatomy (23). One of the main concerns of students from the traditional curriculum has often been overcrowding of anatomic factual knowledge (23). This resulted in a reduction of factual content of anatomic knowledge in newer curricula without defining the “core anatomic curriculum.” In GCC countries, there is no unified method of teaching medicine, particularly anatomy (20). Many medical schools have adapted problem-based learning (PBL) integrated curriculums from Western countries without taking into consideration 1) students’ readiness to address the challenges posed by these active learning pedagogies, 2) development of faculty members to teach in these educational systems, and 3) development of the appropriate infrastructure (small-group discussion rooms, learning resource centers, etc.) to support these curricula (23). None of the GCC countries have a body donor program (23). This has resulted in a lack of availability of cadavers for teaching. Most, if not all, medical schools in GCC countries have abandoned human cadaveric dissections as a teaching method in undergraduate medical schools. There is a dearth of qualified anatomy teaching faculty members around the world and in Saudi Arabia (29, 31). However, the problem is compounded by the fact that most medical schools in Saudi Arabia require only female teaching staff to teach to female students. Moreover, with the adoption of an integrated PBL-based curriculum, many schools are finding it difficult to recruit clinically trained anatomist with experience in PBL settings.

In light of the above-mentioned deficiencies, an innovative medical curriculum was developed in 2008 at the College of Medicine of Alfaisal University, where in a “hybrid” approach was taken. The core to this approach was that multiple educational strategies were used to achieve the desired outcomes. There are three phases of this curriculum: 1) phase 1 (structure-function relationships) of 2 yr in duration, 2) phase 2 (normal-abnormal relationships) of 1 yr in duration, and 3) phase 3 (clinical clerkship) of 2 yr in duration. The key highlights of anatomy teaching in the Integrated Clinical Anatomy Program (ICAP) include the following:

1. Human anatomy is taught mainly in phase 1 of the curriculum using an organ system-based approach with func-
tional and clinical relevance. However, uniquely, core anatomic concepts are revisited and retested in phases 2 and 3 of this curriculum. These core concepts are developed based on essential knowledge and skills required to be a “competent intern.”

2. There is an emphasis on integration between core basic science disciplines, including gross anatomy, embryology, histology, physiology, and biochemistry.

3. More than 90% of our anatomy teaching faculty members are clinical anatomists with many years of teaching experience in PBL-based educational settings. The same faculty members teach both male and female students. The tutor-to-student ratio is 1:12 in an anatomy laboratory setting, where in we teach ~200 students every week.

4. Students are exposed to cadaveric dissections during evening dissection laboratory sessions around the year. This unique program is called the Peer-Assisted Uniform Learning (PAUL) program, where a group of students are asked to perform faculty-assisted prosections and this group uses these prosections to teach fellow students during evening laboratory sessions.

5. Anatomic knowledge and skills are not only tested with multiple-choice questions (MCQs), which, if used solely, have been shown to have a negative impact in the retention of knowledge. Thus, multimodal assessment tools are used, including short-answer questions, clinically integrated objective structured practical examinations (OSPE), and objective structured clinical examinations (OSCE) (32).

6. Several teaching strategies are used, including lectures, large-group discussions, team-based learning (TBL), PBL, laboratory sessions, and clinical skill sessions, to achieve the desired outcomes throughout the curriculum. A typical example of such integration is shown in Table 1.

7. Finally, a state-of-the-art Anatomy Resource Center (ARC) has been developed, which is equipped with modernized anatomic resources, including 1) an anatomage, 2) a digital microscopy laboratory, 3) a clinical simulation center, 4) an ultrasound room and digital radiology laboratory, 5) cadaveric dissection rooms, and 6) a plastic model and plastinated specimen room.

**How Is the Discipline of Anatomy Taught in Alfaisal University?**

**Lectures/large-group discussions.** Highly qualified faculty members are responsible to deliver lectures related to a particular structural or functional theme to both male and female students separately to follow the rules and regulations of the Ministry of Higher Education of the Kingdom of Saudi Arabia. However, to ensure uniformity of teaching methods, the same faculty members teach both male and female groups. Major emphasis in the lectures is to give a broad outline of the subject area, and students are required to fill in details by active learning methods, which include PBL, TBL, and laboratory sessions. Thus, the lectures are organized in such a way that laboratories proceed with a clear understanding of practical/hands-on experience.

