Assessment of Radiation Safety Knowledge Among Urology Residents in the United States

Andrew M. Harris, MD, John Loomis, MD, Marilyn Hopkins, MD, and Jason Bylund, MD, MPH

Abstract

Introduction: Urologists are increasingly exposed to fluoroscopy, which can cause cellular damage. Appropriate awareness and safety precautions concerning fluoroscopy are necessary and likely should be a focus during training. We sought to assess radiation safety knowledge among Urology residents in the United States.

Methods: A 19-question survey was constructed to assess radiation safety training, knowledge, behavior, and attitudes. The survey was sent through REDCap™ (Research Electronic Data Capture) to all Urology program directors and coordinators in the United States with a request to distribute to their residents. The survey was closed after 3 weeks.

Results: One hundred thirty-six urology trainees responded during the study period. Thirteen percent learned fluoroscopic radiation safety formally, 46% informally, 35% both informally and formally, and 6% no education. Forty-six percent reported radiation safety being part of their curriculum. When asked about directional X-ray travel and exposure, only 54% answered correctly. Regarding conditions related to radiation exposure, 94% believe infertility is potentially related, 83% cataracts, 93% leukemia and lymphoma, 57% central nervous system tumors, 77% birth defects, and 4% diabetes. Regarding protection, 9% wear lead-lined glasses, 30% dosimeters, 99% thyroid shields, 0% lead gloves, 97% lead apron, 26% lead shield, and 0% nothing. Regarding fluoroscopy machine settings, 7% knew the machine used was set to continuous, 73% pulse, and 21% were unsure. Sixty-six percent had awareness of the directional travel of the machine routinely used. Regarding safety techniques, 99% knew decreasing time and 100% knew wearing protective materials decrease exposure. However, when asked about distance and exposure, 55% answered incorrectly. Most respondents believe radiation safety is important (89%) and desire more formal education (64%).

Conclusions: Trainees lack sufficient knowledge in several key areas regarding radiation safety. Formal education may be considered during training and is desired by trainees. This education is likely needed to ensure trainees learn methods to keep them safe during their career.

Keywords: radiation safety, fluoroscopy, resident education

Introduction

AS SURGICAL TECHNOLOGY continues to progress, urologists are performing more endourologic procedures.¹ Furthermore, disease states requiring endourologic procedures, such as nephrolithiasis, are increasing in prevalence in the United States.^{2–4} Such procedures generally require specific imaging guidance and techniques to be performed safely and effectively.^{1,5}

Currently, fluoroscopic imaging is routinely used when imaging is required for endourologic procedures. This electromagnetic radiation can cause cellular damage as it passes through the tissues of patients and those in the operative suite.^{6,7} The damage is generally proportional to the duration

and site of the exposure as well as the total exposure dose, and may lead to burns, cataracts, and malignancy.^{6,8–10}

The potential for significant morbidity has led to exposure limit recommendations and protection guidelines, such as “As Low As Reasonably Achievable (ALARA).”¹¹ Unfortunately, studies suggest a lack of appropriate knowledge, education, and implementation of radiation safety practices during fluoroscopic procedures among residents, faculty, and operating room (OR) staff.^{6,12–16} However, many of these studies to date either involve nonphysician operative suite personnel, nonurologic trainees, or trainees outside of the United States. We proposed to examine the knowledge, attitudes, training, and precautionary measures related to fluoroscopic radiation safety among Urology residents in the United States.

Methods

The “Assessment of Radiation Safety Knowledge Among Urology Residents” survey was created and conducted by the Division of Endourology of the Department of Urology at the University of Kentucky in 2017. The Institutional Review Board at the University of Kentucky approved the survey. The survey was then sent to Urology program coordinators and program directors through email with a request to distribute the survey to their residents. The survey was open for 3 weeks.

Study data were collected and managed using REDCap™ (Research Electronic Data Capture) electronic data capture tools hosted at The University of Kentucky.¹⁷ REDCap is a secure, web-based application designed to support data capture and storage for research studies, providing: (1) an intuitive interface for validated data entry; (2) audit trails for tracking data manipulation and export procedures; (3) automated export procedures for seamless data downloads to common statistical packages; and (4) procedures for importing data from external sources.¹⁷

The survey was designed to test four domains: knowledge of radiation effects, radiation safety training/education, personal safety practices, and understanding of exposure physics and mitigation (Appendix A1).

