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The Eye Lens Dose Measurement for Nuclear Medicine Staff in Thailand

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Abstract

The International Atomic Energy Agency (IAEA) has reviewed on the dose limit for the lens of the eye followed the recommendation of the International Commission on Radiological Protection (ICRP) in its statement in April 2011. The dose limit to the eye was reduced from 150 mSv in a year to 20 mSv in a year, averaged over defined periods of 5 years, with no annual dose in a single year exceeding 50 mSv. IAEA still announced a measurement value of personal dose equivalent at 3 mm depth with a dosimeter worn as close as possible to the eye and calibrated on a head shape phantom in IAEA Technical Document No. 1731(2013): Implications for Occupational Radiation Protection of the New Dose Limit for the Lens of the Eye. The new dose limit and the measurement closed to the eye had made an impact to workers who received dose more than 20 mSv per year and worn dosimeter at whole body which not represented to real dose. The Office of Atoms for Peace announced in the Royal Gazette (2018) with the reduction of the dose limits and recommended to Personal Radiation Monitoring Service laboratory for development of the lens of eye dose calibrated at eye adjacent including with to investigate the risk assessment of the effects of radiation on eye lens upon the new dose limit for medical worker. The purpose of this research is to develop the lens of eye dose for Nuclear Medicine (NM) workers due to related with gamma and beta from radioisotope and a longtime exposure.

The risk assessment of radiation lens injury was performed from the relationship of averaged eye lens dose to affect the prevalence of radiation-associated posterior lens opacities or cataract. In this research, calibration technique for a small OSL dosimeter was developed to be eye lens dosimeters which inserted at 3 mm depth of head shape phantom. The calibrated dosimeters were worn from NM workers at eye adjacent for finding averaged accumulative dose in a year. 31 NM workers who received the highest eye doses were chosen to eyes examination by experienced ophthalmologists using slit-lamp. Posterior Subcapsular Cataract (PSC) was graded according to a modified Merriam-Focht scoring system and a grading score of 1 and above in either eye was considered as early cataract by radiation effect. The conclusions of this research shown the NM workers who received high dose might be found the opportunity of cataract when getting older from the results of PSC grades above 1.0 score. From 31 NM workers were found the prevalence of radiation-associated posterior lens opacities in the right and left eye lens was 10 (32.26%) and was 11(35.48%) respectively.

Keywords: Eye lens dose • Nuclear medicine • OSL dosimeter

Introduction

The purpose of this study is to investigate the risk assessment of lens radiation injury of Nuclear Medicine (NM) workers from the relationship of averaged eye lens dose to affect the prevalence of radiation-associated posterior lens opacities or cataract upon the new dose limit. The lens of eye dose measurement techniques were developed to detect gamma and beta rays from radioisotope followed IAEA Technical Document No. 1731(2013), a measurement value of personal dose equivalent at 3 mm depth with a dosimeter should worn as close as possible to the eye and calibrated on a head shape phantom [1].

Materials and Methods

Optically Stimulated Luminescent Dosimeter, OSLD, Model nanoDot have been used for eye lens dose measurement and calibrated in the cylindrical phantom (20 cm in diameter). NanoDot was designed for measuring a small, single point radiation exposure normally worn on a wrist or a finger as shown in figure 1. NanoDots used in this study were calibrated by Thailand Institute of Nuclear Technology (TINT). The irradiated nanoDot dosimeters were read out by a micro star reader.

First, the photon beam qualities were calibrated from gamma-ray source of 137Cs. Three nanoDot dosimeters were inserted into the cylindrical phantom holes representing an eye. These dosimeters were irradiated at Secondary Standard Dosimetry Laboratory (SSDL), TINT. The delivered air kerma values were 2.0 mGy at 0 degree angle of incidence. These values were traceable to Physikalisch-Technische Bundesanstalt (PTB), Germany. Delivered (Hp(3))

Figure 1. Cylindrical phantom and a microstar reader.

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doses using the conversion coefficients from ISO 4037:2019 part 3 were performed [2].