**TBL.** TBL is an instructional format that breaks the passive mood of students observed in lectures. It is a student-centered active learning pedagogy. TBL contains all the elements of participatory learning (discussion, participation, and teaching). We use TBL hybrid model at Alfaisal University to cater to our curricular needs, where it is also supported by a mixture of interactive lectures, flipped classroom activities, and resource sessions in the laboratory.

The application of TBL occurs in three phases. In the first phase, which is the preparatory phase, the learning objectives of the coming week are posted on Moodle during the weekend, with the prereading material required to master the theme of the week. TBL sessions are held on the last day of the week in a 3-h-class session. In this learning strategy, the male class of ~100 students and the female class of 120 students is divided into 4 major groups, named M1, M2, F1, and F2, respectively. Each major group of students then is further divided into teams 1, 2, 3, and so on, with a maximum number of 7–10 students/team. These teams are permanent, diverse, balanced, and facilitator selected. In the second phase, the M1, M2, F1, and F2 groups are assigned to four different lecture halls, where students perform an individual readiness assurance test (IRAT) on clinical scenarios with five likely choices, to measure their understanding of the concepts learned during the week. All MCQs are prepared according to guidelines from the National Board of Medical Examiners. There is a minimum of 10 MCQs, which are designed to activate students’ higher-order critical-thinking skills and are presented in PowerPoint format. Each PowerPoint slide automatically changes after 1 min. Student responses are collected through clickers, an electronic audience response system using Turning Point technology. Test statistics are available immediately, which helps the facilitators in the following discussion session. Students stay with their teams during the entire IRAT to reduce disruption at the beginning of the team test. The same test is then readministered to the students in the preassigned team. The team then discusses and makes a decision about each answer in a team readiness assurance test (TRAT). Team tests are high energy, noisy, and often chaotic events as students discuss and negotiate their answers and deepen their understanding. Typically, we budget 30 min for a 10-question TRAT. After the end of the TRAT, each item of the MCQ is discussed until the concepts are fully clear. The third phase comprises application exercises where students work with their teams on clinical scenarios that allow them to use the knowledge gained during the week with clinical application exercises. All application exercises are prepared in accordance with the four “Ss” of the effective problem rule, which refers to significant problem, same problem, specific choice, and simultaneous report (24, 27). These exercises expose students to different interpretations in controversial scenarios and build their clinical reasoning skills. The integration of all these phases represents an active, student-centered learning environment, a motto of Alfaisal University. At the end, students have the right to appeal against any question/answer.

The TBL grading system ensures that individual students are accountable to both the instructors and their peers. The grading system has an individual performance component (IRAT), a team performance component (TRAT), and a peer evaluation component (22, 24). We are significant among other universities in the Kingdom of Saudi Arabia as we recruit a larger number of international students and have increasing diversity in our classrooms year after year. This makes our teams heterogeneous and ensures that a wide range of skills, opinions,
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CT, computed tomography.
and personal experiences come into play during team deliberations.

Preparations for the coming blocks are made weeks in advance, and all learning objectives are formulated according to Bloom’s taxonomy. Before each TBL, a pre-TBL meeting is held regularly at the start of the week to have a peer evaluation of the content to be tested. A facilitator guide is also prepared in which all possible discussion points are covered. This provides a uniform platform for all facilitators involved (24).

PBL. We use the PBL method as the core educational strategy in years 2 and 3. System-oriented units are taught through tutorials in which problems are discussed. Anatomy is integral to most of these problems. Each group is assigned to a tutor, who remains with the group throughout the block. The tutor, who is not necessarily an expert in anatomy, serves only as a facilitator. Each problem consists of a variable number of triggers that are discussed in the first tutorial session at the beginning of a given week. Students challenge each other and get into a brainstorming exercise using prior knowledge. They identify their learning needs for further independent or group study. Students acquire their learning needs (including anatomy) through textbooks, PowerPoint slides, weekly activities of the ARC, the internet, and clinical skill sessions. At the end of that week, the second tutorial commences with a discussion of those learning needs on which self-study was undertaken. As a result, students acquire the necessary knowledge, skills, and attitudes concerning structure, function, pathophysiological mechanisms, community health aspects, and diagnostic reasoning.

Structured laboratory and clinical skill sessions. It is a well-established fact that learning in a clinical context leads to a deep and lasting understanding if interactive activities are used (6, 18). Our structured laboratory is one of the vibrant dimensions of our teaching strategies. We opted for a multimodality approach here, and we integrated anatomy with physiology and clinical medicine. The structured laboratory is conducted by a highly experienced and dedicated group of clinical anatomists and physiologists. Students in the 21st century are fascinated by technological advances and electronic resources, which act as a catalyst to stimulate their conceptual learning (10). We have large LED projector screens and cameras mounted in each laboratory, which are judiciously used during our sessions. An area is equipped with high-speed computers where students have access to dissection videos and various anatomy software for their self-directed learning.

