FLUOROSCOPIC RADIATION MANAGEMENT REVIEW

General

When using fluoroscopic x-ray equipment, there is always a potential for injury to the patient and/or personnel. Improved technology and advances in medicine have increased the chance of injury. Doses to the patient as well as personnel should be kept as low as possible.

Radiation induced injuries to the patient can result from high dose rates and prolonged exposure times. The effect is usually delayed from the time of irradiation and the patient does not feel any sensation of over exposure.
Injury can also result from multiple exposures to the same area.
Various radiation induced effects are listed in the table below, along with the radiation dose needed to produce the effects.

Radiation Effect	Threshold to Produce (rad)	Amount of Fluoro to Produce Effect @ 5 R/min	Amount of Cine to Produce Effect @ 30 R/min	Time to Effect
Transient Erythema	200	0.7 hours	0.1 hours	24 hours
Epilation	300	1.0 hours	0.2 hours	3 weeks
Main Erythema	600	2.0 hours	0.3 hours	10 days
Pericarditis	800	2.7 hours	0.4 hours	> 10 weeks
Dermal Necrosis	1800	6.0 hours	1.0 hours	> 10 weeks

The following picture illustrates the injury to a patient that can be caused by multiple fluoroscopy procedures in a short amount of time.

photos from Thomas B. Shope, PhD

Radiation injury to the practitioner has been documented in cases were the practitioner's hands were repeatedly in the primary beam. No body parts should be in the field of view other than the area of interest on the patient.

Biological effects from radiation exposure are divided into 2 classes.

1. Stochastic effects: include cancer and genetic effects in progeny. Effects could occur at any dose level. The probability of the effect occurring is increased with increasing radiation dose.

2. Deterministic effects: include erythema and epilation. The effects occur after a threshold dose is received. The severity of the effect depends on the dose received. Severity is increased with increasing dose.

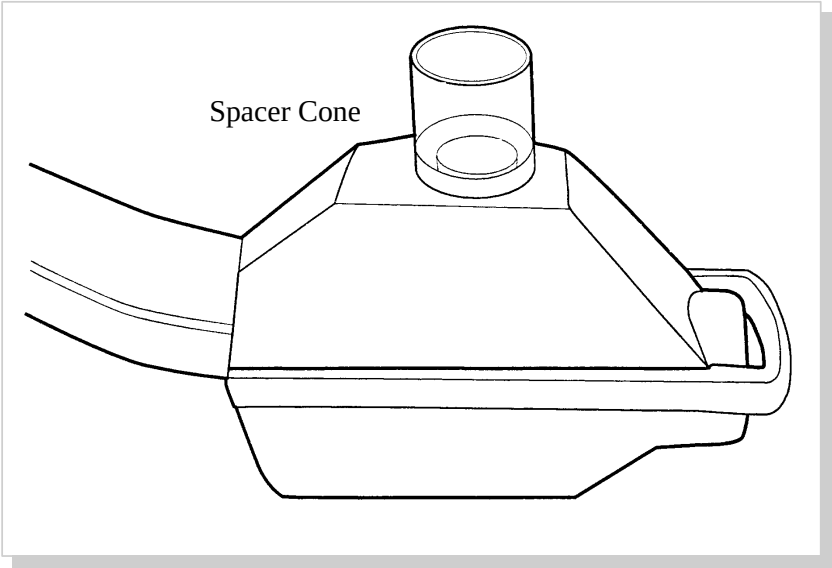
The following ten statements should be kept in mind to reduce the dose to the patient as well as personnel involved in the case:

1. <u>The dose rate is greater and dose accumulates faster in larger patients</u>.
A larger patient decreases the image quality and the unit will compensate by increasing the kVp (penetration) and the mA (intensity of x-rays). Also, the larger the patient, the more scatter x-rays are produced which will increase the dose to personnel.
Fluoroscopic dose rates in the "Normal" mode can range from 1 to 10 R/min (0.01 to 0.1 Gy/min). Dose rates when using "HI" or "Boost" modes usually range from 10 to 20 R/min (0.1 to 0.2 Gy/min). Therefore, for one hour of fluor beam on time, the patient's entrance skin dose is 60 to 600 rads (0.6 to 6.0 Gy) for the normal mode and 600 to 1200 rads (6.0 to 12.0 Gy) for the boost mode.

