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Risk of occupational radiation-induced cataract in medical workers

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Key words
Ionizing radiation; cataract; health care workers

Summary
Background: *Ionizing radiation on the lens of the eye can produce a progressive cataract. Small cumulative doses, over a long time period, can produce adverse effects on the professional capabilities of health workers in the ionizing radiation zone.* **Objectives:** *The aim of this study was to ascertain whether occupational exposure to low levels of ionizing radiation can cause an increase in prevalence of cataract.* **Method:** *We compared a group with occupational cataract, consisting of 115 health workers in the ionizing radiation zone, and two control groups: a group of 100 health-care workers in the ionizing radiation zone, with a higher incidence of chromosomal aberrations, but without cataract; and another control group of 26 health-care workers with cataract, outside the zone; all risk factors for the development of cataract were considered: age, sex, difference in profession, duration of occupational exposure, years of service, level of blood sugar, blood pressure, arrhythmias, etc.* **Results:** *A more significant incidence of cataract was found in workers in the ionizing radiation zone, where the relative risk was 4.6; $p<0.01$. Radiology technicians showed the highest prevalence (63.5%), while physicians-radiologists and pneumologists were second (15.7%) and third (10.3%) respectively; nurses showed a 3.5% incidence and nuclear medicine department workers showed an incidence of only 1.7%. Other risk factors had an effect on the development of cataract ($p<0.05$).* **Conclusions:** *Occupational exposure to low doses of ionizing radiation, together with other risk factors, is a significant cofactor in the occurrence of cataract as an occupational disease among x-ray exposed health care workers. The categories most at risk are radiology technicians, followed by radiologists.*

Riassunto
«Rischio di cataratta indotta da radiazioni in operatori della sanità». *Le radiazioni ionizzanti possono indurre la cataratta del cristallino dell'occhio. Gli effetti di basse dosi cumulative per un periodo di tempo prolungato possono compromettere la capacità professionale dei lavoratori che operano in zone con dispersione di radiazioni ionizzanti. Scopo di questo studio è stato valutare se l'esposizione occupazionale a bassi livelli di radiazioni ionizzanti possano aumentare la prevalenza di cataratta fra gli operatori esposti. Si è pertanto confrontato un gruppo di 115 lavoratori della sanità che avevano operato in zone con radiazioni ionizzanti e affetti da cataratta con due gruppi di controllo: il primo costituito da 100 operatori delle zone con radiazioni ionizzanti portatori di una elevata incidenza di aberrazioni cromosomiche ma non affetti da cataratta ed un altro gruppo di 26 lavoratori della sanità affetti da cataratta che avevano però operato al di fuori della zona con radiazioni ionizzanti. Sono stati presi in*

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esame tutti i fattori di rischio noti come capaci di determinare l'insorgenza di cataratta: età, sesso, diversità nella professione, durata dell'esposizione occupazionale, anzianità lavorativa, glicemia, ipertensione, aritmie, etc. Una significativa più elevata incidenza di cataratta è stata riscontrata nei lavoratori della zona con radiazioni ionizzanti dove è emerso un rischio relativo di 4,6 ($p<0.01$). La più alta prevalenza (63,5%) è stata evidenziata fra i tecnici di radiologia mentre i medici radiologi (15,7%) e i pneumologi (10,3%) si situavano rispettivamente al secondo ed al terzo posto; le infermiere mostravano una incidenza del 3,5% ed i lavoratori operanti in medicina nucleare dell'1,7%. Anche altri fattori di rischio si sono dimostrati in grado di determinare lo sviluppo di cataratta ($p<0.05$). Emerge pertanto che l'esposizione professionale a basse dosi di radiazioni ionizzanti, in presenza di altri fattori di rischio, è un significativo co-fattore nel determinare l'insorgenza di cataratta tra i lavoratori della sanità che operano in presenza di radiazioni e come in questo caso debba essere riconosciuta come malattia professionale. Le categorie più a rischio sono rappresentate dai tecnici di radiologia e dai medici radiologi.

Introduction

Cataract is the most common degenerative opacity of the crystalline lens, that develops with age. The interior capsule of the lens is lined with a transparent layer of epithelial cells which maintains the function of the lens, that is accomplished by cell division at the equator of the crystalline lens and moderate growth towards the center. Multiple factors may interfere with the division process and growth of lenticular epithelial cells, especially in the case of genetic predisposition (4, 7, 20).

