Radiation Risk to Radiographers: What We Know

Best practices to optimize radiation protection.

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The risk of exposure to ionizing radiation is a permanent topic on the agenda of global organizations such as the International Commission on Radiological Protection (www.icrp.org), the United Nations Scientific Committee on the Effects of Atomic Radiation (www.unscear.org), the International Atomic Energy Agency (www.iaea.org), and the World Health Organization (www.who.int). The role of these global organizations is crucial, as they continuously evaluate and analyze the scientific literature on the effects of ionizing radiation and also publish recommendations and guidelines on how to safely use ionizing radiation.

There is an ongoing controversy among the scientific community about the acceptance of the linear no-threshold (LNT) model, which assumes that the long-term, biological damage caused by ionizing radiation (essentially the cancer risk) is directly proportional to the dose, and any increment of exposure above natural background levels will produce a linear increment of risk. The LNT model hypothesis has competing theories: (1) the threshold model, which maintains that very small exposures to ionizing radiation are harmless; and (2) the radiation hormesis model, which assumes that radiation at very small doses can be beneficial.[1]

The French Academies consider that the LNT model for assessing carcinogenic risks induced by low doses, such as those delivered by diagnostic radiology, is not based on valid scientific data and might create anxiety among patients; however, they acknowledge that the model can be practical for the organization of radiation protection.[2] Conversely, the International Commission on Radiological Protection and the National Academy of Sciences (Biological Effects of Ionizing Radiation [BEIR] VII report) support the use of the LNT model.[3] The BEIR VII committee concludes that current scientific evidence is consistent with the hypothesis that there is a linear dose-response relationship between exposure to ionizing radiation and the development of radiation-induced solid cancers in humans.[4]

Radiation is one of the most extensively researched carcinogens, but the effects of low doses are still somewhat unclear. The weight of evidence from experimental and epidemiologic data does not suggest a threshold dose below which radiation exposure does not cause cancer. If there is no such threshold, then diagnostic x-rays are likely to induce some cancers.[5]

Despite the controversies found in the literature, the LNT model hypothesis remains a wise basis for radiation protection at low doses and low dose rates[6] and currently represents the best means for radiation protection standards.[7]

OPTIMIZING RADIATION PROTECTION

Even knowing that there are several controversies regarding the quantification of risks and a lack of agreement on how to present them, the best approach for radiographers using ionizing radiation in clinical practice is to perform a medical imaging procedure following the ALARA principle, which asserts that radiation doses should be kept *as low as reasonably achievable*, taking into account social and economic factors.[8,9]

The ALARA principle is an accepted keystone of radiation protection optimization or in replacement thereof. However, it should be noted that the ALARA principle is only part of the concept of optimization. The entire concept implies, more precisely, keeping patient exposure to the minimum necessary to achieve the required medical objective (diagnostic or therapeutic). In diagnostic imaging and x-ray–guided interventions, it means that the number and quality of images are sufficient to obtain the information needed for diagnosis or intervention. In radiation therapy, ALARA only applies to normal tissue, as the dose to the target is not expected to be as low as reasonably achievable, but rather the opposite. Use of the abbreviation "ALARA" alone and out of this context may be misleading and raise unnecessary controversy.[10]

The largest prospective study published to date, which followed a large cohort of radiographers (90,957), observed elevated risks of brain cancer, breast cancer, and melanoma among radiographers who performed fluoroscopically guided interventional procedures (FGIPs) when compared with those not involved in those procedures. Authors also pointed out that although exposure to low-dose radiation is one possible explanation for these increased risks, results may also be due to chance or unmeasured confounding by nonradiation risk factors.[11] One possible explanation for the study findings is that radiographers involved in FGIPs may not have optimized their radiation protection. First, they may have spent more time than needed in the FGIP room (cath lab). Second, they may have failed to take the necessary measures to be as far as possible from the patient (the main source of scatter radiation) and the x-ray tube when in the cath lab. Lastly, they may not have used tailored personal protective devices (eg, lead aprons, thyroid collars, protective glasses) during FGIPs.[12]