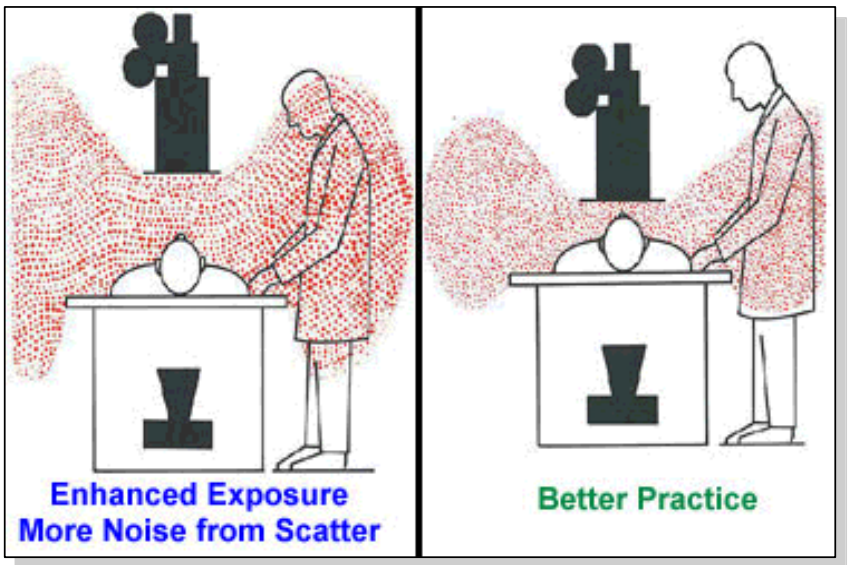
2. <u>Keep the tube current (mA) as low as possible</u>.
The tube current (mA) controls the rate of x-ray production. The higher the mA, the higher the x-ray intensity. If other dose compensating factors are not imposed, increasing the mA will increase the dose to the patient and the dose to personnel.

3. <u>Keep the kVp as high as possible (and mA as low as possible) to achieve the appropriate compromise between image quality and low patient dose</u>.
As the kVp is increases, the penetrability of the x-rays will also increase. By keeping the kVp high and the mA low, the dose rate to the patient and personnel will be lower. High kVp will also decrease image quality and there must be a compromise between image quality and patient dose.

4. <u>Keep the patient at a maximum distance from the x-ray tube</u>.
The dose to the patient's skin is reduced when the patient is moved farther away from the x-ray source. The entrance dose rates can be much higher when using oblique or lateral fluoroscopy than in the AP or PA views. Mobile c-arm fluoroscopic units are equipped with a spacer cone which will limit the minimum separation between the x-ray port and the patient. If the cone is removed for a particular exam, the physician must try to maximize the separation distance and ensure that no part of the patient's body comes in contact with the x-ray port.

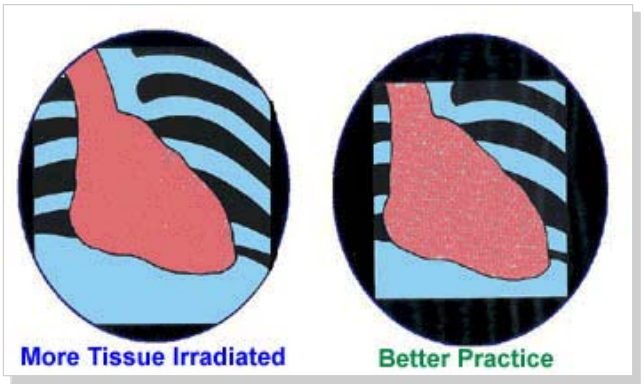


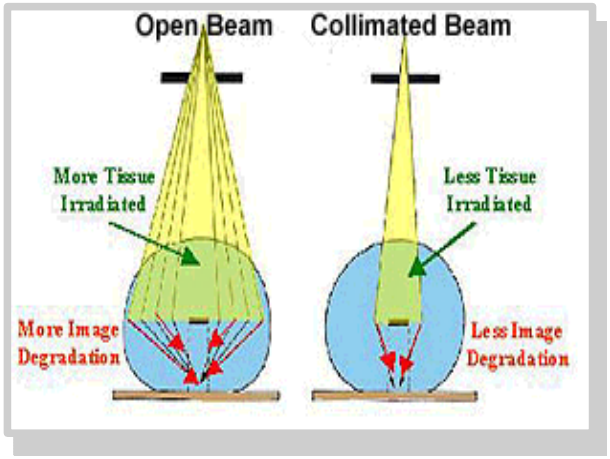
5. <u>Keep the image intensifier as close to the patient as possible</u>.
This will result in a lower dose rate to the patient's skin at the point of entry. The concentration of x-rays at the skin surface where the beam enters the patient will be minimized. If the field is properly collimated, the scatter in the room from the patient is reduced. Also, the image intensifier acts as a shield because it absorbs x-rays that scatter as the beam exits the patient.



