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Radiation Safety FactFinder

Committed to providing helpful information to International Spine Intervention Society members about key patient safety issues, the Society's Patient Safety Committee has developed a FactFinder series. FactFinders will explore and debunk myths surrounding patient safety issues. The intent of this FactFinder is to address radiation safety in fluoroscopic procedures.

Myth #1: Regular dose fluoroscopy is preferred over low dose fluoroscopy for spinal procedures.

Fact: Low dose is usually adequate for visualization during spinal procedures and reduces radiation exposure to patients and providers. Selecting the most appropriate imaging mode is an important skill to minimize radiation exposure.

Low dose fluoroscopy minimizes radiation exposure to providers and patients, and in most cases, provides adequate visualization for safe injection procedures. In the United States, according to the National Council on Radiation Protection and Measurement (NCRP), radiation exposure should be kept "as low as reasonably achievable" (ALARA). The recommended effective dose limit per year for medical staff is 50 milliSievert (mSv) or 5000 millirems (mrem) (See "Terminology" below).[1] For carcinogenesis to become a probability with exposure to the extremities and other small areas, larger doses are required and additional limits were added. The recommended annual equivalent dose limits are 150 mSv (15000 mrems) for eye lens and 500 mSv (50000 mrems) for skin and extremities.[1]

Adjustments to imaging mode can further reduce radiation exposure. Using pulsed imaging will reduce exposure at lower frame rates (*i.e.* eight frames per second for pulsed imaging compared to 30 frames per second for continuous imaging). Many physicians have been instructed to "think with the foot off the pedal", a phrase used to guide providers to minimize fluoroscopy time, and thus, radiation exposure. Collimation can also greatly reduce scatter and focus the beam for better image quality. [1]

Although lateral projection, image magnification, high dose, cine mode and digital subtraction increase radiation exposure, they should be used as is necessary for a safe procedure. [1]

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Terminology[1]

Stochastic effects: Increased likelihood of effects with increased exposure. It increases the probability of developing a problem but not necessarily the severity of that problem (*i.e.* genetic mutations, cancer).
Deterministic effects: Increased severity of effects due to cumulative dose. They have a predictable threshold and cause effects that worsen with increased dosage (*i.e.* skin burns, cataracts)
Absorbed dose: Energy per unit mass = 1 gray (Gy)= 100 rads
Equivalent dose: Average dose x radiation quality = 1 Sievert (Sv) = 100 rem
Effective dose: Sum of equivalent doses to organs and tissues exposed, each multiplied by the appropriate tissue quality

Relative Values[2]

620 millirem per year = The US national average of natural, unavoidable (often referred to as background) radiation dose to each of us (228 of that is estimated to come from radon exposure).
300 millirem per year = The average dose received from all medical exposures. This is a six-fold increase in average medical exposures over the past 25 years. Half of the average background medical exposure (147 mrem) is from computed tomography (CT).
5000 millirem per year = The occupational dose limit to a radiation worker.
100 millirem per year = The established dose limit to a member of the public from non-medical or dental X-ray sources (such as airport X-ray machines).
*There is NO LIMIT for exposure to properly prescribed diagnostic and therapeutic sources for a patient. These exposures can be whatever is necessary based on the patient's medical and dental needs.

Typical Exposure Values[2]

Dental bitewing (3 inch diameter area)
- 300 millirem -- film
- 90 millirem -- digital radiography
- 140 millirem -- computed radiography

Chest X-ray 20 millirem (14 x 17 inch area)
Abdominal film 300 millirem (14 x 17)
Lumbar spine 350 millirem (14 x 17)
Extremity X-ray 30 millirem (8 x 10)
Skull X-ray 100 millirem (8 x 10)
Breast (mammogram) 175 millirads (glandular tissue dose)

Myth #2: If my staff is just running into the procedure room for a moment, they do not need to wear protective shielding.

Fact: Within the United States, restrictions do not allow anyone to be in a fluoroscopy suite without shielding.[2]

Dosimetry badges and lead aprons (0.5 mm lead equivalent) are mandatory for exposed staff. Monthly dosimetry badge testing must be completed to monitor exposure. Thyroid shields, lead equivalent eye glasses, leaded gloves, and upright, mobile leaded protective barriers can be used to further decrease a provider's radiation exposure.[2]

In the United States, exact shielding regulations vary from state to state regarding protective garments such as lead aprons. A list of contacts for each state radiation control program can be found at the Conference of Radiation Control Program Directors website. Details and thickness requirements vary from state to state, and most do not dictate testing intervals of protective garments.[2]

Other United States agencies also enforce inspection of shielding equipment. Due to standards set forth by the Joint Commission, health care organizations are required to perform inspections on medical equipment, including lead aprons. These standards do not dictate inspection frequency, method, or rejection criteria.[2] Typically, a facility will perform an inspection of each apron on an annual basis. Some facilities choose to survey their aprons on a more frequent basis, such as every six months if aprons are heavily used and/or are not always properly stored after use (folded or piled up instead of placed on a hanger).[2]

