

RADIATION SAFETY

Junior Radiology Course

Expectations for the Junior Radiology Course

- Medical School wants students to learn basic principles, factual knowledge, safety info, etc.
- Medical Students want to learn how to read films!

What is an X-ray?

- “... a form of radiant energy similar in several respects to visible light”
- As is the case for rays of light, a small part of an X-ray beam will be absorbed by air, and all of the beam will be absorbed by a thick metal barrier
- Main difference:
 - X-rays have much shorter wavelengths than those of UV light

What is an X-ray?

- X-rays are very short wavelength electromagnetic radiation
- The shorter the wavelength, the greater the energy and the greater the ability to penetrate matter
- X-rays are described as packets of energy called Quanta or Photons
- Photons travel at the speed of light
- Photon energy is measured in electron volts

Ionization

- An atom which loses an electron is ionized
- Photons having ≥ 15 electron volts can produce ionization in atoms and molecules
- X-Rays, Gamma Rays, and certain types of UV Radiation are Ionizing Radiation

Ionizing Radiation in Radiology

- **Ionizing Radiation can be carcinogenic and, to the fetus, mutagenic or even lethal**
- **Patients undergoing these types of studies are exposed to Ionizing Radiation:**
 - **Radiographs**
 - **Fluoroscopy/Conventional Angiography**
 - **CT**
 - **Nuclear Medicine**

Goals of Radiation Safety

- Eliminate deterministic effects
- Reduce incidence of stochastic effects

Exposure to Ionizing Radiation causes two types of effects

- **Deterministic Effects:** A minimum threshold dose must be attained for the effect to occur. Examples include cataract formation, skin reddening (erythema), and sterility. Also referred to as “non-stochastic” effects
- **Stochastic Effects:** The effect may (potentially) occur following any amount of exposure – there is no threshold. Examples include cancer and genetic defects.

RadTech uses collimation and lead apron to reduce unwanted exposure

RADIOGRAPHY

- X-ray photons are produced when a Tungsten anode is bombarded by a beam of electrons
- Matter absorbs or scatters the X-rays
- Some X-rays reach the cassette, which contains an image receptor (either a sheet of film or an electronic device)

Collimation – reduces scatter X-rays, thus reducing dose to healthcare workers, and also improving image quality

LIMITING YOUR EXPOSURE

Three basic methods for reducing exposure of workers to X-rays:

1. Minimize exposure **time**
2. Maximize **distance** from the X-ray tube
3. Use **shielding**.

LIMITING YOUR EXPOSURE:

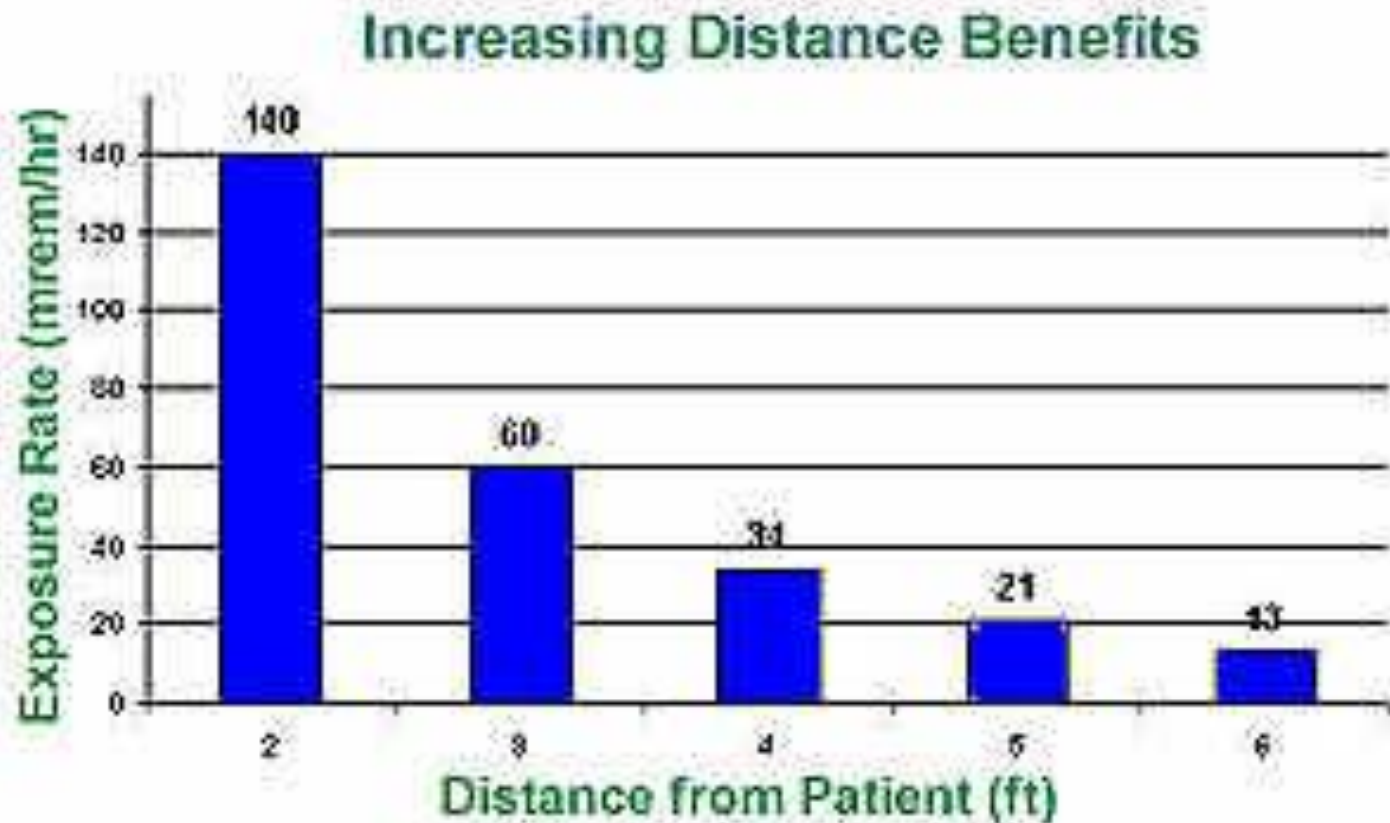
You do the math!

