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Research Article

The urgent need for protective shielding for personnel who administer radiopharmaceuticals

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ARTICLE INFO

Article history:

Received: 23 May, 2019

Accepted: 14 June, 2019

Published: 26 June, 2019

Keywords:

Computed tomography (CT)

estimation

mathematical modeling

nuclear medicine

occupational safety

positron emission tomography (PET)

radiation exposure

ABSTRACT

Traditional practices to administer radiopharmaceuticals to patients for positron emission tomography involve exposure to ionizing radiation. Techniques developed to reduce radiation exposure to personnel who inject radiopharmaceuticals may be considered unnecessary by experienced nuclear medicine personnel. A 69-year-old male nuclear medicine attending developed bilateral cataracts after 18 years of regular administration of radiopharmaceuticals. Although protective shielding was not used for the first 14 years of his practice, it was uniformly applied for the subsequent 4 years. Nuclear medicine personnel are advised to use protective shielding and to design work improvement procedures to minimize radiation exposure for staff and patients.

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Introduction

Decades ago, when positron emission tomography (PET) was developed, physicians who administered the radiotracers used syringes without shielding to inject the radiotracer into the participant. Although protective techniques have since been developed to utilize shielding, lead aprons [1-3], and other procedures to design work improvement to reduce radiation exposure to staff and patients, some experienced nuclear physicians continue the practice of injecting radiotracers without shielding because they believe that there is no significant difference in radiation exposure with or without shielding [4]. Nevertheless, the consensus is that physical shielding is necessary at all times to protect the injector, the participant, and co-workers from unnecessary radiation exposure.

Materials and Methods

A 69-year-old male nuclear physician who had been injecting humans and animals with multiple [^{11}C], [^{18}F], [^{123}I], and [^{15}O] radiotracers for

18 years became concerned about his radiation exposure when he developed bilateral cataracts. Radiation exposure had been continuously monitored by a badge worn on the top pocket of his laboratory coat and a ring worn on the index finger of his dominant right hand. For the first 14 years he followed the traditional approach to carry radiotracers in a syringe in a thick lead pig. When ready to inject the radiotracer into the participant, the syringe was removed from the pig without shielding to be positioned in the stopcock for injection. Sometimes when a large volume of up to 11 mL was administered, the injection lasted more than a minute. During that period the injector, the participant, and the co-workers received exposure to the radiotracer from the unshielded syringe. Although some experienced nuclear physicians disagree with the need for protective shielding from the syringe containing the radiotracer, recently trained nuclear physicians instituted the use of protective shields carried in a box to the participant. The shielded syringe was then connected to the stopcock by the injector for the radiotracer administration. The radiotracer was then administered through a syringe contained in a hand-held lead shield [5]. Thus, the nuclear physician began to carry syringes with protective shielding for each radiotracer

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injection after 14 years of injections without protective shielding. After 18 years of radiotracer injections, the use of protective shielding was

questioned. Therefore, the nuclear physician compared and contrasted his radiation exposure with colleagues as tabulated in Table 1.

Table 1

Dose equivalents in millirems for lifetime exposures of nuclear physicians					
	Collar DDE	Collar LDE	Collar SDE	Ring Finger SDE	Duration of exposure in years
Study nuclear physician	2625	2767	3252	54478	18
Nuclear medicine attendings					
Number	6	6	6	3*	6
Mean	371	382	433	4254	12
Standard deviation	411	426	482	5147	9
Nuclear medicine fellows					
Number	3	3	3	3	3
Mean	202	218	241	2850	7
Standard deviation	81	73	60	2663	0

DDE = deep-dose equivalent, the dose equivalent at a tissue depth of 1 cm (1000 mg/cm²) due to external whole-body exposure to ionizing radiation. The annual occupational limit is 5,000 millirems per year.

LDE = lens dose equivalent (LDE) = the lens dose equivalent at a tissue depth of 0.3 cm (300 mg/cm²) due to external whole-body exposure to ionizing radiation. The annual LDE occupational limit is 15,000 millirems per year.

SDE = shallow dose equivalent, the dose equivalent at a tissue depth of 0.007 cm (7mg/cm²) due to external whole-body exposure to ionizing radiation. The annual SDE occupational limit is 50,000 millirems per year.

Ring finger SDE = extremity (hand, elbow, arm below the elbow, foot, knee, or leg below the knee) shallow dose dose equivalent. The annual extremity occupational limit is 50,000 millirems per year.

*Some nuclear medicine attendings did not monitor ring finger radiation exposure

Results

Table 1 presents a summary of the radiation exposures of the study nuclear medicine attending, other nuclear medicine attendings and nuclear medicine fellows.

Discussion

For radiation workers the whole body limit for the annual total effective dose equivalent (TEDE) is 5,000 mrem (5 rem) with variations for the part of the body affected by the radiation [6], although the limits vary depending on the affected parts of the body. The measurement of radiation exposure by nuclear physicians and other radiation workers is a crucial occupational safety task. By wearing a badge and a ring every time there is radiation exposure, the person's radiation exposure is carefully monitored. Monthly measurement is a common practice for nuclear physicians and other workers. Radiochemists, nuclear medicine technologists, interventional radiologists, and others with high exposure merit weekly measurement of radiation exposure. If the person's exposure for a given period suggests that the individual may exceed the annual limit of 5 rems per year, then the person must reduce radiation exposure.

Approaches have been developed to estimate exposure to ionizing radiation from PET and PET-CT installations [7-10]. However, applying the mathematical procedures to specific situations may be controversial. The utilization of badges and rings to record radiation exposure is a means to generate quantitative measurements of the radiation exposure

of individual radiation workers. By regularly measuring the individual exposure of radiation workers, radiation safety staff may identify those workers whose exposure may exceed the limits. Thus, reduction of radiation exposure can be initiated to ensure the safety of the workers.

Conclusions

The utilization of protective shielding and other procedures to minimize radiation exposure to personnel and patients for positron emission tomography is prudent for occupational safety and compliance with national limits.

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