Your link with current trends in radiation dosimetry

C-ARM FLUOROSCOPES: MONITORING AND REDUCING EXPOSURE LEVELS

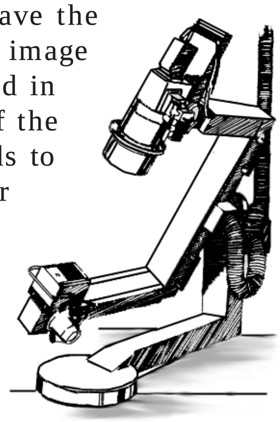
An interview with Mary E. Moore, M.S., Associate Radiological Physicist, Cooper Hospital/University Medical Center, Camden, New Jersey

Nexus: C-arm fluoroscopes seem to have increased in popularity over the past few years. Is personnel monitoring necessary when C-arms are used?

Ms. Moore: Yes. It's been my experience that many C-arm users are unaware of the potential for high exposures from using this equipment. In general, the ways in which the construction and use of C-arms affect exposure levels have not been fully appreciated. Many users are not being properly monitored; without adequate personnel monitors, exposure from daily use of equipment cannot be accurately evaluated.

Nexus: How do C-arms differ from conventional x-ray fluoroscopes?

Ms. Moore: Regular x-ray fluoroscopes have the x-ray tube and image intensifier fixed in one position. If the physician needs to see an organ or catheter from a different angle, the patient must be rotated, which may be unsafe for the patient. A C-arm is an x-ray unit with the support structure shaped like the letter "C" between the x-ray tube and image intensifier. The C-arm permits the physician to rotate and angle the x-ray tube without moving the patient.



Nexus: Where are C-arm fluoroscopes used?

Ms. Moore: C-arms are very effective diagnostic tools used by many medical specialists such as radiologists, surgeons, cardiologists, orthopedists, urologists and gynecologists. As a result, these units are found in radiology departments, operating rooms and cardiac catheterization laboratories. Their flexibility allows the physician to quickly view and monitor the placement of devices such as pacemakers, catheters and prostheses.

Nexus: How do radiation safety procedures differ for C-arm fluoroscopes?

Ms. Moore: Time, distance and shielding are still the three basic guides for safely using radiation. However, there are additional considerations with the C-arm, because of its special construction and use. Under-the-table shielding commonly found on conventional x-ray fluoroscopes may not be feasible on C-arms, particularly if they are portable. Also, it is often difficult for physicians to use distance to reduce their exposure with a C-arm, since they may not be able to perform the study properly unless they stand close to the x-ray tube. As a result, staff exposures often exceed those received during conventional fluoroscopy.

Nexus: What can be done to compensate for these factors?

Ms. Moore: There are several steps that can and should be taken. All users should receive training in C-arm radiation safety procedures and proper imaging techniques. This training should be conducted by a qualified expert, such as a radiologist, radiological physicist or health physicist. Also, appropriate shielding should always be used. For a C-arm, lead aprons, thyroid shields and leaded eye glasses are highly recommended. Wraparound aprons may be necessary for certain types of studies. Additional structural shielding, such as a ceiling-mounted lead acrylic shield and an under-the-table shield, if possible, should also be employed. In performing the study, the fluoroscopy beam-on time and x-ray field size should be reduced as much as possible, and the x-ray beam kept well collimated. Finally, personnel monitors should be used. Prior to patient use, a qualified physicist should measure simulated-skin entrance and exit exposure levels, as well as scattered radiation levels at all occupied locations around the C-arm. When this information is evaluated, the type and number of personnel monitors can be determined.

Nexus: Where should personnel monitors be worn?

Ms. Moore: This question remains a topic of lively debate. Some states have regulations addressing the issue. In addition to complying with those requirements, it is necessary to evaluate how C-arms are used by the different specialists. Generally I recommend that a whole body badge be worn under the lead apron and a second badge be worn outside the thyroid shield. This approach provides the essential protection and monitoring, and also permits evaluation of the effectiveness of the personnel shielding. This can be done by comparing the reading on the outer badge with the reading on the badge worn under the apron. (The effectiveness of the thyroid shield should be the same as that of the apron—assuming both have the same lead content and no defects. This could be verified by wearing both badges underneath their shield for a designated period, then comparing results.)