Damaged cells are moved towards the posterior pole of the crystalline lens, leading to the irregular formation of young lenticular fibers which lose their transparency and prevent straight light movement, manifested by opacification in the posterior subcapsular region (2, 5, 16, 17).

Risk evaluation of presenile cataract revealed that it was connected to phenotype produced by the expression of several different genes and exposure to environmental noxae (15, 18).

Physical agents causing cataract include: infrared, ultraviolet and microwave non-ionizing radiations, electric power and ionizing radiations (5).

Exposure to sunlight may be a risk factor for cataract development. Exposure to the ultraviolet-B (UVB) component of light may be associated with the severity of cortical opacities in men aged 43 to 84 years (2, 4, and 16).

X-rays are the greatest threat to the crystalline lens. Mostly high doses, over 500mGy, cause cataract (11). It is also well known that absorption of low doses of x-rays, from 100mSv up to 150mSv, by the lens of the eye also causes cataract. For instance for opacities and vision impairment the ICRP (Publication 103) indicates a threshold of an annual dose rate between 0,1 and 0,15Gy/a absorbed over many years (8). Low cumulative ionizing radiation doses absorbed by the lens of the eye can produce a progressive cataract (6, 22). The effects of small cumulative doses of ionizing radiations, lower than 100mSv, over a long period of time (at least ten years) has not been investigated sufficiently, and this was the main aim of the present investigation,

Other risk factors for cataract are: alcohol abuse, smoking, systemic diseases (endocrine and metabolic), impaired eye circulation, ocular pressure, refractory eye abnormalities (myopia), blood pressure, heart conditions (15, 17, 20,), and low food antioxidant level. Prophylaxis with antioxidants such as consumption of vitamins C and E over 10 years and more had the effect of lowering the risk of cataract (10).

The symptoms of cataract onset are slow, progressive and painless impairment of vision, sensitivity to light, more defective color perception and diplopia. All these conditions directly diminish working capacity and quality of life, and since cataract may be of occupational origin, the analysis of risk of cataract and the possibilities of detection and treatment are of great importance for the protection of workers and their return to the workplace.

The workers with manifest cataract within and outside the area of ionizing radiations were studied and compared with the intent to evaluate the effect of low doses on the development of cataract. The factors causing cataract of the crystalline lens, except ionizing radiations, were also analyzed: age, sex, occupation, duration of occupational exposure, metabolic disorders (blood sugar content), cardiovascular diseases (high blood pressure and heart condition-arrhythmia), etc.

Methodology

The study involved 3,240 health-care workers of Medical Centers in Serbia in the period 1992-2002, who had worked within and outside the area of ionizing radiations. A total of 1,560 workers were employed in the zone (group A) and 1,680 outside the ionizing radiations zone (group B). Among group B, we selected a group of 26 health-care workers with cataract, control group B-C, in whom there was no risk of occurrence of cataract due to radiations; the mean age was 40 years and the group consisted of 7 females and 19 males.

Among group A, two groups were selected:

– group A-1: Health-care workers in the ionizing radiation zone who contracted lens cataract during their years of service (No. 115); they were chronically exposed to low doses of radiation, mean age 46 years, 56 females and 59 males;

– group A-2c: Health-care workers in the ionizing radiation zone without cataract but who showed a higher incidence of dicentrics (targeted as a second control group, No. 100); these were exposed workers selected on the basis of a higher frequency of chromosomal aberrations due to chronic exposure to low doses, mean age 41 years, 54 females and 46 males.

We compared group A-1, with cataract, and two control groups: A-2c working in the zone, and B-C of health-care workers outside the zone, for all risk factors for the development of cataract: age, duration of occupational exposure (DOE), sex, frequency (f) of chromosomal aberrations (c.a.), different workplaces and professions, high blood sugar level, cardiovascular diseases (arterial hypertension and arrhythmia) and years of service (YS).

Data on smoking, alcohol consumption and corticosteroid therapy as well as exposure to chemical and other physical *noxae*, genetic burden, were obtained from the medical histories recorded in periodical check-ups. The percentage of smokers was nearly equal in all groups (30%, 31% and 33%), and the number of cigarettes smoked was similar for each person. Subjects with chronic consumption of alcohol, drugs or permanently on medication, as well as subjects exposed to other types of radiations, were excluded from the groups under study. Food regime, i.e., antioxidants in food, obesity, genetic factors and exposure to sunlight varied equally in all groups.

