



BASIC RADIATION & MRI SAFETY PROGRAM

Self-Study Guide

OBJECTIVES OF THE BASIC RADIATION & MRI SAFETY PROGRAM

Upon completion of this self-study guide, you should be able to understand common types of ionizing radiation, it's uses in the hospital setting, it's associated risks, and ways in which you can minimize your exposure.

Successful completion of this program can be accomplished by completing the examination on the last page of this self-study guide with a score of 80% or better.

INTRODUCTION

Radiation is simply the transfer of energy. Radiation exists in bundles of energy in the form of electromagnetic waves as well as tiny atomic particles. Examples of electromagnetic waves include visible light and radio.

The type of radiation that we are concerned with is **Ionizing Radiation**. Some forms of radiation can create ions. In other words, the radiation contains sufficient energy to break chemical bonds by removing an electron from an atom or molecule of a substance. **Ionizing Radiation has the potential to cause damage to molecules inside your body.** Other forms of radiation such as laser, ultrasound, and microwave do not ionize, but do have their own associated risks if not used properly. When using proper precautions, ionizing radiation is safe and very useful. In fact, ionizing radiation is part of the backbone of modern medicine and used throughout industry and research.

COMMON TYPES OF IONIZING RADIATION

X-rays - usually generated by equipment (emitted from processes outside the nucleus). X-rays are generally lower in energy and less penetrating than gamma rays. X-rays are the single largest source of manmade radiation because of its many uses. A few millimeters of lead can stop medical x-rays.

Gamma Rays - emitted by radioactive materials (emitted from the nucleus of atoms of radioactive material). Gamma rays are very penetrating; they can pass completely through the human body or be absorbed by tissue, thus constituting a radiation hazard for the entire body. Several feet of concrete or a few inches of lead may be required to stop the more energetic gamma rays. Example: Cobalt-60 used in radiation therapy or in sterilization of medical equipment.

Beta Particles - emitted by radioactive materials (electrons have low mass and a single charge), penetration power is easily stopped with light shielding (layer of clothing or by a few millimeters of aluminum). Example: Phosphorous 32 used in research

USES OF RADIATION IN MEDICINE

If used properly, radiation is beneficial and is found in many work settings. In the medical community, radiation is used in the following ways:

- Diagnosis of illness
- Prevention of illness
- Treatment of illness
- Therapy to treat cancer
- Medical research

The high quality of medical care that we have today would not exist without the use of radiation.

RADIATION SOURCES IN MEDICINE

You will likely encounter sources of radiation from imaging equipment, radioactive material, and radioactive waste. Radiation can be found in many areas of the hospital, including:

- The Diagnostic Imaging Department
- Nuclear Medicine
- Areas where the mobile x-ray units can go (portable and c-arm)

RADIATION TERMINOLOGY

rem - “roentgen equivalent to man” The conventional unit of dose equivalent. The dose equivalent in rem is numerically equal to the absorbed dose. For most medical applications involving x-ray or gamma emitters, the numerical values of the absorbed dose in rad, dose equivalent in rem, and exposure in roentgen(R), is roughly equivalent numerically. The rem is being replaced by the sievert (Sv). (1 rem = 0.01 sievert, or 1 Sv (sievert) = 100 rem.)

rad – “radiation absorbed dose” the unit of dose or energy absorbed per unit mass in materials, including tissue. It is being replaced by the Gray (Gy). (1 rad = 0.01 Gy or 1 Gy = 100 rad).

roentgen (R) - The special unit of exposure, based on the quantity of ionization (charge) produced by the absorption of x-ray or gamma radiation energy in a specified mass of air under standard conditions.

dose – Generic term for quantity of absorbed radiation per unit mass. Dose Equivalent is the term for quantity of absorbed dose in tissue as modified by certain risk factors dependent upon the type of radiation to which one was exposed. (measured in Sievert)

dose rate – absorbed dose delivered per unit of time.

absorbed dose – the energy imparted to matter by ionizing radiation per unit mass of irradiated material at the point of interest. (measured in Gray).

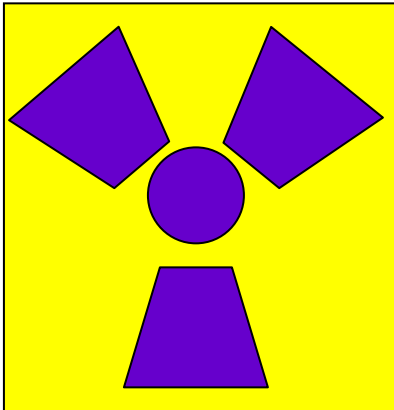
Somatic effects – detrimental effects of radiation manifested in the person irradiated. (affecting the body).

