MRAD 254: Fluoroscopic Imaging

Outcome: 7

Minimizing Dose

MRT Program

Objectives

7.1) Define the use of pulsed images and last image hold

7.2) Indicate the exposure concepts used in fluoroscopy

7.3) Discuss the rule regarding excessive use of time in obtaining an image

7.4) Describe the ways in which positioning can be used to decrease patient dose

7.5) State the purpose and benefits of automatic brightness control (ABC)

7.6) Identify rules of fluoroscopic equipment use

7.7) Describe the effect that magnification has on dose

7.8) Explain the optimum operation of an image intensifier (II) as it relates to safety

Why Does it Matter?

- Why do we care about minimizing radiation doses?
- Even if it helps us diagnose (or cure) disease, it can still harm us in large amounts

Effects of Radiation - Stochastic

- Effects that occur by chance
- Cancer and hereditary genetic changes are the prime examples
- There is no threshold for these effects
- Can happen at any level of radiation exposure, but the probability increases as the dose does
- The severity of the effects does not change with the dose level
    - You either get cancer, or you don't

Effects of Radiation – Non-Stochastic

- There is a firm threshold for these effects
  - They will be no examples of (X effect) below (Y amount) of radiation

- Threshold effects
  - Cataracts
  - Skin erythema (redness)
  - Desquamation (skin sloughing)
  - Epilation (hair loss)
  - Sterility (temporary or permanent)



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Dosages in Radiology

- Normally only worry about stochastic effects in X-ray
  - Diagnostic doses aren't high enough to reach the threshold for other effects
- Fluoro does have the potential to reach these thresholds if care is not taken
- Lengthy procedures where the beam is aimed at one location for a long time
  - Not UGI's or joint injections
  - Pacemaker insertions or interventional procedures like angiograms (you'll learn about these next semester)

Who Gets the Dose?

- Everyone in the room!
- The patient
- The doctor
- Techs
- Other staff
  - Nurses, residents, anesthesiologists, etc

How Do We Reduce the Dose?

- Dose reduction methods have been built into the equipment itself over the years
- The technologist and radiologist have a tremendous amount of control over the dose received

Built In – Image Intensifier

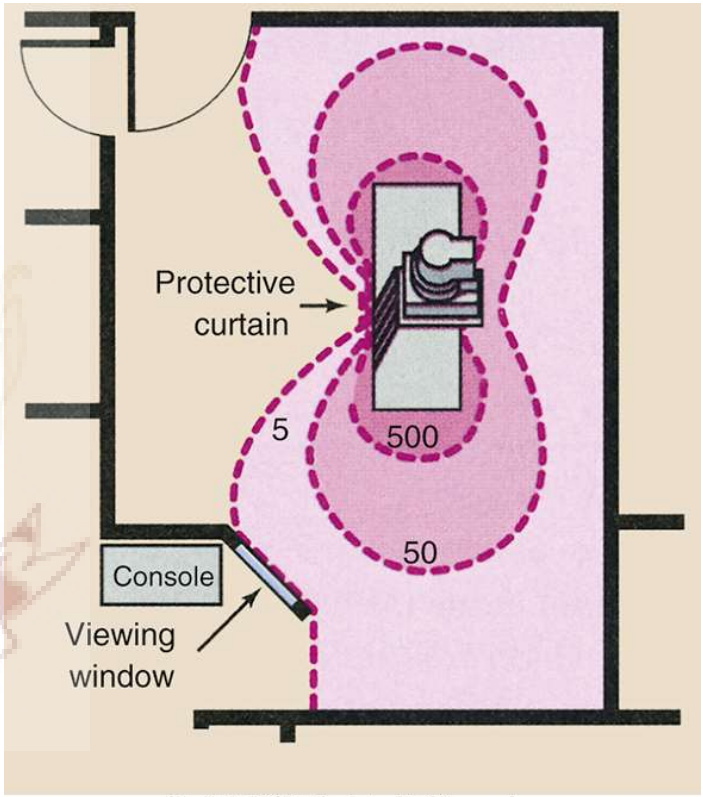
- Before the II was created, the radiologist had to stand directly in front of the screen to see the image
- Image only visible as long as the beam was on
  - Had to be on for a long time to make a diagnosis
- Even before digital systems, the II increased the distance that the rad could stand
  - Monitors have made this even more true!
- Less mA was required to make the image bright enough to be seen