6. <u>Do not overuse electronic or geometric magnification</u>.
Many fluoroscopic units allow the choice of electronic magnification modes (14", 12", 9", 6", 4"). As the magnification increases from 14" to 4" modes, the dose rate increases. To use geometric magnification, either the distance between the patient and the image intensifier is increased or the distance between the patient and the x-ray tube is decreased. The dose to the patient will increase with the square of the magnification (double the magnification, increase dose by a factor of four). While image quality improves with magnification, the least magnification necessary for the procedure should be used in addition to proper collimation. As magnification is increased, the dose rate to the personnel in the room may increase or stay the same.

7. <u>If the image quality is not compromised, remove the grid during procedures on small patients or when the image intensifier cannot be placed close to the patient</u>.





The grid removes scatter x-rays from the image intensifier and thereby increases image quality. Some grids are not designed to be removed and should remain in place. The use of a grid will increase the dose to the patient and the dose to personnel. Small patients do not generate much scatter and the grid could be removed for these patients which would reduce the dose rate. If a procedure requires a large distance between the image intensifier and the patient, the amount of scatter radiation reaching the image intensifier will be small.

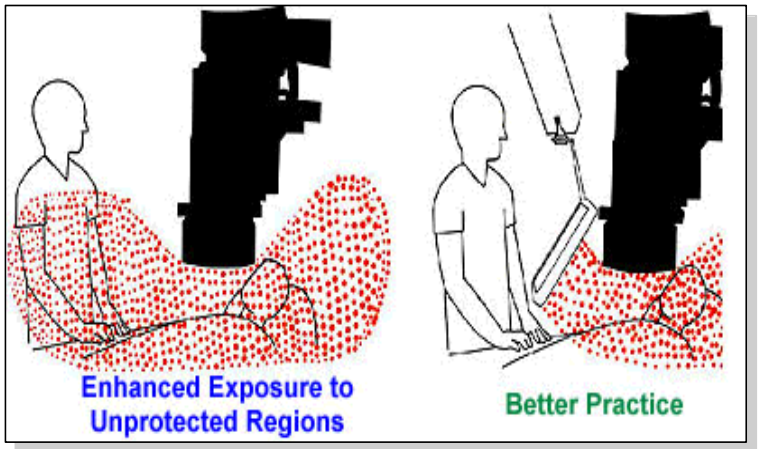
8. <u>Always collimate down to the area of interest</u>.
Collimators define the area in which the x-rays can pass. The collimator blades should be visible at the edge of the field when fully open. By adjusting to the area of interest, the amount of tissue exposed will be minimized. This will also reduce the amount of scatter produced and improve image quality.

9. <u>Personnel must wear protective aprons, use shielding, monitor their doses, and know how to position themselves and the machines for minimum dose</u>.

The main source of exposure to the operator and other personnel in the room is from scatter radiation generated by the patient.

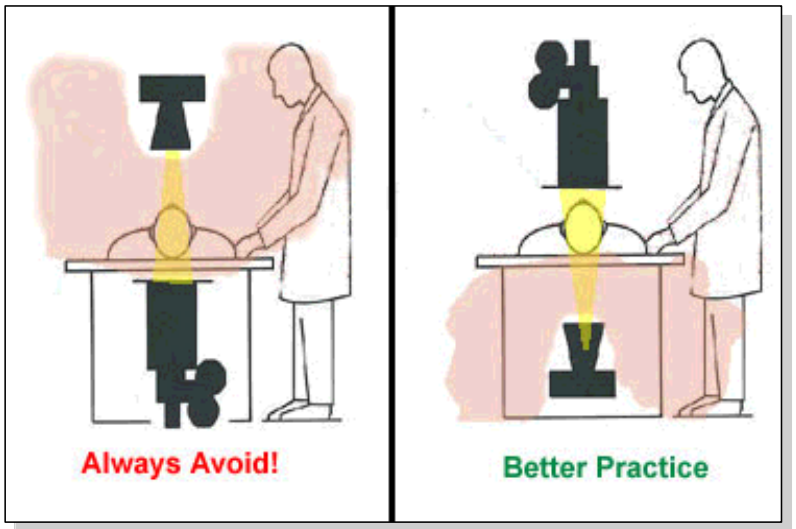
Exposure from scatter radiation can be reduced by the use of shielding and personnel positioning with respect to the patient.

