



Occupational eye lens dose in interventional radiology and cardiology: new insights

Interventional radiology and cardiology procedures deliver high radiation dose to physicians and interventional suite staff. Nowadays the interest has been focused on occupational dose to the lens of the eye. Recent epidemiological studies have shown that radiation-induced cataract is observed in lower dose threshold than the previous considered by ICRP 103. Based on these studies, in 2011, ICRP reduced the annual occupational dose limit for the lens of the eye to 20 mSv while the dose threshold was determined 0.5 Gy. Many reports have demonstrated that the occupational ocular dose may exceed the new annual limit if radiation protection equipment is not used. New considerations regarding the dose to the eye necessitate the education of medical personnel on radiation protection issues and the dosimetry of the lens in clinical routine.

KEYWORDS: Occupational eye lens; Interventional radiology; Cardiology

The advances in digital imaging and the improvement in interventional tools and devices like catheters and stents have expanded the use of interventional procedures. During the period 1998-2008, the total number of interventional procedures increased by 78% [1]. Interventional radiology [IR] and cardiology [IC] procedures deliver high radiation doses both to patients and medical personnel, which has raised serious concerns regarding the harmful effects of ionizing radiation. Lately, the interest has focused on the occupational dose to the lens of the eye. It is well known that ionizing radiation is associated with posterior sub-capsular cataract [PSC] and cortical opacities [2]. Interventional radiologists, cardiologists and other medical staff who stand close to patient and the x-ray source during the fluoroscopy-guided procedures are at high risk concerning radiation-associated cataract, especially when the lens of the eye is unprotected. Ciraj-Bjelac *et al.* [3], showed that there is a strong correlation between radiation-induced cataract and exposure to medical staff working in IC when the protection tools are not used. More specifically, the investigators found that 52% of interventional cardiologists and 45% of nurses had posterior lens opacities while this quota amounted 9% for the control group. In a similar study conducted by Vano *et al.* [4], eye lens changes appeared to 38% of interventional cardiologists, 21% of nurses and 12% of unexposed controls. According to International Commission of Radiological Protection [ICRP] publication 103 [5], cataract formation is considered a deterministic effect with a threshold dose of 0.5-2 Gy for acute

exposure and 5-6 Gy for chronic exposure. In the same report [5], the recommended annual

occupational equivalent dose for the lens of the eye is 150 mSv. However, recent epidemiological studies based on atomic bomb survivors [6,7] and Chernobyl cleanup workers [8,9] suggest a lower dose threshold for radiation-induced cataract than the previously proposed by ICRP 103. Nakashima *et al.* [6], in a reanalysis for radiation cataractogenesis among atomic bomb survivors, determine a threshold of 0.6 Sv for cortical cataract and 0.7 Sv for PSC whereas in a similar study, Neriishi *et al.* [7] gave a dose threshold

from 0 to 0.8 Gy. An evaluation study among Chernobyl clean-up workers 12 and 14 yr after the accident [8] determined the threshold of cataract under 1 Gy. Particularly interesting are the low radiation dose studies. Chodick *et al.* [9], in a prospective study among radiologic technologists, showed a correlation between exposure to low dose ionizing radiation and the risk of developing cataract. These studies raised the concern regarding radiation-induced character and in 2011 ICRP published "The Statement on Tissue Reactions" [10]. In this statement the threshold for the lens of the eye is determined 0.5 Gy whereas the equivalent dose limit was decreased by 87%. The new dose limit for the lens of the eye is now considered 20 mSv/year for occupational exposure. The dose for the lens of the eye varies among medical staff performing IR/IC procedures and depends on several factors such as the type of procedure, the exposure parameters [kVp, mAs,

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fluoroscopy time, magnification], the patient size, the position and the angle of the x-ray tube, the position of the operator and the use of radiation protection devices. Efsthopoulos *et al.* [11] investigating the occupational doses in 25 diagnostic and therapeutic IR/IC procedures concluded that the interventionists receive 64-1129 μSv to the lens of the eye and the nurses 4- 16 μSv . The investigators also found that the annual eye dose was 8.2 mSv for the interventional cardiologist and 0.5 mSv for the interventional radiologist with the highest workload while the corresponding dose was 27.9 mSv for the interventional radiologist who performed vertebroplasties. In a retrospective study, including 129 interventional cardiologists and electrophysiologists who worked for an average of 22 years, Jacob *et al.* [12] estimated the cumulative dose to the lens from 25 to 1600 mSv. In addition, Vano *et al.* [13] found that the cumulative eye dose for the catheterization laboratory staff ranged from 0.1 to 18.9 Sv. It is obvious from all these studies that the dose to the lens of the eye can exceed the new annual limit for personnel working in IR/IC. A pan-European project, called ORAMED [The Optimization of Radiation Protection for Medical Staff] project [14], that included six different countries and more than 1300 IR/IC procedures revealed that eye lens doses range from 10 μSv to 4 mSv

