ABC MEDICAL CENTER
Fluoroscopic Privilege Certifying Exam

Physicians performing fluoroscopically guided procedures should be aware of the potential for serious radiation-induced skin injury. Occasionally this is an unavoidable consequence of the time required to perform complex procedures. Some of this, however, can be minimized through a better understanding of how the equipment works and how some operational procedures affect the total skin dose. Following is a summary of desirable techniques to optimize C-Arm use and reduce dose to patient and operator. The attached lecture slides add detail to this discussion and some are referenced in the text.

TUTORIAL

Significant patient dose reduction can be achieved by proper use of the fluoroscopic unit, and many of these dose reduction measures will also produce higher quality images. The most common operator error when using portable C-arm units (where the operator can vary the distance from the x-ray tube to the skin entry point) is to place the x-ray tube too close to the patient skin. Because dose reduction is proportional to the square of the tube-focal-spot-to-skin distance, moving the tube housing closer to the patient can greatly increase the patient skin dose, and will also result in blurring of the image. The image intensifier should be lowered to touch or come as close as practical to the patient's skin to maximize the gap between the x-ray tube and the skin. Even for a fixed fluoro unit (tube fixed under unit's table such that tube to skin distance is fixed) this measure will lower skin dose.

Closing the collimators down to irradiate only the tissue of interest will reduce the area and volume of tissue irradiated, and will improve the image contrast by reducing the amount of radiation which scatters back into the intensified image (slide 13). Magnifying the image by selecting a smaller field size (e.g. 6" vs 9") will markedly increase patient dose, so should only be used when necessary to visualize small objects (slide 24). For those units with selectable kVp and automatic exposure control, raising the kVp of the beam will improve penetrability of the x-rays and markedly lower patient dose at the expense of a small loss in image contrast. Directing the beam through the patient at an oblique angle will markedly raise radiation dose due to increased tissue thickness, which results in automatic higher tube current, while the skin surface is forced closer to the x-ray tube.

Several newer units have the capability of boosting the fluoro output to a higher level for larger patients. Care should be exercised since the dose can increase significantly over normal fluoro (slide 24). Many of these same units can pulse the beam on and off several times per second, sparing patient dose due to turning the beam off between pulses (slide 16). Image processors on newer units make any image flicker from a low frame rate relatively unobjectionable. All newer units also have a "last image hold" feature which leaves the last fluoro image on the screen after the beam is turned off, allowing one to study the image or discuss it with colleagues without the need to keep the radiation beam on. Also, any x-ray unit can have its dose rate lowered by a serviceman at the expense of producing a noisier image. Physicians are generally reluctant to make this compromise, except where the tissue is easily visualized due to large objects with high natural contrast (e.g. bones) or artificial added contrast (barium enema, etc).

Often a procedure will produce as much radiation dose to the skin from associated recorded spot images as from the fluoroscopy portion itself, such as fluoro plus cine in the cardiac catheterization lab, and fluoro plus digital frame acquisitions in radiology interventional special procedures. For these cases the skin dose from each contribution should be added to obtain a total dose. Typical dose rates from all contributions are measured annually by a medical physicist and fluoro outputs are posted on each image intensifier. A log book for recording each fluoroscopy exam is kept for each fluoro unit.

For a given amount of radiation, small children are more sensitive to harmful skin effects than adults. Fortunately, their small size means less radiation is needed, and automatic fluoro units will automatically reduce radiation levels resulting in lower skin doses for the same procedure compared to an adult. There is no difference in skin sensitivity between males and females. The determinant of radiation induced skin injury is the total amount of dose received by skin at the peak exposed location. Varying the entry point of the radiation beam, when practical, will spread the radiation over more skin and reduce the likelihood that any one area will be overexposed. For high radiation dose procedures, radiation induced skin reactions should be included on the list of possible complications on the patient consent forms. Be aware that recent exposures from previous exams can also contribute to the totals and may need consideration.

Radiation induced injuries from fluoroscopy are generally not immediately apparent. Other than the mildest symptoms, such as transient erythema, effects of radiation may not appear until weeks following the exposure, when the fluoroscopist has lost contact with the patient. Early transient erythema occurs after exposure to as little as 200 rads of radiation. It will appear in several hours,

peaks at about 24 hours, and fades in several days. For doses exceeding 600 rads, this will be followed by the main erythema effect which usually appears at 10 days, peaks at 2 weeks, and fades around 4 weeks after irradiation. Permanent depilation will occur at slightly higher doses, around 700 to 800 rads. On equipment with optional high level radiation exposure rate feature, serious effects could occur after 45-60 minutes of exposure, and may have a delayed appearance of about 10 weeks (slide 19). For higher exposures, these injuries can continue to progress to more serious effects many months later. An excellent review of these biologic effects can be found in JVIR 5:71-84, 1994.

The absorbed radiation dose to hospital personnel in the procedure room is directly proportional to the dose the patient receives. At one meter, a physician will absorb about 0.1% of the patient dose due to scatter, and a smaller additional contribution due to leakage through the side of the tube housing. The most common 0.5 mm lead equivalent aprons used by the physician during fluoroscopy attenuate 95% of the scattered radiation to the shielded torso, vs 80% for the lightweight 0.25 mm aprons. After a lead apron, leaded thyroid shields and eyeglasses provide additional protection in descending order. Leaded gloves should be worn if it is necessary to put one's hands near the beam. The maximum allowed effective dose equivalent to the physician's body is 5000 mRem per year (slide 7). For comparison, natural background radiation amounts to about 300 mrem per year (slide 6).

C-Arm positioning greatly influences the amount of scattered radiation affecting the fluoroscopist. Whenever possible, the C-Arm should be positioned with the image intensifier above the patient and the x-ray tube below, directing scatter toward the operator's feet instead of the head, since the highest scatter component is the scatter reflected from the primary beam initial impact on the patient (slide 12). When fluoroing across the patient, the operator should be positioned on the same side of the patient as the image intensifier, not the x-ray tube side. Personnel dosimeters (e.g. film badges) must be worn by persons operating fluoro equipment and medical personnel required to be present within 6 ft of the primary beam during fluoro procedures. The dosimeter must be worn such that it is not shielded by lead aprons or other shields (except in special multi-badge programs).

The certification exam questions are intended to be a learning tool for the physician as well as a measure of acquired knowledge. Please print a copy, fill it out and return it to *John Smith, ABC Medical Center*. When you pass the exam, a certificate of completion will be issued to you, and a record of this successful effort will be sent to the hospital's credentialing office for reference in the next credentialing cycle. If you have any questions, please email *John Smith jsmith@abcmc.org or call 888-555-2222.*