The Journal of Emergency Medicine, Vol. 63, No. 5, pp. 645–650, 2022

0736-4679/$ - see front matter

https://doi.org/10.1016/j.jemermed.2022.08.002

Selected Topics: Emergency Radiology

Risk of Radiation Exposure to Emergency Department Personnel From Portable Radiographs

Blake Briggs, MD, Sarathi Kalra, MD, MPH, and Edward Panacek, MD, MPH

Department of Emergency Medicine, University of South Alabama, Mobile, Alabama
Reprint Address: Blake Briggs, Department of Emergency Medicine, University of South Alabama, 2451 USA Medical Center Drive, Mobile, AL 36617

□ **Abstract—Background: There are concerns that emergency health care workers are exposed to ionizing radiation as the result of frequent portable radiographs obtained in the emergency department (ED) during active patient care. Objective: Our aim was to investigate whether ED staff are exposed to significant radiation due to scatter from portable radiography at a busy trauma center and whether exposure was related to factors such as location or distance. Methods: This was a prospective cohort study performed during 3 consecutive months in the ED at a large, academic trauma center. Volunteer attendings, nurses, and resident physicians were asked to wear dosimeter badges during their shifts throughout the study period. Twelve stationary dosimeters were placed in selected locations in the ED, particularly in the resuscitation rooms, where most of the portable radiographs were obtained. Results: During the 3-month study period, 1464 portable radiographs were obtained in the resuscitation rooms in the ED, mostly chest and pelvic radiographs. Analysis from stationary dosimeters placed in the ED showed a median of 0.18 mSv (95% CI 0.16–0.22 mSv) for the main resuscitation room and 0 mSv for other critical care patient rooms. Analysis of dosimeters worn by staff showed no measurable radiation exposure (0.00 mSv). Conclusions: The level of radiation exposure to ED staff found in this study was well below the recommended allowable occupational exposure of 50 mSv/y. Radiation exposure is not a significant occupational hazard in a busy ED level I trauma center. Existing precautions should adequately protect staff from occupational exposure, and use of further protective gear, or the need for individual monitoring using dosimeters, appears unwarranted. © 2022 Elsevier Inc. All rights reserved.**

□ **Keywords—radiation; occupational health; occupational hazards; emergency radiology**

Presented at the Fourth Mediterranean Emergency Medicine Congress Annual Meeting, October 1, 2007.

Introduction

Medical imaging represents the greatest contribution to annual per-capita effective radiation dose in the United States (1,2). High doses of ionizing radiation have been proven to have detrimental results in humans, most notably cancer. Radiography use continues to increase in the health care setting, likely secondary to wider available equipment and increased physician and patient demand (3).

Radiation doses are measured as an absorbed dose in each material (gray [Gy]), or a dose equivalence in a biologic substance (sievert [Sv]) (4). One Gy essentially equals 1 Sv. The LD_{50} is the dose at which one-half of people die at 60 days after radiation exposure. For adults, this is 6–7 Sv. The maximum permissible occupational exposure for whole body radiation as set by the U.S. Nuclear Regulatory Commission is 5000 millirem (mrem) or 50 millisievert (mSv) per year (4,5). This is based on prior

Received: 27 March 2022; Final submission received: 1 July 2022;
Accepted: 4 August 2022

studies that found exposure ≥ 5000 mrem has an annual fatality rate similar to fatality rates for industrial, agricultural, and motor vehicle accidents (6). The mrem, one thousandth of a roentgen equivalent man (rem), is an older unit of radiation dose, and refers to the dose equivalent of radiation. It is an older, less commonly used measure of radiation exposure. Internationally, the SI unit Sv and mSv are the norm, and are being used increasingly in the United States.