We organize each laboratory according to the theme of the week and divide it into four stations. Station 1 comprises a gross anatomy section, where prossected specimens of cadavers with relevant plastinated/plastic models are used side by side. Station 2 is usually based on clinical cases, where MRI, computed tomography, and endoscopy images are used. This allows a student to visualize what a real structure looks like and can compared it with different imaging modalities (3, 19, 33). Station 3 allows the use of an anatomic, examination of surface anatomy, and a relevant ultrasound on a standardized patient. Utilization of standardized patients in our teaching-learning methodologies enhances hands-on experience, which is quite close to the real clinical situation. Station 4 encompasses the microscopic anatomy component with a functional perspective. These efforts are made for students to understand the human body more meaningfully. At the end of the block, students are also exposed to an Objective structured practical examination (OSPE).

Male and female students are divided into eight subgroups separately. Four groups are rotated through these dynamic laboratory stations facilitated by a faculty member for a period of 2 h; each station is ~20–25 min in duration. Our laboratory stations are designed to develop a relevant concrete background supporting students to acquire and relate the content expressively.

PAUL program in the evening. Various studies have concluded that the involvement in teaching as an undergraduate medical student is helpful for the student-teacher, student-learner, and program. The most effective retention of knowledge results through teaching others. This activity also develops communication skills, respect for peers, teamwork capabilities, and professionalism (13, 17). We have been using the PAUL dissection program for the last 7 yrs at the ARC of Alfaisal University (8). These sessions are held 4 days/wk, 2 days for each sex separately, from 5 to 8 PM. Our dissection program is a traditional full body dissection program through groups of students.

In this PAUL program, 32 peer teachers in total are selected on a voluntary basis (16 male students and 16 female students). The rest are enrolled as peer students. For standardization purposes, we have developed a training course for peer teachers. At the start of each week, the peer teachers meet with the instructor in a pre-session preparatory meeting where the peer teachers discuss, review, and dissect the material related to that week’s theme. These peer teachers then meet with the peer learners in small groups to deliver the content of the session. They explain the concepts of anatomy using prossected and dissected cadavers along with other resource material that is part of the course. Later, the peer learners with their peer teachers are involved in dissection. All these activities are facilitated under the watchful supervision of our experienced faculty members.

The PAUL program is supplemented by multiple imaging modalities and a clinical framework within it. The program is a voluntary activity, but due to its tremendous benefits for the students, ~70–80 students participate in it every year. It has gained remarkable popularity among the students. The peer learners also feel comfortable and accept peer teachers as information providers, role models, and facilitators (7).

Teaching anatomy in the clerkship phase. “Anatomic principles in clinical practice” is a newly introduced component of the anatomic teaching for students in years 4 and 5 who are undertaking rotations in surgery, internal medicine, and gynecology and obstetrics. The aim of this course is to refocus, revise, and vertically integrate applied anatomic concepts that are essential for clinical practice.

The ARC

Organization. The Department of Anatomy at the College of Medicine of Alfaisal University has a state-of-the-art ARC, which provides an ideal learning environment for the study of all components of anatomy. The ARC is configured to support the instruction of the ICAP at all levels. These modern, fully equipped facilities are also appropriate for numerous other
activities, including surgical skills, research and development, and laboratory skill practice. Consistent with our approach, cadaveric specimens together with medical visualization technologies provide the ideal environment for anatomy study. At present, the ARC is located in the basement of the College of Medicine building and consists of two wings. A blueprint of the ARC is shown in Fig. 1.

**WING A.** Wing A consists of the histology laboratory, preparation room, two dissection halls, mortuary, and living anatomy room.

**WING B.** Wing B consists of the digital anatomy resource center, research laboratory, technician’s room, dry anatomy laboratory, anatomy museum, and small-group discussion room.

