

## Original Studies

# Guidelines for Personnel Radiation Monitoring in the Cardiac Catheterization Laboratory

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The Laboratory Performance Standards Committee of the Society for Cardiac Angiography and Interventions has devised guidelines to inform catheterization laboratory personnel about appropriate radiation monitoring and protection.

A personal monitoring dosimeter must be placed over any radiation protective garments on the collar near the thyroid.

A second dosimeter, worn at the waist level under any radiation protective garments, is mandatory for any declared pregnant workers exposed to radiation. This dosimeter is recommended, but not required, for all personnel in the catheterization laboratory.

The limit for whole body radiation exposure is stated in terms of the effective dose equivalent (EDE). Different formulas are used for calculating the EDE, depending on the number of dosimeters worn simultaneously by the individual.

Finger dosimeters should be worn by personnel whose hands are likely to be directly exposed to the x-ray beam.

Initial and periodic training in radiation protection is a part of good laboratory practice. © 1993 Wiley-Liss, Inc.

**Key words:** occupational exposure, radiation dosage, radiation monitoring, radiation protection, thermoluminescent dosimeter

Radiation exposure of the cardiac catheterization laboratory staff is a known hazard. The risk of radiation exposure is related to the dose absorbed by individual tissues [1]. This document specifies a standard monitoring method that will provide a uniform measurement basis for estimating dose and radiation risk.

In the United States, radiation monitoring regulations are included in the state or local health codes. These regulations usually follow the recommendations of the National Council on Radiation Protection and Measurements (NCRP) and the International Commission on Radiological Protection (ICRP) [2-4]. Specific requirements are often based on the "Suggested State Regulations" promulgated by the Conference of Radiation Control Program Directors. Additional requirements may be imposed by local regulations or by traditional practice.

Radiation monitoring regulations establish a set of maximum permissible doses (MPD) for different organs. The important concept of maintaining dose levels below the MPD has been given the acronym ALARA (as low as reasonably achievable). Regulatory oversight of cardiac laboratories enforces both MPD and ALARA.

The review of radiation safety in the cardiac catheterization laboratory published by Johnson et al. in 1992 summarizes most of the information needed to understand the basic principles of radiation [5].

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4. Effective dose equivalent should be estimated by the following procedure (assuming that the operator uses a wraparound lead apron of 0.5 mm lead equivalent):

When one individual monitoring device located at the neck outside the protective shielding is used, the reported deep-dose equivalent value multiplied by 0.3 shall be the effective dose equivalent for external radiation; or

When two individual monitoring devices are worn, one under the protective apron at the waist and the other outside the protective apron at the neck, the effective dose equivalent for external radiation shall be assigned the value of the sum of the deep-dose equivalent reported for the individual monitoring device located at the waist multiplied by 1.5 and the deep-dose equivalent reported for the individual monitoring device located at the neck outside the protective apron multiplied by 0.04.

The two dosimeter monitoring method gives a more accurate measurement of EDE than does the one dosimeter method. In addition, under normal conditions in the cardiac catheterization laboratory, it is likely that the two dosimeter method will yield a more accurate, smaller calculated value for EDE.

5. Finger dosimeters should be worn by those individuals whose hands are likely to be directly exposed to the useful x-ray beam.

A finger dosimeter monitors compliance with regulatory dose limits to the hands. Its use is critical if the operator's hands are exposed to the primary x-ray beam. Each operator who routinely sees his or her hands on the monitor is strongly encouraged to use finger dosimeters.

Standard TLD ring dosimeters have withstood two months of wet-dry cycling through a cold-soak sterilization solution (information on manufacturers will be supplied on request) with no loss of legibility of the identification and no degradation of dosimetric accuracy.

6. The laboratory radiation safety program, including personnel monitoring records, should be regularly audited by a qualified physicist. (Qualified means physicist diplomates with appropriate credentials from the American Board of Radiology, American Board of Medical Physics, or equivalent qualifications.)