Portable radiography plays an important role in the evaluation of critically ill patients in the emergency department (ED). Most patients undergo portable chest, and often other, radiography during trauma resuscitation as part of the standard protocol recommended by the American College of Surgeons Advanced Trauma Life Support course (7). Additional radiographs are often required in many other situations. These patients often cannot leave the resuscitation room to undergo imaging due to constant monitoring and need for health care workers at bedside. The average radiograph is < 10 mSv; a chest radiograph is approximately 0.1 mSv and pelvic radiograph is 1.1 mSv. Extremity x-ray studies have a radiation dose of 0.001 mSv. The time it takes to accumulate a comparable natural background dose of radiation compared with radiation from chest and extremity radiography is 10 days and < 1 day, respectively. By comparison, abdominal and pelvic computed tomography without contrast is 10 mSv (8).

Health care workers may be especially exposed to ionizing radiation, as they often have clinical care responsibilities during portable imaging, such as cervical spine stabilization; moving extremities for ideal imaging; or restraining patients who are uncooperative, altered, or young children.

A 1990 study suggested that the radiation exposure of ED personnel might be significant (9). More recently, studies in other settings have evaluated ionizing radiation levels and found minimal exposure if standard precautions are taken. Like the ED, the intensive care unit (ICU) setting has also been speculated to have an increased association with radiation exposure for staff and patients. Studies from the ICU have found that the exposure level was well below the lower limits recommended by national standards and posed no risk to staff or patients in beds adjacent to those undergoing x-ray studies (10,11). There are limited data on such assessments done in the ED, and studies have shown that there is a lack of consistency in the knowledge of ED staff about the risks of radiation exposure. Prior ED studies have evaluated exposure for only a short period or were not performed at a high-volume trauma center (9). Our aim was to investigate whether ED staff are at risk of significant exposure to radiation due to scatter from portable radiography at a busy trauma center and whether exposure is related to factors such as location or distance.

Methods

This was a prospective cohort study performed in the ED at a busy, academic trauma center, with 59,346 ED visits per year, including 6205 trauma activations. The goal was to collect data during a period with > 1000 portable radiographs performed in the ED. The study was approved by the Institutional Review Board and conducted for 3 consecutive months from February through April.

Emergency medicine (EM) attendings, nurses, and resident physicians (EM and trauma surgery) were solicited to participate in a volunteer study to wear dosimeter badges during their shifts for the 3-month period. National and standard Department of Radiology guidelines were followed to adhere to dosimeter use. The dosimeters were supplied by Global Dosimetry Solutions, Inc, and detect x-rays, beta rays, and gamma rays. These dosimeters can detect a minimum level of 10 mrem, with a useful range of 10 mrem to 500 rads. Twelve stationary dosimeters were placed in selected locations in the ED, especially the resuscitation rooms. These locations (see Figure 1) were selected to be a representative sample of the spectrum of locations in the ED where portable radiographs are frequently obtained.

Standard radiation precautions were used by the staff throughout the study in accordance with the National Council on Radiation Protection (NCRP). This includes the availability of lead aprons in the resuscitation room and on the portable radiography machine. Staff were encouraged to use them liberally and were instructed not to stand in the immediate x-ray path whenever possible. Participating staff wore the dosimeters per NCRP guidelines and carried out their typical daily duties without any interruption. At the end of each month, dosimeters were collected and sent to the manufacturer for analysis.

Results

During the 3-month study period, 1464 portable radiographs were obtained in the resuscitation rooms in the ED, mostly chest and pelvic radiographs. This information was reported by the radiology department from their logs of portable radiographs. Monitoring of dosimeter stationary placement and wearing by participants was performed on approximately 25% of study period shifts by the investigators. It found excellent compliance (> 95%), with three exceptions. During the study period, one resident dosimeter and one stationary dosimeter were lost and not recovered. A third dosimeter was lost but recovered prior to the end of the study, and all others were collected in usable condition.

