Are Radiation Exposure Levels Used in Cardiology Dangerous?

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Abstract

Background: The number of interventional cardiology procedures performed has increased rapidly over the past years. While these procedures help physicians avoid using highly complicated invasive methods, it usually leads to high levels of exposure to ionizing radiation of both patients and cardiologist. The dose received by the cardiologist during interventional cardiology procedures is determined by a wide range of factors such as clinical problems to be treated, the interventional technique to be used, the x-ray system employed, experience of the cardiologist, the protective measures taken as well as their use during the examination.

Objective: To measure the dose received by 22 cardiologists, radiology residents, radiologic technologists and nurses during interventional cardiology examinations performed in various teaching hospitals affiliated to Shiraz University of Medical Sciences.

Methods: The radiation dose was basically measured by thermoluminescence dosimeters (TLD). Other personal dosimetry devices such as film badges and pen dosimeters were also used. According to IAEA guidelines, the dosimeter should be worn under the lead apron (at waist level) for estimating the effective dose but due to high workload in interventional radiology and since the areas of the body which are not protected by the apron receive much higher radiation doses, in this study an additional dosimeter was used over the apron (at collar level).

Results: The mean±SD monthly dose recorded by dosimeters of cardiologists over the apron at collar level was 912.1±224.4 (range: 660.8–1176.4) μGy; hands received doses up to 9674.4 μGy $month^{-1}$ as recorded by TLD chips.

Conclusion: The annual effective dose received by interventional cardiologists who use standard lead aprons hardly reaches the occupational exposure dose limit of 20 mSv/y.

Keywords

Interventional cardiology; Radiation; Dose; Cardiologists; Radiation protection

Introduction

Over the past years, the number of interventional cardiology (IC) procedures performed has increased rapidly [1-3]. It is widely reported that interventional cardiology is associated with high exposure to radiation [4-7]. Over the past years, the workload and complexity of procedures in interventional cardiology have led to great public concerns regarding the safety of these procedures [8]. While interventional procedures make only 1% of the medical applications of ionizing radiation, the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) has reported that the contribution of

these procedures to collective dose is 10% [9]. On account of these facts, interventional cardiology in comparison with the procedures that need invasive surgeries and relatively long hospitalization, contributes significantly to radiation exposure of the population. As interventional cardiologists receive the highest radiation exposure among health care professionals, effective radiation safety training programs are an essential part of every cardiologist's safety [7]. The radiation dose received by the cardiologists during interventional cardiology procedures is influenced by a wide range of factors such as clinical problems to be treated, the interventional cardiology techniques used, type and performance of x-ray systems employed, operator experience, training level, the protective measures taken as well as their use during the examination. The main objective of this study was to measure the dose received by 22 cardiologists, radiology residents, radiologic technologists and nurses during interventional cardiology examinations performed in various teaching hospitals affiliated to Shiraz University of Medical Sciences, Shiraz, southern Iran.

Materials and Methods

In this study, radiation dose measurements were carried out using thermoluminescent dosemeters (TLD) of LiF:Mg,Ti (TLD100). Other conventional personal dosimetry devices such as film badges and pen dosimeters were also used. According to the guidelines of international regulatory bodies, the dosimeter should be worn under the lead apron (at waist level) for estimating the effective dose; however, due to high workload in interventional radiology and because the areas of the body which are not protected by the apron receive much higher radiation doses, in this study an additional dosimeter was used over the apron (at collar level). For each participant, nine TLD chips were used (3 chips were placed on the right wrists, 3 under the lead apron and 3 over the apron).

We used the NCRP method for calculating the effective dose [10] as follows:

$$E = 0.5H_w + 0.025H_N \quad \text{(NCRP Report No. 122)}$$

where E, H_W, and H_N are effective dose, personal dose equivalent at waist or chest under the apron and personal dose equivalent at neck over the apron, respectively. For TLD dosimetry, TLD-100 chips were annealed at 400 °C for one hour and 100 °C for 20 hours. After exposing the chips to x-ray during the study period, the chips were readout in a Harshaw 4500 TLD reader.

Results

The mean±SD monthly dose recorded by dosimeters of cardiologists over the apron at collar level was 912.1±224.4 (range: 660.8–1176.4) μGy. Using NCRP equation, the effective dose of cardiologists participated in this study ranged from 16.52 to 29.41 μSv month^{-1}. Furthermore, the mean±SD cardiologists hands' monthly dose recorded by dosimeters was 4967.7±3247.7 (range: 904.4–9674.4) μGy. Surprisingly, the radiology residents doses were much higher than that of the cardiologists. The mean±SD monthly dose recorded by dosimeters of radiology residents was 1326.3±1643.4 μGy (ranged from non-detectable, *i.e.*, <30 μGy to 3164.8 μGy). In case of radiologic technologists who were employed in cardiology departments, the mean±SD monthly dose recorded by dosimeters was 294.2±374.8 μGy (ranged from non-detectable, *i.e.*, <30 μGy to 1048 μGy). Finally, the mean±SD monthly dose recorded by dosimeters of nurses who were employed in cardiology departments was only 52.5±98.4 μGy (ranged from non-detectable, *i.e.*, <30 μGy to 200 μGy) (Table 1).

Discussion

Exposure to ionizing radiation leads to stochastic effects (no threshold dose) and deterministic effects (threshold dose). In this study, the mean±SD monthly dose recorded

Table 1: The mean±SD monthly dose recorded by dosimeters of cardiologists, radiology residents, radiologic technologists and nurses over the apron at collar level

Work Groups	Monthly Dose Over the Lead Apron (μGy)		Monthly Dose of Hands (μGy)	
	Mean±SD	Range	Mean±SD	Range
Cardiologists	912.1±224.4	660.8 – 1176.4	4967.7±3247.7	904.4–9674.4
Radiology residents	1326.3±1643.4	ND–3164.8	NA	NA
Radiologic Technologists	294.2±374.8	ND–1048	NA	NA
Nurses	52.5±98.4	ND–200	NA	NA

ND: Non-detectable (<30 μGy)
NA: Non-applicable

by dosimeters of cardiologists over the apron at collar level was 912.1±224.4 (range: 660.8–1176.4) μGy. Furthermore, hands doses up to 9674.4 μGy month^{-1} were recorded by TLD chips. Findings of this study showed that the annual effective dose of interventional cardiologists who use standard lead aprons hardly exceeds the occupational exposure dose limit of 20 mSv/y. The effective dose calculated for an interventional cardiologist who uses one or two personal dosimeters does not reflect the radiation dose received by unprotected areas of the body such as eyes. It is worth mentioning that the radiation susceptibility of different organs to radiation varies significantly. Studies conducted in the last decade showed that radiation-associated lens opacities occur at much lower doses than the ICRP estimated thresholds [11]. Therefore, interventional cardiologists may develop cataract [12, 13] and brain cancer [7, 14] at a higher incidence.

Conflict of Interest: None

Acknowledgments

This study was financially supported by a grant from Shiraz University of Medical Sciences (SUMS) Vice Chancellor for Research. This study was also partially supported by the Center for Research on Radiation Sciences (CRRS), SUMS.

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