Genetic effects – changes in reproductive cells that may result in abnormal offspring or persons or animals. (affecting your offspring).

RECOGNITION OF A RADIATION AREA

Universal symbol for a radiation area. (yellow background with a purple propeller)

CAUTION RADIATION AREA



Radiation Hazard signs can be found posted on doors to the department, hallways, or rooms, work areas within restricted areas, waste cans, package labels, sinks, refrigerators, or fume hoods. Illuminated signs above the doors indicate when an exposure is being made.

TECHNIQUES USED TO REDUCE OR PREVENT RADIATION EXPOSURE

- First and foremost use **UNIVERSAL PRECAUTIONS** at all times.
- Concept called: **TIME, DISTANCE, and SHIELDING.**

TIME – the less time you spend near a source of radiation, the less exposure you will receive.

DISTANCE – the more distance you put between yourself and the source, the

less exposure you will receive. If the distance from a point source of radiation is doubled, the exposure is quartered. (i.e. a person standing 4 meters from an x-ray source will be exposed to only $\frac{1}{4}$ as much radiation as a person standing 2 meters from the source [Inverse Square Law]).

SHIELDING – the more shielding that is worn or is in place, the less exposure you will receive. Shielding can be lead aprons, leaded glass, physical barriers (walls, tables, nightstands, beds, etc.).

- Principle called **ALARA** “**A**s **L**ow **A**s **R**easonably **A**chievable”. The principle of limiting the radiation dose of exposed persons to levels as low as is reasonably achievable, economic and social factors being taken into account.
- Along with these concepts and principles, common sense must be used. You must be able to recognize a restricted area (radiation area). you must not drink, eat, smoke, or apply cosmetics when working in areas with radioactive materials. You must also notify the Diagnostic Imaging Department, and Radiation Safety Officer, of any spills before proceeding to clean it up yourself.

EFFECTS OF RADIATION

- Radiation exposure is “cumulative” for your entire life.
- It can leave short term and long lasting effects depending on the dosage and the type of radiation received. Probability of cancer increased with dose. Cancer produced by 100 rads is no different than cancer produced by 10 rads. Cancer is cancer!
- No radiation exposure is completely risk free!
- It can adversely affect individuals directly exposed as well as their descendants.
- Ionizing radiation affects people by depositing energy in body tissue, which can cause cell damage or cell death. In some cases there may be no effect. In other cases, the cell may survive but become abnormal, (either temporarily or permanently) or an abnormal cell may become malignant.

TYPES OF EXPOSURE

- **Chronic Exposure** – is a continuous or intermittent exposure to low levels of radiation over a long period of time. Chronic exposure is considered to produce only effects that can be observed some time following initial exposure.

- **Acute Exposure-** is a large single dose or a series of doses for a short period of time. In most cases, a large acute exposure to radiation can cause both immediate and delayed effects.

The serious radiation –induced diseases of concern in radiation protection fall into two general categories: **stochastic effects** and **non-stochastic effects**. (stochastic means random in nature).

- **Stochastic effect** – is defined as one in which the probability of occurrence increases with increasing absorbed dose but the severity in affected individuals does not depend on the magnitude of the absorbed dose. A stochastic effect is an all – or – none response as far as the individuals are concerned. Cancers (solid malignant tumors and leukemia) and genetic effects are regarded as the main stochastic effects or risks to health from exposure to ionizing radiation at low absorbed doses (NCRP, 1987a).
- **Non-stochastic effect** – is defined as a somatic effect which increases in severity with increasing absorbed dose in affected individuals, owing to damage to increasing numbers of cells and tissues. Non-stochastic late effects, i.e., diseases characterized by organ atrophy and fibrosis, are basically degenerative, is contrasted with the neoplastic growth characteristic of cancer. In general, considerably larger absorbed doses are required to cause non-stochastic effects to a degree of severity which seriously impairs health, as compared with absorbed doses required for a significant increase in cancer incidence. Examples of non-stochastic effects attributable to radiation exposure are lens opacification, blood changes, and a decrease in sperm production in the male (NCRP,1987a).

