2006 Whitley Award Recipient

Part I: Preparing First-Year Radiology Residents and Assessing their Readiness for On-Call Responsibilities[1]

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Rationale and Objectives. The aim of the study is to evaluate the effectiveness of an Emergency Radiology (ER) Core Curriculum training module and a Digital Imaging and Communications in Medicine (DICOM)-based interactive examination system to prepare first-year (postgraduate year 2 [PGY-2]) radiology residents and assess their readiness for taking overnight radiology call.

Materials and Methods. Institutional review board approval was obtained, and the study was compliant with Health Insurance Portability and Accountability Act (HIPAA) regulations. A dedicated month-long ER curriculum was designed to prepare new radiology residents for overnight radiology call that includes interpretation of off-hour urgent and emergent studies without immediate direct attending supervision. Lectures of the curriculum, provided by department staff, were based on the American Society of Emergency Radiology core curriculum. The lecture series was implemented after PGY-2 residents had completed formal introductory resident rotations during their first 6 months of training. A DICOM-based interactive computer-based testing module was developed and administered at the end of the lecture series. The module consisted of 19 actual emergency department cases with entire series of images, simulating an on-call setting. Tests were scored by two staff members blinded to resident identifying information. Upper-level residents also were tested, and comparison was made between first-year and upper-level resident test scores to determine the effectiveness of the test in determining first-year resident preparedness for call. Statistical analysis of results was performed by using *t*-test ($P < .05$).

Results. All residents in the residency program present during the month (nine PGY-2, six PGY-3, seven PGY-4, seven PGY-5 residents) attended the lecture series and finished the testing module at the end of the lecture series. Of 19 actual emergency cases on the testing module, five cases were neuroradiology, three cases were thoracic imaging, eight cases were body imaging, and three cases were musculoskeletal. PGY-2 residents scored an average of 73.0% (range, 63.2%–81.6%) of total points possible. PGY-3 residents scored an average of 76.8% (range, 68.4%–86.8%); PGY-4 residents scored an average of 77.4% (range, 65.8%–100%), and PGY-5 residents scored an average of 81.2% (range, 68.4%–94.7%). There was no statistically significant difference in scores according to level of training.

Conclusion. First-year radiology residents who underwent 6 months of formal radiology training followed by an intensive ER lecture series before taking overnight call had scores similar to upper-level colleagues on an interactive computer-based ER simulation module.

Key Words. Radiology, residency program; Emergency Radiology; computers, educational aid; computers, teaching aid.

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Imaging studies performed in the hospital and emergency department setting continue to escalate for a multitude of reasons, including the need for accurate and prompt diagnoses and the wealth of diagnostic information that current imaging techniques provide. Annual growth rates of computed tomographic (CT) studies performed in emergency departments on Medicare patients were 36.5%, 24.9%, and 22.8% in 2000, 2001, and 2002 (1). It is only logical that with the increase in number and clinical importance of imaging studies performed in emergency settings, there is an increasing need to assess preparedness before on-call duties in the emergency department.

At training institutions, radiology residents often interpret studies off-hours, providing preliminary reports that subsequently are reviewed by staff radiologists, who then issue a final report. Overnight call and responsibility for emergency studies remains a staple part of radiology residency programs, with important and demanding responsibilities as the workloads of radiology departments continue to increase (2–4). On-call resident responsibilities include interpreting emergency overnight cases for inpatients, in addition to those generated in the emergency department. In response to these increased demands and current resident work-hour restrictions, most radiology residency programs are moving toward night-float systems for overnight call (2).

However, the point at which new residents start overnight call or night float and the increased set of responsibility that this entails differ between training programs (2). Past studies showed discrepancy rates between radiologist-in-training on-call interpretations and attending final interpretations in multiple modalities that ranged from 1%–7% (5–10). The impact of level of training on report discrepancy rates within these studies was mixed.

Moreover, how to best prepare and assess resident readiness for overnight call is not well established. Simulation-based education can be an important tool for improving patient safety and clinical competence of health professionals. Simulation-based medical education is being used increasingly in clinical training in various medical fields, including radiology (11–13). These techniques can help provide an objective way to assess radiology resident knowledge and competence before the independent setting of overnight call.

