Radiation Protection

Radiation Protection Concepts Review

MRT Program

Risk vs. Benefit

- Benefit
  - Advantage or good result arising from a specific activity
- Risk
  - Probability of injury, ailment or death resulting from an activity
- Effective communication of the benefits compared to risk of the procedure is very important
  - Exposure should always be kept at the lowest possible level for the public

Risk vs. Benefit (cont'd)

- Decision about whether the x-ray is taken is the patient's
- Patient that understands the procedure is more likely to consent and cooperate
- When someone is injured a decision must be made: is the risk worth the diagnostic data gained?

Risk vs. Benefit (cont'd)

- Exposure to the radiation must be considered as a benefit and risk
- Technique must be as low as possible but still enough to obtain a diagnostic image
- Be mindful of techniques to keep a balance between the possible damage to tissue and value of the diagnostic data collected

Risk vs. Benefit (cont'd)

- With digital post-processing capabilities, "dose creep" can occur
- Every manufacturer has specifications for the range of the exposure index
- Phillips – Exposure Index (EI) is 100–300 and 450 for chest
  - Above Range – overexposure
  - Below Range – underexposure

Risk vs. Benefit (cont'd)

- Patients should be the only person exposed to the primary beam.
- Primary radiation worker (Tech) should never be exposed to a primary beam while working.
- Technologists are predominantly exposed to secondary radiation (scatter and leakage).

Risk vs. Benefit (cont'd)

- Chronic low doses of radiation could have damaging effects if radiation protection principles are not applied by a primary radiation worker.
- Radiation workers are exposed to low dose scatter every day.
- Must be aware of the risk and benefits of the decisions that are made while working in the radiation environment.
  - E.g., holding or restraining patients

Three Cardinal Rules of Protection

- Time
- Distance
- Shielding

Time

- Reduce the amount of time in the area of radiation
- Double the time, double the exposure
- We may have to stay with our patients, but try to limit this
- Do not routinely hold patients
- Fluoroscopy is the largest contributor to chronic low-dose exposure for a technologist

Time (cont'd)

- Fluoroscopy can go on for several minutes up to several hours
- Technologist caring for the patient must be in the room—be aware of the "beam on time"
- Ensure that all the protective equipment is worn and utilized
- Stay behind protective barriers as much as possible and limit amount of time spent near beam

Distance

- Distance is the most effective means of reducing radiation exposure
- Patient is the source of most of the exposure to technologists
- Exposure switch must not be located in the room so the tech can remain behind the barrier
- Increase the distance between you and the beam wherever possible
  - I.e., while using mobiles, OR and fluoroscopy

Distance (cont'd)

- Inverse Square Law (ISL)
  - Intensity of radiation at a given distance from a point source is inversely proportional to the square of the distance.

$$\frac{I_1}{I_2} = \frac{(d_2)^2}{(d_1)^2}$$

Inverse Square Law

- If the distance between you and the beam is increased, what is the reduction in exposure?
  - Exposure is 9 mGy at 1 metre
  - What is it at 2 metres?

$$\frac{9\ \text{mGy}}{I_2} = \frac{(2\ \text{m})^2}{(1\ \text{m})^2} = \underline{2.25}\ \text{mGy @ 2 metres}$$

Inverse Square Law (cont'd)

- What is it at 3 metres?

$$\frac{2.25\ \text{mGy}}{I_2} = \frac{(3\ \text{m})^2}{(2\ \text{m})^2} = \frac{1}{}\ \text{mGy @ 3 metres}$$

- Reduced by a factor of $(3)^2$ or by 9
- You would get one ninth of the original scatter

Why is the Formula Important?

- Cardinal rule for distance as a radiation protection tool
- If distance between an individual and the x-ray source or scatter is cut in half, the intensity will increase by a factor of four
- For every metre that the technologist stands closer to the patient or source of radiation, their exposure increases 4 times

Distance

- Intensity of an x-ray beam decreases as the individual moves further away from it
- There are the same rules for the number of photons in the scatter, but they are more spread out over a larger area
- If the distance between you and scatter is doubled, intensity of the scatter photon will have less energy

Shielding

- Use when time and distance are not an option
- Any material will attenuate the beam
- How much depends on atomic #, density and thickness of the material
- There are several types of shielding:
  - Primary or secondary (permanent)
  - Fixed or mobile shields, in the room or worn

Shielding (cont'd)

- Radiation protection barriers
- Who designs them?
  - A diagnostic radiological physicist
- Why?
  - To protect staff and the public

Structural Barriers

- Structural barriers need to be classified as
  - Primary
    - Can be struck directly by the beam
      - Wall behind the detector
        - Needs 1/16th" of lead and 7' from the floor
  - Secondary
    - Scattered and leakage radiation
      - Wall 1/32nd" of lead

What are the requirements?

