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METHODOLOGY

Integrating radiology vertically into an undergraduate medical education curriculum: a triphasic integration approach

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Abstract: Fulfilling the goal of integrating radiology into undergraduate medical curricula is a real challenge due to the enduring faith assuming that traditional medical disciplines are worthy of consuming the available study time. In this manner, radiology is addressed occasionally and with relevance to these traditional disciplines. In Al-Baha University Faculty of Medicine, Al-Baha, Saudi Arabia, efforts have been made to integrate radiology vertically and in a structured manner into the undergraduate curriculum from the first year to the sixth year. For achieving convenient integration of radiology, a triphasic approach to integration is adopted. This approach consists of the integration of radiology foundations into the basic sciences phase, development of a distinct 4-week module in year 4, and finally, integration of clinical applications of radiology in the clinical phase modules. Feedback of students and inferences obtained through assessment and program evaluation are in favor of this approach to integration. Minor reform and some improvement related to time allocated and content balancing are still indicated.

Keywords: radiology foundations, radiology module, students assessment

Introduction

To strike a target, it is necessary to see it. This is why more care should be paid to teaching radiology in medical education. We should no longer willingly cede the use of imaging in medical education to other disciplines.[1]

Nowadays, advances in imaging technology have intensified the need for undergraduate teaching of radiology. Within the same timescale there have been developments in educational delivery and a wider awareness of modern learning strategies, objectives, and scope of teaching. Some instructional methods, notably computer-assisted methods, are amenable to aid learning of medicine in general and radiology in particular.[2]

Tomorrow's physicians will need to make effective and efficient use of new imaging techniques. The responsibility for preparing them to do so rests squarely on the shoulders of today's radiology educators. This is why radiology should be integrated into medical curricula through specialized radiology leaders.[3]

Issues such as how to develop a medical school radiology course and get it accepted by a curriculum committee have been examined before. A key issue is the content of the course itself or, in other words, what medical students most need to learn about radiology. A good course needs to accomplish a number of key objectives, but course developers must bear in mind that most students do not intend to pursue careers in radiology. The course needs to provide a working knowledge of the appropriate radiologic examination for different clinical situations. It needs to cover the basics

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of image interpretation, including urgent, life-threatening findings, yet before students can grasp what examination to order and what findings to look for, they need to understand the radiologic imaging techniques themselves.[4]

Al-Baha University Faculty of Medicine (ABUFM) in Al-Baha, Saudi Arabia, since its foundation in 2008, has adopted a fully integrated body systems-based curriculum through all phases of the 6 years of its educational program. The main feature of this innovative curriculum is the ten system-based basic sciences modules studied in the 3 years of the basic sciences phase and other mirror image system-based modules studied in the 3 years of the clinical phase.

The ten body systems-based modules, in either the basic sciences phase or the clinical phase, are supported by another set of modules. This set of supporting modules comprises the foundations of natural and basic medical sciences in the basic sciences phase, as well as the foundations of clinical medicine in the clinical phase.

During the early phases of curriculum development, the questions raised by the radiology course committee were what, when, and how to integrate radiology into the undergraduate curriculum of ABUFM. The alternatives to answer this question were to address radiology within other clinical disciplines through a "when indicated" approach, to allocate a distinct and specialized module, or to integrate a related theme longitudinally into the curriculum all through its 6 academic years.

This article reviews efforts and experience in integrating the discipline of radiology into the undergraduate medical curriculum of ABUFM, with emphasis on the identified themes, instructional methodologies, assessment methods, required resources, obstacles, lessons learnt, and recommendations.

Methodology

A radiology course committee was formed. The committee consisted of faculty staff members with the following specialties: radiology, pathology, physics, and anatomy. The committee also included representatives of the different clinical disciplines. The main goal of the committee was to establish an expert consensus on the content and approach to integrating radiology into the undergraduate curriculum of ABUFM. All through the planning and implementation phases, the radiology course committee worked in coordination with curriculum committees of the other disciplines.