Results

Demographics

One hundred thirty-six Urology residents completed the survey. Respondent post-graduate year (PGY) level was as follows: PGY1—14%, PGY2—22%, PGY3—20%, PGY4—18%, PGY5—18%, PGY6—6%, >PGY6—2%.

Education history

Concerning fluoroscopic radiation safety education, 94% of respondents reported at least some radiation safety training. Thirteen percent had received only formal education, 46% reported informal education only, such as education from colleagues or in the work place, and 35% received both.

Of those who received formal education, 10% received education in medical school and 90% in residency. Forty-six percent of respondents believed radiation safety was part of

the Urology residency teaching curriculum, whereas 29% did not and 25% were unsure.

Basic X-ray/machine knowledge

Concerning directional X-ray flow exposure affects, 26% of respondents incorrectly stated that flow originating below the patient exposed the operator to higher doses of radiation, whereas 6% responded there was no difference in exposure based on directional flow, and 15% were unsure. Only 54% of respondents correctly identified that X-rays originating from above the patient exposes the operator to more radiation.

Thirty-four percent were unaware of the direction of electromagnetic radiation flow from his/her currently used machine. Concerning the continuous or pulse setting, 21% were unsure how their machine was set, whereas 7% believed the machine to be set to continuous and 73% pulse. Ninety-nine percent answered correctly regarding the relationship between exposure and time and 100% answered correctly regarding exposure and protective equipment. However, 55% answered incorrectly regarding distance and exposure (Fig. 1).

Precautions/attitudes

Regarding protective equipment, 99% wore thyroid shields, 97% lead aprons, 30% dosimeter badges, 9% lead-lined glasses, 27% lead shields, 0% lead lined gloves, and 0% went without protective equipment (Fig. 2). Regarding importance of radiation safety, 99% believed it to be important, with 54% selecting “extremely important.” Using a 5-point Likert scale regarding the need for more formal radiation safety education during training, with 5 being significantly more, 88.3% chose 3 or higher and 64% chose either 4 or 5 (Fig. 3).

Exposure effects assessment

Regarding potential exposure morbidity, 93% percent of respondents believed leukemia and lymphoma are potentially related and 94% believed infertility is potentially related as well. Eighty-three percent believed cataracts to be potentially related to exposure, and 57% believed central nervous system tumors are possibly related. Seventy-seven percent believed

FIG. 1. Respondent answers, in %, concerning X-ray physics and exposure.

FIG. 2. Respondent answers, in %, concerning protective measures.

birth defects in children conceived after fluoroscopic radiation exposure to be potentially related. Lastly, 4% believed diabetes to be possibly related (Fig. 4). Further subgroup analysis was not performed secondary to sample size and number of variables, such as PGY years.

Discussion

Our survey results reveal several pertinent findings. Nearly half of the respondents reported never receiving formal radiation safety education and less than half of the respondents knew radiation safety was part of the core curriculum for Urology residents. Forty-six percent were unaware of the effect of directional X-ray flow on exposure and 55% answered incorrectly regarding exposure by distance. Also, 1/3 of respondents were unaware of directional flow regarding the machine they routinely use. Interestingly, the majority believe radiation safety to be important and would like more formal education. Regarding exposure effects, the respondents answered poorly regarding fertility, birth defects, and central nervous system tumors.

Exposure based on directional flow has been well studied. Over couch, where X-rays flow from above to below the patient, systems have been found to expose the user to 5 to 10 times greater radiation when compared with under-couch systems.^{18,19} Unfortunately, over-couch systems are still

prevalent today.¹⁸ However, the International Commission on Radiological Protections (ICRP) recommends using under-couch systems for this reason.²⁰ Given this, it is concerning that nearly half the respondents were unaware of this potentially dangerous directional relationship and 1/3 were unaware of directional travel regarding the machine routinely used.

