Review

Occupational Radiation Protection Methods in Interventional Radiology

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Abstract

The use of medical imaging to illustrate and help diagnose illness and injury and to guide therapeutic interventions into disease and disability has expanded greatly during the past 2 decades and has been so well established that it is difficult to imagine contemporary medical profession without it.The largest group of individuals exposed occupationally to artificial radiation sources is that employed in health facilities. Occupational radiation protection measures are necessary for all individuals who work in the radiological area to protect them from hazards of ionizing radiation. All workers require appropriate monitoring, along with protection tools and equipment. They should also receive education and training appropriate to their jobs. The level of training should be based on the level of risk. This document focuses to discuss various radiation protection equipments and methods for the protecting of healthcare personnel against exposure to ionizing radiation.

Keywords: Shielding; Monitoring; Dosimeters; X rays; Medical Imaging

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INTRODUCTION

The use of medical imaging to illustrate and help diagnose illness and injury and to guide therapeutic interventions into disease and disability has expanded greatly during the past 2 decades. Today, imaging is universal in health care, and patients with a wide spectrum of sufferings benefit from imaging procedures.[1] As the imaging modalities deploy ionizing radiation, hence as a consequence, the exposure of interventional radiologists and other working staff in the radiology department to radiation has increased as medical imaging has expanded. The largest group of individuals exposed occupationally to artificial radiation sources is that employed in health facilities. These individuals include: radiologists; radiation oncologists; other physicians who use X rays and radionuclides in their practices; other practitioners, such as dentists, paediatricians and chiropractors, who are licensed to use X rays; radiographers and radiological technologists who assist in the production of images and the management of patients; radiological physicists; installers; repairmen; and inspectors and regulators.[2]Ionizing radiation, such as x-rays, is uniquely energetic enough to overcome the binding energy of the electrons orbiting atoms and molecules; thus, these radiations can knock electrons out of their orbits, thereby creating ions. In biologic material exposed to x-rays, hydroxyl radicals are formed from x-ray interactions with water molecules; these radicals in turn interact with nearby DNA to cause strand breaks or base damage. X-rays can also ionize DNA directly. Most radiation-induced damage is rapidly repaired by various systems within the cell, but DNA double-strand breaks are less easily repaired, and occasional misrepair can lead to induction of point mutations, chromosomal translocations, and gene fusions, all of which are linked to the induction of cancer.[3]The probability of cell damage remaining unrepaired increases with dose, and is dependentupon whether the dose was acute or chronic. A single accidental exposure to a high dose of radiation during a short period of time is referred to as an acute exposure, and may produce biological effects within a short period after exposure. These effects are nausea, vomiting, malaise, fatigue, increased temperature, bone marrow damage, damage to cells lining the small intestine, damage to blood vessels in the brain. Also, there may be delayed effects of acute exposure, including various forms of cancer (leukaemia, bone cancer, thyroid cancer, lung cancer) and genetic defects (malformations in children born to parents exposed to radiation).[4] On the contrary Scott BR et al[5,6] revealed that in discussing the biologic effects of low doses of ionizing radiation, the authors, while mentioning the potential cancer-inducing implications of DNA double-strand breaks and their misrepair, do not consider the adaptive response of humans to ionizing radiation. Low doses and low dose-rates of some forms of radiation (e.g., x-rays and gamma rays) stimulate the body's natural defenses. This effect has been called radiation activated natural protection (ANP). Radiation ANP includes selective removal of aberrant cells (e.g., precancerous cells) via apoptosis and stimulated immunity against cancer cells. Thus, radiation ANP can prevent some cancers (sporadic and hereditary) that would otherwise occur in the absence of radiation exposure. However, occupational radiation protection measures are necessary for all individuals who work in the radiological area. This includes not only technologists and nurses, who spend a substantial amount of time in a radiation environment, but also individuals such as anesthesiologists who may be in a radiation environment only occasionally. All of these individuals may be considered radiation workers, depending on their level of exposure and on national regulations. All workers require appropriate monitoring, as well as protection tools and equipment. They must also receive education and training appropriate to their jobs . The level of training should be based on the level of risk.[7] This document focuses to discuss various radiation protection equipments and methods for the protecting of healthcare personnel against exposure to ionizing radiation.

To reduce this risk to an acceptable level it is necessary to work in two fields in medical installations, firstly the maintenance and enhancement of safety and protection measures for equipment and radioactive sources, and secondly the training of workers exposed during their professional duties.[2] The greatest source of radiation exposure to the operator and staff is scatter from the patient. Generally, controlling patient dose also reduces scatter and limits operator dose. However, chronic radiation exposure in the workplace mandates the use of protective tools in order to limit occupational radiation dose to an acceptable level. The purpose of radiation protection tools is to improve operator and staff safety without obstructing the procedure or jeopardizing the patient's safety.[7]

Shielding

Use of radiation shielding is highly effective in intercepting and reducing exposure from scattered radiation. The operator can realize radiation exposure reductions of more than 90 percent through the correct use of any of the following shielding options. Shields are most effective when placed as near to the radiation scatter source as possible (i.e., close to patient). Many radiological systems contain side-table drapes or similar types of lead shielding. Use of these items can significantly reduce operator exposures. Ceiling-mounted lead acrylic face shields should be used whenever these units are available, especially during cardiac procedures.[8] If the source is a high energy beta or gamma or x-ray emitter, shielding will reduce the dose rate. For beta emitters, low atomic number material such as plastic can be used. For gamma and x-ray emitters, high atomic number materials such as steel or lead are preferred. Lead is a toxic material; use gloves when handling it and wash when you finish. Contact the hazardous waste staff to dispose of lead shielding that is no longer needed.[9]

Use Protective Equipment

Personal protective devices are aprons, eyewear, thyroid shields and gloves. Protective aprons with thyroid shields are the principal radiation protection tool for interventional workers. The vest/skirt configuration is preferred by many operators in order to reduce the risk of musculoskeletal/back injury.[10]

Personnel monitoring

Personnel monitoring is usually done by employing Film badges, Thermo luminescent dosimeters (TLD) or optically stimulated luminance dosimeter (OSL), and pocket dosimeter.[11] Thermoluminescent dosimeters (TLDs) and films badges are wearable devices that measure ionizing radiation exposure levels. These instruments are often worn by personnel near the torso as this represents the primary location of body mass and organs, but they may also be attached to objects. These devices typically remain in place for extended intervals to assess cumulative exposure. They are considered 'delayed read' dosimeters as the instruments must be processed post-exposure to obtain dosage measurements.[12]

Other Measures

Elimination: If an exposure cannot be justified, it should not occur.

Substitution: If risk assessments demonstrate that exposures will not be within limits or ALARA/P, alternative technologies should be utilised.[13]

Time: The less time a person spend around a potentially hazardous material, the less the risk. If a person is not needed in a work area, or if ones task can be done elsewhere, then should not stay in that area.

Distance: Increasing the distance reduces the risk from any potentially hazardous material.

For gamma radiation sources, the dose rate goes down rapidly with distance. When working with high energy beta and gamma emitters, remote handling tools can dramatically reduce hand dose.[9]

CONCLUSION

Occupational radiation protection necessitates both appropriate education and training for the interventional radiologist and the availability of appropriate protection tools and equipment. Occupational radiation protection measures must also comply with local and national regulations, and any exposures exceeding the established ALARA levels should be investigated to determine whether corrective action can eliminate or reduce exposures for all concerned.

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