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Eye lens dosimetry and the study on radiation cataract in interventional cardiologists

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ABSTRACT

Purpose: To determine the eye lens dose of the Interventional Cardiology (IC) personnel using optically stimulated luminescent dosimeter (OSLD) and the prevalence and risk of radiation – associated lens opacities in Thailand.

Methods and results: 48 IC staff, with age- and sex- matches 37 unexposed controls obtained eye examines. Posterior lens change was graded using a modified Merriam-Focht technique by two independent ophthalmologists. Occupational exposure (mSv) was measured in 42 IC staff, using 2 OSLD badges place at inside lead apron and at collar. Annual eye lens doses (mSv) were also measured using 4 nanoDots OSL placed outside and inside lead glass eyewear. The prevalence of radiation-associated posterior lens opacities was 28.6% (2/7) for IC, 19.5% (8/41) for nurses, and 2.7% (1/37) for controls. The average and range of annual whole body effective dose, Hp(10), equivalent dose at skin of the neck, Hp(0.07) and equivalent dose at eye lens, Hp(3) were 0.80 (0.05–6.79), 5.88 (0.14–35.28), and 5.73 (0.14–33.20) mSv respectively. The annual average and range of eye lens dose using nano Dots OSL showed the *outside* lead glass eyewear on left and right sides as 8.06 (0.17–32.45), 3.55(0.06–8.04) mSv and *inside* left and right sides as 3.91(0.05–14.26) and 2.44(0.06–6.24) mSv respectively.

Conclusion: Eye lens doses measured by OSLD badges and nano Dot dosimeter as Hp(10), Hp(0.07) and Hp(3). The eyes of the IC personnel were examined annually by two ophthalmologists for the prevalence of cataract induced by radiation.

1. Introduction

The interventional cardiology procedures have potential to impart high radiation doses to personnel performing the procedure [1–3]. The lens of the eye is one of the most radiosensitive tissues in the body [4–6]. Opacification of the lens associated with visual impairment may be classified into three forms: nuclear, cortical, and posterior subcapsular (PSC), according to anatomic location [7]. Among the three major forms, PSC is the least common but this form is most commonly associated with ionizing radiation exposure [4,5,7]. Radiation cataract severity and latency are related to the radiation dose. While early stages of opacification may not cause visual disability, the severity of such changes increases progressively with dose until vision is impaired and cataract extraction surgery is required [8,9]. In addition to ionizing radiation, other factors commonly associated with PSC are the use of systemic steroids and diabetes [8]. For occupation exposure in planned exposure situation, the revised equivalent dose limits for the lens of the eye are 20 mSv in a year, average over 5 consecutive years (i.e.100 mSv in 5 years), and 50 mSv in any single year [11,12]. This is very significant decrease by a factor of 7.5 indicating acceptance that the lens of the eye is now considered more radio-sensitive than it was before. Further, the threshold values for detectable opacities earlier given by ICRP in 1990 of 5 Sv for chronic exposures and 0.5–2.0 Sv for acute exposures are now reduced to 0.5 Sv in 2011 [10,11]. Although interventional cardiologist works closest to the source of radiation, the lack of protective screen such as ceiling suspended screen for nurse or technologist who may stand near the patient's bed for significant time creates potential for their higher exposures.

The use of radiation monitoring and protective devices by interventional cardiologists and nurses are often very limited, unreliable, or unavailable [13,14]. A number of studies reported that 20–50% of cardiologists were not using their dosimeters routinely [13,14].

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Table 1
Types of subject with level of training, average age, years of work, and estimated cumulative eye lens dose from questionnaires.

Subject	Qualifications and level of training	Av. age ± SD (range), y	Av. years of work ± SD (range)	Estimated cumulative eye lens dose ± SD (range) (Sv) as radiation workers
Interventional cardiologist (7)	M.D., Thai Board of Cardiovascular Intervention (Thai Med Council)	36 ± 5 (32–46)	5.7 ± 6.3 (1 − 17)	1.5 ± 3.1 (0.09–8.50)
Nurse and Technicians (41)	B.Sc. Trained in Int Cardiology	34 ± 9 (19–59)	8.1 ± 7.8 (0.4–35)	1.1 ± 1.2 (0.03–5.85)
Control (37)	B.Sc., RN, M.D.	32 ± 8 (22–55)		

The aim of this study is to determine the annual eye lens dose of the Interventional Cardiology (IC) personnel using optically stimulated luminescent dosimeter (OSLD) and to determine the prevalence and risk of radiation-associated lens opacities among IC personnel in Thailand.

2. Materials and methods

This study has been started since November 2015 at King Chulalongkorn Memorial Hospital, Bangkok, Thailand, consisted of a comprehensive dilated slit-lamp examination of the eye lens of cardiologists, nurses and technologists working in interventional laboratories as well as control subjects. The average age, years of work, qualifications, and level of training of interventional cardiologists, nurses, technicians and unexposed controls are shown in Table 1.

2.1. Complexity of intervention

Two third of the patients have lesion type BII or C (according to AHA classification) and about 12% are chronic total occlusion (CTO) percutaneous coronary intervention (PCI).

The eyes of the subjects were examined after full dilation with 0.1% Tropicamide (Mydriacyl®). Posterior lens opacities were evaluated by slit lamp examination using a modified Merriam-Focht scoring system [16], which describes the severity of posterior lens opacities in half steps from 0 to 3.0 (Fig. 1). Each participant was evaluated separately by two independent ophthalmologists oriented in the recognition and evaluation of characteristic radiation-induced lens morphology. Images of the lens were recorded through the camera attached to the slit lamp. In cases where there was a difference in scores, the image was reviewed and scored again by both examiners. The lens changes only of 1.0 and above were used for analysis as change of 0.5 was considered small and subject to inter-observer variation.

A written survey was completed by each participant before pupillary dilation and slit lamp examination. The questionnaire contained information about type of work and profession, type and model of the X-ray equipment used, use of protective screens and personal protective devices, typical workload (number of procedures, average fluoroscopy time, and number of frames and series) and working habit (left/right hand, radial/femoral access). X-ray examinations received in the past and other ionizing radiation exposures unrelated to their work in interventional cardiology. Lifestyle and medical factors including potential sunlight exposure, steroid use, cigarette smoking, alcohol consumption, medical and ocular history of eye disease were also noted. Participants were also asked about use of personal dosimeter and the availability of individual dose records. Written informed consent was obtained from all individuals prior to participation in the study. The protocol was approved by Institutional Review Board, Faculty of Medicine, Chulalongkorn University. The occupational eye lens dose in 42 IC personnel were estimated using 2 OSLD badges (InLight Badge; Landauer, Glenwood, IL, USA), one worn on the trunk under lead apron and another at collar outside lead apron to determine annual whole body effective dose, Hp(10) mSv, from the first dosimeter and annual equivalent dose at skin or eye lens, Hp(0.07) mSv, and eye lens equivalent dose, Hp(3) mSv, from the second dosimeter. Even though the OSL dosimeters are not broadly available for Hp(3), they comply with internationally agreed performance requirements stated in standards of the International Electromechanical Commission (IEC62387). In this study, the eye lens doses were also measured using 4 nanoDots (Landauer), placed at outside and inside lead glass eye wear close to the end of each eye on left and right sides (Fig. 2). The occupational eye lens doses were evaluated by converting monthly values into annual values. The supply, calibration, and readout of the OSLD badges and nanoDots were provided by Thailand Institute on Nuclear Technology, Bangkok, Thailand.