Basics of Radiation Safety

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Introduction

Cardiac catheterization procedures expose both the patient and operator to the hazards of radiation. The hazards of repeated radiation exposure are serious, but not obvious. Four rational principles are evident.

- Radiation-induced biological effects are the result of random statistical probability for low radiation doses. The probability of these effects is directly proportional to the radiation dose received. The effects of radiation are described in Fig. 1.1.
- Since radiation-induced biological effects are random, and no threshold dose exists for these effects, even a small dose could potentially induce biological effects, and therefore no level of radiation exposure can be considered completely safe.
- Radiation exposure is cumulative and there is no washout phenomenon as with other toxin exposures.
- Each person involved in the cardiac catheterization lab has accepted a certain degree of risk posed by radiation exposure. Current regulatory considerations for radiation limit are listed in Table 1.1.

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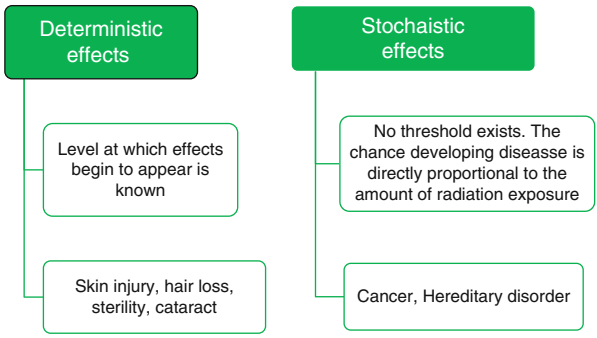

Fig. 1.1 Effects of radiation

Table 1.1 Current regulatory considerations for radiation limit

Tissue	Risk	Recommended maximum dose	
		NCRP	ICRP
Occupational	Stochastic	50 mSv/year	100 mSv/5 year
Lens of the eye	Stochastic	150 mSv/year	150 mSv/year
Extremities	Stochastic	500 mSv/year	500 mSv/year
Embryo-fetus	Stochastic	0.5 mSv/month	1 mSv/term
General public	Stochastic	1 mSv/year	1 mSv/year

National Council on Radiation Protection and Measurements (NCRP)
International Commission on Radiological Protection (ICRP)
10 mSv = 1 rem

ALARA

ALARA is a radiation safety principle and regulatory requirement for radiation safety of all personnel. It stands for "as low as reasonably achievable." If the radiation exposure exceeds the ALARA limit, the radiation safety officer (RSO) will have a discussion with operator to assess different possibility of radiation exposure reduction and regarding the possible side effects. Three principles help in maintaining ALARA practice:

- *Time*: Reducing the duration of radiation exposure will reduce the dose.
- *Distance*: Radiation follows the inverse square law. Doubling the distance from source will reduce the radiation exposure by factor of 4.
- *Shielding*: Using absorbent material like lead for x-rays reduces the exposure.

Monitoring Patient Dose

Fluoroscopic time: Total time of fluoroscopy use during procedure.

Air kerma (AK): Refers to x-ray energy delivered to air at the interventional reference point. It is a measure of patient's dose burden and correlates to determine the effects.

Dose area product (DAP)/air kerma-area product: Product of total radiation dose and area of x-ray field. It is expressed as $Gy.cm^2$. It is a measure of radiation exposure and correlates with possible risk of stochastic effects.

Safety Components

Radiation monitoring

- Mandate the use of the dosimeter.
- Review the practice pattern of every individual and especially if the dosimeter records high radiation doses.
- Advisory agencies such as NCRP give 2 options of measuring effective dose equivalent (EDE) for workers who use lead aprons. The first option is to have one badge on the collar outside the apron and the other badge under the apron at the waist level. The second option is to use only one badge outside the lead apron on the collar level.

Shielding

- Lead garments to protect the gonads and approximately 80 % of the bone marrow.
- 0.5 mm lead apron stops approximately 95 % of the scatter radiation.
- Separate thyroid collars, especially for the young and in those whose radiation dose exceeds 4 mSv/month.
- 0.25 mm lead eyeglasses for eye protection (radiation can cause posterior subcapsular cataracts).
- Use of below the table-mounted shields.
- Transparent ceiling-mounted shields.
- Disposable radiation absorbing sterile drapes.
- Proper maintenance and periodic inspection (atleast once a year) of lead aprons.

Procedural Issues [1]

Precautions to minimize exposure to patient and operator

- Utilize radiation only when imaging is necessary to support clinical care.
- Minimize use of cine.
- Minimize use of steep angles.
- Minimize use of magnification modes.
- Minimize frame rate of fluoroscopy and cine.
- Keep the image intensifier close to the patient.
- Utilize collimation to the fullest extent as possible.
- Monitor radiation dose in real time.

Precautions to minimize operator exposure

- Use and maintain appropriate protective garments.
- Maximize distance of operator from x-ray source and patient.
- Keep above and below table shields in proper position at all times.
- Keep all body parts out of field.

Precautions to minimize patient exposure

- Keep table height as high as comfortable for the operator.
- Vary the imaging beam angle to minimize exposure to any one skin area.
- Keep patient's extremities out of beam.

Impact on Patient Care

Inclusion of radiation dose on cardiac catheterization reports is mandatory.
Follow-up based on AK:

- AK >5 Gy:
  - Patient education regarding potential skin changes like redness and report if seen.
  - Patient to be contacted within 30 days.
- AK >10 Gy:
  - Qualified physicist to perform detailed analysis and calculate peak skin dose
  - Office visit in 2–4 weeks with skin examination
- PSD (peak skin dose) >15 Gy:
  - Contact hospital risk management.
  - Notification to regulatory agencies.

Reference

1. Chambers CE, Fetterly KA, Holzer R, Lin PJ, Blankenship JC, Balter S, Laskey WK. Radiation safety program for the cardiac catheterization laboratory. Catheter Cardiovasc Interv. 2011;77(4):546–56. doi:10.1002/ccd.22867. PubMed PMID: 21254324.