Using the pulse setting, as opposed to continuous, can decrease exposure dose by 64% and exposure time by 76%.²¹ However, 30% of the respondents were unaware if the machine routinely used was set to continuous or pulse. This is somewhat better than recently studied house staff from all specialties exposed to fluoroscopic radiation, where half the respondents were unaware of their machine's setting.¹⁶ Decreasing exposure by limiting fluoroscopic time, using protective equipment, and increasing distance from the source are also part of the ALARA principle.²⁰ Respondents answered correctly regarding exposure time and the majority took appropriate precautions. However, when queried regarding exposure by distance, over half answered incorrectly. Clearly, there seems to be opportunities to enhance education regarding exposure mitigation among Urology house staff, which could help decrease exposure to residents and personnel in their current and future operative suites.

Radiation exposure can lead to significant morbidity and mortality and can occur by two mechanisms. First, cellular damage can occur over time by cumulative dose, or stochastic

FIG. 3. Respondent answers, in %, concerning attitudes toward radiation safety.

FIG. 4. Respondent answers, in %, concerning exposure effects from fluoroscopic radiation. CNS = central nervous system.

effects, which may eventually lead to “leukemia, lymphoma, thyroid cancer, lung cancer, bladder cancer, liver cancer, esophageal cancer, breast cancer, skin cancer, cataracts, and tumors of the central nervous system.”^{10,16,22–25} Second, radiation can cause cell death from high doses in a single setting, known as deterministic effects.^{12,22} Based on available data, Urology residents had appropriate knowledge of well-known potential harms of radiation exposure. However, nearly all respondents believed infertility to be potentially related to exposure and highlights a common misconception regarding radiation treatment vs exposure. Furthermore, although data regarding birth defects in children conceived after fluoroscopic exposure is deficient, nearly 80% of respondents answered this incorrectly; risk of radiation exposure to the fetus once present, on the other hand, is established.²⁶ Recently studied house staff from all specialties exposed to fluoroscopic radiation reveal similar results.¹⁶

Urology residents in other countries have been studied, with similar results. In Europe, Urology residents were found to have low knowledge regarding exposure effects, with half being unaware of a malignancy risk, slightly over 50% knowing the meaning of ALARA, and only 28% always wearing dosimeters.¹⁴ A study regarding Urology residents in India found no residents used dosimeters, 85% had not received any formal education, 83% felt they had inadequate knowledge regarding radiation safety, and only 60% always took steps to protect against radiation exposure.²⁷ In Turkey, nearly 75% of residents did not wear dosimeters and the majority did not wear protective glasses or gloves.¹³ Studied house staff at Emory were also found to take appropriate precautionary measures, but had little radiation safety knowledge.¹⁵ Recently studied house staff from all specialties exposed to fluoroscopic radiation from a single institution found poor radiation safety knowledge, only 23% wore dosimeters, and only 36% had formal education.¹⁶ Furthermore, studies regarding operative suite personnel show similar results, as dosimeters were infrequently used and less than half had received formal education.¹²

Radiation safety education programs in some settings have resulted in increased use of precautionary measures and better fund of knowledge for house staff.¹⁴ Also, those residents undergoing training reported they do better job of personal radiation protection than those not trained.⁵ Educational and awareness programs involving surgeons have

been shown to decrease both fluoroscopic usage and exposure doses.^{7,28} Currently, the ICRP recommends radiation safety training for those operating the radiation equipment.²⁹ The “operator” may vary across and within institutions and urology residents may run the fluoroscopy equipment. However, studies involving other specialties in the United States, including those who may operate the equipment, show radiation safety education comes from faculty members, other trainees, or textbooks.¹⁵ Congruent with these studies, the majority of our respondents had not received formal education, which perhaps explains their knowledge deficits.^{12,14,27} However, the majority of respondents expressed a feeling of importance for radiation education and a desire for more formal radiation safety education.