Built In – Inherent Filtration

- Fluoro tubes are built with aluminum filtration permanently in the path of the beam.
- Filters out the weak photons that only increase dose without contributing to diagnosis
- Minimum of 2.5mm AL is required
- 3mm is preferred
  - Dose drops by 25% with 3mm AL
- When you include the II housing, you usually get between 3 - 4.5mm AL

Built In – Lead Curtains

- Under-couch fluoro systems have a lead curtain on the II
  - Cannot be done for Over-couch systems
- Stops scatter from the patient reaching the radiologist (or anyone else standing there)
- Must be at least 0.25mm pb equivalency

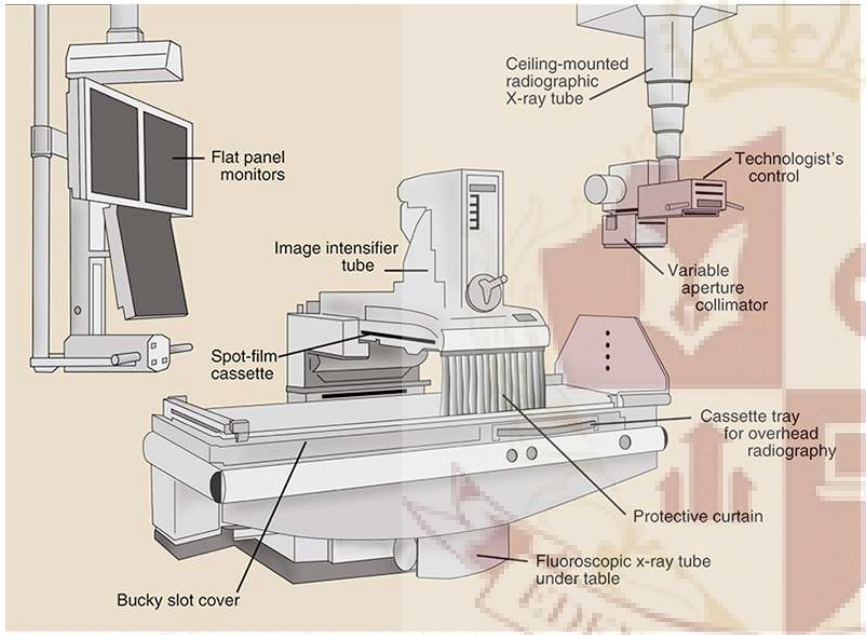


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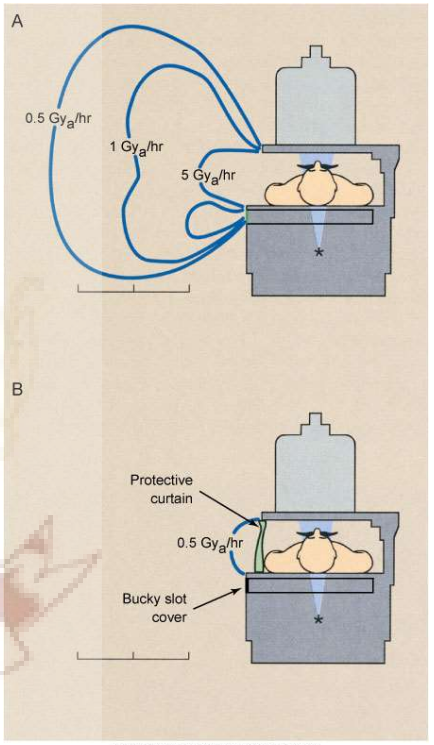
Built In – Bucky Slot Cover

- Some tables have a movable cassette/detector holder for use with a separate radiographic tube
- There is a large gap when this holder is at the bottom of the bed
- Adding a lead strip to this gap lessens dose considerably

Bucky Slot Cover



From Bushong SC: *Radiologic Science for Technologists: Physics, Biology and Protection*, ed 10, St. Louis, 2013, Elsevier.