Dosimetry analysis from the film badges worn by 48 staff members (16 each month) found none registered any

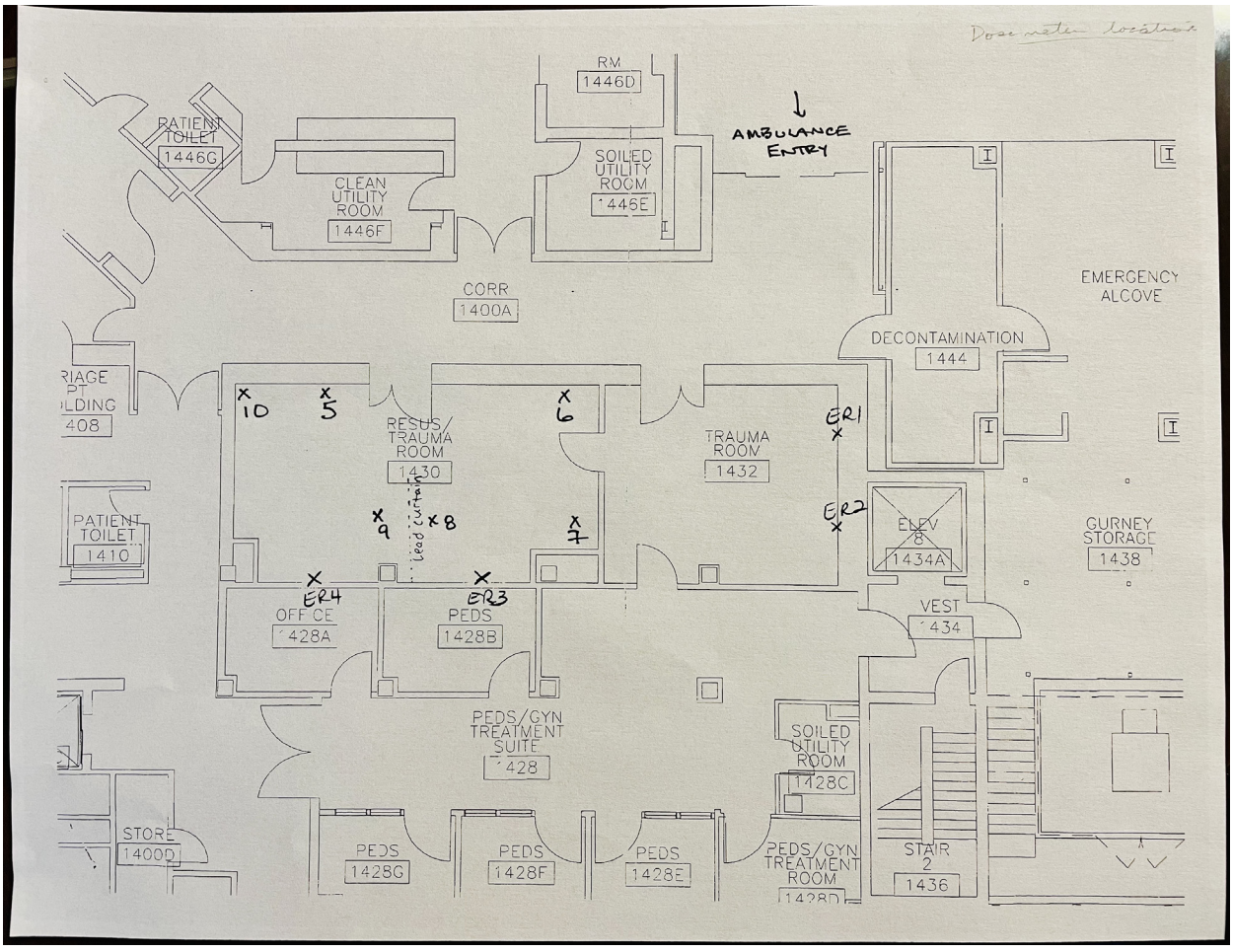

Figure 1. Enhanced view of emergency department with numbers marking location of dosimeters.

detectable radiation each month. This includes all badges worn by nurses, EM attendings, and both surgery and EM residents and was consistently 0 mSv for all the 3-month study period.

Analysis from stationary dosimeters placed in the ED showed a median of 0.18 mSv (95% CI 0.16–0.22 mSv) for the main resuscitation rooms and 0 mSv for the other critical care patient areas (95% CI 0.00–0.06 mSv).

Discussion

This is the first ED study to simultaneously measure radiation exposure with dosimeters on staff and stationary dosimeters placed in the most used areas of the ED. Our data demonstrated that, despite a high number of portable radiographs obtained in critically ill patients in this ED, the resulting ionizing radiation exposure is not a significant occupational hazard in this setting.