The impetus for this study came out of a need to assess and create standards for our residents who are given the responsibility of covering overnight emergent studies, including those generated by our level I trauma center. We analyze a technique currently adopted by our residency program to prepare and assess resident readiness for overnight call. We hypothesized that first-year (postgraduate year 2 [PGY-2]) radiology residents would benefit from the development of a dedicated month-long emergency radiology (ER) lecture series provided to all residents, but mostly directed at educating PGY-2 residents before starting overnight call. The overnight call preparation technique also uses a novel computer-based simulation testing module at the end of the lecture series for objective resident assessment. By comparing first-year and upper-level resident test scores on the interactive examination system, we hope to determine the effectiveness of the ER Core Curriculum training module and first-year radiology resident readiness for taking overnight radiology call.

MATERIALS AND METHODS

ER Curriculum

The study was performed with the approval of our institutional review board and was compliant with HIPAA regulations. Informed consent was waived by the institutional review board because of the educational nature of the study. The study was conducted using our university-based radiology residency program, which consists of 36 residents (nine residents per year) and 45 full- and part-time staff radiologists.

A dedicated month-long ER curriculum was designed based on the American Society of Emergency Radiology (ASER) core curriculum in ER (14). Each lecture of the curriculum (List 1) lasted 45 minutes and was provided by a department staff radiologist who is subspecialty trained in the area of interest. The department staff used the ASER core curriculum as a guideline for material to be covered within their assigned lecture. Sixteen different staff members participated in the lecture series, and all used computer-based slide presentations [ie, PowerPoint (Microsoft, Redmond, WA), Keynote (Apple Computer Inc., Cupertino, CA)]. The format of the lecture (didactic vs case based) was left to the lecturer's discretion because a standard lecture format was not provided. However, most lecturers combined both didactic slides with slides of example images from actual radiology cases. All lecturers included images from actual cases that were either given to residents as unknown cases or described by the lecturer to illustrate salient radiological findings. Residents were encouraged to ask questions on the material being covered both during and after the lecture.

List 1
ER Core Curriculum Topics (45-minute lecture each)

Intracranial ischemia and hemorrhage	Abdomen: right and left lower quadrant pain
C-spine trauma: radiographs and CT	Abdominal vascular emergencies
C-spine trauma: MRI	Blunt abdominal trauma
Spine: infection, compression, ischemia	Urinary tract: ER scenarios
Head infections	Pelvic trauma
Neck infections	Upper and lower extremity trauma
Neck vascular injury	Trauma angiography
TLS-spine	Vascular ultrasound in ER
Nontraumatic thoracic emergencies	Ultrasound for nonobstetric pelvic emergencies
Chest trauma	Imaging of obstetric emergencies
Pain MIBI and ventilation/perfusion scans	Scrotal ultrasound
Pharynx, esophagus, stomach, duodenum	Abdomen: right upper quadrant pain and pancreatitis
Gastrointestinal bleeding and biliary imaging: nuclear medicine	

Lectures were given during protected resident teaching time before clinical duties each morning, and all residents in the residency program (PGY-2–PGY-5) were required to attend. The lecture series was implemented January 2005, six months after the beginning of the academic year. Each first-year resident completed introductory month-long core radiology rotations in thoracic imaging, neuroradiology, body CT and fluoroscopy, musculoskeletal imaging, abdominal and obstetric ultrasound, and nuclear medicine before and during the month of the lecture series.

Computer-Based Testing System

Unlike traditional methods of using selected key images (either digital or hard copies) as primary examination content, we developed a computer-based system that uses full Digital Imaging and Communications in Medicine (DICOM) studies with interactive picture archive and communication system (PACS) features, such as image scrolling, window and leveling, and linear measurement. By using a testing format that used the interactive abilities of the PACS in the emergency department, the overnight call experience and interpretation of cases was closely simulated. This system contains two separate modules: a "Data Collection" module and "Image Viewing" module.

The Data Collection module was configured as a data center for collecting DICOM images. We used the personal computer–based freeware Mallinckrodt Central Test Node DICOM software-testing suite (wuerlim.wustl.edu/DICOM/ctn.html) for image collection. Entire patient studies can be sent directly from other DICOM modalities (eg, workstation and PACS) to this module by using a standard DICOM protocol. For the purpose of this precall evaluation application, all cases collected were primarily emergency department studies.