**What makes the ARC compatible?** The ARC has the following features:

1. Teaching laboratory facilities for up to 300 male and female students
2. Well equipped
3. Well staffed
4. Comfortable infrastructure
   - Spacious laboratories
   - High-performance ventilation
   - Temperature and humidity controls
   - High-performance audio-visual system
   - Mortuary
5. Optimal learning and teaching environment
   - Range of technologies to support multiple methods of teaching and learning
   - Flexibility of space usage
   - Simultaneous teaching in both wings
   - Safe and smooth movement between wings to promote student-faculty interactions

An integrated approach to teaching and learning anatomy is facilitated by the following resources:

**ANATOMY DISSECTION HALLS.** Many anatomists postulate that dissection leads to a better understanding of human anatomy (1, 14, 15). Students who received dissection-based training score higher in short- and long-term education (26). Whole body dissection is the hallmark at the College of Medicine of Alfaisal University. It is carried out in the ARC’s anatomy dissection laboratories. The cadavers for dissection are procured from commercial sources from the United States and Germany. The laboratory comprises two dissection rooms, a dedicated anatomy classroom, a mortuary, a self-directed learning area, and an embalming room. The dissection rooms are large, and 4 groups of 10–12 students may work side by side to explore human Anatomy. The ARC obtains several cadavers each year to teach our students topographical anatomy. They are safely stored in the mortuary. There is also a range of previously prospected specimen readily available for students to view and study. These prospected specimens are prepared by students under the supervision of experienced anatomy faculty members. These resources are complemented by a wide range of plastinated specimens. There are two experienced embalmers who prepare the dissecting rooms in a customized way to fulfill the requirements of each class. Classes are run by senior and junior anatomy faculty members,
and students are encouraged to play an active role in dissection. All students are provided with dissecting instruments and are strictly required to follow the dissection methods and dress code protocol.

HISTOLOGICAL RESOURCES. Histology is a traditional core basic science component of most medical education programs. For the past two decades, numerous digital teaching systems have been developed. The ARC has a very spacious histology laboratory. It can accommodate 50–60 students. It is equipped with several LED monitors connected to a computer, multimedia projector, and good audio system. It holds various light microscopes for students to investigate histology. There are >3,000 microscopic slides stained with hematoxylin and eosin and special stains, which are stored in slide cabinets. The histology laboratory also has a binocular digital research microscope. Each week, during structured laboratory rotations, histology slides on the current topics are put out on slide trays for students to examine. Expert help and advice in the form of senior histologists are always present to guide the students. Recently, a multipurpose digital slide scanner has also been added as a useful resource. The scanner can take five slides at a time to digitalize the pictures. Students can take home all digital pictures that they have seen under the microscope.

ANATOMY MUSEUM/RESOURCE AREA. There is a dedicated area in the ARC where all materials are displayed and stored in glass cabinets. Students are encouraged to come and look at these resources on their own time in small groups or as part of self-study to aid their understanding of the topics being studied that week. The anatomy museum serves as the resource center. It holds a large number of prosected models, plastinated specimen, preserved specimens, plastic models, skeletal material, medical images, charts, posters, transparencies, and cross sections.

LIVING ANATOMY. Living anatomy is an essential skill required by all anatomists to acquire the ability to identify the position of anatomic structures on the body surface. Surface anatomy is important for clinicians because it covers the inspection part of the physical examination (2). A prudent physician is one who is capable of identifying crucial landmarks necessary for preliminary diagnosis during the clinical setting. A standardized patient is hired for the surface anatomy practical/laboratory sessions, and safe body paint colors are used (21).

A dedicated and specially designed area is reserved for teaching living anatomy in the ARC. Living anatomy is taught using different methods. These include body painting, peer volunteer surface anatomy, palpation of landmarks on peers and a cadaver, and the use of collaborative, contextual, and self-directed learning. Hands-on sessions are conducted under supervision for the students to demonstrate the surface markings of organs and bones. This is complemented by inviting trained standardized patients in collaboration with the Clinical Skills Department.

Another interesting component of the living anatomy program at Alfaisal University is the use of ultrasound to teach living human anatomy. Ultrasound is a safe diagnostic imaging modality that is widely used in clinical settings (11). Our objective is to enable first- and second-year medical students to interpret normal ultrasound images. To achieve this goal, we use an ultrasound machine in the Anatomy Department to teach ultrasound-based anatomy and living anatomy. Intensive ultrasound training was given to the faculty members to equip them with sufficient knowledge and skills and qualify them to teach our medical students. Our curriculum includes a dedicated 30-min station at each of teaching modalities/blocks allotted for the usage of the ultrasound machine. A standardized patient is devoted to this particular learning station. Students are trained to handle the ultrasound probe and properly place it on the designated examination area. The instructor then captures images and records video clips of the examined organ(s) in an interactive session of questions and answers. Student evaluations have provided positive feedback and responses for the ultrasound sessions.