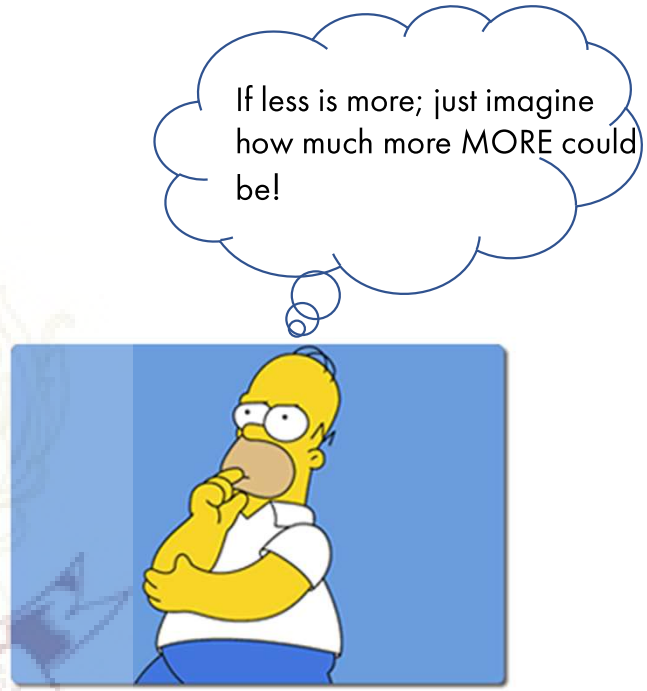
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Built In - ABC

- Automatic Brightness Control allows the image to stay at a constant brightness, even when moving over areas of different thickness
- When over an area of thicker tissue, the ABC cell will read the decreased number of electron moving through the II and will increase mA to compensate
- Increases dose
- But wait?! If it increases dose, how can it also decrease dose?

ABC cont.

- People tend to vastly overestimate how much they need to increase exposure factors
- The ABC increases the mA just enough to achieve the desired effect
- Less dose in the long run



Built In – Last Image Hold

- When you remove your finger or foot from the fluoro switch, the last image obtained stays on the monitor
- Lets you (or the rad/surgeon) stand there and look at an image without having to constantly fluoro
- Modern equipment lets you save this image
  - Saves taking an exposure if LIH will do
  - Common in pain management procedures

Built In – Fluoro Switch

- All fluoro switch must be "dead man" switches
- Stops the beam as soon as the switch is no longer depressed
- Prevents accidentally leaving the beam on if you leave or are incapacitated
  - Unless you fall on the switch. I can't help you there....

Built In – Audible Sound

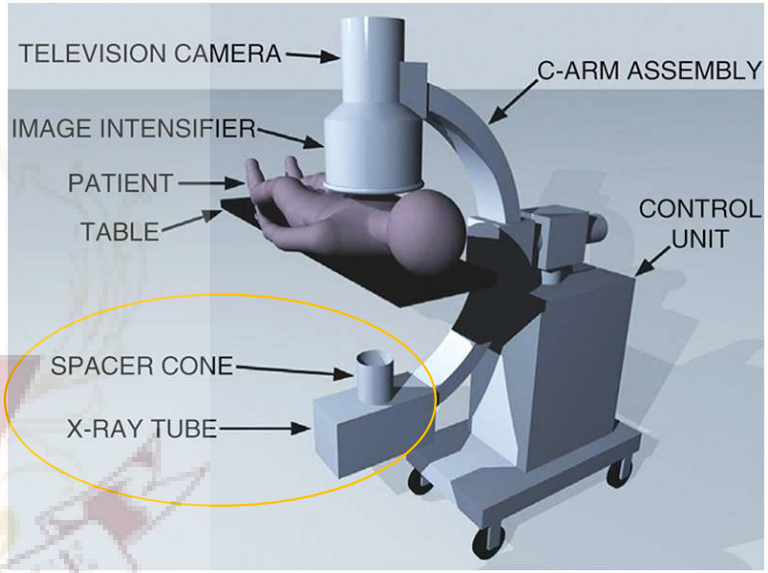
- Audible beeping when the beam is on
- Makes it difficult to forget that you're using fluoro when it won't stop beeping at you