In our study, no single individual exceeded background exposure during the 3-month period. This is consistent with older, smaller studies performed previously in EDs (12–15). Extrapolating these data to a hypothetical staff member who would stand for 1 year in an area of the department with the highest level of scatter radiation, they would have an exposure of approximately 2.6 mSv over 365 days. That is orders of magnitude below the U.S. Nuclear Regulatory Commission's allowed limits. It is only slightly more than undergoing pelvic radiography two times. One prior study performed in an ED raised concerns for significant exposure to emergency physicians working in a trauma center. However, it was a small study with only 481 radiographs obtained. In addition, their extrapolations used assumptions of much higher frequencies of exposures (9). Our study had a much larger sample size of 1464 radiographs. Our study also used stationary dosimeters in the busiest areas of the ED, demonstrating measurements well within acceptable levels.

A similar study performed in the trauma and critical care area with 44 stationary dosimeters over a period of 6 months showed a radiation exposure well under 50 mSv, with the highest measurement at only 4.31 mSv (16). A

more recent study from Australia done on mannequins with radiation detectors demonstrated that staff involved with direct patient care at the bedside during imaging had a ninefold reduction in radiation exposure if they used a lead gown with a thyroid collar (17). Another Australian study showed that exposure to ionizing radiation during trauma resuscitations was well below the recommended occupational dose limit when the staff members wore lead aprons (18). In that study, staff were not required to be present immediately at bedside during imaging and stood at least 6 feet away. Staff directly involved with bedside radiography procedures (e.g., fluoroscopy and repeat imaging) wore lead aprons.

Typically, health care providers are not directly at the bedside during imaging. However, those in the room, and even those wearing lead aprons, may be subject to scatter radiation, which is radiation that spreads in multiple directions from a source after a beam encounters a substance (19). Scatter radiation is usually of lower energy than a direct ionizing beam, but more difficult to measure or predict. At present, the long-term effects of low-dose radiation are unknown. Current recommendations emphasize standard precautions in the ED to reduce exposure. These include lead aprons and moving to a safe distance of $>$ 2 m away. Both have been shown to be protective. ED staff taking such precautions would be exposed to negligible radiation amounts, regardless of how often they worked in an ED resuscitation room.

Limitations

There are several potential limitations to this study. First, the study was performed at a single center and did not include radiology technologists and other staff (beyond nurses and physicians), so the results should not be generalized to all settings and all staff. The dosimeter used had a minimum reportable dose of only 10 mrem, therefore, lower doses were not recorded, but levels $<$ 10 mrem are considered insignificant for ionizing radiation exposure (equivalent to 0.1 mSv) (5). Every facility has individual factors, for example, variable use of lead shielding, so it may not be appropriate to generalize our findings to all trauma center EDs.

Conclusions

The level of radiation exposure in ED staff found in this study was well below the recommended allowable occupational exposure of 50 mSv/y. Existing standard precautions should adequately protect staff from occupational exposure, and use of additional protective gear, or the need for individual monitoring using dosimeters appears unwarranted. Current NCRP practices are emphasized for staff working in the ED, where portable radiography remains common.

Acknowledgments

The authors would like to thank Dr. David Shelton, Dr. Mohammad Nazari, and Mrs. Linda Kroger and the University of California Davis Departments of Emergency Medicine and Radiology for their contributions to this work.