7. All individuals working in the laboratory shall receive initial and periodic refresher training in radiation safety and related topics. These refresher courses should be held at least every 3 to 5 years.

## REFERENCES

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**TABLE I. Summary of Recommendations for Annual Radiation Exposure Limits From NCRP Report No. 91—1987**

	Dose	
	m Sv	rem
1. Effective dose equivalent limit (stochastic effects) <sup>a</sup>	50	5
2. Dose equivalent limits for tissues and organs (deterministic effects)		
a) Lens of eye	150	15
b) All others (e.g., red bone marrow, breast, lung, gonads, skin and extremities) <sup>b</sup>	500	50
3. Embryo-fetus exposure		
a) Total dose equivalent limit	5	0.5
b) Dose equivalent limit in a month	0.5	0.05
4. Guidance: cumulative exposure <sup>c</sup>	10 × age (yr)	1 × age (yr)

<sup>a</sup>This limit of 50 m Sv (5 rem) per year may be changed to 20 m Sv (2 rem) by the NCRP or by state health codes. This lower value has already been recommended by the ICRP.

<sup>b</sup>The hands are limited to 500 m Sv per year. This limit could be exceeded by less than one minute per month of exposure to an unattenuated fluoroscopic beam.

<sup>c</sup>This recommendation may be the most restrictive of all of the exposure limits if the collar badge reading is interpreted as the EDE.

The most recent recommendations of the NCRP are summarized in Table I. The limit for whole body exposure is stated in terms of an effective dose equivalent (EDE). It is important to note that the EDE is very different from the reading of an unshielded film badge worn on the collar. Most states require a collar dosimeter. The readings of this dosimeter need considerable evaluation before they can be used to estimate EDE. Some of the controversy relating to dosimeter placement and interpretation is discussed in the papers of Brateman, Bushong, and Webster [6-8].

The SCA&I Personnel Radiation Monitoring Guidelines form a consistent measurement basis that will permit the uniform assessment of the operators' radiation dose. The guidelines constitute one element in a complete radiation safety program that must have as its objective the minimization of radiation risk [9].

## PERSONNEL RADIATION MONITORING GUIDELINES 1993

1. Each individual working with ionizing radiation in a cardiac catheterization laboratory shall<sup>1</sup> use personal monitoring devices (dosimeters). Individuals working in more than one laboratory should<sup>2</sup> use the same set of dosimeters to monitor all occupational exposures.

The use of a single set of dosimeters gives the most

<sup>1</sup>The NCRP defines *shall* as a recommendation that is necessary to meet the currently accepted standards of radiation.

<sup>2</sup>The NCRP defines *should* as an advisory recommendation that is to be applied when practicable.

accurate assessment of the exposure received by an individual worker. Each individual should have a primary facility to administer his or her personal monitoring program. Secondary facilities should receive copies of all personal monitoring reports from this primary facility. Additional dosimeters may be required by a secondary facility.

2. A dosimeter shall be worn on the collar near the thyroid. It shall be placed over any radiation protective garments. Notation should be made in the records documenting the use of thyroid shields or radiation protective eyeglasses.

This dosimeter assesses the dose to the eyes and thyroid to monitor compliance with regulatory dose limits for these organs. Caution should be exercised in interpreting dosimeter measurements when eye or thyroid shielding is used.

This dosimeter is mandated by most regulatory authorities. Its absolute readings should be evaluated critically before using them to estimate EDE. Changes in month to month readings not explainable by clinical workload represent valuable information in the implementation of the ALARA program.

3. A second dosimeter should be worn at waist level on the midline. If it is used, it shall be placed under any radiation protective garments. The use of this dosimeter is mandatory for declared pregnant radiation workers.

Measurements made by this dosimeter *underestimate* the EDE. The correction factor is a function of lead apron thickness and style, other protective devices, imaging equipment, and clinical working procedures. The reading of this dosimeter shall be used to monitor the fetal EDE.