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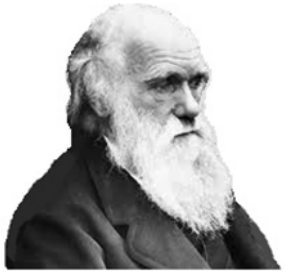

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Risks of eye pathology with the victims of the Chernobyl catastrophe

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ABSTRACT

In this document, the authors present the results of the long-term monitoring of the condition of the eyes of victims of the Chernobyl catastrophe. The patient examinations were conducted using our system of standard inspection and description of the condition of the eye. We have summarized the development of this system in another paper. Ocular effects in patients as a result of the Chernobyl accident have been classified either as specific irradiation injuries, attributable only to radiation exposure, or ophthalmopathology that is observed under normal conditions, but for which radiation exposure is an important risk factor. This division is particularly apparent when examining the clean-up workers in Chernobyl.

Keywords: Risks of eye pathology, Chernobyl catastrophe

1. INTRODUCTION

In this document, we will present the results of the long-term monitoring of the condition of the eyes of victims of the Chernobyl catastrophe. The patient examinations were conducted using our system of standard inspection and description of the condition of the eye. We have summarized the development of this system in another paper [1].

Ocular effects in patients as a result of the Chernobyl accident have been classified either as specific irradiation injuries, attributable only to radiation exposure, or ophthalmopathology that is observed under normal conditions, but for which radiation exposure is an important risk factor. This division is particularly apparent when examining the clean-up workers in Chernobyl.

Therefore, firstly we will describe the results of our examination of the condition of eyes in clean-up workers.

The first group of radiation eye diseases includes radiation cataract and radiation chorioretinopathy including “chestnut” and “diffraction grating” syndromes. "Chestnut syndrome" is a type of radiation angiochorioretinopathy and was first recorded in autumn 1986, just a few months after the accident. Multiple microaneurisms, dilations and sacs in the retinal veins were found in the area around the macula in a shape similar to a chestnut leaf. In remote period - degenerate changes of retina in the form of chestnut leaves. "Diffraction grating syndrome", in which spots of exudate were scattered on the central part of the retina, was observed in an individual irradiated in special conditions, within direct sight of the exposed core of the 4th reactor [5].

Radiation cataracts (fig. 1) can be caused by high dose exposure, but also by doses of less than 1 Gy. Mathematical modeling data indicate that radiation cataracts are a stochastic effect of radioactive exposure. The absolute risk of radiation cataract is adequately described by non-threshold model, based on a wholebody external radiation dose and the exposure time. The relative risk per 1 Gy is 3.45 (1.34-5.55) [10, 11].

The second group of pathologies – diseases which appear under normal conditions, but which are more widespread in radiation irradiated populations - is more significant. Radiation exposure caused by participation in emergency work at the Chernobyl NPP promotes the premature occurrence of involutional and dystrophic changes to the eyes, development of ocular vessel diseases, and leads to a significant dose-dependent increase in chorioretinal degeneration, such as age-dependent macular degeneration (AMD) and involutional cataracts. Central chorioretinal degeneration with clinical symptoms of age-dependent macular degeneration (AMD) was the most frequent form of retinal pathology in the later period (136.5±10.7 per 1 000 persons in 1993 and 585.7±23.8 per 1 000 persons in 2004). Involutional cataracts are the most widespread form of crystalline lens pathology. Their prevalence during the period of monitoring increased from 294.3±32.0 per thousand exposed individuals in 1993 to 766.7±35.9 per thousand in 2004 [1, 5, 7, 12, 14].

