

Radiation Safety Knowledge and Perceptions among Residents:

A Potential Improvement Opportunity for Graduate Medical Education in the United States

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Rationale and Objectives: To investigate residents' knowledge of adverse effects of ionizing radiation, frequency of their education on radiation safety, and their use of radioprotective equipment.

Materials and Methods: Residents from 15/16 residency programs at Emory University were asked to complete a resident radiation safety survey through SurveyMonkey®. The associations between the residents' knowledge and use of radioprotective equipment with residents' specialty and year of training were investigated.

Results: Response rate was 32.5% (173/532 residents). Thirty-nine percent residents reported radiation safety is discussed in their residency curriculum at least every 6 months. Ninety-five percent believed in a link between radiation exposure and development of cancer. Overall and Radiology residents' knowledge about specific estimated dose effects (correct responses) was limited: radiation dose associated with fetus brain malformation in pregnancy (10% vs. 26%), risk of developing cataract in interventional personnel (27% vs. 47%), lifetime risk of cancer mortality from a single abdominal computed tomography (CT) in children (22% vs. 29%), greater radiosensitivity of children compared to adults (35% vs. 50%), and relative radiation dose from an abdominal CT compared to a chest x-ray (51% vs. 48%). Radiology residents had modestly higher knowledge. There was no significant difference in residents' knowledge across their postgraduate training years. Use of lead thyroid shields was reported by 86% (97% radiology vs. 80% nonradiology; $P = .03$) and radiation-monitoring badges in 39% (68% radiology vs. 15% nonradiology; $P < .001$) of the residents.

Conclusions: Although radiology residents scored higher, knowledge of radiation safety for patients and healthcare workers is limited among residents regardless of medical specialty. These findings emphasize the need for educational initiatives.

Key Words: Knowledge; medical education; radiation safety; resident; radioprotective equipment.

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The National Council for Radiation Protection and Measurement (NCRP) (1) performs periodic surveys of radiation exposure from all sources to the American population. Their most recent survey reported that there is a rapid increase in average exposure to the American population from medical imaging, particularly computed tomography (CT) and cardiac nuclear medicine testing, from 15% in the early 1980s to 48% in 2006 (2). Effective dose is a risk estimate for a patient population from radiation exposure and is expressed in Sieverts (Sv) (3,4). The risk that a radiation dose will induce a cancer in a specific organ changes with age, gender, and individual patients' variations of intrinsic radiation sensitivity. The population baseline lifetime cancer risk is 25%. For every 100 mSv of radiation dose to an

average population, lifetime cancer mortality risk increases from 25% to 25.5% (5,6). The relationship between radiation dose and cancer risk is highly controversial; however, the scientific community generally assumes that there is no safe threshold at low dose (the linear no-threshold model) (7). There is growing public concern that low-dose (<100 mSv) ionizing radiation from diagnostic imaging may be associated with increased cancer risk (8–11) depending on radiation dose and duration of exposure. Extrapolating from data of the Life Span Study of Japanese atomic bomb survivors, Brenner and Hall (4) estimated that up to 2% of future cancers may be attributable to CT scanning.

The potential for cancer induction associated with medical radiation is even more important in children and pregnant women. The younger a patient, the more radiosensitive they are for certain tumors (12). They also have a greater post-radiation exposure life expectancy compared to adults in which to manifest radiation-induced tumors (13,14).

Over the past several years, surveys have documented a lack of knowledge and awareness of radiation doses and safety—underestimating both dose and potential effects—among referring physicians regardless of field of expertise (15–21).

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The purpose of the current study was to determine: (1) the frequency of discussion about radiation safety in residency curricula; (2) the level of awareness of residents on radiation doses of imaging tests and radiation safety principles; and (3) perceived level of importance and the self-reported behavior regarding wearing radiation-monitoring badges and thyroid lead shields in a sample of medical and surgical residents at Emory University.

METHODS

Study Population

The Resident Radiation Safety Survey (RRSS) included detailed information about resident level of knowledge and perception regarding potential adverse effects associated with ionizing radiation exposure from diagnostic imaging procedures and safety strategies. Institutional review board approval was waived for this study.

