
Volume 11 - Issue 2, 2011 - Cover Story: A Primer on Radiation Protection: Patient & Personnel Safety in Focus

Radiation Safety and the International Radiologist

Developments in the applications for minimally invasive interventional procedures carry a parallel increase in the use of fluoroscopy and CT, both of which are associated with potentially excessive radiation exposure to patients and personnel. Interventional radiologists (IRs) use image guidance in each and every intervention. Most of the image guidance systems are based on ionising radiation, mainly fluoroscopy. IRs of all generations are thus natural leaders in the responsible use of radiation-based imaging tools. Here we explain some of the guiding principles fundamental to patient and personnel health protection.

IRs wield a double-edged sword in terms of ionising radiation, using it for imaging on one hand and for image guidance on another. IRs perform the whole spectrum of interventional procedures, comprising both vascular and nonvascular. Moreover IRs use imaging tools of all kinds. For example, ultrasound allows us to see virtually any access procedure and has become a must in IR labs. MR guidance is evolving for various interventions, especially in oncologic patients. CT-guided interventions are widely used and CT fluoroscopy with real time CT imaging is evolving. Patient and staff radiation protection are very much connected, as the main source of personnel exposure is the patient. In fluoroscopic image-guided interventions we are talking about intelligent dose management and not merely protection. We need a technology that will really reduce exposure, not just measure and record it.

Personnel radiation protection is very complex and comprises passive and active tools. Passive radiation protection represents the means provided with and by the angiography system. Passive protection tools are operator independent and must be applied in daily practice. Active radiation protection is about our behaviour and responsibility. Image-guided interventionists are obliged to be protected from ionising radiation using any available passive means, dose reduction methods, and by behavioral adjustment to the hostile setting of the angiography room. The active methods allow proper performance of the interventional procedures with the lowest radiation exposure possible for patients and staff.

Who Oversees Radiation Protection?

As a rule, the hospital authorities and governmental bodies control patient and personnel protection. It is mandatory that heads of IR services and heads of medical imaging departments carry an absolute responsibility to proper patient and staff dose management based on the ALARA (As Low As Reasonably Achievable) principles and the latest guidelines.

Recently, two joint guidelines emerged from both sides of the Atlantic: one for patient protection and another on personnel protection, published by the North American Society of Interventional Radiology (SIR) and the Cardiovascular Interventional Radiology Society of Europe (CIRSE) in both societies' journals (JVIR and CVIR). These guidelines provide a comprehensive overview that comprises detailed instructions on why and how to protect patients and IRs from occupational exposure. These should become an integral part of any IR fellowship programme as well as routine practice in IR labs.

Other Image-Guided Interventionalists & Irs Apply Same Guidelines

Since many non-radiologists (e.g. cardiologists, vascular surgeons) routinely practice endovascular interventions we have to make clear that the same basic principles of dose management apply to all parties involved. The difference is usually in the set-up. IRs perform interventions in dedicated rooms with dedicated equipment that includes a large image receptor as well as protective tools. Cardiologists use dedicated cardiac angiography systems with smaller size image receptors. In many hospitals, vascular surgeons perform combined surgical and endovascular interventions in the operating rooms using mobile C-arm fluoroscopy systems without any protective tools on the equipment.

Mobile C-arm fluoroscopy is widely used in operating rooms, but recently there is a "new kid in town", the hybrid room. This is a complete and very powerful angiography system used for complex procedures that comprise simultaneously open and endovascular techniques during same intervention on the same operating table. These rooms represent a real challenge for staff protection, as too many people are involved at the same time and the protective means are available in the best scenario only on one side of the operating table.

Rotational angiography with cone beam CT capabilities is available and is utilised extensively in neuro-interventions, oncologic interventions and in bleeding patients. Image acquisition in rotational angiography has a wide range of geometry and consequently significantly limits patient and staff protection and is difficult to validate.

Utilisation of pre-procedural noninvasive imaging, when applicable, saves valuable time in the IR room and reduces possible complications from diagnostic angiography. CT angiography (CTA) almost instantly provides an accurate diagnosis, an access map and a measurement tool in most cases. It is noninvasive and saves time as well as patient and personnel exposure. MR angiography (MRA) should be the preferred option when possible. The IR has to read CTA and MRA studies her/himself. It is also highly recommended to install and routinely use a dedicated PACS monitor in the IR lab for real time viewing and if possible processing the studies directly from the PACS system.

In our department we've found such a set-up extremely useful in daily practice. Such an attitude is invaluable in emergency set-ups, especially in bleeding trauma patients. CTA is more sensitive than angiography in location of the bleeding and can show the extraluminal pathology as well.

Basic Principles of Patient Protection

The following basic principles of proper radiation management of patients should be routinely used in any IR practice:

1. Obtain a thorough medical history to determine if the patient has had any previous radiation related procedures such as:
 - Radiation therapy
 - Previous fluoroscopically-guided interventional procedure
2. If a previous radiation history exists:
 - Examine the patient for signs of skin changes related to radiation exposure
 - Avoid further irradiation of any such area, if possible
3. Consider including the potential for skin injury in informed consent:
 - Essential for a large patient,
 - If the procedure could be prolonged
 - Counsel the patient about these and other risk patient specific factors (i.e. weakened skin from previous procedure, obesity, collagen vascular disease or diabetes)
 - Ask the patients to examine themselves for several weeks for any skin changes or hair loss at the area of beam entry and to report any changes to you.
4. Review the patient's medical history for conditions that might increase radiation sensitivity.

Medical Simulators

One of the most challenging issues in radiation protection is adequate training depending on the level of dose associated with the procedures practiced. As most staff exposure is linked with scatter from the patient, the experienced operator will require the shortest fluoroscopy time with a smaller dose. Medical simulators are aimed at improving IR skills using IR lab equipment. Simulators proved to be an efficient and safe educating tool for fellows in training as they rehearse in a complete IR lab environment with no radiation and no possible complication. They provide tactile sensations of guidewires, balloons, stents, embolisation coils and more; as well as simulation and display of relevant fluoroscopic images with Cine, DSA and C-arm operation. Virtual reality endoluminal simulators create an interventional environment and are expected to significantly improve our skills and reduce complication rates and radiation exposure of patients and personnel.

Future Trends

- Real time dosimetry of the operator;
- Medical simulation training of staff;
- Routine planning of interventions using noninvasive imaging, and
- Dose management measures to become an integral part of every procedure.

Conclusions

Important variations in patient and staff dose values take place in IR suites. This very new technology is not a guarantee of low radiation risk. The image-guided interventionist has to have a deep knowledge of x-ray systems and good training in dose management. IRs have to be aware of the efficacy of the different passive and active RP methods and tools, as well as typical exposures for the available operational modes.

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