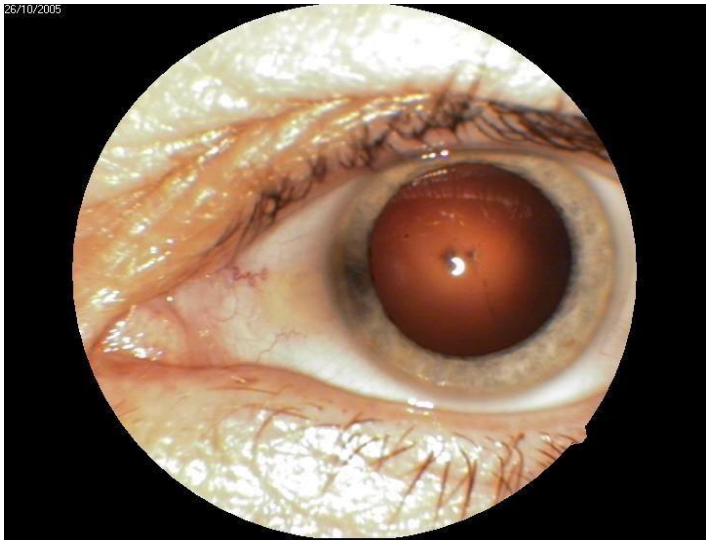

Fig. 1. Radiation cataract. Back and front subcapsular dimness

The age, time after exposure and the absorbed dose of external irradiation are the risk factors for involutional cataracts and central chorioretinal degeneration in clean-up workers, according to mathematical modeling data. Relative risk of age-dependent macular degeneration was 1.727 (1.498; 1.990) per year of calendar age, 6.453 (3.115; 13.37) per 1 √(d * t), where d is the dose in Gy and t - time under risk in years [11].

Moreover, there was a high prevalence of dose dependent vitreous destruction, chronic conjunctivitis and benign neoplasm's of the skin of the eyelid [1, 5, 8]. Irradiated individuals also suffered a decrease in ocular accommodation ability (Fig. 2) - of 0.78 dioptries per 1 Gy [20].

As a result of long-term monitoring of the eyes of irradiated populations and mathematical modeling of absolute risks of ocular diseases for radiation irradiated persons in the dose range 0.01-2.2 Gy, it was proven that in a remote period after a radioactive irradiation retinal angiopathy is the primary nosologic unit, whose rate of increase can be predicted with a statistically significant precision. A statistically significant increase of involutional cataracts risk can be expected by the fifth year after exposure and age dependent macular degeneration by six years after exposure. Radiation exposure promotes premature ageing of the eye [11].