The annual periodical preventive checkups of workers' health also included ophthalmological examination. After visual acuity measurement, the lens was examined by the retro-illumination method (red reflex) and using a biomicroscope. In the case of impaired visual acuity or presence of cloudy lens, the examination was performed in mydriasis.

The absorbed dose on the body surface of the exposed subjects was measured by personal thermo-luminescent dosimeters (TLD) worn under the protective gown during the entire shift in the radiation zone and they were read on a monthly basis. Doses were expressed as annual or 5-years radiation dose equivalent in millisievert (mSv). The ambient dose equivalent rate (ADER) in mSv/h and surface contamination (SC) in Bq/cm^2 at the workplaces was also measured.

Chromosomal aberrations in lymphocytes were analyzed. Chromosomes were observed in peripheral blood lymphocytes. A modified Moorhead micromethod for peripheral blood lymphocytes and conventional cytogenetic techniques of chromosome aberration analysis were used for analysis of chromosome aberrations (14). A dicentric form of chromosome is a specific, radiation-induced change of DNA in lymphocytes. The presence of chromosomal aberrations (dicentrics) indicates higher exposure to ionizing radiations. A higher frequency of dicentrics, which is a complete biomarker, suggests higher radiobiological risk of disease due to ionizing radiation exposure at the

workplace (3). Dicentrics frequency was measured in 200 mitoses of lymphocytes sampled and prepared from blood of subjects in all groups. Stained preparations (Giemsa) of karyotype of 200 lymphocytes in metaphase were observed in immersion by light microscope (12). The appearance of one dicentric for every 200 cells matches the frequency of chromosomal aberrations of 0.5%. This indicates exposure to small doses, not exceeding 100 mSv Although dicentrics are unstable aberrations they are meaningful in the case of doses protracted over many years during the period of exposure to low level radiation. However, dicentrics cannot be meaningful after a break in the period of exposure because they disappear after 220 days.

Cumulation of small doses above 100 mSv can cause the appearance of 2 or more dicentrics, i.e. a frequency of chromosomal aberrations above the 1% rate. Increased frequency of chromosome aberrations (1.5%-3.0%) is caused by cumulative, total dose in the range of 100-500 mSv. The frequency of dicentrics increases and is linearly correlated with the dose if it is above 500 mSv.

Statistical analysis

The study used methods of descriptive statistics consisting of central tendency measurements: arithmetical mean (X), variability measurements: variation interval (max-min) and standard deviation (±SD); to assess the significance of difference: we applied the Student's t-test and χ^2 test and for correlation significance we used Spearman's rank correlation coefficient. The incidences (I) (I=rate/100,000/years) were compared and represented as relative risk, RR.

Results

Ambient dose equivalent rate (ADER) in mSv/h was low; ranging from 0.5 μSv/h to 8 μSv/h. Surface contamination (SC) ranged from 0.41Bq/100 cm^2 up to 330Bq/100 cm^2.

Accepted doses in group A-1 measured by TLD ranged from 2.64 to 48.10, mean value: 7.58±4.78 mSv/5 years, or 1.59±1.30 mSv/year, and did not differ from the mean absorbed annual doses in the exposed subjects without cataract (1.63±1.45 mSv/year), since they were below the maximum dose limit of 100 mSv/5years. This means that the radiation dose could not be the only cause of occurrence of cataract.

Dicentric type aberrations were not found in Group B-C. In Group A-2c the frequency (f) of dicentrics was 1.5% (range 1%-2%), which is significantly higher than in group A-1 (f=0.5%), $p<0.05$; (table 1). This means that the occurrence of cataract does not depend only on the radiation dose but also jointly with other factors, both occupationally or individually.

There was a significant difference ($\chi^2=65.92$; $p<0.01$) of crystalline lens cataract between group A in the zone and Group B outside the ionizing radiation zone. Cataract was more common in Group A and the relative risk (RR) was 4.6 (IA/IB=700:150). 98.5%, of the workers in group B did not have cataract, and only 1.5% (No. = 26) had a cataract, which is not statistically significant. On the contrary in group A, 115 workers or 7.34% of the total had a cataract, an this have to draw our attention. Most of these subjects were radiology technicians (4.7%), followed by physicians exposed to x-rays (1.9%), while all the other subjects in different jobs exposed to other sources amounted to less than 1%.

