IACRS INTER-AGENCY COMMITTEE ON RADIATION SAFETY

Information Update – New dose limit for the lens of the eye

What are cataracts?

A cataract is clouding of the lens of the eye, which impedes the passage of light.

There are three predominant forms of cataract depending on their anatomical location in the lens:

- cortical cataracts are formed in the cortex of the lens, which is the outside edge of the lens;
- nuclear refers are found in the central portion of the lens; and
- posterior subcapsular cataracts (PSC) are formed at the back of the lens. It is called "subcapsular" because it forms beneath the lens capsule, which is a small "sac," or membrane, that encloses the lens and holds it in place.

What are the known causes of cataracts?

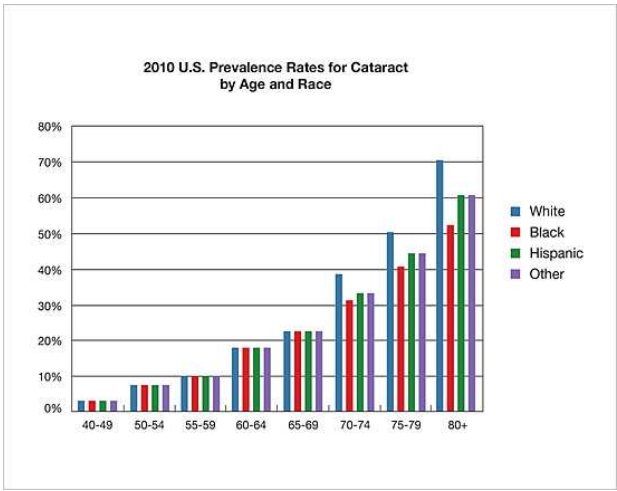
Most cataracts are related to ageing, although occasionally children may be born with the condition, or cataract may develop after an injury, inflammation or disease.

The risk factors for age-related cataract include prolonged exposure to ultraviolet radiation, diabetes, tobacco use and drinking of alcohol.

Exposure to ionizing radiation can cause cortical cataracts and posterior subcapsular cataracts.

What is the prevalence of cataracts?

In the economically developed countries, the prevalence of cataracts roughly doubles with each 10 years of age after the age of 50. The prevalence rates in the USA for cataracts with age and race is shown in the figure [1].



The prevalence in developing countries also increases with age. However, cataracts in many developing countries occur earlier in life than in developed countries, and cataracts are more common. For example, in an Indian study, visually significant cataract occurred 14 years earlier than in a comparable study in the United States [2].

According to the latest assessment [3], cataracts are responsible for 51% of world blindness, which represents about 20 million people. Although cataracts can be surgically removed, in many countries barriers exist that prevent patients to access surgery. As people in the world live longer, the number of people with cataracts is anticipated to grow. Cataract is also an important cause of low vision in both developed and developing countries [3].

How are cataracts treated?

The only treatment for cataracts is surgical removal. This involves removing the opacified lens, and a plastic lens is inserted. Surgery is normally performed when the cataracts begin to affect the quality of life or interfere with the ability to perform normal daily activities of the individual.

Why has the dose limit for the lens or the eye for workers been reduced?

The previous limit on equivalent dose to the lens of the eye of 150 mSv in a year was based on a dose threshold of 0.5–2 Gy for single acute (or brief) exposure and 5 Gy for protracted exposure for detectable opacities and 5 Gy for single acute (or brief) exposure and 8 Gy following fractionated or prolonged exposure for visual impairment (cataract) [4]. However, some of the earlier epidemiological studies, on which this limit was based may not have had sufficient follow-up to detect either radiation-induced lens changes or visual disability requiring cataract surgery. In addition, better techniques for detecting, quantifying, and documenting early radiation-associated lens changes, as well as better dosimetry, may have been factors that contributed to the more recent findings of radiation-induced cataracts at low exposures.

In ICRP Publication 118 [5], ICRP presented its review of recent epidemiological evidence regarding the induction of deterministic effects and concluded that there were some deterministic effects, particularly those with very late manifestation, where threshold doses were or might have been lower than previously considered [5, 6].

The ICRP concluded: “For cataracts in the lens of the eye induced by acute exposures, recent studies, where formal estimates of threshold doses have been made after long follow-up periods, indicate values of approximately 0.5 Gy with 90–95% confidence intervals including zero dose. This is lower by a factor of 10 than deduced in earlier studies. Those studies generally had short follow-up periods, failed to consider the increasing latency period as dose decreases, did not have sufficient sensitivity to detect early lens changes using the various techniques employed, and had relatively few subjects with doses below a few Gy. For fractionated and protracted exposures, values of approximately 0.5 Gy have been similarly deduced from recent studies. However, the evidence pertaining to the latter exposures mainly refers to opacities rather than cataracts impairing vision because the follow-up times are shorter in those studies. For chronic exposure over several to many years, much of the evidence refers to minor lens opacities. Nonetheless, there is no indication that the threshold accumulated doses are higher in this scenario. These are no established mitigators of lens radiation injury leading to opacities or cataracts, but lens replacement is a well-established surgical procedure.”

