Early Resident-to-Resident Physics Education in Diagnostic Radiology

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The revised ABR board certification process has updated the method by which diagnostic radiology residents are evaluated for competency in clinical radiologic physics. In this work, the author reports the successful design and implementation of a resident-taught physics course consisting of 5 weekly, hour-long lectures intended for incoming first-year radiology residents in their first month of training. To the author's knowledge, this is the first description of a course designed to provide a very early framework for ongoing physics education throughout residency without increasing the didactic burden on faculty members. Twenty-six first-year residents spanning 2 academic years took the course and reported subjective improvement in their knowledge (90%) and interest (75%) in imaging physics and a high level of satisfaction with the use of senior residents as physics educators. Based on the success of this course and the minimal resources required for implementation, this work may serve as a blueprint for other radiology residency programs seeking to develop revised physics curricula.

Key Words: Education, physics, residency, teaching

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INTRODUCTION

Despite the close relationship between clinical radiology and imaging physics, formal instruction in physics is perceived to be lacking in many radiology residency programs [1,2]. Where available, such instruction has traditionally focused on directed preparation for Part I of the ABR's Initial Qualifying Exam (the physics examination) and accordingly, has taken place after the formative first year of radiology training.

Beginning with the radiology residency class entering in 2010, the ABR examination structure has changed [3-7]. The physics examination has been integrated into a comprehensive written examination (the core examination) taken late in residency and revamped to maintain a strong focus on the physics that is relevant to the daily practice of clinical radiology. This revision of the board certification process has created an opportunity to update traditional methods of physics education in radiology residency to mirror the emphasis on clinically relevant physics and has led to proposals ranging from continuous, multiyear didactic training to internet-based self-study modules [6,8-10].

This paper describes the design and successful implementation of an abbreviated, resident-taught physics course offered to first-year radiology residents during their first month of training and designed to provide an early foundation of knowledge to serve as the basis for ongoing learning is described in this paper. The results of a post-course survey given to these residents to assess the effectiveness of the didactic strategy are also reported. It is hoped that this experience will serve as a useful and practical model for other training programs interested in refining their own physics curricula to meet the demands of the new ABR board examination and enhance the training of the current generation of radiology residents.

METHODS

Design and Objectives

Program faculty developed an introductory physics course around 3 overarching design principles pertaining to the timing, content, and delivery of specially designed physics lectures.

First, lectures were to be delivered early in training to provide a foundational understanding of clinically relevant imaging physics timed to coincide with residents' first introduction to the prescription and interpretation of medical imaging. It was hoped that exposing new residents to physics and clinical radiology at the same time would result in the natural integration of these two disparate bodies of knowledge into a single cohesive framework.

Second, lectures were to be abbreviated and focused on the essential physical principles underlying each imaging modality rather than detailed minutiae. It was believed that maintaining a strong emphasis on conceptual structure would encourage the development of long-lasting physical intuition and an appreciation of the most important tenets of imaging physics, while

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Table 1. Lecture content and timing

Topic	Duration (min)
Lecture 1	
Electromagnetic radiation: definition, properties	5
Atomic structure: electronic structure and electronic-level transitions, nuclear structure and nuclear transitions	10
X-ray production: x-ray tube design, conversion of free electron energy to x-rays, characteristics of x-ray spectrum	25
X-ray interaction: types of x-ray interactions, linear attenuation and energy dependence, dual-energy x-ray	20
Lecture 2	
Projection radiography: geometry and magnification, detectors, scattered radiation, modulation of radiation dose	40
Fluoroscopy: hardware components and geometry, device operation and image acquisition, modulation of radiation dose	20
Lecture 3	
Computed tomography: multiprojectional radiography, scanner geometry, detector arrangement	10
Image formation: data acquisition, reconstruction algorithms, Hounsfield units	20
Image quality: quantum statistics, signal-to-noise ratio, contrast-to-noise ratio, spatial resolution, reconstruction kernels	20
Radiographic artifacts: Mach effect, partial volume averaging, motion, beam hardening	10
Radiation dosimetry: units and measures, radiation exposure from common studies	5
Lecture 4	
Sound waves: definition, wave properties, interaction with tissue	10
B-mode ultrasound: piezoelectric arrays, pulsed echoes and pulse repetition frequency, beam steering and focal zones, frame rate, choice of transducer frequency	25
Doppler ultrasound: principles and geometry of the Doppler effect, color Doppler imaging, spectral Doppler imaging, power Doppler imaging	10
Ultrasound artifacts: localization artifacts, transmission artifacts, multiple echo artifacts, spectral aliasing	10
Fluid dynamics of blood flow: patterns of flow, patterns of pulsatility	5
Lecture 5	
Nuclear magnetic resonance: nuclear spin, spin manipulation, spin relaxation	35
Magnetic resonance imaging: signal localization, pulse sequences	25
Magnetic resonance artifacts: signal localization artifacts, susceptibility artifact, gradient artifact	15
Magnetic resonance safety	5

avoiding esoteric topics that have traditionally discouraged interest among residents.

Third, lectures were to be organized and delivered by residents, thereby avoiding additional burden on faculty members, encouraging scholarship and the development of didactic skills among interested residents, and increasing familiarity and mentorship opportunities between residency classes. In addition, it was anticipated that a course run entirely by residents would be easier to implement at small teaching institutions that might not have access to the in-house, faculty-level expertise in medical physics available at most large academic centers.

Implementation

The course was offered in the 2011-2012 and 2012-2013 academic years to each member of the entering residency class, representing a total of 26 postgraduate year (PGY) 2 residents. The course consisted of 5 weekly, approximately hour-long lectures starting in the first month of residency (Table 1). Each lecture took place in a central location at 6 PM on a weekday, leaving sufficient time for residents to travel from their respective clinical rotations.

One resident functioned as a course director, selecting didactic content from standard reference texts, identifying resident lecturers, and making logistical arrangements for each lecture. Lectures were delivered by 1 of 3 residents, each of whom had prior physics training and a stated interest in radiologic physics and/or education. Two of these residents were at the PGY 3 level in the 2011-2012 academic year, and 1 was at the PGY 5 level. Participation from these residents was strictly voluntary, and none was offered specific incentives or preparation time. Each of the 3 resident lecturers who participated in the first offering of the course also took part the following year.

Data Collection

Course evaluations were distributed at the conclusion of the course, after each resident had completed at least one CT-based rotation. Evaluations were strictly anonymous and completed on a voluntary basis. At the time of survey administration, faculty lecturers had delivered approximately 120 lectures on clinical radiology topics but no lectures on physics topics. As such, questions on the evaluation were designed to assess the quality and value of resident-given lectures compared with nonphysics faculty lectures, didactic impact of the course, degree of intellectual stimulation, appropriateness of course timing, and interest in teaching future iterations of the course, rating each of these items on a 5-point, Likert-type scale. Surveys were distributed to first-year residents via e-mail, with a follow-up e-mail reminder approximately 2 weeks later.

As a secondary, objective measure of performance, raw scaled scores on the physics subsection of the ACR