Radiographers involved in FGIPs can be at risk of exceeding annual radiation dose limits and thus be at risk for long-term adverse health effects if they do not practice proper radiation protection measures and adherence to safety practices.[13]

The only way to promote a professional safety culture among radiographers and reduce the risk to both professionals and patients is to incorporate a structured radiation protection curriculum into education and training programs with a clear set of knowledge, skills, and competences as expressed in the MEDRAPET (Medical Radiation Protection Education and Training) guidelines.[14]

ATTITUDES AND BEHAVIORS TO DECREASE EXPOSURE TO IONIZING RADIATION IN FGIPs

Education and training in radiation protection is an essential component when implementing a culture of safety among health professionals in general.[15] However, it is important to be aware that knowledge of radiation protection alone is not enough, and further skills and competencies are needed to ensure education and training are effective. It is also essential to pay special attention to practical aspects regarding communication, teamwork, and the full use of radiation-reduction features available in angiography equipment.

Good communication between the health care professionals involved in FGIPs is an important tool to improve clinical practice. Through preprocedural communication and postprocedural analysis, it is possible to identify pitfalls and lack of information about the FGIP and radiation protection issues. Radiographers can and should contribute to the coordination of radiation protection practice among other health professionals working in FGIPs, ensuring that all colleagues understand that radiation protection is the responsibility of each individual and act accordingly. Clearly, irresponsible and/or ignorant behavior from any member of a FGIP team can be associated with significant collateral damage to the patient and personnel.

Figure 1 outlines a pathway for implementing a culture of patient safety for the FGIP before, during, and after a procedure. Such a pathway will minimize practice errors and maximize patient and staff protection.

Before the procedure begins, it is important that the radiographer and the interventionist correctly identify the FGIP by selecting the proper procedure name and imaging protocol for the clinical task to be performed. The imaging protocol should be discussed and agreed upon with the interventionist, since the type of fluoroscopy used will affect the patient and staff dose (eg, low, standard, or high fluoroscopy mode). A recent development in FGIP is the use of cone-beam CT for imaging and guidance. This new technology requires well-trained and highly skilled staff, and radiographers have the main responsibility of optimizing

Figure 1. Pathway for a safe fluoroscopy-guided procedure that promotes a culture of patient safety.

its use by choosing the most adequate exposure factors to provide the required image quality, while taking into account the clinical task and the lowest required dose.

The radiographer, together with the medical physicist, should develop dose reduction measures for FGIPs and implement them in daily practice. Dose reduction strategies will benefit patients and staff and include the choice of the best exposure factors, taking into consideration the patient's anthropomorphic characteristics (exposed area, age, and body mass index), the clinical task, and equipment typology.

Radiation Protection Apparel and Shielding

The radiographer should pay special attention and ensure that all health professionals involved in FGIPs use protective shielding devices (eg, aprons, thyroid shields, leaded goggles), protective screens (important to reduce dose to the eye lens), and other shielding devices. Radiographers play a key role in the choice, adaptation, and maintenance of the protective apparel. Procedures and frequency of routine quality assurance should be established to test aprons and their acceptance limits for x-ray transmission at specific kVp values. The objective is to identify and remove equipment bearing large holes or tears that could compromise the safety of individuals using this shielding device.[16,17]

The radiographer should also pay special attention to the use of personal dosimeters and positioning of the health professionals inside the room during the FGIP, as well as recommend proper placement of dosimetry badges where lower dose levels are expected in cases when being inside the room is mandatory.

SUMMARY

The radiographer has several important roles that contribute to decreasing patient and staff exposure to ionizing radiation: (1) working with the medical physicist and interventionist to implement a quality control model and develop optimized protocols; (2) accurately identifying the type of procedure and imaging protocol for an individual patient; and (3) maintaining a good safety culture to protect patients and staff in the daily routine.

The risk from exposure to ionizing radiation exists and is an important focus of international organizations. However, the harmful effects of ionizing radiation can be diminished if the occupational exposure is maintained under recommended annual limits, the FGIP is optimized with the use of radiation reduction features on angiography equipment, and health care professionals appropriately use protective devices and attire. ■

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