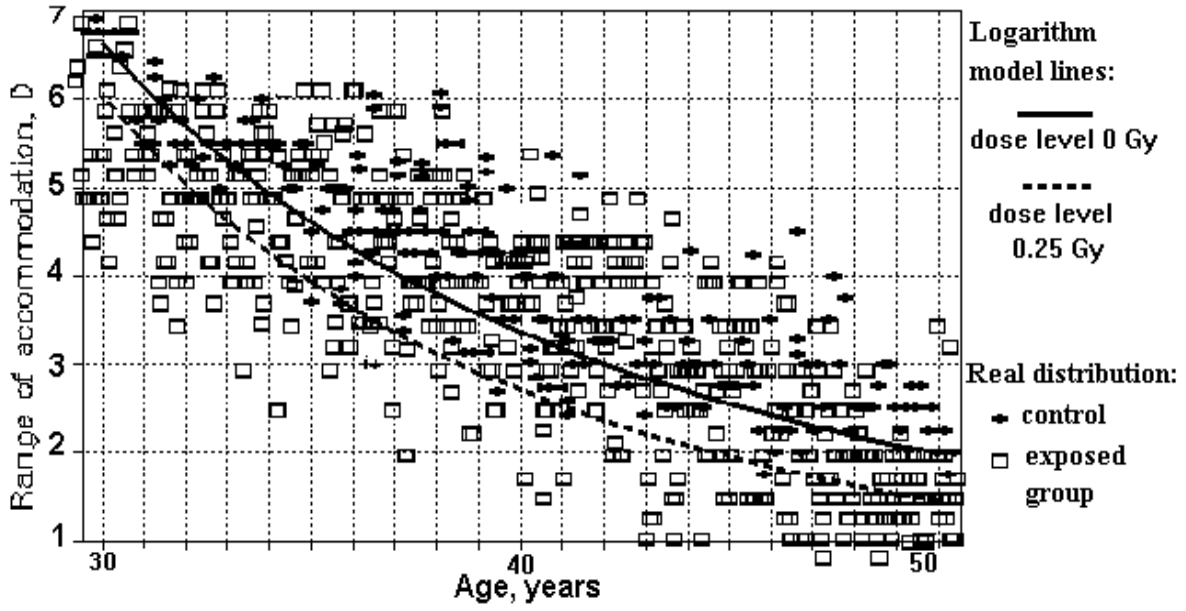

Fig. 2. Range of accommodation, D, in control group and in the exposed group. Lines - logarithm model lines, symbols - real distribution

We have also examined other categories of people exposed to radiation caused by Chernobyl catastrophe. These were adults and children from the radioactive contaminated territories, the people evacuated from the zone in around ChNPP and descendants of those exposed to radiation.

2. IVANKIV RESEARCH INTO EYE CONDITION IN CHILDREN

In March 1991, we carried out an ophthalmologic examination of all children of school age (from 7 to 16 years) in 4 villages of the Ivankiv district of the Region of Kyiv [6,16]. The total number of children examined was 512. The villages located alongside differ only in the degree radioactive contamination of the soil. For the first villages inspected the level of soil contamination

137Cs was: 12.4 Ci/km² average, max 8.0 Ci/km²; 90% index 5.4 Ci/km²; for the second these levels were, respectively, 0.89 Ci/km²; 2.7 Ci/km², and 1.87 Ci/km²: for the third 1.26 Ci/km², 4.7 Ci/km², and 2.1 Ci/km²; and for the fourth 3.11 Ci/km², 13.8 Ci/km², and 4.62 Ci/km². All other characteristics, such as chemical composition of soil, vegetation, way of life, peculiarity of nutrition, were identical in all villages. Genetically the inhabitants belong to the same population. The difference in the level of contamination may be attributed to the interaction between the wind that dominated over the region while radioactive clouds passed over the district. The situation in this region is valuable for scientific study as it establishes conditions, which may provide accurate investigative results.

To register the results we applied the system of objective description of the condition of the eye. This system was developed by the authors and makes it possible to define the localization, size, dimness intensity, and other changes to the lens.

In 1991 no cataracts were found. Typical lensopathies have been detected in 51% of those surveyed, and the frequency was the same in all villages. Atypical changes were found in the lenses of eyes in 61 children: density of back subcapsular layers, dimness in the form of small spots and points between the back capsule and the core, and vacuoles. A statistically significant difference in frequency of eye optical media changes in villages with high and comparatively lower levels of radioactive contamination has been established. ($\chi^2 = 9.12$, $p < 0.01$). The frequency of atypical changes of lens of the eye is connected with the average and, maximal level of soil contamination ^{137}Cs($r = 0.992$) [6, 16]. The repeated investigation carried out in 1995 showed that the frequency of atypical changes to the lenses of eyes of inhabitants of villages with the average soil contamination over 2 Ci/km² increased to 34.9%. The increase of pathology frequency as compared with 1991 was significant ($\chi^2 = 5.17$; $p < 0.05$). In two girls, dimnesses suggesting the development of involutional cataracts were recorded (in 1991 early changes to their lens, such as density of cortical layers were recorded). The increase in the frequency of diseases in inhabitants of villages with a level of soil contamination below 2 Ci/km² was not significant.

Just as in 1991, the frequency of lens pathology was higher in villages with a higher level of soil contamination with ^{137}Cs ($\chi^2 = 5.27$; $p < 0.05$). [2, 6, 16]. Other authors have obtained similar results, but their examinations were carried out only once [3].

