Fluoroscopic X-Ray Equipment
Ionizing Radiation
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Objectives
Participants will be knowledgeable of:
- Biological effects of radiation exposure
- Dosimetry and Occupational Exposure /Limits
- Principles of Time Distance and Shielding
- General Fluoroscopy Guidelines
- Joint Commission requirements for a Sentinel Event for patient skin doses.
- State Regulations

Non Ionizing Radiation
Non Ionizing Radiation - that has enough energy to move atoms in a molecule around or cause them to vibrate, but not enough to remove electrons.
- Sound waves – Radio waves broadcasting
- Visible light – Infrared lamps that keep food warm in restaurants, ultraviolet light
- Microwaves

Ionizing Radiation
Ionizing Radiation has enough energy to remove tightly bound electrons from atoms, thus creating ions.
This is the type of radiation that people usually think of as “radiation.” It breaks the bonds and damages DNA.
- Alpha
  - Uranium-235 mining
  - Radon-220 and methods for processing phosphate ore for fertilizer
- Beta
  - Radioactive iodine, medical imaging, diagnostic and treatment procedures
  - Phosphorus-32
  - Iodine-131
  - Nuclear reactor accident and find its way into the food chain.
  - Industrial gauges and instruments containing concentrated beta-emitting radiation sources can be lost, stolen, or abandoned. If these instruments then enter the scrap metal market, or someone finds one, the sources they contain can expose people to beta emitters.

Gamma Ray - Background Radiation
…is a relatively constant low level radiation from environmental sources such as the earth building materials, cosmic rays, and naturally occurring radionuclides found in the body.
Varies depending on location, altitude and radioactive material in the ground
No known carcinogens effects from background radiation
- NYC = 300 mrem/yr.
- Denver = 500 mrem/yr.
- Grand Central station >500 mRem
- Banana = 0.1 mrem
- Flight from La to London= 5 mrem
- Mountains of South America/Andes -1,000 mrem/year= 1 Rem

AVOIDING RADIATION
Be aware of potential sources of radiation exposure.
Be careful of how you handle nuclear materials.
Be careful of how you handle radioactive waste.
Use proper shielding when necessary.
Be aware of the potential dangers of radiation exposure.
Be careful of how you handle radioactive waste.
Use proper shielding when necessary.
Gamma Rays

- Direct external exposure
- Gamma and x-rays travel through air and penetrate several centimeters in tissue.
- Enough energy to pass through the body, exposing all organs.

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X-Ray Imaging

- Originates from the X-ray tube.
- Beam is travels through the patient.
  - Those parts of the patient that are thick, dense or of high atomic number, absorb more X-rays than surrounding tissues.
- Transmitted through the patient and is changed from a beam to a visible image imaged.

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Scatter

... is secondary radiation emitted from the interaction of x-rays with matter.

Intensity of the scatter depends on:
- The dose rate at the skin of the patient
- The size of the beam hitting the patient
- Your distance from the patient

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Reducing the Dose

- Image Intensifier above patient and close

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Radiation at High Doses

- Eye Cataracts
- Thyroid Cancer
- Breast Cancer
- Sterility
- Skin Erythema
- Leukemia
- Birth Defects in human fetus
- 200 Rad (200,000 mRad)
- 200 Rad
- 100 Rad
- 500 Rad
- 200 Rad
- 100 Rad whole body radiation
- 10 Rad in first trimester
R.S.O.
Radiation Safety Officer

- Any institution that uses radiation for diagnostic and/or therapeutic purposes must name a R.S.O.
- Responsible for the day to day safe use of radiation at the institution/facility.
- All unsafe conditions must be reported to the R.S.O.

OSHA
Training Requirements

Title 10, Part 19, of the Code of Federal Regulations

- All individuals who, in the course of their employment, are likely to receive a dose of more than 100 millirem in a year, must receive adequate training to protect themselves against radiation.
- Right to know the amount of radiation to which they have been exposed.
- Right to ask the NRC to conduct an inspection if they believe their working environment has safety problems.

