UDC 617.7

M.H. Yeltokova
JSC "Medical University Astana"Institute of Radiobiological Research, Astana city, Kazakhstan
JSC «National Scientific Medical Research Center», Astana city, Kazakhstan

RISK OF CATARACT AFTER EXPOSURE TO LOW DOSES OF IONIZING RADIATION

BACKGROUND

Of the ocular tissues, by far the most sensitive to ionizing radiation is the lens [1, 2, 3,4]. whilelens of the eyeis a kind ofbiological dosimeter[12,13,14,!5]. Radiation can cause an opacification or cataract in the lens. Cataract– it is a typicalremote consequenceof total body irradiation and loca lirradiation of the lens. [5]. Opacities in the lens of the eye differ widely in severity, from those causing no obvious decrease in visual acuity to those severe enough to cause significant visual impairment. While not unique to radiation, radiation cataracts initially manifest as defects in the transparency of the posterior superficial cortex of the lens and is referred to as posterior subcapsular (PSC) cataract. It is critical in studies of purported eye exposure to recognize that PSC cataracts are, as Otake and Schull stated, the ultimate expression of radiation damage to the lens. [6]. Cataracts appear to develop some time after radiation exposure. The latency duration is dependent on the rate at which damaged epithelial cells undergo aberrant differentiation (fibregenesis) and accumulate in the PSC region.[7,8,9,10,11] It appears that up to a certain dose, the latency time to appearance is inversely related to dose. At higher doses, the cataract onset time cannot decrease further. As it relates to cataracts following the Chernobyl accident, the UNSCEAR 2000 report limits itself to the following statement: "Cataracts, scarring and ulceration are the most important causes of persistent disability in acute radiation sickness survivors [16,17].

CURRENT STATUS OF EVIDENCE

There have been several studies undertaken regarding cataract formation in the populations exposed to radiation from the Chernobyl accident. [18,19,20,22,24,31,32]. Accordingto the director ofthe research laboratoryto studythe effects of radiation and the environment on the bodyofthe Columbia Universityprofessor BasilVorgul, "Radiationallows everyoneto getcataract.Therefore,we need to start-research thatwill helpin the futureto all mankind."Much effort has been focused on the first responders, who suffered acute radiation effects, and the liquidators involved in the extended clean-up and stabilization of the site .[25,26,27]. An exception was a study investigating the prevalence and the characteristics of lens changes in a pediatric population (5–17 years of age) surrounding the Chernobyl area (Day, Gorin, and Eller, 1995). [23]. Of the 1787 subjects (996 exposed, 791 unexposed) in an extensive study, a small (3.6%), but significant, group of exposed children manifested PSC lens changes consistent with those observed in other exposed individuals, such as the atomic-bomb survivors. These observations were supported by Fedirko and Khilinska (1998), who found PSC lens changes in a study of 461 children. The findings of the recent Ukrainian/American Chernobyl Ocular Study and*the Italian-American Cataract Study Group.* are currently being prepared for publication. [28,29]. Beginning 10 years after the accident, ophthalmic examinations were conducted in 6 cities located in 5 Ukrainian regions or oblasts. A total of 8607 liquidators, who had adequate dosimetry and epidemiological data and had no preexisting incidental eye disease, have received two ophthalmologic examinations. The liquidators in the study averaged about 33 years of age at exposure time, and about 45 and 47 years at the time of two eye examinations. Using corrected gamma dose estimates, the individual beta dose values to the lens of the eye were estimated, and individual uncertainty distributions were simulated (Worgul, 2005). [31,32,33]. There have been a number of other Ukrainian studies of Acute Radiation Sickness (ARS) survivors and liquidators, which reportedly have made estimates of relative risk by dose and found vascular pathology and deterioration of accommodative capability). [30]. Cataract studies also have been conducted at the Medical Radiological Research Center of Russia[34] and at the Republican Research Center of Radiation Medicine and Human Ecology of Belarus. The Belarusian results to date are mixed: while the liquidators have statistically greater numbers of cataracts than the general population, the evacuees and residents of contaminated areas have statistically fewer cataracts. This unexpected result is being subjected to investigation. Besides, dose estimates for Belarusian liquidators also need further clarification. Unfortunately, the Expert Group did not have access to this material and therefore could not assess or comment on the findings.

CONSENSUS

Studies available indicate an increased incidence of changes in the lens of the eye following radiation exposure. Continuing the studies should provide a clearer picture of any risk at low doses, allow further refinement of the dosimetry, and defining the temporal pattern of progression of early cataracts or pre-cataract lens changes. Knowing that the latency for radiation cataracts is inversely related to dose, continued follow-up will help to define the low dose risk more precisely and improve information on the influence of other exogenous factors.