per procedure, the cumulative annual eye lens dose from less than 1 mSv to 150 mSv whereas the 24% of medical personnel exceeds the new annual limit of 20 mSv. The results of the studies highlight the need for education and training of medical staff involved with IC/IR procedures on radiation protection issues. Physicians and other medical personnel should have deep knowledge about radiation protection principles and rules, be aware of the radiation-associated risk and use properly the radiation protection equipment. It has been proved that the use of radiation protection eyeglasses reduces the dose to the lens by 83-90% [14]. However, it is impressive that only 31% of interventional radiologists wear lead eyeglasses during interventional procedures [14]. In addition, Pantos *et al.* [15] showed that the dose to the eyes of the primary operator performed catheter ablation procedures was below 9 μSv per procedure when the interventionist used lead glasses and ceiling protection shield. New considerations concerning the radiation dose to the lens of the eye require more epidemiological studies especially at low radiation doses in order to have a more clear answer whether radiation-associated cataract is a deterministic or a non-threshold based effect. In addition, it is significantly important the establishment of an effective method for the dosimetry for the lens of the eye in clinical routine.

REFERENCES

- Hart D, Wall BF, Hillier MC *et al.* Frequency and collective dose for medical and dental X-ray examinations. Chilton: Health Protection Agency. *HPA.CRCE.012.* (2010).
- Brown NP. The lens is more sensitive to radiation than we had believed. *Br J. Ophthalmol.* 81, 257 (1997).
- Ciraj-Bjelac O, Rehani MM, Sim KH *et al.* Risk for radiation-induced cataract for staff in interventional cardiology: is there reason for concern? *Catheter. Cardiovasc. Interv.* 76, 826-834 (2010).
- Vano E, Kleiman NJ, Duran A *et al.* Radiation cataract risk in interventional cardiology personnel. *Radiat. Res.* 174, 490-495 (2010).
- ICRP International Commission on Radiological Protection Recommendations of the International Commission Radiological Protection. *ICRP. Publication.* 103, 1-7 (2007).
- Nakashima E, Neriishi K, Minamoto A. A reanalysis of atomic-bomb cataract data, 2000-2002: a threshold analysis. *Health. Phys.* 90, 154-160 (2006).
- Neriishi K, Nakashima E, Minamoto A *et al.* Postoperative cataract cases among atomic bomb survivors: radiation dose response and threshold. *Radiat. Res.* 168, 404-408 (2007).
- Worgul BV, Kundiyeve Y, Sergiyenko NM *et al.* Cataracts among Chernobyl clean-up workers: implications regarding permissible eye exposures. *Radiat. Res.* 167, 233-243 (2007).
- Chodick G, Bekiroglu N, Hauptmann M *et al.* Risk of cataract after exposure to low doses of ionizing radiation: a 20-year prospective cohort study among US radiologic technologists. *Am. J. Epidemiol.* 168, 620-631 (2008).
- Authors on behalf of ICRP, Stewart FA, Akleyev AV, Hauer-Jensen M *et al.* ICRP publication 118: ICRP statement on tissue reactions and early and late effects of radiation in normal tissues and organs--threshold doses for tissue reactions in a radiation protection context. *Ann. ICRP* 41, 1-322 (2012).
- Efsthopoulos EP, Pantos I, Andreou M *et al.* Occupational radiation doses to the extremities and the eyes in interventional radiology and cardiology procedures. *Br. J. Radiol.* 84, 70-77 (2011).
- Jacob S, Donadille L, Maccia C *et al.* Eye lens radiation exposure to interventional cardiologists: a retrospective assessment of cumulative doses. *Radiat. Prot. Dosimetry.* 153, 282-293 (2013).
- Vano E, Kleiman NJ, Duran A *et al.* Radiation-associated lens opacities in catheterization personnel: results of a survey and direct assessments. *J. Vasc. Interv. Radiol.* 24, 197-204 (2013).
- Vanhavere F, Carinou E, Gualdrini G *et al.* ORAMED: Optimization of Radiation Protection for Medical Staff. 7th. *EURADOS. Report.* ISBN 978-3-943701-01-2 (2012).
- Pantos I, Koukorava C, Nirgianaki E *et al.* Radiation exposure of the operator during cardiac catheter ablation procedures. *Radiat. Prot. Dosimetry.* 150, 306-311 (2012).