- Doubling your distance from the X-ray tube reduces your exposure by a factor of four
- Tripling your distance from the X-ray tube reduces your exposure by a factor of nine!

LIMITING YOUR EXPOSURE

- Maximize distance from the X-ray tube:
- Exposure varies inversely with the square of the distance from the X-ray tube

LIMITING WORKER EXPOSURE



Imaging in Pregnancy

- Reference:
- 1) Toppenberg, MD, Hill MD, & Miller MS, Safety of Radiographic Imaging During Pregnancy, **American Family Physician**, Vol. 59, No. 7, pp. 1813 – 1818, April 1, 1999.
- 2) Roberts MD, Radiographic Imaging During Pregnancy: Plain X-rays, **Emergency Medicine News**, Vol. 24, No. 3, March 2002.
- 3) Roberts MD, Radiographic Imaging During Pregnancy: MRI and CT Scan, **Emergency Medicine News**, Vol. 24, No. 4, April 2002.

Risk to Fetus

- Radiation causes harm through the excitation created by X-ray photons striking atoms, which may either disrupt the molecule directly, or create a free radical, which is capable of reacting with other biologic molecules.

FETAL EXPOSURE

- The maximal limit of ionizing radiation to which the fetus should be exposed during pregnancy is a cumulative dose of 5 rad.

Radiation Exposure

- Cervical spine 0.002
- Upper or lower extremity 0.001
- Chest (two views) 0.00007 =
>70,000 exams to reach max exposure
- Abdominal (multiple views) 0.245

Pregnancy Radiation Risk

- For counseling purposes, know that at doses < 5 rem, there have been no proven effects on the fetus, but extrapolation from higher doses suggests that the risk is 0.5-1%/rem for radiation induced congenital defects. The natural occurrence of congenital defects is approximately 5%.
- Radiation effects on the fetus are cumulative throughout the pregnancy.

Basic Radiation and Pregnancy Facts

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- **Fetal malformations from radiation are uncommon at standard medical doses of radiation, however the fetus is most sensitive at 8-17 weeks of gestation. Non-urgent studies should be avoided in this window.**

Abdominal Shield

- **If the study is above the abdomen or below the hips, no risk is present to the fetus, shield the abdomen**
- For studies in which the fetus comes under direct exposure of the radiation beam, for all doses of radiation: 1. Contact staff & arrange a discussion between the referring physician and the staff on-call.

STEPS

- **2.If exam is appropriate and necessary, have the clinician write a note in the chart stating the study is indicated for the management of the patient.**
- 3.Explain the procedure to the patient with the assurance that the dose will be kept as low as possible consistent with obtaining the diagnostic information

Risk to Fetus

- The developing CNS is most frequently affected after high levels of radiation in utero, with common defects being mental retardation and microcephaly. Malignancy can also result, with the most common radiation-induced cancer being childhood leukemia.

Risk for Cancer

- The probability of developing radiation-induced carcinogenesis increases with radiation dose, but the severity of the malignancy is independent of the radiation dose.
- Leukemia = Most Common*

Pregnancy

- MRI: There are no documented adverse effects upon the fetus, but it is recommended that all non-essential studies be avoided in the first trimester.
- Ultrasound: Recommended that the average power setting for ultrasound studies in the area of the fetus be kept to a minimum consistent with achieving a diagnostic study.

Consent forms

- 1-5 rem: Inform the patient and family of the risks and benefits, and have the patient sign the informed consent form.
- > 5 rem: Counsel patient and family about risks and benefits. Referring physician, radiologist, and radiation physicist should all write notes in the patient's chart explaining the circumstances and medical justification for the exam or procedure. Have the patient sign the informed consent form.