The six-step approach of curriculum development in medical education developed in 2003 by Kern et al[5] was followed by the committee to integrate basic and clinical aspects of radiology vertically into the curriculum of ABUFM. The six steps utilized are as follows:

- Step 1: problem identification
- Step 2: educational needs assessment
- Step 3: setting goals and objectives
- Step 4: identification of educational strategies
- Step 5: implementation
- Step 6: evaluation and feedback

Results and discussion

Following the six-step approach of curriculum development has made the process of integrating both basic and clinical aspects of radiology into the undergraduate curriculum of ABUFM a systematic process. The process started as early as the beginning of development of the whole undergraduate curriculum.

Step 1: problem identification

In Saudi universities, no study has been conducted to define a certain academic framework for teaching medical radiology at the undergraduate level. Benchmarking undergraduate curricula of 15 established Saudi medical schools versus two well-recognized international Western medical schools has revealed that the majority of local schools are not designating specialized modules or courses for radiology. The majority provide only occasional learning opportunities for radiology within some areas of their undergraduate curricula. A common tradition was to address the applications of radiology within the study of other clinical disciplines late in the clinical phase.

The assigned radiology committee of ABUFM has obtained evidence on the deficiency of the reviewed curricula with regard to the following: teaching foundations of radiology, curricular time allocated for radiology, and utilized instructional and assessment strategies that are knowledge based in most cases.

Step 2: educational needs assessment

Exploring the views of stakeholders through focus groups and revision of radiology syllabi of international medical schools together have resulted in identification of a scale of themes that can be addressed through the intended radiology course of ABUFM (Table 1). Involvement of past students in this phase was inapplicable because of the novelty of this curriculum and because there are no graduates for the time being.

Step 3: goals and objectives

The developed course aims to provide a distinct teaching/learning opportunity for radiology as with other

Table 1 Identified themes for integration in Al-Baha University Faculty of Medicine radiology course

I.	Foundations of radiology
1.	Terminology in radiology
2.	General characters of human morphology in health and disease
3.	Physics concepts and modality differences
4.	Chemical and physiological backgrounds of contrasts
II.	Orientation to radiology department
5.	Procedure for ordering a radiologic exam
6.	Critical information that should be included in a radiology request
7.	Writing a radiology report
III.	Diagnostic radiology
8.	Correlation between clinical evaluation and imaging
9.	Different imaging techniques
10.	Utilization of basic imaging techniques
11.	Interpretation of commonly used basic imaging studies
IV.	Radiology in management
12.	Introduction to interventional radiology
13.	Role of clinical radiology in patient management
14.	Introduction to nuclear medicine
V.	Specialized radiology
15.	Chest imaging
16.	Abdominal imaging
17.	Musculoskeletal radiology
18.	Vascular radiology
19.	Neuroradiology
20.	Pediatric radiology
21.	Women's radiology
VI.	Professionalism and patient issues
22.	Professional behavior of radiologists
23.	Management of conflicts of interest
24.	Patient safety and confidentiality in radiology
25.	Ethics and informed consent in radiology
26.	Understanding patients' experience and psychology
27.	Issues of cost-effectiveness in radiology
28.	Time management and prioritization of patients' problems

medical disciplines. The ultimate goal was to equip ABUFM students with basic competences needed for utilization of diagnostic ultrasound and interpretation of findings in X-rays, computed tomography, and magnetic resonance imaging at the level of general practice.

A set of specific learning objectives were formulated by the radiology committee based on the previously identified themes (Table 1). These objectives were formulated in relevance to the cognitive, psychomotor, and affective domains of learning. Content selection and organization were then conducted based on the identified objectives. These objectives and related content are distributed in relevance to the different modules in the 6 years of the undergraduate curriculum. A distinct and specialized 4-week module on clinical radiology was developed and introduced for study among a set of other clinical foundation modules in the first semester of year 4, the first in 3 years of the clinical phase.

