Neuromodulation Special Interest Group

American Society of Regional Anesthesia and Pain Medicine

Radiation Safety Part 2

By David Provenzano, MD
President
Pain Diagnostics and Interventional Care
Pittsburgh, PA

Background: Patient and Physician Safety

The foundation for radiation safety is the ALARA Principle (As Low As Reasonably Achievable), described in 1987 by the National Council on Radiation Protection and Measurements (NCRP), which recognizes that there is no magnitude of radiation exposure known to be completely safe for both the patient and physician. The principles of ALARA for radiation safety include: (1) reducing exposure time, (2) increasing the distance from the source of radiation, and (3) shielding. Individuals utilizing fluoroscopy are mainly exposed to secondary radiation (scatter and leakage) as long as their body is outside the primary beam. The major source of scatter radiation is the patient. At 1 meter, the scatter exposure level is approximately 0.1% of the skin entrance exposure.

The primary means to quantify the level of exposure is the monthly radiation dosimeter report which provides information collected from the thermoluminescent dosimeter badges. The dosimeter report provides information on the levels of radiation exposure at different depths. The numbers are compared to recommendations for effective dose equivalent (EDE) limits from the NCRP. Based on their degree of exposure individuals may exceed certain ALARA levels, which triggers warnings and possible procedural recommendations.

Although the degree of risk associated with the use of fluoroscopy is still a heavily debated topic, lifetime radiogenic risk depends on the annual operative load, the years of occupational exposure, and the radiation protection measures employed. In other fields that utilize fluoroscopic imaging, lifetime cancer risks have been estimated. For example, an orthopedic surgeon who practices for 35 years with an annual workload of 50 hip, 50 spine, and 50 kyphoplasty procedures per year has been estimated to have an estimated lifetime excess risk of fatal cancer of 0.75%. Furthermore, it has been documented that when radiation safety measures are not appropriately employed, cancer risk significantly increases. Mastrangelo et al. demonstrated that a population of Italian attending orthopedists in a community hospital with poor radiation protection measures was 5 times more likely to develop cancer than other individuals in the institution utilizing radiographic technology. Although these estimates are hard to calculate and verify, they do emphasize the importance of understanding radiation safety and employing dose-reduction measures. Interventional pain physicians have a responsibility to employ recommend safety measures in order to reduce the risk of radiation exposure to themselves, patients, and assisting staff.

Below are 10 TIPS for reducing radiation exposure through the informed use of dose-controlling strategies.

Best Practices: 10 TIPS to Reduce Radiation Exposure

1. One should stand as far away from the radiation source as possible according to the principal of the inverse square law. Radiation exposure is inversely proportional to the distance squared. For example, if the distance from the source is increased by a factor of 2, radiation exposure decreases by a factor of 4.
2. The two main determinants of image quality are kVp (tube voltage) and mA (tube current). Typical tube currents are 1-5 mA, and tube voltages are 75-125 kVp.
3. The automatic brightness control (ABC) on the fluoroscopy unit adjusts the mA and kVp to enhance image quality (brightness and contrast) while balancing patient safety. If one decides to put the fluoroscopy unit into the manual mode ideally the kVp should be increased prior to increasing the mA. For an equivalent increase in exposure, the mA must be doubled while the kVp would only have to be increased by 15%.
4. Following the technical principles of the ABC adjustments, interventional pain physicians should not place lead-lined gloves in the field of the primary beam. Lead-lined gloves are only utilized to reduce exposure to scatter radiation. Wearing lead-lined gloves with your hands under the primary beam in the ABC mode causes the fluoroscopy machine to produce higher levels of radiation which negates the protective property of the gloves.
5. Understand the relationship between radiation exposure, the x-ray tube, and the image intensifier locations and orientations. It is important to review the isodose curves for each respective C-arm orientation. In the anterior posterior (AP) plane, the radiation source should be below the patient. As one progresses from the AP plane to the oblique plane, radiation exposure increases significantly. Radiation dose exposure is higher on the x-ray tube side. Therefore, when utilizing the lateral orientation (e.g. caudal procedures), it is preferable to stand on the side of the image intensifier. Scatter radiation levels can be 2-3 times lower on the image intensifier side.
6. Skin entrance dose is lowest when there is a small distance between the image intensifier and patient and a large distance between the x-ray tube and patient. The minimal x-ray tube to patient distance should be 30 cm.

7. Limit the fluoroscopy beam time to the absolute minimum. Techniques that assist with limiting fluoroscopy beam time include pulse mode fluoroscopy and last image hold. Avoid continuous fluoroscopy when possible. Although digital subtraction has its place in helping to prevent intravascular injection, it also requires larger aggregate doses of radiation.
8. Utilize collimation via adjustments in the linear and iris collimators to focus solely on the area of interest. This will significantly reduce radiation exposure and improve image quality. The intensity of scatter radiation is a function of exposed field size. Therefore, doubling the field-of-view doubles scatter radiation dose rates.
9. Protective shielding is an important factor in reducing radiation exposure. Examples of personal shielding include lead gowns, thyroid shields, and lead-lined gloves and glasses. Other shielding devices include table-mounted lead flaps, protective scattered guards, and movable lead shields.
10. Lead aprons come in 0.25 mm lead-equivalent thickness, but 0.5 to 1 mm lead-equivalent aprons provide better protection. Lead-lined gloves usually have a lead equivalent of 0.25 mm to allow for dexterity. The thyroid shield should be 0.5 mm lead equivalent. The clinic should have a protocol to test lead-shielding devices periodically for defects.

In conclusion always remember the three cardinal principles of ALARA: 1) increasing distance, 2) decreasing time, and 3) using shielding.

References

1. Hirshfeld JW,Jr, Balter S, Brinker JA, Kern MJ, Klein LW, Lindsay BD, et al. ACCF/AHA/HRS/SCAI clinical competence statement on physician knowledge to optimize patient safety and image quality in fluoroscopically guided invasive cardiovascular procedures: a report of the American College of Cardiology Foundation/American Heart Association/American College of Physicians Task Force on Clinical Competence and Training. Circulation 2005 Feb 1;111(4):511-532.
2. Rathmell JP. Atlas of Image-Guided Intervention. Philadelphia, PA: Lippincott Williams & Wilkins; 2006.
3. Valentin J. Avoidance of radiation injuries from medical interventional procedures. *Ann. ICRP* 2000;30(2):7-67.
4. Mastrangelo G, Fedeli U, Fadda E, Giovanazzi A, Scoizzato L, Saia B. Increased cancer risk among surgeons in an orthopaedic hospital. *Occup Med.* (Lond) 2005 Sep;55(6):498-500.
5. Theocharopoulos N, Perisinakis K, Damilakis J, Papadokostakis G, Hadjipavlou A, Gourtsoyiannis N. Occupational exposure from common fluoroscopic projections used in orthopaedic surgery. *J Bone Joint Surg Am.* 2003 Sep;85-A(9):1698-1703.