Built In – Cumulative Timer/Time Alarm

- Counts how long the beam has been on
- Resettable
  - Often the equipment will do this itself between cases
- Loud alarm when 5 minutes of "beam on" time has been reached.
  - Forces you to hit a button to restart fluoro or turn off alarm
  - Reminds the operator that they are using a lot of radiation
  - Rarely reached in standard cases, but common in complex surgeries, interventional cases, or pacemaker insertions
- Thorough time logs are kept
  - This is what I'm referring to when I tell you to record the fluoro time in the patient's chart

Built In – Maintaining SSD

- Minimum Source to Skin Distance
  - 38cm (15 inches) for fixed units
  - 30cm (12 inches) for mobile C-arms
- Larger SSD means less dose because the weak photons dissipate before they reach the patient
- Modern equipment is designed so that it's impossible to go closer than minimum SSD, even if you want to



Courtesy Mark Rzeszotarski.

Built In – Magnification Mode

- Can be a significant source of increased dose
  - Must be used judiciously
  - Formula for dose increase is on the next slide
- Used correctly it can reduce dose
  - Reduces need for repeat exams due to missed small pathology
  - Allows you to "zoom in" on small structures or pathology
- Flat panel detectors are even better!
  - No image intensifier
  - All mag is done digitally so no increased dose

Magnification Factors

- Patient Dose Formula

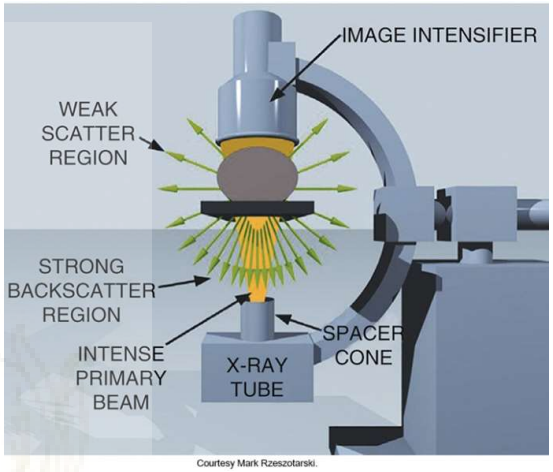
$$\text{Dose} = \frac{(\text{Full Field Diameter})^2}{(\text{Magnification Field})^2}$$

$$= \frac{(25)^2}{(17)^2} = \frac{625}{289}$$

= 2.2 times the dose

Staff Controlled – Patient Position

- Where possible, have the beam come from behind the patient
- Lessens direct dose to breasts, thyroid, retinas, and gonads
- Under couch fluoro is especially good for this
  - Also means that strong scatter is directed towards the ground

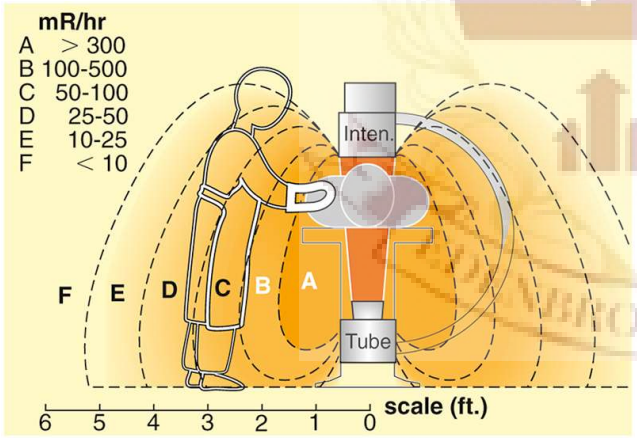


Courtesy Mark Rzeszotarski.

