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A Review of Radiation Protection Standards for Workers in Hospital Radiology: A Narrative Literature Review

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A B S T R A C T

One of the goals of radiation protection is to prevent stochastic effects from occurring and to limit the chances of stochastic effects occurring to a limit value that is acceptable to society. This literature review aims to describe radiation protection standards for workers in hospital radiology. To prevent non-stochastic effects, a limit of 0.5 Sv (50 rem) in 1 year was used for all tissues except the lens of the eye. For eyepieces, the recommended annual limit is 0.15 Sv (15 rem). This limit value is used either for radiation reception by a single tissue or for radiation reception by multiple organs. To limit stochastic effects, the annual effective equivalent dose (HE) limit for whole-body radiation reception is 50 mSv (5 rem). The radiation protection equipment that must be available at a radio diagnostic facility is a lead apron, thyroid shield, gonad protectors, gloves, Pb goggles, and lead curtains. In conclusion, radiation protection equipment must be provided by radiology facility operators and used by radiation workers, especially radiologists and other competent doctors. Periodic inspection and standardized maintenance of radiation shields must be carried out for the sake of public safety.

1. Introduction

Radiation protection is an action taken to reduce the negative effects of radiation exposure.[1] One of the goals of radiation protection is to prevent stochastic effects from occurring and to limit the chances of stochastic effects occurring to a limit value that is acceptable to society.[2] The stochastic effect is a radiation effect that occurs randomly without a threshold dose, appears after a latency period, and there is no spontaneous healing.[3-5] The radiation dose will affect the chance of a stochastic effect.[4] One example of the stochastic effect is cancer. This literature review aims to describe radiation protection standards for workers in hospital radiology.

In order to achieve the goal of radiation protection for workers, the public and the environment, in the philosophy of radiation protection, three principles of radiation protection are permitted, including justification, limitation and application of radiation safety optimization.[6] These radiation protection requirements must be applied at the planning, design and use stages of the facilities at the radio diagnostic and interventional installations.[7,8] The principle of justification is that the use of technology must be justified if it produces benefits for one or many individuals and for the exposed community to offset the radiation damage caused. The principle of optimization is a principle in which radiation exposure must be kept as low as possible by considering economic and social factors.[9] Meanwhile, the principle of limitation is the provision of clear boundaries for radiological measures to prevent the negative effects of radiation exposure.[10]

The dose limit value (NBD) is the largest permitted dose that can be received by radiation workers and members of the public within a certain period of time without causing significant genetic and somatic effects due to the use of nuclear energy.[11] The principle of dose limitation does not apply to intervention activities because in carrying out these activities, the amount of radiation given must be in accordance with the therapeutic dose. The NBD for radiation workers is 20 mSv per year, while the NBD for the general public is 1 mSv per year.[11]

To prevent non-stochastic effects, a limit of 0.5 Sv (50 rem) in 1 year was used for all tissues except the lens of the eye.[12] For eyepieces, the recommended annual limit is 0.15 Sv (15 rem). This limit value is used either for radiation reception by a single tissue or for radiation reception by multiple organs. To limit stochastic effects, the annual effective equivalent dose (HE) limit for whole-body radiation reception is 50 mSv (5 rem).[13]

Radiation protection equipment in radiodiagnostics

Radiation protection equipment must be provided by radiology facility operators and used by radiation workers, especially radiologists and other competent doctors. The use of radiation protection equipment is intended to ensure that the dose limit value for workers is not exceeded. In addition, all radiation workers in radiodiagnostics must also use individual dose monitoring equipment. The radiation protection equipment that must be available at a radio diagnostic facility is a lead apron, thyroid shield, gonad protectors, gloves, Pb goggles, and lead curtains.[14,15]

A lead apron is one of the personal protective equipment in the form of an apron and made of lead (Pb) used by radiation officers. A lead apron is a very important part of individual radiation protection. Lead aprons are used in radiology rooms for individual radiation shielding. Lead aprons that are capable of withstanding radiation exposure usually have a minimum lead thickness equivalent to 0.35 mm used for the front and a lead thickness equivalent to 0.25 mm for the sides and rear.