Acute Radiation Effects

- Erythema (reddening of skin)
- Epilation (loss of hair)
- Nausea
- Diarrhea

These appear within a short enough period of time after an exposure to make it obvious that radiation was the cause. Acute effects have been observed only following high dose exposures, typically greater than 1 Gy (100 rads) to the whole body. The severity of the acute radiation effects observed following high doses is dependent upon the amount of tissue exposed, the nature of that tissue exposed, the dose rate and the total dose received. The potential for exposures that would result in acute effects generally does not exist in medical facilities.

Cancer

The most serious delayed effect of radiation is cancer. Radiation induced cancers arise years or decades after exposure and they are indistinguishable from those, much more

frequent ones, that are due to other causes. These characteristics make it difficult to provide firm numerical estimates but it has been generally agreed that the general risk of developing cancer in a lifetime, which is 33 percent (SEER,1981), is increased by about one percent by a whole body dose of 100 mGy (10 rad) (UNSCEAR, 1988).

Genetic Effects

A genetic effect of radiation is one that is transmitted to the offspring of the exposed individual. Radiation can impart energy to the germ cell nucleus, thereby causing breakage or alteration of molecular bonds which can result in mutation or chromosome breakage.

Radiation induced mutations do not differ from spontaneously induced mutations. At exposures typically received in today's medical setting, the probability of radiation – induced genetic effects is very small.

Embryonic and Fetal Effects

The embryo or fetus is comprised of large numbers of rapidly dividing and radiosensitive cells. The amount and type of damage which may be induced are functions of the stage of development at which the fetus is irradiated and the absorbed dose.

Radiation received during the pre-implantation period can result in spontaneous abortion or resorption of the conceptus. Radiation injury during the period of organogenesis (2 – 8 weeks) can result in developmental abnormalities. The type of abnormality will depend on the organ system under development when the radiation is delivered. Radiation to the fetus between 8 and 15 weeks after conception increases the risk of mental retardation (Otake and Schull, 1984) and has more general adverse impact on intelligence and other neurological functions. The risk decreases during the subsequent period of fetal growth and development and during the third trimester, is no greater than that of adults.

DOSE LIMITS

Occupational exposures (annual)	5 rem (50 mSv)
Public exposures (annual)	0.1 rem (1 mSv)
Embryo – fetus exposures Total	0.5 rem (5 mSv)
Embryo – fetus exposures Monthly	0.05 rem (0.5 m Sv)

MEASURING RADIATION

- **Survey Meter** - used for detection and measurement of radiation (not used for quantitative radiation exposure measurements).

- **Personnel Monitors** – (film badges worn by individuals for the purpose of estimating exposure to radiation. Will be worn at the collar and waist.
- **Well Counter** – instrument used to measure the activity of individual doses.
- **Crystal Detectors** – piece of equipment used to perform the Nuclear Medicine procedure.

RADIOACTIVE MATERIALS (for Nuclear Medicine)

- **Radioisotopes** – injected into patients to perform certain procedures. They are delivered in single unit doses from Cardinal Health. We do not have a hot lab here; we do not mix our doses.
- **Sources** - used for quality control tests and are stored in a shielded area.
- **Waste** – stored in a shielded area and monitored until it reaches an acceptable level (background) and then it is disposed of in the normal trash.

RADIATION SAFETY COMMITTEE & RSO

It is required by law that we form a Radiation Safety Committee and appoint a Radiation Safety Officer (RSO). We must meet quarterly and discuss exposures levels, any spills or misadministrations, and any changes that deals with radiation safety.

The Radiation Safety Officer (RSO) is Dr. Scott Logan, M.D.

Committee Members include:

Scott Logan, M.D. – Radiation Safety Officer
Unicon Physicist – Consulting Physicist
Craig Solle, President and CEO – Administrative Representative
Linda James, RN, V.P., Patient Care – Nursing Representative
Gary Damron, Manager, Environmental Services – Hospital Safety Officer
Sherry Dively, Assistant Manager, Diagnostic Imaging
Donna Corcoran, Manager, Diagnostic Imaging
Brooke Dalton, Nuclear Medicine Technologist

EMERGENCY PROCEDURES

SPILLS

Accidental spillage of radioactive material is rare; however, spills may occur. These spills may occur anywhere where transportation of radioactive materials happens or in any hospital room where a patient may vomit or be incontinent.