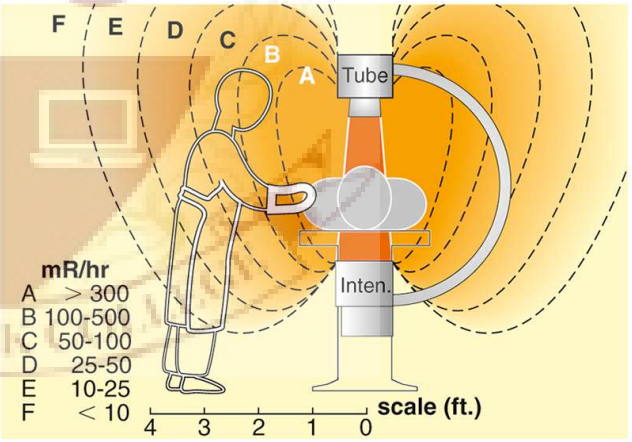

Source: Siemens Healthineers

Staff Controlled – Tube/II Position

- Tube on the bottom and II on the top is safest for the staff in the room
- Strongest scatter is directed towards the operator's midsection
  - Covered by lead



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Adapted from *Technical reference*, Salt Lake City, Utah, 1996, OEC Medical Systems; and Geise RA, Hunter DW: Personnel exposure during fluoroscopy procedures, *Postgrad Radiol* 8:162–173, 1988.

Tube/II Position cont.

- If the beam must be horizontal, the safest place is on the side of the II.
  - Very important for the surgeon because they can't step away
- When possible try to limit the angulation of the fluoro tube
  - Increased angle means more tissue for the beam to travel through. ABC will increase the mA and the patient dose rises
  - Increased mA also means increased scatter in the room so increased dose to the staff
- Image intensifier must be as close as reasonably possible to the patient
  - Ensures the maximum number of X-ray photons leaving the patient make it to the II
  - Too few photons reaching the II means the ABC will increase the mA to compensate

Staff Controlled - Collimation

- Closing the collimation shutters whenever possible
- Decreasing the area being irradiated decreases the dose
- Less matter being irradiated means less scatter to you as well

Collimation and Dose Area Product

- Dose Area Product (DAP) is a measure of how much dose is being delivered to an area of the patient's body
  - Used almost exclusively in fluoro
- Measured in mGy-cm^2
- Formula is:
  - Dose x irradiated area
  - 20mGy x 100cm^2 = 2000 mGy-cm^2
- Even if the beam strength is not increased, if you increase the field size, you have more dose. DAP measures this

Staff Controlled – Primary Barriers

- All staff in the room must wear lead aprons
- Aprons must be at least 0.25mm pb equivalency
  - 0.5mm is preferred
- The full wraparound is preferred for fluoro over the apron "half-lead".
  - Allows staff to turn their back to the beam if necessary
  - Protects against any scatter bouncing off objects behind them
  - To keep weight manageable, these aprons are made with 0.25mm pbE. When overlapped in the front they provide 0.5mm pbE
- Must be stored properly
  - Do not drop or fold or the lead inside may crack
  - Hang on designated racks

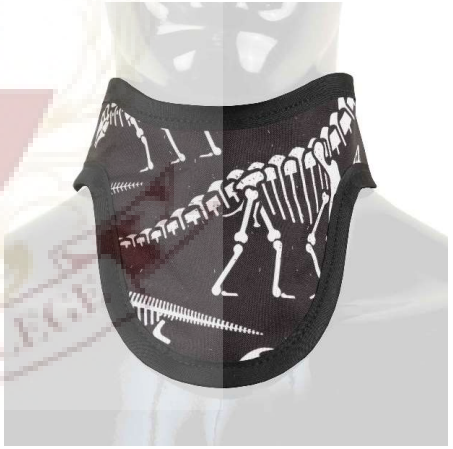
Lead Accessories



https://www.infabcorp.com/product/full-coat-wrap-apron-lead-apron

- Full wraparound lead
- Available in many styles and colours

- Thyroid collar
- Come in 0.25-1mm pbE



https://www.infabcorp.com/product/full-coat-wrap-apron-lead-apron/

Lead Accessories cont.