- Type of equipment, layout of the room, occupancy of adjacent rooms and other factors such as kVp
- Protective barrier must be material that reduces radiation intensity—can be estimated by ½ value or 1/10th value layers
- HVL/TVL is thickness of absorber that reduces intensity of ½ or 1/10th its original value

Shielding

- Permanent structures are the radiation protection barriers built into the department
- Structural barriers
  - Lead sheet – 1/16th, 1/32nd
  - Concrete – 7.4 cm
  - Lead glass – 1.5 mm
  - Steel
  - Lead-infused Acrylic – 30% less weight

Shielding (cont'd)

- Mobile shields like lead-equivalent aprons and gloves are used by individuals
- Mobile barriers
  - Aprons – 0.25, 0.5 or 1.0 mm
  - Gloves – 0.25–0.5 mm
  - Thyroid collars – 0.5 mm
  - Lead glasses – .35 mm
  - Gonadal shielding – 1.0 mm
  - Lead walls mounted on wheels

Lead is a Balance

- It is standard to wear 0.5 mm of lead equivalent for a 100 kVp beam
- Slightly higher for some wraparound aprons
- Increase lead, increase protection
- Increase lead, increase weight
- Remember, we may be wearing lead for hours so wear it properly!

Protective Devices

- Ensure that protective devices are worn by all personnel.
  - Nurses, physicians, aides in the vicinity of the beam or scatter
- Be aware of who is in the room, coming in or leaving.
- Everyone in the vicinity should be aware of an exposure.
  - Call a warning: "x-ray"

Reducing Dose in Other Ways

- Correct Collimation
  - Gonads, breast tissue and thyroid avoided if possible
- Minimize exposure to children and adolescents
  - Benefit must outweigh risk
- Use of gonad shielding
  - Whenever possible

Reducing Dose in Other Ways (cont'd)

- Appropriate technique selection
  - Higher kVp and lower mA when possible
- Maintain sensitivity of imaging system
  - Higher sensitivity equipment decreases dose
- Correct positioning of anatomy
  - Reduce the repeats

International Agencies

- International Commission on Radiological Protection (ICRP)
  - Authority on the safe use of ionizing radiation
- National Council on Radiation Protection and Measurements (NCRP)
  - Incorporates ICRP recommendations

International Agencies (cont'd)

- United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR)
  - Formulates radiation guidelines
- National Academy of Sciences/National Research Council on Biological Effects of Ionizing Radiation (NAS/NRC-BEIR)
  - Reviews studies of biological effects

International Agencies (cont'd)

- Responsible for evaluating relationship between radiation and biological effects
- Concept of radiation exposure and associated risk of malignancies is the basis of the effective-dose limiting system
- Organizations serve as a resource for revised recommendations

Safety Code and Personnel Radiation Safety

- Safety Code 35 is issued by Health Canada.
- Replaces the Safety Code 20A and 31
- Sets out the requirements for the safe use of radiation
- Contains personnel requirements, safety procedures, equipment and facility guidelines

Safety Code and Personnel Radiation Safety (cont'd)

- For any person concerned with equipment performance, image quality and radiation safety in a facility
- Primary for instructions and guidance for radiation personnel employed in a facility
- SC 35 regulations and publications are followed within Canada above all others

Safety Code and Personnel Radiation Safety (cont'd)

- SC 35 does not cover radiation protection for dental or mammography
- Each have their own safety code
  - SC 30 – Radiation Protection in Dentistry
  - SC 33 – Radiation Protection in Mammography

Radiation Emitting Devices (RED) Act

- Standards for information, labelling, construction and performance of equipment with respect to radiation safety
- All new, used and refurbished medical x-ray equipment and accessories in Canada must meet the RED act regulations

Diagnostic Reference Levels (DRL)

- Dose guidelines for typical exams based on standardized patients and phantoms
- Promotes better control of patient exposures
- Facilities should strive to meet these levels, but may not always be possible
- Normally reviewed annually

Diagnostic Reference Levels (cont'd)

- Beneficial in large dose examinations where large reductions are possible
  - CT
- May lead to large reductions in the collective dose in exams done frequently or for young patients
  - Chest x-rays
  - Pediatrics