Step 4: educational strategies

According to Kern et al,[5] educational strategies comprise both content and methods of instruction. To enhance teaching/learning in radiology and related content, a variety of relevant topics and instructional methods were identified and utilized.

These identified educational strategies (content and methods) relevant to radiology can be noted in three main areas throughout the 6-year curriculum of ABUFM (Table 2) – first, in the preparatory and basic sciences

Table 2 Distribution of themes, instructional methods, and assessment tools relevant to the radiology course through the 6 years of Al-Baha University Faculty of Medicine curriculum

Phase	Theme	Approach to study	Methods of instruction	Assessment
I. Preparatory phase (year 1)	Radiology foundations	Integrated within syllabi of natural sciences (physics, chemistry, and biology)	• Lectures • Practical laboratory sessions	• MCQs and short essays • OSPE
II. Basic medical sciences phase (years 2 and 3)	Imaging of human body in health and disease	Integrated within the system-based basic medical sciences modules	• Tutorials • PBL • Seminars	• MCQs and short essays • OSPE
III. Clinical phase				
• Year 4	Radiology module	Distinct 4-week module on clinical radiology	• Skills laboratory training • PBL • Hospital-based training	• MEQs • Clinical skills assessment • OSCE • Structured viva
• Years 5 and 6	Clinical applications of radiology	Integrated within the study of other system-based clinical modules	• PBL • Bedside teaching • Clinical case presentations • Shadowing	• Extended matching questions • Long case examination • Short case examinations • OSCE

Abbreviations: MCQs, multiple choice questions; MEQs, modified essay questions; OSCE, objective structured clinical exam; OSPE, objective structured practical exam; PBL, problem-based learning.

phase, which comprises the first 3 years of the curriculum. As a foundation for radiology, relevant topics from physics, anatomy, chemistry, biology, terminology, and ethics were integrated into the curriculum of these 3 years. These topics were integrated into the module of integrated natural sciences, as well as the basic sciences system-based modules, in a temporal coordination pattern of integration defined by Harden's "ladder of integration."[6] According to Bradley and Mattick,[7] through radiology basic medical sciences can be approached differently. For example, the anatomy encountered by radiology is not the static, distorted anatomy of the cadaver or the pathologic specimen but living anatomy of patients whose history and physical examination findings can be directly correlated. Not only anatomy but physiology and pathology are brought to life by radiology.

The second area in the ABUFM educational program where radiology is addressed is a 4-week specialized module on clinical radiology. This module is incorporated into the first semester of year 4. The modules of this semester stand as foundations of study in the three years of the clinical phase. The goal of this module is to address radiology in a holistic and timely manner. All the students in year 4 study this module in classrooms, skills laboratories, radiology units, and some occasional community-based campaigns.

The third area in the ABUFM educational program where radiology is addressed is the integrated system-based clinical modules in years 4, 5, and 6. The diagnostic and interventional applications of radiology are essential requirements in each of these modules. Intended learning outcomes and content on clinical applications of radiology are consistent in the different clinical modules and rotations all through the 3 years of the clinical phase. Within the timetable of each clinical module, at least one interactive lecture on radiology relevant to the addressed body system is conducted by a radiologist.

Methods of instruction that can help achieve intended learning outcomes of the integrated radiology syllabus included a wide array of methods. These methods were allocated according to the level of students. In the basic sciences phase, radiology foundations are addressed through lectures, tutorials, practical laboratory sessions, and site visits to radiology units in local hospitals.

In the clinical radiology module of year 4, instruction is characterized by more emphasis on hospital-based training compared with the study of foundations, in the basic sciences phase, and applications, in the clinical phase. Throughout this module, students are trained through role plays, laboratory skills settings, demonstrations, videos of real cases, reporting, and hospital-based training.