The Chernobyl experience represents a fertile resource to establish rational and representative standards for radiation protection of the visual system and provide reasonably definitive assessment of cataract risk from protracted radiation exposure. As mentioned in the earlier chapters of this report, there are significant issues with regard to the accuracy of external doses recorded in Registries for liquidators. Dosimetry relative to the lens of the eye, and, in particular, for beta radiation, poses significant additional obstacles. Refinements in dose estimates are needed in the future. A focus of the Chernobyl eyes studies is a hypothesis that radiation cataract/opacifications detectable by an experienced examiner may occur at doses lower than previously thought. These studies do not appear to support the older classic literature on radiation cataracts, which concluded that a relatively high dose threshold (e.g. 2 Gy) must be exceeded for cataracts to appear after ionizing radiation exposure. A recent ophthalmological screening of the Japanese cohort (Minamoto et al., 2004), [35]. analysis of patients who had computerized tomography (CT) scans in the Beaver Dam Eye Study (Klein et al., 2011) and a U.S. National Aeronautics and Space Administration (NASA) study of cataracts in the astronaut corps (Cucinotta et al., 2007) are all consistent with the findings from Chernobyl eye studies showing that even relatively low doses (about 0.25 Gray) may be associated with excess lens opacities.

GAPS IN KNOWLEDGE

As it is not clear that a high dose threshold exists for radiation cataract onset (i.e. low-grade cataracts), an effort to characterize the magnitude of excess risk per unit dose to the lens and the dose threshold level should be investigated. Continued follow-up, together with increased inter-study cooperation, is necessary to achieve this goal. There is also a need to obtain precise estimates of radiation doses to the lens, and to control for potential confounding factors.

Chernobyl studies and indirectly, the most recent atomic-bomb survivor study provide uncertainty as to whether or not cataract progression may have a radiation dose threshold. [36]. To this end, it is important to carefully document the severity of cataracts so that better estimates of risk for vision-impairing cataracts can be obtained. Relative to the above, criteria need to be developed to allow one to predict the eventual severity of visual function loss from radiation exposure of the eye. What are the effects of the Chernobyl experience on ocular tissues other than the lens? There currently exists considerable controversy regarding effects on ocular tissues even at moderate radiation doses (<5 Gy), particularly on endpoints such as retinopathy, including maculopathy, and vascular potency.

In some studies it is not clear whether or how beta radiation may have contributed to the development of cataracts in liquidators. There is some indication that, under certain conditions, the beta contribution to cataract development could even exceed that of the gamma component (Osanov et al., 2010)

CONCLUSIONS

The eye studies reported for children and liquidators suggest that posterior subcapsular (PSC) cataracts are associated with exposure to radiation from the Chernobyl accident. Data from the liquidator studies suggest that exposures to doses on the order of 250 mGy may also be cataractogenic. Possibly related to the cataractogenecity of radiation is the finding of a dose dependent loss of accommodative function of the lens. Retinopathy (maculodystrophy) and vascular changes are also non-lens endpoints of interest.

RECOMMENDATIONS

A. Continued eye follow-up studies of the Chernobyl population, particularly the liquidators for whom reliable dosimetry exists, will allow greater predictive capability of the risk of radiation-induced cataract onset and will provide the data necessary to be able to assess the likelihood of resulting visual dysfunction.

B. All studies should provide careful evaluation and description of how the doses to the lens of the eye have been calculated and their possible biases and magnitude of uncertainty. Particular attention needs to be paid to the clinical expression of the cataract, especially to opacities in the PSC regions, as a potential indicator of radiogenic origin of the opacity.

C. For reasons noted above, continued follow-up for cataracts in those who have been already recruited into on-going studies is highly desirable. However, an ocular examination, as a part of general-population monitoring after radiation exposure from Chernobyl, is unwarranted and a wasteful use of resources. Because cataracts are a major aging disorder, they are generally self-diagnosed. Since patients are aware of their reduced vision, they visit an ophthalmologist. Typically, if asymptomatic cataractous changes are diagnosed during a routine eye exam, the physician records the fact, but no treatment is prescribed until sufficient severity is achieved for surgical intervention.

D. The only indication for specific monitoring for radiation cataract development is in radiation exposed workers. Radiological workers, with a history of working at the Chernobyl site in the early days of the accident, should be examined at least annually. If early lens changes (precataractous) consistent with radiogenic damage appear, more frequent follow-up (2–3 times a year) is indicated, given the worker continues to be exposed. If subsequent exams identify a definitive PSC cataract, the individual should no longer be permitted to work in a radiation environment.

E. Careful assessment of ocular tissues other than the lens should be incorporated into all ongoing Chernobyl eye studies. The possibility of low dose effects in the back of the eye (retina and choroids) deserves particular attention.

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