A lead apron is an equipment used as a protective material against X-ray radiation. Its function as a protector against X-ray radiation is indicated by its absorption power against X-ray radiation. The principle of radiation shielding is to reduce the radiation flux behind the shield. In addition to accommodating the main function as a radiation absorber, the lead apron must have other supporting properties, such as being strong and comfortable when used so that the lead apron is suitable for use.[15,16]

In accordance with the provisions of BAPETEN Regulation No. 8 of 2011, it is stated that in the use of diagnostic and interventional radiology X-ray equipment, radiology facility operators must provide an apron equivalent to 0.2-0.25 mm Pb for the use of diagnostic radiology X-ray equipment, and 0.35 -0.5 mm Pb for interventional radiology X-ray equipment. To meet the absorption capacity requirements, the existing lead apron material uses a mixture of natural rubber with lead and uses pure lead. A lead apron with a mixture of natural rubber still feels thick, while a lead apron with pure lead has several drawbacks, namely, the shape is very stiff, breaks easily if dropped, and cannot follow the shape of the body, so it is less comfortable to wear.[14]

A thyroid shield is used to protect the thyroid from X-ray radiation. The thyroid shield is made of a material equivalent to 1 mm Pb. Gonad protection is equivalent to 0.2-0.25 mm Pb for radio diagnostic X-ray machine use and 0.35-0.5 mm Pb for interventional radiology X-ray equipment. This protection must be of an appropriate size and shape to prevent radiation exposure to the gonads.[15]

Further protection standards are gloves, lead goggles, and lead curtains. Protective gloves used for fluoroscopy must provide an equivalent attenuation of at least 0.25 mm Pb at 150 kVp. This protection must be able to protect the whole, including the fingers and wrist. Pb glasses are glasses made of a material equivalent to 1 mm Pb. This protection is used to protect the eye from scattered radiation that hits the eye. Curtains used by radiographers must be coated with a material equivalent to 1 mm Pb, with a height of 2 m and a width of 1 m.[16]

Lead apron maintenance

Security for radiation workers, the public, and the surrounding environment against radiation must be pursued as carefully as possible to prevent excessive exposure. All irradiation must be attempted as low as possible, which is known as the principle of as low as reasonably achievable (ALARA), taking into account economic and social factors. To prevent radiation exposure, we can maintain a safe level of distance from radiation sources, limit the time not to be too long near the source, and use radiation protection equipment.

Lead apron maintenance is also very important for the safety of workers from radiation exposure. Lead apron maintenance includes avoiding factors that cause damage, such as damage caused by falling or piling up lead aprons. When not in use, all protective clothing must be hung on a special storage rack. Proper education and training on the use of radiation protection equipment are necessary to reduce radiation exposure in practice.[11]

The lead apron does not need to be cleaned with alcohol or bleach. Dirt that sticks to the lead apron can be cleaned using water and soap. Lead apron maintenance can be done by cleaning it every day using a soft brush or paintbrush. Never fold the lead apron because it can damage the lead apron.

The Apron lead testing

Lead apron testing using the radiographic method can be carried out once every 12-18 months to see the physical condition of the lead apron as needed. Lead apron testing can be done using a fluoroscopy unit. This test uses a fluoroscopy X-ray machine by spreading the lead apron on the examination table and irradiating it. The test results are seen on the monitor. If at the time of testing, it is seen that there are holes or tears in the lead apron of more than 15 mm^2 in sensitive areas such as the gonads and thyroid, the lead apron can no longer be used. If the lead apron leaks in an insensitive area, for example, the abdomen, chest, and shoulder, more than 670 mm^2, then the lead apron can no longer be used and must be replaced. Thyroid shield with damage greater than 11 mm^2 must be replaced.

Lead apron testing can also be done using computed radiography (CR). The test is carried out by placing a phosphor plate (imaging plate) measuring 35 x 35 cm to evaluate the presence of fractures, cracks, and holes in the deepest structures. The collimator is opened as wide as the size of the cassette used, set the focus distance with the lead apron is as far as 110 cm. Tests on protective equipment from radiation exposure must be carried out routinely for the safety of radiation workers and the general public around radiology laboratory facilities.[11,15,16]

2. Conclusion

Radiation protection equipment must be provided by radiology facility operators and used by radiation workers, especially radiologists and other competent doctors. Periodic inspection and standardized maintenance of radiation shields must be carried out for the sake of public safety.

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