Major radiation accidents or serious spills of radioactive contamination have rarely involved medical and allied health personnel. Usually spills in hospitals have involved only small amounts of radioactivity in which a main concern is the spread of the contamination, i.e. from shoes or contaminated clothing, into public areas. The following is a general outline of the procedure to be followed in the event of a spill.

1. Clear the area and confine the spill immediately, by dropping paper towels or other absorbent material onto it.
2. Put on protective clothing (impermeable gloves, mask, and shoe covers if shoes are not contaminated).
3. Check shoes for visible signs of contamination. If it appears possible that they are contaminated, remove shoes when leaving the contaminated area.
4. Mark off or isolate in some way the entire suspect area and guard it to be sure that no one walks through it.
5. Detain all evacuees from the area in a place where they can be surveyed by the Radiation Safety Officer (RSO) or tech in charge.
6. CALL THE RADIATION SAFETY OFFICER (RSO) and the consulting physicist. Both numbers should be posted in Nuclear Medicine.
7. In general, inexperienced personnel should not attempt to clean up a spill. It is better to wait a little while for the RSO than to risk spreading the contamination by erroneous procedures.
8. If personnel are contaminated, they should be decontaminated as soon as possible. Outer garments should be removed and left in the contaminated area. Hands or skin areas should be washed thoroughly with soap and water in the nearest wash basin, if by doing so the area of contamination is not enlarged. Care should be taken not to abrade or inflame the skin surfaces. If it is uncertain as to whether or not shoes are contaminated, the walkway to a washing facility shall be treated as a contaminated area until the RSO or person in charge has certified that it is uncontaminated.

9. The RSO or tech in charge will bring decontamination materials and a survey meter and the cleanup operation will proceed.
10. If the RSO is not immediately available and cleanup must be initiated, as few people as possible should be involved. Impermeable gloves, shoe covers, and a surgical mask should be worn if available. The spilled material shall be taken up with absorbent paper, which is handled with forceps or tongs, and deposited immediately in a waterproof container. After as much contamination as possible has been removed in this way, the surface should be washed with damp- not wet – paper towels held in forceps, always working toward the center of the contaminated area rather than away from it.
11. A survey meter should be available, and careful monitoring of both area and personnel should be carried out during this procedure. The survey meter should be operated by someone who is not involved in the cleanup, so that the instrument does not become contaminated. Cover the probe with thin, clear plastic wrap, if possible.
12. Reduction of the counting rate to several times background is usually satisfactory. Higher counting areas can be covered with plastic – backed absorbent paper and held in place with tape to await further evaluation by the RSO or tech in charge. The RSO or tech in charge should survey the area and certify adequate decontamination prior to its return to routine use.
13. When the operation is finished, gloves and other protective garments should be checked carefully for residual contamination. If any is found, the garments should be left with the other contaminated material in plastic bags for ultimate disposal by the RSO or tech in charge.
14. Proper paperwork shall be completed.

LOSS OF A SEALED SOURCE

Immediately upon discovery of a loss of a sealed source, an appropriate plan of action should be initiated. An example of such a plan would be as follows.

1. Call the Radiation Safety Officer (RSO) immediately.
2. Make a list of all possible places in which the source might have been and where it might be found.
3. Choose the most sensitive and appropriate portable survey instruments for conducting the search.
4. If the source had been transported, check the entire route of travel.

5. If the source had been used with a patient, survey the patient, the patient's room, and all bandages, linen, bedding and trash from the patient's room.
6. Survey the entire route from the patient's room to the laundry and the laundry facility.
7. Survey the entire route from the patient's room to the incinerator, the incinerator, trash awaiting incineration, and the incinerator ash.
8. Survey the entire route from the patient's room to the dumpster and the trash dumpster. If needed, request Security or Housekeeping to impound the dumpster until the search can be completed.
9. If instruments had been used with the patient, survey the entire route from the patient's room to the instrument cleaning and sterilization area
10. Survey all areas where the source might be found, such as sink drains or plumbing fixtures, elevator shafts, waste cans, trash bins, and vacuum cleaners or house vacuum systems.
11. Continue the search until the source is found or the search is terminated by the RSO.

A RUPTURED OR BROKEN SEALED SOURCE

1. Shut off all fans and ventilators.
2. Drop damp towels on the suspect material; throw nothing away.
3. If possible, evacuate the room. If not, keep all personnel as far as possible from the suspect material until the RSO or tech in charge arrives. Do not attempt to clean up or remove any material.
4. Call the RSO or tech in charge to remove the questionable material and check the area or contamination.