Program directors of 16 residency programs at Emory University were contacted in September 2012 and asked to e-mail the RRSS link to the participating residents in their program. All residency programs except for pediatrics (citing too many e-mailed surveys as the reason) agreed to participate in this survey. Participants of the survey were Emory University residents in Emergency medicine, family medicine, internal medicine, transitional year, obstetric/gynecology (OB/GYN), general surgery, neurosurgery, orthopedics surgery, vascular surgery, thoracic surgery, plastic surgery, urology, radiology, radiation oncology, and nuclear medicine residency programs. These residency programs were selected, as their residents either constitute the majority of referring/ordering physicians or have occupational exposure to ionizing radiation.

Survey

The RRSS consisted of four sections: (1) participants' gender, specialty, and postgraduate year (PGY); (2) frequency of discussion about radiation safety in general, and specific to pediatric and pregnant patients in their residency curriculum, the resources they use to increase their knowledge about radiation safety; (3) participants' knowledge about potential adverse effects from exposure to ionizing radiation including cancer, skin burns, and cataract formation, knowledge about radiation dose from an abdominal CT scan and its resulting estimated risk of lifetime fatal cancer induction in children (stochastic effect), the relative radiosensitivity of children compared to adults, and finally the radiation dose associated with fetal brain malformation during pregnancy (deterministic effect); and (4) their perception of importance in wearing radiation-monitoring badges and lead thyroid shields when working in ionizing radiation exposed areas as well as the self-reported frequency of wearing them.

The survey was made available through SurveyMonkey® (www.surveymonkey.com), an online survey software and questionnaire tool. An invitation to access and complete the

questionnaire was e-mailed with an embedded link to Emory University residents on three occasions, over three consecutive weeks. The online survey remained accessible for a total of a 3-week period (September 2012). A pilot study of the survey questions was performed among 10 residents before e-mailing the invitation to assess for any confusion about the questions and solicit comments for improvement. No change was made.

Data Analyses

Survey responses were downloaded from SurveyMonkey and were analyzed using STATA 10 (Stata Corp., College Station, TX). Study outcomes were frequency of discussion of radiation safety in residency curriculums, residents' knowledge about radiation doses and radiation safety, residents' perception of importance of using radiation-monitoring badges and lead thyroid shields, and the frequency of their use.

Frequency of discussion of radiation safety in residency curriculum was collapsed into a dichotomous variable where survey responses "at least once a month" and "at least once every 6 months" were categorized as "at least every 6 months" and survey response "at least once a year", "less than once a year", and "never" were categorized as "less than every 6 months". The response choices for questions assessing residents' knowledge about radiation doses and its adverse effects were purposely widely categorized to allow the respondent to estimate the answer without necessarily knowing the correct response. Therefore, the responses were initially collapsed as dichotomous variables (correct answer vs. incorrect answer) for analyses. We further evaluated the rate of overestimation or underestimation of the radiation adverse effects for each individual question. Finally, wearing radiation safety equipment was categorized to "frequent" when survey responses were "everyday" and "most of the time" versus "infrequent" when survey responses were "sometime" and "rarely". Categorical variables were reported as frequency and percentage, and quantitative variables were reported as mean and standard deviation (SD).

Participants' specialty was further categorized into four groups: (1) medicine which included family medicine, internal medicine, emergency medicine, and transitional year; (2) surgery which included general surgery, neurosurgery, plastic surgery, vascular surgery, thoracic surgery, orthopedics surgery, and urology; (3) obstetrics and gynecology; and (4) radiology, which included diagnostic radiology, radiation oncology, and nuclear medicine. Responses were compared among specialty, PGY, and gender.

Chi-squared tests for categorical variables determined significant differences between groups and were used to assess the association between frequency of discussion about ionizing radiation and residents' specialty, residents' perception and knowledge about radiation safety and their specialty, PGY training, or gender. Resident's perception of the importance of wearing radiation safety equipment was compared

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