References

1. Brenner DJ, Hall EJ. Computed tomography—an increasing source of radiation exposure. N Engl J Med 2007;357:2277–84.
2. Mettler Jr FA, Huda W, Yoshizumi TT, Mahesh M. Effective doses in radiology and diagnostic nuclear medicine: a catalog. Radiology 2008;248:254–63.
3. Smith-Bindman R, Miglioretti DL, Larson EB. Rising use of diagnostic medical imaging in a large integrated health system. Health Aff (Millwood) 2008;27:1491–502.
4. Part 20-Standards for Protection Against Radiation. US Nuclear Regulatory Commission. Updated September 14, 2021. Accessed on March 14, 2022. https://www.nrc.gov/reading-rm/doc-collections/cfr/part020/full-text.html
5. Ionizing radiation. US Department of Labor, Occupational Safety and Health Administration. Accessed on March 13, 2022. https://www.osha.gov/ionizing-radiation/standards
6. Luftig SD, Wienstock L. Establishment of Cleanup Levels for CERCLA Sites with Radioactive Contamination, OSWER Directive No. 9200.4-18. August 22, 1997. Accessed August 17, 2022. https://semspub.epa.gov/work/06/659465.pdf
7. American College of Surgeon, Committee on Trauma. Advanced Trauma Life Support Course Manual. American College of Surgeon; 2018.
8. Lin EC. Radiation risk from medical imaging. Mayo Clin Proc 2010;85:1142–6.
9. Weiss EL, Singer CM, Benedict SH, Baraff LJ. Physician exposure to ionizing radiation during trauma resuscitation: a prospective clinical study. Ann Emerg Med 1990;19:134–8.
10. McEvoy JH, Bihari S, Hooker AM, Dixon DL. Cumulative radiation in critically ill patients: a retrospective audit of ionising radiation exposure in an intensive care unit. Crit Care Resusc 2019;21:212–19.
11. Lynch L, Bowen M, Malone L. Patient exposure to ionising radiation in the intensive care unit due to portable chest radiography. Ir J Med Sci 1994;163:136–7.
12. Ciraulo DL, Marini CP, Lloyd GT, Fisher J. Do surgical residents, emergency medicine physicians, and nurses experience significant radiation exposure during the resuscitation of trauma patients? J Trauma 1994;36:703–5.
13. Grazer RE, Meislin HW, Westerman BR, Criss EA. A nine-year evaluation of emergency department personnel exposure to ionizing radiation. Ann Emerg Med 1987;16:340–2.
14. Grazer RE, Meislin HW, Westerman BR, Criss EA. Exposure to ionizing radiation in the emergency department from commonly performed portable radiographs. Ann Emerg Med 1987;16:417–20.
15. Gottesman BE, Gutman A, Lindsell CJ, Larrabee H. Radiation exposure in emergency physicians working in an urban ED: a prospective cohort study. Am J Emerg Med 2010;28:1037–40.

16. Quick JA, Lewis GL, Coughenour JP, Barnes SL. Provider x-ray exposure in the trauma bay: results of a radiation field analysis. Emerg Radiol 2014;21:11–15.
17. Ittimani M, Goozée G, Manovel A, Holdgate A. Trauma team radiation exposure: the potential need for dosimetry monitoring. Emerg Med Australas 2007;19:494–500.
18. Tan GA, Van Every B. Staff exposure to ionizing radiation in a major trauma centre. ANZ J Surg 2005;75:136–7.
19. Scatter radiation. NCI Dictionary of cancer terms. National Cancer Institute; 2021 Accessed February 18 https://www.cancer.gov/publications/dictionaries/cancer-terms/def/scatter-radiation .

ARTICLE SUMMARY

1. Why is this topic important?

There continues to be ongoing concern that emergency health care workers are exposed to ionizing radiation from portable radiography. These workers are often engaged in active patient care and cannot leave the bedside or room.

2. What does this study attempt to show?

Using personal and stationary dosimeters, we measured radiation exposure in a busy, level I trauma center. We wanted to determine whether emergency department (ED) staff are exposed to significant radiation due to scatter from portable radiography, and whether exposure was related to factors such as location or distance.

3. What are the key findings?

The level of radiation exposure to ED staff found in this study was well below the recommended allowable occupational exposure of 50 mSv/y. Levels of radiation measured on stationary dosimeters in the busiest areas, when extrapolated for 1 year, would still be well within acceptable levels. Radiation exposure is not a significant occupational hazard in a busy, level I trauma center.

4. How is patient care impacted?

Current and standard precautions should adequately protect staff from occupational exposure. The use of protective gear or the need for individual monitoring using dosimeters appears unwarranted. Current National Council on Radiation Protection practices are emphasized for staff working in the ED, where portable radiography remains common.