While several studies exist regarding radiation effects, attitudes, and the efficacy of educational programs, we believe this to be the first study involving a nationwide sample of Urology residents in the United States. Based on our results, it seems that Urology residents have clear knowledge deficiencies regarding basic radiation knowledge, machine settings, and possible exposure morbidity. Addressing these deficiencies represents an opportunity that may lead to decreased exposure and subsequent morbidity for residents and OR staff. Encouragingly, Urology residents generally take appropriate precautions, although only a minority wear dosimeters, making dose monitoring impossible. These findings are similar to those in other specialties and further highlight the need for more formal radiation safety education.

This study does have limitations. The study is a survey and therefore subject to those who respond and may include an element of selection bias. The actual response rate is impossible to calculate as we are unaware of how many programs actually distributed the survey to their residents. This study also only involves Urology residents and may not be applicable to other specialties. The results also depend on appropriate question comprehension, reception, and interpretation.

Conclusions

Appropriate fluoroscopic radiation safety knowledge will continue to be and become more important for the foreseeable future, to not only the user, but also the patient. Most residents desire more formal education, which could result in

further use of dose reduction techniques and decrease the risk of dose-induced complications. Appropriate formal education may be needed to satisfy this potential deficit and protect residents in their future practices.

Author Disclosure Statement

No competing financial interests exist.

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Address correspondence to:

Andrew M. Harris, MD
University of Kentucky Medical Center
800 Rose Street, MS 237
Lexington, KY 40536-0298

E-mail: andrew.harrismd@uky.edu

Abbreviations Used

ALARA = As Low As Reasonably Achievable
OR = operating room
PGY = post-graduate year
REDCap™ = Research Electronic Data Capture

Appendix A1

**Assessment of Radiation Safety Knowledge
Among House Staff**

Most of what I have learned about fluoroscopic radiation safety is from:

- a. Formal education (lectures, presentations, required reading)
- b. Informal Education (colleagues, in the work setting)
- c. Both, informal and formal
- d. Neither

If you have had formal training in fluoroscopic radiation safety, where did this take place:

- a. Medical School
- b. Residency
- c. Fellowship
- d. None

To your knowledge, is fluoroscopic radiation safety part of your specialty's teaching curriculum?

- a. Yes
- b. No
- c. I do not know

Which of the following exposes the operator to more radiation?

- a. X-ray traveling from below to above the patient
- b. X-ray traveling from above to below the patient
- c. There is no difference in exposure to the operator based on X-ray direction
- d. Do not Know

Leukemia and lymphoma are believed to be potentially related to radiation exposure.

- a. True
- b. False

Infertility is believed to be potentially related to radiation exposure.

- a. True
- b. False

Cataracts are believed to be potentially related to radiation exposure.

- a. True
- b. False

Central Nervous System Tumors are believed to be potentially related to radiation exposure.

- a. True
- b. False

Birth defects in children conceived after fluoroscopic exposure are believed to be potentially related to radiation exposure.

- a. True
- b. False

Diabetes is believed to be potentially related to radiation exposure.

- a. True
- b. False

Which of the following do you routinely wear during cases involving fluoroscopy (choose all that apply)?

- a. Lead lined Glasses
- b. Dosimeter Badge
- c. Thyroid Shield
- d. Lead gloves
- e. Lead apron
- f. Lead Shield
- g. None

Are you aware of which direction the fluoroscopic radiation travels from the machine you commonly use?

- a. Continuous
- b. Pulse
- c. Unsure

Decreasing fluoroscopic time is a way to decrease fluoroscopic exposure.

- a. True
- b. False

Wearing protective materials such as a thyroid shield and lead apron is a way to decrease fluoroscopic exposure.

- a. True
- b. False

Decreasing distance to the fluoroscopic source is a way to decrease fluoroscopic exposure.

- a. True
- b. False

How important do you believe radiation safety is for you and other physicians in your specialty (1 being not important and 5 being extremely important)?

- a. 1
- b. 2
- c. 3
- d. 4
- e. 5

To what degree would you like more formal radiation safety education during your training (1 being none and 5 being significantly more)?

- a. 1
- b. 2
- c. 3
- d. 4
- e. 5

What is your Level of Training?

- a. PGY1
- b. PGY2
- c. PGY3
- d. PGY4
- e. PGY5
- f. PGY6
- g. >PGY6