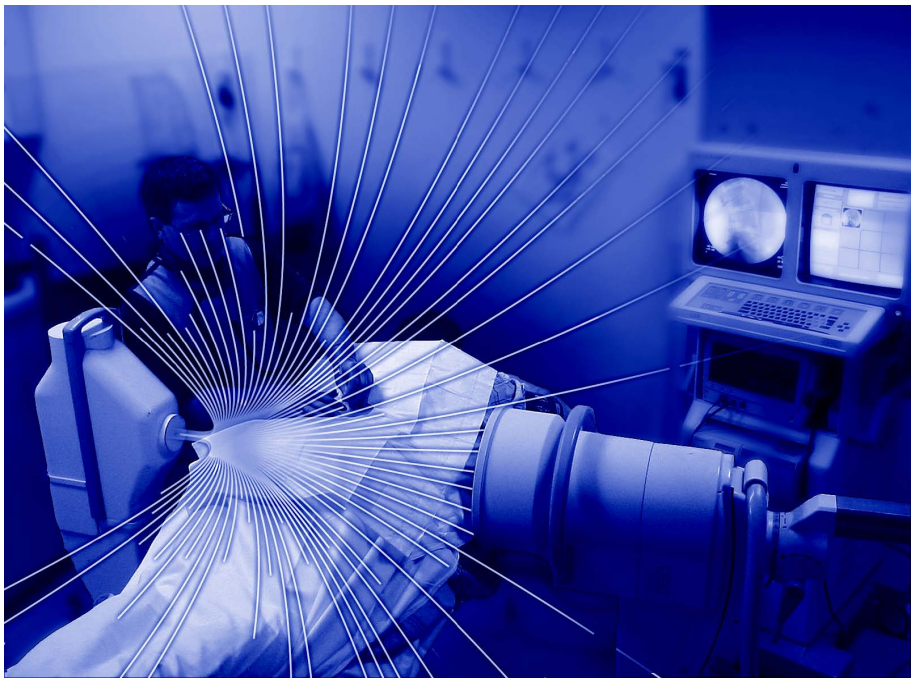
Myth #3: It is acceptable to expose your own hands intermittently.

Fact: The highest rate of exposure is likely to be to the clinicians' hands, which are often kept in close proximity to the X-ray beam and skin entry point. The cumulative effects of high dose exposure to the hands can significantly increase risk to the provider.

Direct exposure of the hands within the beam is associated with exposure rates as high as 4,000 mrem per minute of fluoroscopy.[3] In contrast, Botwin *et al.*,[4] found that by standing back two feet during a lumbar transforaminal epidural steroid injection with an average fluoroscopy time of 15.16 seconds, hand exposure was merely 2.77 mrem per minute. Similar precautions were used during lumbar discography, resulting in an average of 4.03 mrem per minute of exposure during a three-level procedure.[5] Exposure rates due to scatter radiation to the clinician with the hands out of the direct path of the beam and at a distance from the beam's skin entrance point are exponentially less than the exposure rate to hands within the beam.

These findings are supported by the physics. Primary X-ray beams travel in straight but divergent directions as they exit the X-ray tube port and collimator. This divergence increases with distance and the inverse square law can be used to calculate the primary beam exposure. The law states that the intensity of X-ray exposure (X) is inversely proportional to the distance (d) squared: $X=1/d^2$. If the distance from the source is tripled, the exposure is reduced to one-ninth.

To increase distance from the radiation beam, physicians are encouraged to use longer microbore extension tubing during live contrast injection and longer (5-10 cm) surgical instruments to decrease hand dose rate by 25%-45%.[1] Particularly during lateral lumbar imaging, providers should avoid standing close to the beam entry point where the highest doses occur. If possible, stand behind the beam source.



Depiction of beam scatter during lateral projection fluoroscopy.
(Photograph reprinted with permission from: Rittenberg J, Plastaras CT. Radiation Safety for Spine Providers: *SpineLine,* May/June 2006; pp 9-13. © North American Spine Society.)

Leaded gloves do not block radiation exposure if your hands are directly in the beam. In fact, they may increase the exposure due to automatic exposure control on the fluoroscopy unit.

Myth #4: If a patient who has a fluoroscopic procedure was unknowingly pregnant, the pregnancy must be terminated.

Fact: There is increased risk of leukemia and birth defects due to radiation exposure. 25rem is considered the relative threshold for pregnancy termination.[6]

There is not an absolute radiation dose that necessitates pregnancy termination. Due to the increased risk of diminished mental capacity and risk of childhood malignancies, 25 rem is the "liberal" threshold for termination. When a patient is discovered to have received a dose of radiation to a fetus, contact your facility's Radiation Safety Officer or a consultant medical radiation physicist for an assessment of the dose and relative risk to the fetus. [6]

References:

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