In the clinical phase, radiology applications are taught through interactive lectures, seminars, problem-based learning, self-directed learning, case studies, clerking, and shadowing.

Step 5: implementation

Implementation of the radiology course in ABUFM through an integrated approach with other medical disciplines aims to promote holism relevant to the real practice of medicine.[8] Allocation of human and financial resources was the first step in the implementation process. Shortages in specialized faculty members and time for implementation were the main obstacles.

Essential teaching facilities, tools, and equipment were considered during the needs assessment phase. Examples are a variety of films with normal and abnormal findings, illumination devices and box viewers, radiology protective and safety aids, computers, and printers. Provision of the required resources did not necessitate extra funds beyond the allocated total budget of the school.

As the university hospital is still in the process of construction, the medical centre of Al-Baha University and two other local hospitals belonging to the Ministry of Health were utilized for training of students through the radiology module, as well as other clinical modules, after an agreement between the university and local health authority.

Step 6: evaluation and feedback

Assessment of students is being conducted all through the three phases: the foundations phase, the module phase, and the applications phase. Different assessment methods are utilized. Through both the foundation and applications phases, students' competences in radiology are assessed within assessment of the different modules. On the other hand, assessment of students in the radiology module is conducted through two main domains: 1) continuous weekly assessment by the end of each week through portfolio assessment, and 2) final assessment by the end of the module through case-based multiple choice questions, a practical multistation exam, and a case-based structured viva exam.

Obtaining inferences on students' performance and learning gain in radiology in the foundations and applications phases has not been tried yet. After implementing the radiology module in year 4 for two successive years, the failure rates (percentages of total students' scores below 60%) were 12% and 19% in the years 2013 and 2014, respectively.

Table 3 Results of radiology course evaluation obtained through self-administered anonymous student questionnaire

Students' satisfaction with …	Percentages[a]
Foundations of radiology integrated in the basic sciences phase	92
Content of the radiology module	66
Teaching/learning facilities allocated for the radiology module	92
Methods of instruction allocated for teaching in the radiology module	85
Time allocated for the radiology module	36
Balance between basic sciences content and specialized radiology content	48
Clinical applications of radiology integrated in the clinical phase	Not evaluated yet

Note: [a]Figures presented are the means of percentages obtained from two student cohorts in 2013 and 2014.

Most of the failed students had low scores in performance assessment compared with viva and written examinations. Also, they were mostly irregular in attendance to the different practical learning activities of the module.

Program evaluation is conducted by the end of each module throughout the six years of the ABUFM curriculum. Through the years 2013 and 2014, evaluation of the radiology module was conducted using students' and faculty self-administered anonymous questionnaires (Table 3).

In regards to the radiology module, the main percentages of students' satisfaction through the two years of implementation were as follows: satisfaction with content of the module 66%, with the allocated facilities 92%, and with the instructional methods 85%. Criticism was directed mainly to the short time period allocated for the module (64%). A majority of students (52%) stated that there is an imbalance between time allocated for didactic teaching and teaching in hospital-based settings. On the other side, students evaluated the basic sciences content of the radiology module as more than enough compared with the specialized content related to radiology.

A majority of students (92%) rated the foundations of radiology in the basic sciences phase as efficient. As regards the applications of radiology within the clinical phase, it is still under consideration.

Conclusion

Integrating radiology vertically into the undergraduate educational program of ABUFM can be considered as a unique experience that is worth studying. Integration of the radiology course was conducted in three phases: a foundation phase, a specialized module phase, and an application phase. The six-step approach for curriculum development was utilized to guide this experience. Program evaluation and inferences obtained from students' assessment were in favor of continuity of this experience. Minor reform in the form of balancing between didactic teaching and training from one side and between basic sciences content and applied radiology content from the other side is still indicated. Utilization of a picture archiving and communication system to provide economical storage of, and convenient access to, images from multiple modalities is important for teaching/learning and assessment in radiology.

Disclosure

The authors report no conflicts of interest in this work.

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