https://www.infabcorp.com/product/incredibles-medical-safety-glasses/

- Lead glasses
- 0.75 pbE
- Come in many styles
- Can be made with prescription lenses
- As essential as an apron for full time fluoro staff

- Lead gloves
- 0.5mm pbE
- Used if you will be reaching near the field



https://www.infabcorp.com/product/revolution-maxi-lead-gloves/

Staff Controlled – Personal Dosimeter

- Wear your personal dosimeter
- Sounds silly, but we can't know how much dose you're getting unless you wear it!

- If you have a reason to think your hands will get close to the primary beam often, you can get a ring dosimeter
  - Common for radiologists doing injections

Staff Controlled - Distance

- The inverse square law applies here
  - $\frac{I_1}{I_2} = \frac{(D_2)^2}{(D_1)^2}$
- If you double the distance from the beam your dose is ¼ the intensity
  - 3x the distance = 1/9 the intensity
  - 4x the distance = 1/16 the intensity
- The difference between standing 1m away from the patient or standing 4 meters away is dramatic
  - If 1m = 1 mGy, 4m = 0.063 mGy
- The most effective way to reduce occupational exposure
- Step back when you don't have to be right near the patient
- If you can use a corded fluoro switch or pedal, do so

Staff Controlled - Time

- The less time the beam is on, the less dose to everyone
  - Seems obvious, but can be tricky in practice
- When doing a series of images (ie an upright swallow for a UGI), set your frames/second as low as possible
- When doing live fluoro pulse the beam on and off (not to be confused with pulse progressive fluoro)
- Avoid repeated radiographic strength exposures if live fluoro or LIH will do

Staff Controlled – High Level Fluoro

- Some units have a "High Level Fluoro" setting
- Increased exposure factors and pulse rate for live fluoro
- Shows structures that can be difficult to see on standard fluoro
- Common in interventional radiology where you need to see small blood vessels
- Pretty much doubles the dose
- Must be used with caution
  - 30 minutes of fluoro time on the same spot is enough to cause redness of the skin (erythema)
  - Takes up to 10 days to manifest, so you won't even know you have reached that point
  - Watch your fluoro time readout!

Quality Control

- Malfunctioning equipment can cause increased dose
- Some tests that must be done regularly to ensure proper function:
- Exposure linearity
  - Tests for constant radiation output at various mA and exposure times
  - Need to know that by bumping your mA 1 station, you're actually getting a predictable increase in X-ray photons produced
  - Must be within 10% of adjacent mA stations

Quality control cont.

- Exposure reproducibility
  - Tests sequential exposures
  - Makes sure that every time you set a specific technique, that's the technique that is exposed
  - Should be within 5% of each other

- Apparel testing
  - Check all lead aprons, thyroid shields, lap aprons, and gloves for tears, holes, or cracks
  - Use live fluoro to check
  - Done yearly
  - Replace as needed

Summary – ↓ Occupational Dose

- Reduce tech time in the room (rotate schedules)
- Wear full lead protection or use mobile shields
- Stand as far away as possible and keep hands out of the beam
- Keep II above the table when possible
- If the beam is horizontal, stay by the II
  - More useful for the radiologist or surgeon who cannot step away
- Use live fluoro and LIH instead of exposures
- Reduce "beam on" time as much as possible by only using fluoro when necessary

Summary - ↓ Patient Dose

- Maximize the distance between the tube and Pt
- Minimize the distance between the Pt and the II
- Limit magnification mode
- Limit “beam on” time
- Use a low frame rate when exposing
- Use Live fluoro and LIH where possible
- Collimate the field size
- Document the fluoro time
- Provide dose report image if generated by your equipment