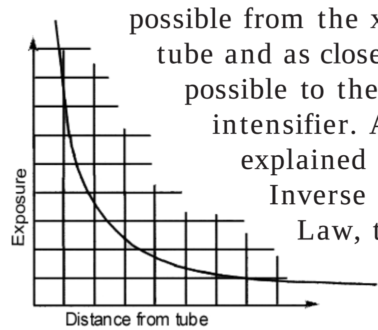
Depending on sterility requirements, a third badge—either a ring badge or a wrist badge—should be worn on the hand closest to the x-ray beam, to monitor extremity exposures. The hand/wrist monitors are important, since it is not uncommon for the physician's hands to be in the primary beam during certain procedures. Also, the hands of the nurse or technologist may be very close to the primary beam while assisting the physician. Because of sterility limitations, the accurate evaluation of extremity exposures is difficult to achieve on a routine, case by case, basis. However, gas sterilization is safe for TLD ring badges, permitting the monitoring of individual studies. In any case, if the badge worn outside the thyroid shield approaches the maximum permissible dose, then extremity exposures should be evaluated.

Also, it should be noted that eye and facial exposure can be monitored more accurately by placing TLDs on the nosepiece of eyeglass frames.

Nexus: How can the patient's exposures be evaluated and reduced?

Ms. Moore: Federal regulations limit the maximum output for C-arms to 10 Roentgens/minute at 12 inches (30cm) from the image intensifier. The thickness of the patient determines the exposure rate: the thicker the patient, the higher the exposure. The exposure rate at a designated distance from the x-ray source for different techniques should be measured by a qualified physicist. However, the distance of the patient from the x-ray tube, the kV, mA, and total fluoroscopy beam-on time must be known for an accurate evaluation. Calibrated TLDs can be placed on the patient to directly measure skin dose from a specific procedure.

Since shielding the patient is not usually possible, time and distance are the two major methods used to reduce exposures. The shorter the fluoro beam-on time, the lower the patient's exposure. Short fluoro times are achieved by the physician using intermittent (rather than continuous) fluoroscopy, and by utilizing the image hold capacity. (Most C-arms now have the capability of storing up to 25 images, which can be recalled for continuous viewing.) In addition to short exposure times, patient exposures can be reduced by positioning the patient as far as possible from the x-ray tube and as close as possible to the image intensifier. As explained by the Inverse Square Law, the patient's exposure increases exponentially the closer he or she is placed to the x-ray tube. For example, assuming a source-to-image distance of 35 inches, an exposure rate of 7 R/minute at 23 inches from the x-ray source would increase to 26 R/minute at 12 inches from the source.



Patient exposure can also be reduced by decreasing the x-ray field size.

Nexus: If you were to condense your message to a single point, what would it be?

Ms. Moore: With C-arms, education is a major factor in properly monitoring and reducing exposure levels for patients and staff. It is essential for all users to receive training in C-arm radiation safety procedures and proper imaging techniques. This training should be conducted by a qualified expert such as a radiologist, radiological physicist or health physicist.

Mary E. Moore, M.S.

Ms. Moore is an Associate Radiological Physicist at Cooper Hospital / University Medical Center, Camden, NJ and Adjunct Assistant Professor of Radiation Science at Rutgers University, New Brunswick, NJ. She is certified in radiological physics by the American Board of Radiology. At Cooper Hospital, she is responsible for developing and evaluating radiation safety programs, teaching radiological physics and radiation protection to the staff, as well as acceptance testing and calibration of new diagnostic imaging equipment. She also conducts research in diagnostic imaging and serves as consultant for several radiology and medical imaging departments on the eastern seaboard.

Her numerous professional affiliations include the Health Physics Society, the International Radiation Protection Association, the American Association of Physicists in Medicine, the Society of Nuclear Medicine, and the Society for Magnetic Resonance Imaging.