What is meant by a threshold dose?

The IRCP defines the threshold dose for practical purposes as the dose resulting in a 1% incidence of the specified reaction in the tissue or organ [6].

What is the new dose limit for the lens of the eye for occupational exposure?

In 2011, the ICRP has recommended that the occupational dose limit for equivalent dose for the lens of the eye be reduced from 150 mSv in a year to 20 mSv in a year, averaged over defined periods of 5 years, with no single year exceeding 50 mSv.

The recommended dose limit for the lens of the eye for occupational exposure was incorporated into the revised International Basic Safety Standards during the most recent revision [7].

Has the dose limit for the lens or the eye for the public been reduced?

ICRP did not recommend reducing the dose limit for public exposures to the lens of the eye, as the Commission judged that the existing limit was adequately protective. It is considered to be highly improbable that any member of the public would receive a dose to the lens of the eye over a lifetime in excess of the nominal threshold of 0.5 Gy from a licensed practice considering: application of the effective dose limit of 1 mSv/year; the low likelihood of the lens of the eye being preferentially exposed for any significant period; and optimisation of protection below the equivalent dose limit for the lens of the eye.

The dose limit for equivalent dose for the lens of the eye for members of the public remains unchanged at 15 mSv in a year.

What categories of workers may be affected the new dose limit?

There are a number of workers where the doses to the lens of the eye can exceed the new dose limit if appropriate protective actions are not taken. Examples include:

- Medical specialists operating image guided equipment in interventional cardiology and interventional radiology;
- Medical specialists performing some tasks in nuclear medicine;
- Workers involved in some tasks in the decommissioning of nuclear facilities;
- Workers in nuclear facilities using glove boxes;
- Workers that carry out some tasks in fuel cycle facilities;
- Industrial radiographers.

What actions need to be taken by employers?

Employers have prime responsibility for radiation protection and safety of workers. Employers are responsible for carrying out a safety assessment to identify those workers at risk of receiving doses to the lens of the eye that may exceed the new dose limit.

Examples of such employers are managers of hospitals that perform image guided interventional radiology; managers of nuclear facilities processing fuel; managers of companies involved in decommissioning of nuclear facilities; and managers of industrial radiography companies.

Actions to optimize protection of workers against high doses to the lens of the eye, in order of priority, rely on:

- Engineered controls such as shielding to reduce exposure of the eyes;
- Administrative controls such as written rules to control exposure in normal operations;
- Personal protective equipment such as protective glasses. Glasses made of Perspex may be sufficient for those workers where the exposure is primarily due to beta radiation. Protective glasses containing lead can be used to protect against scattered X rays;
- Information, instruction and training for workers on any changes to the radiation protection program to reduce doses.

When considered necessary, appropriate dosimeters are to be provided to workers to measure the dose to the lens of the eye to verify compliance with the dose limit.

What action is for regulatory bodies?

Regulatory bodies in Member States are responsible to establish and enforce compliance with the new dose limit. Regulatory bodies will need to ensure that the appropriate changes are made to national regulations to establish the new dose limit for the lens of the eye.

References:

[1] USA Department of Health and Human Services, The National Institutes of Health, National Eye Institute: Cataracts, https://nei.nih.gov/eyedata/cataract

[2] Brian, G., Taylor, H., Cataract Blindness – Challenges for the 21st Century, Bulletin of the World Health Organization, 79 (2001) 249-256.

[3] World Health Organization, Prevention of Blindness and Visual Impairment, World Health Organization website, (2015). http://www.who.int/blindness/causes/priority/en/index1.html

[4] International Commission on Radiological Protection, 1990 Recommendations of the International Commission on Radiological Protection, ICRP Publication 60, Ann. ICRP 21 (1-3) (1991).

[5] International Commission on Radiological Protection, ICRP Statement on Tissue Reactions / Early and Late Effects of Radiation in Normal Tissues and Organs – Threshold Doses for Tissue Reactions in a Radiation Protection Context, ICRP Publication 118, Ann. ICRP 41 (1/2) (2012).

[6] International Commission on Radiological Protection, The 2007 Recommendations of the International Commission on Radiological Protection, ICRP Publication 103, Ann. ICRP 37 (2-4) (2007).

[7] EUROPEAN COMMISSION, FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, INTERNATIONAL ATOMIC ENERGY AGENCY, INTERNATIONAL LABOUR ORGANIZATION, OECD NUCLEAR ENERGY AGENCY, PAN AMERICAN HEALTH ORGANIZATION, UNITED NATIONS ENVIRONMENT PROGRAMME, WORLD HEALTH ORGANIZATION, Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards, IAEA Safety Standards Series No. GSR Part 3, IAEA, Vienna (2014).