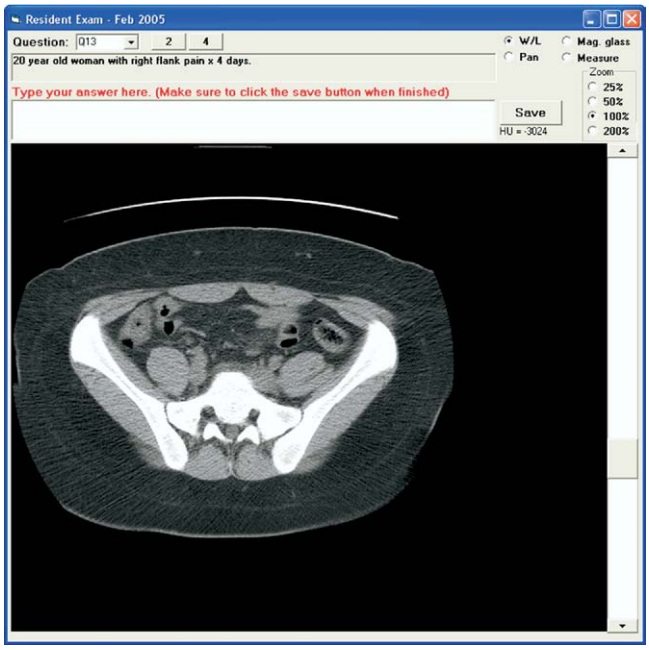

Figure 1. Screen capture of the DICOM viewer.

The Image Viewing module is a DICOM viewer software application that simulated our PACS viewing environment (Figure 1). This custom software was developed at our institution, based on a freeware tool Java (15). The viewer application was installed in multiple personal computer systems that were connected to the Data Collection module simultaneously. During the examination, each resident was randomly assigned to a computer with the viewer application installed.

Resident Testing and Evaluation

Nine separate computers were loaded with our Image Viewer software, and all residents who attended the lecture series underwent the testing module in four separate shifts. Residents were asked not to discuss the cases with each other during or after taking the testing module. Cases for the testing module were selected from a larger group of cases collected during the preceding year by staff members of the department. These cases then were reviewed by two staff radiologists, and 19 representative cases from different radiology subspecialties were selected for loading into the testing module. Topics covered by lectures of the core curriculum were considered when selecting the cases, as well as representative cases of pathological states typically encountered in our emergency department.

Five cases were neuroradiology based (CT–subarachnoid hemorrhage; CT–cerebral infarction; CT–isodense subdural hemorrhage; CT–cervical-spine fracture; magnetic resonance imaging [MRI]–epidural abscess), three cases were thoracic imaging based (CT–pulmonary embolism; CT–type A aortic intramural hematoma with classic type B aortic dissection; CT–Lemierre syndrome, peritonsillar abscess with jugular vein thrombosis), eight cases were body imaging based (CT–acute appendicitis; CT–acute cholecystitis; CT–diverticulitis; CT–small-bowel obstruction secondary to femoral hernia, CT–obstructing renal stone in duplicated collecting system; CT–unilateral pyelonephritis with an adnexal cyst; CT–traumatic bowel injury; CT–active extravasation from a ruptured hepatocellular carcinoma; ultrasound–testicular fracture), and three cases were musculoskeletal imaging based (plain film–anterior shoulder dislocation; plain films–foot osteomyelitis; MRI–hip fracture).

In an attempt to simulate the emergency department environment, residents were provided with minimal clinical information for each case and instructed to enter their findings, diagnosis, and recommendations for each imaging study on the computer. Residents typed free-text format answers into the testing module for each case, which was recorded on a computer server. A time limit was not set per case, but a total of 3 hours and 30 minutes was allowed for the entire test.