As the distance from the patient is increased, the dose to personnel will decrease.

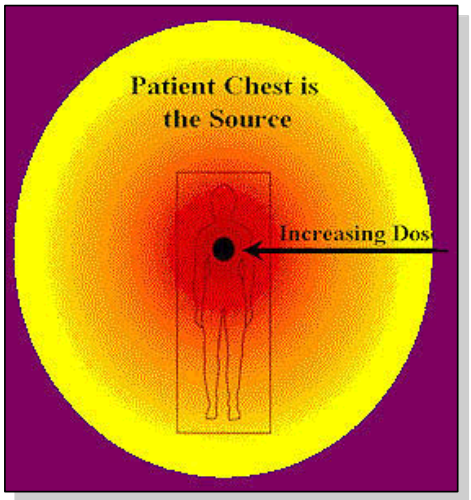


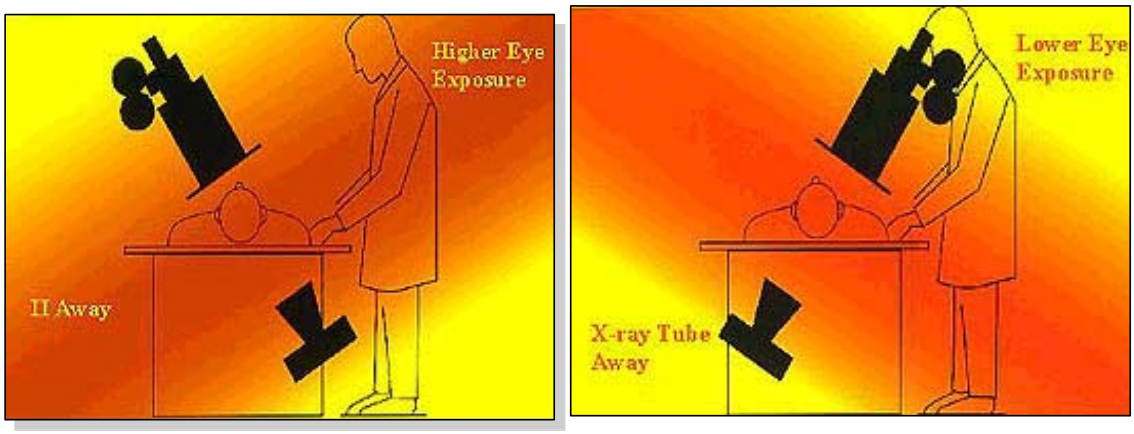
Lead aprons will stop approximately 90-97% of the scatter x-rays. Radiation monitoring devices should be worn at the collar level outside of the apron.

Portable shields mounted from the ceiling or on wheels can be placed between the patient and the operator.



The x-ray tube should be placed underneath the table whenever possible. The majority of x-rays are scattered back towards the x-ray tube. With the x-ray tube above the table, the dose rate is higher at the operator's head and eyes.





When working with a fluoroscopic c-arm unit in the lateral or oblique mode, try to orient oneself on the image intensifier side of the unit. The dose rate on this side is much lower than the x-ray tube side.

10. <u>Keep beam-on time to an absolute minimum</u>.

Minimizing the amount of time that the fluoroscopic unit is on is the most important item in keeping doses as low as possible. The fluoroscopic pedal should be pressed only as needed to quickly view the area of interest. For prolonged viewing of the image, many systems have a last image hold option in which the image can be viewed without the use of x-rays.

Some systems can be operated in a pulsed fluoroscopy mode. Radiation is produced in short pulses within a given time interval. No radiation is produced between pulses. This mode can reduce the dose rates compared to continuous fluoroscopy. (Warning: not all pulsed fluoroscopy units reduce dose rates)

All units are equipped with a five minute timer which allows the operator to keep track of the amount of time that the unit is on. A record of the total amount of fluoroscopic time should be kept for each patient.

<u>References</u>

Wagner, Louis K., Archer, Benjamin R. Minimizing Risks from Fluoroscopic X Rays, third ed. 2000.

Jackson, Alan. Fluoroscopic Radiation Safety Training. Henry Ford Health System