Annual Occupational Dose Limits

1910.1096 Ionizing Radiation

Every employer shall maintain records of the radiation exposure of all employees for whom personal monitoring is required under paragraph (d) of this section and advise each of his employees of his individual exposure on at least an annual basis.

Every employer is responsible for monitoring ionizing radiation and having a plan and process in place to ensure the monitoring process is followed.

- Whole Body=5,000mrem - Since most radiosensitive organs are protected by the lead apron in fluoro, the EDE is less than 30% of the collar level badge reading.
- Lens= 15,000 mrem
- Extremity=50,000 mrem
- Fetus=500 mrem for the entire gestational period (50 mrem/month)

Personnel Monitoring/Dosimetry

1 Badge - Collar/Chest – worn on collar or chest exposed to radiation
2 Badge system - Waist badge worn under the lead at waist level and collar/chest badge worn on collar or chest exposed to radiation.

This is used for high exposure (EDE calculation) takes into account devices such as protective aprons which allows physicians to continue to work throughout the year and remain below the annual occupational dose limit.

Pregnancy

- Pregnant workers may declare their pregnancy in writing to the Radiation Safety Officer.
- An additional fetal badge will be issued, to be worn at waist level inside the lead apron to monitor fetal exposure.

Personnel Monitoring/Dosimetry

A.L.A.R.A.

“As Low As Reasonably Achievable”

radiation safety principle for minimizing radiation doses and releases of radioactive materials by employing all reasonable methods

ALARA I
- Exceeding 125 mrem/Quarter
- Notify associate

ALARA II
- Exceeding 375 mrem/Quarter
- Notify associate and investigate
General Fluoroscopy Guidelines

- Physicians and Technologists should radiate only when necessary and for a short of time as possible.
- Pulse can be set to produce less than the conventional 30 images/sec.
- Automatic dose rate
- Collimate as much as possible
- Stand as far away as possible
- Wear aprons and glasses
- X-ray tube to skin distance should be kept as large as possible to reduce absorbed close to the patient as well as scatter radiation to the staff. This is accomplished by keeping the image intensifier as close to the patient as possible.
- Only necessary personnel in the room
- Remove hands from the primary beam
- X-ray source under the table for added user safety.

Protective Measures

Time

- Work as quick as possible!

Distance

- Radiation exposure follows the inverse square law:
  - Move twice as far from the source the exposure decreases by 4.
  - Standing 6 feet away from the exam table will significantly decrease your exposure.

Shielding

- Alpha Particles - stopped by a sheet of paper, i.e. Radon, gas seeping up from the ground
- Beta Rays - stopped by a layer of clothing or less than an inch substance, i.e. abandoned industrial instruments
- Gamma Rays - stopped by inches to feet of concrete or an inch of lead, i.e. Most exposure to gamma and beta is direct external exposure.

www.hps.org

Shielding Wear Lead!


**Patient Medical Exposure /Skin Dose**

- No limit on the amount a patient may receive, since all such exposure is medically indicated.
- 1994 - FDA had called attention to the problem of skin burns from fluoroscopy, and recommended methods for minimizing skin dose.
- 2006 - FDA required new fluoroscopy units to monitor patient skin dose.
- 2007, The Joint Commission has deemed a radiation dose to the skin of the patient in excess of 15,000 mGy (=1,500 rad = 15 Gy) from fluoroscopic x rays to constitute a Sentinel Event.

**Patient Skin Dose**

Some states now require:
- Radiologists, Radiation Oncologists, or other physicians to complete a Radiation Safety Awareness training prior to utilizing fluoroscopic systems.
- Established reference levels for FGI procedures.
- Established actions to be taken if reference levels are exceeded.