Resident answers were provided to two fellowship-trained radiologists for scoring. All resident identifying information, including name and year of training, was blinded, and questions were provided in random order. Neuroradiology cases for each test were scored by a neuroradiology subspecialty trained radiologist, and the remaining cases were scored by an ER subspecialty trained radiologist. The scoring system consisted of 0, 1, or 2 points awarded per case. A score of 0 was given for answers that missed or largely misinterpreted the main findings. A score of 0 was given for answers that recognized the main findings, but failed to describe a life-threatening condition (ie, uncal herniation, active extravasation of intravenous contrast). A score of 1 was given to cases for which the major findings were made, but possibly not all pertinent findings were identified, or main findings were made, but not interpreted correctly. A score of 2 was given to answers for which all pertinent findings were made and interpreted correctly. Scores then were returned to the computer server that contained all resident identifying information. A final score was provided after matching scored answers to each resident.

Statistical Analysis

Range and average scores for each level of training were calculated. The significance of the difference between scores from each level of training was performed by using *t*-test. Positive statistical significance was determined by using $P < .05$. Chi-square test was used to determine whether there was a statistical difference between PGY-2 and upper-level resident scoring on the three questions with the lowest overall average score. Statistical analysis was performed using statistical software (SPSS 11.0 for Windows; SPSS Inc, Chicago, IL).

RESULTS

Of all radiology residents in our program (n = 34), those in the residency program present during the ER training month (n = 29) attended the lecture series and finished the testing module at the end of the lecture series. Nine PGY-2, six PGY-3, seven PGY-4, and seven PGY-5 residents attended the lecture series and completed the computer-based testing module. Five residents were not able to complete the lecture series and/or testing module (two residents were away at the Armed Forces Institute of Pathology, two residents were rotating at an outside pediatric hospital, and one resident was on vacation at the time of the lecture series). Of 19 cases, PGY-2 residents scored an average of 73.0% (range, 63.2%–81.6%) of total points possible. PGY-3 residents scored an average of 76.8% (range, 68.4%–86.8%), PGY-4 residents scored an average of 77.4% (range, 65.8%–100%), and PGY-5 residents scored an average of 81.2% (range,

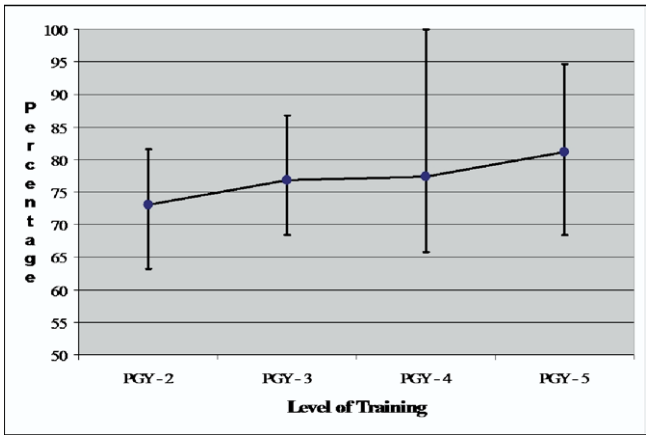

Figure 2. Average percent correct on the simulation computer-based testing module with ranges by level of training.

68.4%–94.7%; Figure 2). A *t*-test found no significant statistical difference between these results ($P > .05$).

Cases with lowest overall resident scoring were a CT scan showing left-sided pyelonephritis with an ipsilateral complex adnexal cyst (average score, 0.86/2.0), a CT scan with active contrast extravasation from a ruptured hepatocelluar carcinoma (0.90/2.0), and a CT scan with a small-bowel obstruction secondary to a femoral hernia (1.1/2.0). Lowest average scores among the PGY-2 class also were these three cases, with scores of 0.33, 0.22, and 0.44 of 2.0, respectively. However, a statistical difference between PGY-2 and upper-level resident scoring on these three questions was not identified. Cases for which residents scored the highest were a CT scan showing acute appendicitis (1.97/2.0), a CT scan showing a cerebral infarction (1.86/2.0), and a CT scan showing a cervical-spine fracture (1.86/2.0).

DISCUSSION

Diagnostic imaging continues to become an increasingly essential component of modern clinical medicine. Patient care has become highly dependent on timely and accurate readings of imaging studies. As a result, there is an increasing need to assess resident preparedness before taking overnight call.