Second, the correction factor of Hp(3)/Hp(0.07) for beta particles which energies less than 3 MeV was performed by exposing with 90Sr/90Y. The nanoDot dosimeters were inserted at the depth of 3 mm in a cylinder phantom to evaluate Hp(3) while dosimeters to evaluate Hp(0.07) were inserted in a ring holder on ISO rod phantom . The delivered dose was 5 mSv at 0-degree angle of incidence. The correction factors of Hp(3) /Hp(0.07) were evaluated from average count readings.

The annual eye doses measurement were performed for 56 NM staffs in 6 Nuclear Medicine Sections as shown in figure 2. 31 NM workers who received the highest eye doses were chosen for eyes examination by experienced ophthalmologists using slit- lamp. Posterior Subcapsular Cataract (PSC) was graded according to a modified Merriam-Focht scoring system and a grading score of 1 and above in either eye was considered as early cataract by radiation effect.

Results and Discussion

The correction factor to estimate the lens of eye dose, Hp (3)

The correction factor to estimate eye dose measurement from radionuclides which emitted gamma rays such as Tc-99m and electrons energy above 700 keV as I-131 were 0.998 and 0.412 respectively (Table 1). The averaged eye lens doses in mSv were measured for 56 NM staffs [3,4]. The values eye lens dose, Hp (3), using nanoDots from the left eyes, the average and range were 1.74(0.07-6.14) mSv, and the median was 0.78 mSv, the average and range of right eyes lens dose were 1.75(0.09-2.21) mSv, the median was 0.80 mSv as shown in table 2.

The relative risk of NM staffs was calculated by the ratio of incidence risk among an exposed group and incidence risk among a non-exposed group (Table 3). Relative risk was 6.77 (95% confidence interval 2.435 to 18.846). The Office of Atoms for Peace, Thailand, announced in the Royal Gazette (2018) with the reduction of the dose limits and recommended to Individual Monitoring Service laboratory for development of the lens of eye dose calibrated at eye adjacent instead of wearing dosimeter at whole body which not represented to real dose (Figure 3) [5].

Figure 2. Irradiation of Cs137(left) and 90Sr-/90Y sources (right) to nanodot dosimeters in term of eye lens dose.

Table 1. The estimate of Hp (3) from radionuclides were evaluated from correction factor.

Radionuclides	Delivered Does (mSv)	Estimated Dose (mSv)
Ga-68	5.00	4.87
I-131	2.00	1.94
Tc-99m	2.00	1.89

Table 2. The average of eye lens doses on left and right sides (mSv) of 56 NM staffs.

N=56	The Lens of Eye Dose (mSv)	
	Left Eye	Right Eye
Volunteers (56)	1.74(0.07-6.14)	1.75(0.09-2.21)
Median	0.78	0.80

Table 3. 31 NM workers and 60 control subjects were chosen for eyes examination. Psc was graded from left and right eyes.

	With Lens Opacity (grade > 1) (N= 14)	Without Lens Opacity (grade 0-0.5) (N= 17)
Age, Mean (SD); Years	43 (10.61)	32.5 (6.98)
Sex (Male:Female)	3:4	5:13
Unilateral (%)	7 (22.6)	-
Bilateral (%)	7 (22.6)	-
Relative risk	6.77	-

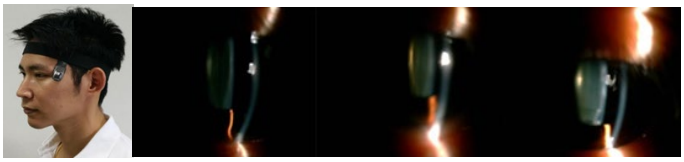

Figure 3. The lens of eye dose measurement with head band set (left) and merriam-focht scoring system shown grading score.

Conclusion

The conclusions of this research shown the NM workers who received high dose might be found the opportunity of cataract when getting older from the results of PSC grades above 1.0 score. From 31 NM workers were found the prevalence of radiation-associated posterior lens opacities in the left and right eyes were 7 (22.60%) and (22.60%) respectively. The eyes examination was kindly provided by Department of Ophthalmology, Faculty of Medicine, Chulalongkorn University.

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Conflict of Interest

No conflict of interest.

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