3. OVROUCH - BOYARKA COMPARATIVE RESEARCH INTO THE CONDITION OF EYES IN CHILDREN - INHABITANTS OF RADIATIONCONTAMINATED TERRITORIES

Between 1992 and 1998 the inhabitants of radiationcontaminated territories in Ovruch and Boyarka were subjected to research into the conditions of their eyes. Ovruch and Boyarka are town-type settlements. Ovruch is located in the 3 zone, the density of soil contamination

^{137}Cs being -185-555 kBq$*m^2$, Boyarka is located in the 4 zone, the density of soil contamination ^{137}Cs being 37-184,9 kBq$*m^2$. The third zone is the zone of voluntary migration into other regions; the fourth zone is an area of intensive radiation monitoring.

We have inspected 1948 children and teenagers, among them 461 inhabitants from Ovruch, and 1487 from Boyarka. The age of inspected people statistically did not differ. When analyzing the spread of primary preclinical changes of lens of the eye we noted that in the third zone it was 234.27 per 1000, and in the fourth, 149.29. The relative risk was 1.6, CL = 1.3; 1.97, χ^2 =18.34, p<0,001. The most significant lens disease was recorded in 1.34 children in 1000, in the fourth zone, and 6.51children in 1000 in the third. Thus, the changes of lenses are proved to occur more often in children who live on the territories with a higher level of radioactive contamination [17].

The spread of retinal diseases was 10.85 per 1000 inhabitants in the third radiation contaminated zone and 2.02 in the fourth. In the third zone, angiopathy was present (6.51 in 1000) and 2 cases of congenital retinal degeneration were found in the fourth (this was the only angiopathy detected, 2.02 in 1000). We have shown that children living in radiation - contaminated territories often show preclinical changes to retinal vessels, and these occur more often in more contaminated zones [13, 17]. It was shown that the inhabitants of the third zone are more susceptible to myopia than those in the fourth zone. The relative risk of astigmatism is consistently higher in inhabitants between the ages of 8 and 12 in the third zone when compared with the same age group in the fourth zone (RR = 1.6; CL –1.01; 2.55, χ^2 = 3.95, p = 0.047). At the same time, the relative risk of hypermetropia was less for inhabitants of the more contaminated zone (RR = 0.5; CL- 0.3, 0.82, p<0.01) [2, 13, 17].

4. ADULT POPULATION OF RADIATION-CONTAMINATED TERRITORIES

841 inhabitants of radiation-contaminated territories were examined between 1991 and 1997. The eye pathology structure of inhabitants of radiation-contaminated territories has been shown to change directly during the monitoring process due to increased risks of retinal diseases and involutional cataracts. An uncommonly early occurrence of such a pathology (even in the age group up to 30) was recorded. A high risk of chronic conjunctivitis and vitreous destructions was also recorded. A comparative analysis of the distribution of eye diseases has been conducted. When comparing the results of the examinations of inhabitants in the third zone with those in the fourth one, a higher risk for residents of the third zone in a relatively young age group (up to 40 years) was shown. Thus, the relative risk of retinal diseases for inhabitants of the third zone was 1.47 (1.08; 1.99) when compared with the fourth zone. It is recommended to continue the monitoring of eye diseases among the inhabitants of radiation-contaminated territories on a regular basis [4, 9].

5. MONITORING THE CONDITION OF EYES IN THE CHILDREN OF CLEANUP WORKERS BORN AFTER THE CATASTROPHE

Monitoring of the conditions of the eyes of children of cleanup workers born after the catastrophe has been conducted since 1999. 2202 persons have been examined. It was established that the risk of pathological changes to the retina in descendants of atomic

irradiated people is significantly higher when compared with other groups of children. The data collected proves that continuous monitoring of the eye conditions of these categories of population is necessary. Further epidemiologic analysis of eye condition in the children of clean-up workers will first study the eye vessel system and retinal conditions and functional condition of vision organ [13, 15].

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