RESEARCH LABORATORY. Faculty members interested in biomedical research in the department use the research laboratory. The researchers are funded by the university and the King Abdulaziz City for Science and Technology a national granting agency. At present, the laboratory is fully equipped with instruments related to molecular biology research and for estimation of biomolecules using HPLC with several detectors. It also houses a fully equipped cell culture laboratory.

TECHNICIAN ROOM. Two technicians monitoring the daily activities at the ARC are present at all times. These technicians are responsible for the structured laboratory sessions and guide the students for self-directed learning on a daily basis.

SELF-DIRECTED STUDY AREA. This facility includes dedicated areas for our anatomy students. They are located in both wings and are well equipped and contain computing facilities, LED projectors, white boards, and flip charts to aid teaching. There are bookshelves containing a range of anatomic textbooks books and atlases. The e-versions of the books facilitate students with their self-directed study. All resources, including the anatomage, models, slides, etc., of resource center remain available to students. The evening laboratory geared toward the PAUL program is also the part of the student self-directed learning.

Student Assessment and Program Evaluation

Students are assessed using a variety of methods. Although TBL/PBL remains the primary tool for continuous assessment, MCQs, short-answer questions, and OSPEs are used for summative examinations and provide the basis for evaluating students’ knowledge, skills, and attitudes. Students must also obtain a satisfactory score in clinical skills to progress from one year to another. For more understanding of our assessment system, the readers are encouraged to read a previous paper (32).

For the past 3 years, our students have participated in a nationwide “progress test.” Progress testing is a longitudinal testing approach of comprehensive knowledge. This test can be conceived as a final comprehensive examination at the end of the medical program, testing end-of-training competencies and outcomes. It has been used by medical schools both in McMaster University in Canada and Maastricht University in The Netherlands (5, 28).

In the progress test conducted in Saudi Arabia, 15 different medical schools participate nationwide at one time. It consists of ~200 MCQs with 5 options stratified in categories based on the International Classification of Diseases. A test item can be responded by choosing one of the four options or with an option of “I do not know.” The option of “I don’t know” is not
penalized or rewarded. A correct answer is rewarded with one mark, whereas an incorrect answer is given a −0.25 mark. This is done to discourage guessing among students. To allow comparisons, the test scores are expressed as percentages. The purpose of this test is to sample relevant knowledge across all disciplines of medicine.

To study the impact of the ICAP on the scores of students of Alfaisal University in the progress test, we compared the mean scores of students from Alfaisal University in the anatomy and physiology components of the examination with the national average on the progress test. The comparison was made by paring mean scores of students from Alfaisal University with the average score at the same year of study at the national level. The test results revealed that students from Alfaisal University were able to score significantly higher in the anatomy and physiology components of the examination on the paired analysis with the corresponding year of study at the national level, with \( P \) values of 0.0179 and 0.0015, respectively. The frequency distribution graphs demonstrating these results are shown in Figs. 2 and 3. These data show that the ICAP is successfully achieving its aims.

**Future Prospects and Conclusions**

Early signs are showing that the ICAP is a unique program that caters toward the needs of 21st century medical students in the Kingdom of Saudi Arabia. However, we did face some hurdles during the development of this program, which included 1) infrastructural constraints, as the College of Medicine did not have its own purpose-built campus and we therefore had to be innovative to develop this unique program in the available building space, and 2) training faculty members to effectively conduct this program. The ICAP is an evolving program, and we are keen in introducing innovative technology to make it beneficial for the students. In the future, our focus is to introduce more functional integration in our program by introducing laboratory techniques like electrocardiogram, electromyography, nerve conduction, and echocardiogram studies in our laboratory sessions. We are also keen to acquire Thiel-embalmed cadavers. These cadavers are soft cadavers where tissue structures are preserved close to the living state. These cadavers will provide students with the following advantages: 1) students can appreciate the color and texture of the tissues, which will be close to surgical anatomy; 2) students can perform clinical examinations on the cadavers; and 3) these cadavers can be used to teach endoscopic anatomy and ultrasound-based anatomy and to teach surgical procedures. Moreover, we are also very keen to teach clinical examination techniques as an integral part of the ICAP. We believe that with these innovations in teaching, the ICAP will become a unique program that can be used as a model to teach clinically applied functional anatomy to medical students in the Gulf region in particular and around the world in general.

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**DISCLOSURES**

No conflicts of interest, financial or otherwise, are declared by the author(s).

**AUTHOR CONTRIBUTIONS**


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