Radiation Safety and Medical Education:

Development and Integration of a Dedicated Educational Module into a Radiology Clerkship, Outcomes Assessment, and Survey of Medical Students' Perceptions

Nicholas A. Koontz, MD, Richard B. Gunderman, MD, PhD

Rationale and Objectives: This study assesses the effect on medical student understanding of a new radiobiology and radiation safety module in a fourth-year radiology clerkship.

Materials and Methods: A dedicated radiobiology and radiation safety module was incorporated into the fourth-year medical school radiology clerkship at our institution. Student understanding of the material was assessed via pretest and posttest. Statistical analysis was performed to assess significance of changes in student performance. In addition, we surveyed student perceptions of the importance of this material in medical education and practice.

Results: Monthly pretest mean scores ranged from 47.8% to 55.6%, with an average monthly pretest score of 50.3%. Monthly posttest mean scores ranged from 77.3% to 91.2%, with an average monthly posttest score of 83.9%. The improvement in exam scores after the educational intervention was statistically significant (all $P < .01$).

Conclusion: The introduction of a new educational module can significantly improve medical student understanding of radiobiology and radiation safety.

Key Words: Radiation safety; radiobiology; medical student education; ionizing radiation.

"Primum non noncere" –Anonymous (1)

Radiation safety is arguably one of the most pressing and controversial issues facing radiology today. Whether in newsprint (2–5), over the airwaves (6,7), or in the blogosphere (8,9), numerous recent articles have raised concerns about the risks of medical imaging and stirred public concern about the effects of exposure to ionizing radiation. Widely reported incidents of patients undergoing excessive numbers of computed tomography (CT) scans (3), epilation after brain perfusion CT scans (4), and improper dosing of radiopharmaceuticals (5) might be dismissed as outliers, but the public and members of the medical community are understandably concerned about the risks of medical imaging.

The news media have often reported that up to one third of all medical imaging studies are unnecessary (2). This is disputable, but there has been a substantial increase in the number of medical imaging procedures using ionizing radiation over the past 30 years (2). It is estimated that the number of CT scans performed each year in the United States has increased from 3 million in 1980 to upwards of 60–70 million today (2,10). In 1980, medical imaging constituted approximately 15% of a person's annual exposure to ionizing radiation, whereas now it accounts for at least 50% (11). A recent study of five large US health care markets between 2005 and 2007 suggests that 42.5% of all patients younger than age 18 underwent medical imaging involving ionizing radiation, with 7.9% of the children undergoing at least one CT scan (12). Efforts to raise awareness and decrease unnecessary exposure, such as the *Image Gently* (13) and *Image Wisely* (14) campaigns as well as new clinical decision support tools (11,15,16) may reduce unnecessary imaging, but there are other opportunities to help health professionals better understand the benefits and risks associated with radiologic imaging.

Prior studies have documented a disappointing level of understanding of radiobiology and radiation protection on the part of both radiologists and other physicians (17–20). The latter group's level of understanding is especially important because they order the vast majority of radiologic

Acad Radiol 2012; 19:491–497

From the Indiana University School of Medicine, Department of Radiology and Imaging Sciences, 550 University Boulevard, Room 0663, Indianapolis, IN 46202-5253 (N.A.K., R.B.G.). Received September 7, 2011; accepted December 22, 2011. **Address correspondence to:** N.A.K. e-mail: nakoontz@iupui.edu

doi:10.1016/j.acra.2011.12.013

TABLE 1. Demographic Characteristics of Surveyed Fourth-year Medical Students

	n	Age, Mean Years (SD)	Basic Science Undergrad Major	Nonbasic Science Undergrad Major	Intended Radiology or Radiation Oncology Residency	Other Intended Residency	Prior Graduate School
Men	130	26.3 (2.1)	102	28	13	117	20
Women	106	26.3 (1.9)	80	26	3	103	13
Unspecified	2	31.5 (9.2)	2	0	0	2	0
All	238	26.3 (2.1)	184	54	16	222	33

examinations. A medical school radiology clerkship represents an especially good opportunity to reach these future physicians, who will soon complete their training and serve as radiology's referral base for decades to come.

All fourth-year medical students at our institution enroll in a month-long radiology clerkship. In this study, we designed and implemented a radiobiology and radiation safety module that aimed to enhance student understanding of the physics and biology underlying radiologic imaging and methods to limit exposure to ionizing radiation. This material had not been included in our medical school's curriculum in the past. In addition, we administered a survey of student perceptions regarding this material in medical education and practice.

MATERIALS AND METHODS

For the 2010–2011 academic year, we introduced a radiobiology and radiation safety module into our required radiology clerkship. General topics included the physics and chemistry of radiobiology, radiation units, sources of ionizing radiation, and techniques for limiting radiation exposure. Specific topics are detailed in Appendix 1. Sources included radiologic physics textbooks, diagnostic radiology textbooks, and recent medical literature. The lectures were delivered in an image-rich, interactive format over 2 lecture hours. Students received a syllabus for study, and the lecture slides were made available on the secure clerkship website. In consultation with the clerkship director, the lectures were prepared and delivered by a second-year diagnostic radiology resident (PGY-3). All fourth-year medical students at our institution ($n = 296$) participated in the lecture series.

Learning Assessment

Pretests and posttests were used to assess the change in student understanding of radiobiology and radiation safety (Appendix 2). Both tests consisted of 10 multiple-choice questions regarding material presented in the module, asking students to select the single best response. The pretests were administered before the module. Posttests were administered before the clerkship final exam at the end of the month. The mean interval between pr-test and posttest was 19 days (range, 2–39 days; standard deviation, 10 days). Participation in the study was strictly voluntary and anonymous, and 231 of 296 students elected to participate (78%).

Survey Instrument

We also examined student perceptions regarding the importance of radiobiology and radiation safety as a component of their medical education, using a Likert-scale format survey (Appendix 3). The survey was administered before the radiation safety module, and participation was strictly voluntary and anonymous. Again, a relatively high proportion of students elected to participate, 238 of 296 (80%; Table 1).

Statistical Analysis

Statistical analysis was performed using GraphPad (GraphPad Software, Inc., La Jolla, CA). Monthly and aggregate average pre- and posttest scores were compared with an unpaired two-tailed *t*-test, and a P value less than .05 was considered statistically significant.

RESULTS

Pre- and Posttest

Monthly pretest mean scores ranged from 47.8% to 55.6%, with an average monthly pretest score of 50.3% (Table 2). Monthly posttest mean scores ranged from 77.3% to 91.2%, with an average monthly posttest score of 83.9%. Total mean score standard deviation of pretests and posttests were similar (0.127 versus 0.140). This represented a highly statistically significant improvement in monthly and total mean exam scores following the educational module, with all calculated P values less than 0.01 (Fig 1).

Survey

Students largely agreed on the importance of weighing radiation exposure when ordering an imaging study on a patient, with 32.8% ($n = 78$) responding "very important," 53.8% ($n = 128$) responding "somewhat important," 7.1 % ($n = 17$) responding "neutral," 5.5% ($n = 13$) responding "somewhat unimportant," and 0.8% ($n = 2$) responding "very unimportant" (Fig 2). When asked how often they personally consider radiation exposure when ordering or proposing an imaging study, 19.7% ($n = 47$) responded "always," 63.4% ($n = 151$) responded "sometimes," 12.6% ($n = 30$) responded "never," and 4.2% ($n = 10$) responded "unsure" (Fig 3). Students anticipated that their radiology ordering patterns would