The impetus for this study and curriculum came out of a well-realized need to assess and create standards for residents in our program before being given the responsibility of overnight call. Having basic requirements before interpreting studies generated by inpatients and emergency department patients in our level 1 trauma center with minimal supervision was important. By instituting an official curriculum and testing standards, these standards could be provided to the hospital and other departments as a "credentialing" of residents who interpret studies on call.

In our study, the average score obtained by PGY-2 residents on the computer module (73.0%) was not statistically different from averages of upper-level classes (76.8%–91.2%) who currently were taking or had previously taken overnight call. There was considerable overlap of ranges of scores between different levels of training (Figure 2).

The computer-based testing module is a useful way to objectively identify residents who may need more individual attention and/or instruction before undertaking overnight call. It can be difficult to identify residents who may need individualized attention before undertaking overnight call in the way most residency teaching programs are currently designed. Especially in larger departments, multiple radiologists are involved in resident teaching and assessment, and objectively identifying residents in need of further instruction can be difficult. Having a standardized simulation testing module can be a benefit in this aspect.

In addition to identifying residents who need more instruction and time before starting overnight call, results of the testing module can be used to identify areas in which residents as a group can benefit from additional instruction. After scoring of the testing module was completed in our department, cases and findings were reviewed with the residents in a didactic teaching session. Cases with the lowest average scores were each complex abdominal imaging cases with multiple findings, and the most time was spent reviewing these cases. No designated additional lecture was added to the curriculum in response to the testing module outcomes, but this also could have been performed.

Limitations of the study include lack of a pre-lecture series assessment to specifically assess the impact of the month-long ER lecture series on resident competence. However, the authors acknowledge that a month-long ER lecture series alone will never be enough to prepare radiology residents for overnight call. The need for traditional radiology education, including independent reading and rotating through different imaging modalities with direct attending teaching and supervision, remains.

Moreover, although the average score obtained by PGY-2 residents was not statistically different from the averages of the upper-level classes, there was a trend

toward higher scores with superior levels of training. Failure to show differences among residents based on their level of training may be related to the case selection for the test module and the small sample size. We postulate that a selection of more cases or more difficult cases may allow for this level of discrimination. We also postulate that with a higher level of discrimination, we may have observed differences between residents who were in the midst of taking call and residents who had taken call previously and were not currently. We postulate that residents, regardless of level of training, who are used to seeing emergency department–style cases at the time of the testing module would score well, although determining this would require additional investigation.

The DICOM-based testing module simulates actual emergent imaging cases in that entire series of images are provided with scrolling and windowing functions, simulating interpreting cases on PACS while on call. Often in teaching and testing in radiology, only selected images that no doubt contain pathological states are provided because of display constraints. This is unrealistic compared with how cases are interpreted on call, when significant images are not annotated for the benefit of the radiologist. However, because of time constrains, no "normal" cases or cases without significant pathological states were provided in our simulation module, as is often seen in a series of on-call cases. Also, the testing module was performed in a protected setting that may be unrealistic compared with modern overnight call situations. Added distractions from interpreting studies on call, including telephone calls, pages, and questions and consultations from radiology technologists and clinicians, can be difficult to handle. Furthermore, the simulation test score correlation to actual resident on-call performance is not directly measured.

The authors consider the DICOM-based testing module to be a valuable adjunct to the more comprehensive resident evaluation process at this point. Thorough resident evaluation after completion of each monthly rotation remains a key component of the evaluation process at this time. The authors acknowledge the need to gain more experience with this tool and its validity as a method for resident evaluation before using it as the sole tool to determine resident pre-call preparedness.

In conclusion, development of a month-long lecture series based on the ASER core curriculum in ER to prepare new radiology residents for upcoming overnight call was performed. A computer-based simulation testing module also was developed to objectively assess resident performance in an on-call situation. Simulation test scores of new radiology residents who had not taken call, but had attended the lecture series, were similar to those of upper-level residents who attended the lectures and taken overnight call. These findings indicate the benefit of having a dedicated ER lecture series and help validate the department's opinion that the new residents after 6 months of formal training and who had attended the dedicated ER lecture series were ready for overnight call in our hospital.

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