**Effects of High Skin Doses**

<table>
<thead>
<tr>
<th>Skin Dose</th>
<th>Within 1 month</th>
<th>1 month to 1 year</th>
<th>After 1 year</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 to 2000 mGy</td>
<td>No effect expected</td>
<td>No effect expected</td>
<td>No effect expected</td>
</tr>
<tr>
<td>2,000 to 5,000 mGy</td>
<td>Transient erythema, hair thinning</td>
<td>Hair recovery</td>
<td>No effect expected</td>
</tr>
<tr>
<td>5,000 to 10,000 mGy</td>
<td>Transient erythema, epilation</td>
<td>Recovery, but prolonged erythema at high doses</td>
<td>Recovery, but possible permanent skin changes at high doses</td>
</tr>
<tr>
<td>10,000 to 15,000 mGy</td>
<td>Erythema, epilation, moist desquamation</td>
<td>Permanent epilation, prolonged erythema</td>
<td>Telangiectasia, induction, weakened skin</td>
</tr>
<tr>
<td>&gt; 15,000 mGy</td>
<td>Erythema, epilation, moist desquamation at very high doses</td>
<td>Dermal atrophy, ulceration, dermal necrosis. Destruction of skin/ tissues to ~cm depth. Surgical intervention often required.</td>
<td>Telangiectasia, induction, dermal atrophy, ulceration. Any healing without plastic surgery will lead to scar tissue, weak skin</td>
</tr>
</tbody>
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**Reducing Patient Dose**

Factors that increase the dose:
- 1. Magnification
- 2. Increasing fluoroscopy time
- 3. Multiple procedures
Collimation

... describes how divergent a beam is. Long cones produce better collimated (less divergent) beams. Longer source-to-object distances reduce magnification and increase image sharpness.

Pulsed vs. Continuous Fluoroscopy

Continuous fluoroscopy
- X-ray beam is on continuously as long as the foot pedal is activated
- The image receptor is read and the image on the monitor updated at real-time (~30 fps frames per second)

Pulsed fluoroscopy (may be available)
- X-ray beam is on for short bursts, each lasting ~3 to ~10 msec
- Short burst needed to freeze patient motion
- The rate of these pulses is user-selectable:
  - Real time: ~30 frames per sec (fps), or pulses per sec (pps)
  - Less than real time:
    - 15 fps: ~½ the dose
    - 7.5 fps: ~¼ the dose

- Patient and staff dose may be reduced using pulsed fluoroscopy; however, there is poorer temporal resolution, since the image is not updated as often.

State Regulations Mandatory Training for Fluoroscopy

- Alaska
- California
- Colorado
- Massachusetts
- Oregon
- Rhode Island
- Texas
- Vermont
- Wisconsin

Strategies to Minimize Radiation Dose to Patients

Immediate
- Use proper technique
- Minimize distance between patient and image receptor
- Limit use of electronic magnification

Control fluoroscopy time:
- Limit use to necessary evaluation of moving structures
- Display Last Image Hold to review findings

Control images:
- Limit exposure to essential diagnostic and documentation purposes
- Reduce dose:
  - Reduce field size (collimated and minimum field overlap)
  - Use pulsed fluoroscopy and low frame rate

Optimize dose to patient:
- Include medical physicist in decisions
- Machine selection and maintenance
- Incorporate dose-reduction technologies and dose-measurement devices in equipment

Establish a facility quality improvement program that includes an appropriate ray-elimination quality assurance program, commonly by a medical physicist, which includes equipment evaluation/inspection or appropriate intervals.

Long-term

- Guidelines for Patient Radiation Dose Management (Journal of Vascular and Interventional Radiology, 2009)

Summary

Follow General Fluoroscopy Guidelines and utilize Time Distance and Shielding to protect you and your patients!

It is your responsibility!
Educational Opportunities

American Society of Radiological Technologists
www.asrt.org

State mandated have online courses available

References


www.astaritaassociates.com/

http://www.hps.org

www.osha.gov

OSHA: Occupational Safety and Health Standards. Toxic and Hazardous Substances. 1910.1496 Ionizing radiation. Occupational Radiation Protection in Interventional Radiology; A Joint Guideline of the Cardiovascular and Interventional Radiology Society of Europe and the Society of Interventional Radiology. Donald L. Miller, MD, Eliseo Vañó, PhD, Gabriel Bartal, MD, Stephen Balter, PhD, Robert Dixon, MD, Renato Padovani, PhD, Beth Schueler, PhD, Joel P. Cassady, MD, and Thierry de Baère, MD.


http://www.e-radiography.net/radsafety/reducing_exposure.htm


