Radiation Safety: How Do You Protect Yourself?

Practical tips related to imaging system settings, radiation protective equipment, and measures to reduce scatter radiation.

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Over the last 3 decades, fluoroscopy-guided endovascular interventions have been increasingly performed in number and complexity. In the beginning, the dangers of working with ionizing radiation were underestimated, and the pioneers of endovascular procedures had developed lens injuries and even malignant tumors. Thus, per-procedural exposure of the operative staff to protracted low-dose radiation throughout their entire career has become one of the main concerns.[1,2]

Physicians' exposure to radiation derives from scatter radiation from the patient, linked to x-rays reflected in the opposite direction than the main beam. Scatter is higher when close to the source and when elevated doses are used. The effects (deterministic and stochastic) are cumulative and permanent.[3]

The cumulative radiation dose produced and absorbed by the team per procedure can vary greatly (up to 80%), depending on the operator's expertise and awareness of radiation use, the imaging system, and the dose settings.[2,4] Thus, an appropriate operative practice and some general precautions are pivotal.

IMAGING SETTINGS AND PREOPERATIVE PLANNING

Clinicians using radiation should familiarize themselves with the regulations governing their jurisdiction. It is advisable to work with a flat-panel detector over an image intensifier because it achieves a higher level of radiographic performance, as well as with a floating table that simplifies positional changes, which diminishes the need for fluoroscopic adjustments. Complete operator-controlled imaging from tableside also contributes to decreased radiation exposure, as well as a large display monitor properly positioned in front of the operator, which minimizes the need for magnification. An automated contrast injector allows the staff to get out of the room during digital subtraction angiography (DSA) and decreases the need for multiple shots.[2,5,6]

It is of utmost importance to adjust the settings of the system to work by default with a low-dose mode and a pulsed mode (≤ 7.5 frames/sec) to reduce radiation exposure. Modern hybrid rooms have high-powered fluoroscopic units that can be associated with high radiation exposure for both the patient and staff if their settings and workflows are not optimized. Physicians should therefore adjust the expected image quality to their daily practice and needs, with the help of the manufacturer, to systematically start a procedure with the lowest settings for a sufficient image quality to perform the procedure safely. The ability to upgrade these settings from tableside, when necessary, must be available. Additionally, the routine use of advanced imaging applications (imaging fusion) can significantly reduce radiation doses. Finally, we advise limiting the use of antiscatter grids because they reduce the background noise but increase both the amount of radiation required to obtain a satisfactory image and the backscatter to the patient and staff. Their removal reduces the exposure by two- to fourfold.[2,5]

Fluoroscopy time and radiation exposure are reduced by meticulous preplanning of the procedure on a three-dimensional workstation based on the preoperative CTA. Preoperative registration of the appropriate angulation to visualize the target vessels can limit the overall number of acquisitions and attempts in lateral and oblique projections to identify its origin.[6]

PROTECTIVE EQUIPMENT

The standard individual protection must be used appropriately and in all circumstances. Individual equipment includes a 0.3- to 0.5-mm lead apron, thyroid collar, lead eyeglasses, leg shields, and personal dosimeters

placed both at breast and on the hand most likely to be exposed. Lead-lined gloves can be uncomfortable but may help reduce exposure in some cases.[5]

The operating room should have ceiling-mounted lead shields, table-mounted lead skirts, and movable radiation wall shields that reduce radiation to the operator by a factor of 20 to 35.[5,6] Audible radiation monitors that alert the user when exposure has reached a specific limit are also mandatory because simply measuring the fluoroscopic time increases awareness and reduces overall exposure for both the staff and the patient.

MEASURES TO DECREASE SCATTER RADIATION TO THE OPERATOR

Positioning

The air gap between the detector and patient should be minimized to reduce the amount of scatter radiation and the beam source placed under the table. The operator should always maximize the distance from the point of x-ray entrance to the patient using long-shaft devices. As previously noted, the dose to operator is linked to the scatter radiation from beam dispersion. Given that scatter decreases with the square of the distance from the source, a significant drop in operator exposure is achievable by simply moving 30 to 50 cm away from the generator.[5]

When a fluoroscopy loop is not appropriate and high-quality DSA is necessary, the use of an automated contrast injector allows the staff to step out of the room and shield behind a leaded glass.

Steep angulations should be avoided as the patient thickness increases laterally and the system automatically adjusts the dose production settings to maintain adequate image quality. If steep angulation is necessary, the staff should stand on the side of the detector to reduce exposure. More specifically, the 90° lateral projection is the most dangerous (with a dose of about 69 mSv/hour for users), followed by the 45° oblique imaging (about 10.9 mSv/hour) and the direct anteroposterior shot (4.53-4.98 mSv/hour).[3]

Field of View

Collimation automatically adapts to the beam extent so that scatter radiation proportionally decreases with the image size. Thus, the use of collimation should be maximal to focus only on the area of interest, reducing exposure of surrounding tissues for the patient and scatter for the staff. Collimation should be combined with digital zoom on a high-definition large monitor that returns large-size images and allows the operator to work comfortably, even though the resolution is lower compared with magnification.[3,6]

Guidance Imaging System

The "roadmapping" technique should be avoided because it remarkably increases exposure. This technique can be replaced by regular fluoroscopy and the use of imaging fusion guidance (if available) and bony landmarks or other landmarks on the screen. A fusion imaging system in hybrid rooms also allows the operator to adjust table and gantry positioning on the area of interest without x-rays.

ALTERNATIVE IMAGING MODALITIES

Exposure to ionizing radiation will be further reduced in the future thanks to the application of alternative modalities to x-ray. For instance, transesophageal echocardiography, duplex ultrasonography, intraoperative real-time contrast-enhanced ultrasonography, intravascular ultrasonography, and real-time endovascular navigation using Fiber Optic Realshape (FORS, Philips) or IOPS intraoperative positioning system (Centerline Biomedical, Inc.) will be implemented for navigation and to intraoperatively assess vessel patency, endoleak, and stent graft integrity.

CONCLUSION

The optimization of angiographic system settings, the correct use of individual radiation protection, and the application of appropriate practices lead to a significant reduction in radiation dose, ensuring both efficacy of the procedure and safety for the staff. ■

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Disclosures: None.

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Disclosures: Consultant fees from Cook Medical and Philips.