Among patients with cataract contracted during occupational exposure, radiology technicians were the most prevalent (63.5%), while physicians – radiologists and pneumologists – came second (15.7%) and third (10.3%) respectively (table 2); nurses with cataract showed a prevalence of 3.5% and nuclear medicine workers with cataract had a prevalence of only 1.7%. Among radiology technicians, 20.9% had cataracts with 11-20 years of DOE.

Among physicians, the distribution of risk of contracting the disease according to exposure time intervals was approximately the same.

The correlation of cataract incidence and duration of exposure (DOE) was not linear: in 10 years of exposure, the incidence was 31.3%; 11-20 years: 31.3%; 20-30 years: 29.6% and the remaining incidence of 7.8% was found in older workers with over 31 years of service (table 2). An increase in cataract occurrence in the first decades of occupa-

Table 1 - Frequency of chromosomal aberrations in occupationally exposed health workers with and without lens cataract according to occupation (workplace)

Group	Nm	ΣΣ	f	Occupation (workplace)															
				Radiology-technicians		Radiologists		Pneumologists		Specialists in Nuclear medicine		Dental technician		Health-care technicians (Nurses)		Anesthesiologist		Other workers (Specialists) in zone	
				N (%)	Σ (f)	N (%)	Σ (f)	N (%)	Σ (f)	N (%)	Σ (f)	N (%)	Σ (f)	N (%)	Σ (f)	N (%)	Σ (f)	N (%)	Σ (f)
A-1	23000	115	0.50	73 (63.5)	73 (0.5)	18 (15.7)	18 (0.5)	12 (10,4)	12 (0.5)	2 (1.7)	2 (0.5)	1 (0.9)	1 (0.5)	4 (3.5)	4 (0.5)	1 (0.9)	1 (0.5)	4 (3.5)	4 (0.5)
A-2c	20000	300	1.50	57 (57.0)	175 (1.5)	12 (12.0)	36 (1.5)	5 (5,0)	15 (1.5)	11 (11.0)	44 (2.0)	0 (9.0)	0 (1.0)	9 (6.0)	18 (1.0)	0	0	6	12
p-value										<0,05									

A-1: occupationally exposed health-care workers with cataract; A-2c: occupationally exposed health-care workers without cataract; Nm: number of cell-mitoses
Σ: Sum of chromosomal aberrations; f: Frequency of chromosomal aberrations (no. dicentric/200cells)

Table 2 - Presence of cataract in exposed workers in different professions during work in radiation zone

DOE* Year	Occupational (workplace)																	
	Radiology technicians		Radiologist		Pneumologist		Specialists in nuclear medicine		Dental technician		Health-care technicians (Nurses)		Anesthesiologist		Other workers in zone		Total	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
1-10	20	17.4	6	5.2	4	3.5	0	0	1	0.9	2	1.7	0	0	3	2.6	36	31.3
11-20	24	20.9	5	4.3	4	3.5	2	1.7	0	0	1	0.9	0	0	0	0	36	31.3
21-30	21	18.2	6	5.2	4	3.5	0	0	0	0	1	0.9	1	0.9	1	0.9	34	29.6
31-40	8	6.9	1	0.9	0	0	0	0	0	0	0	0	0	0	0	0	9	7.8
All	73	63.5	18	15.7	12	10.3	2	1.7	1	0.9	4	3.5	1	0.9	4	3.5	115	100

DOE*: duration of occupational exposure to ionizing radiations

tional exposure in the radiation zone was identified mostly in the group of radiology technicians, followed by physicians-radiologists and pneumologists (figure 1). In control group B-C, cataract incidence was correlated with age, covering the age class 41 to 70 years (figure 2). Cataract was most frequently diagnosed in the age class 41 to 50 years in Group A-1, and thereafter the incidence of cataract tended to decline. The peak of the highest cataract incidence in Group A-1 shifted 10 years forward, to a younger age in relation to Group B-C (figure 2). Group A-1 had longer DOE in comparison to Group A-2c (table 3).

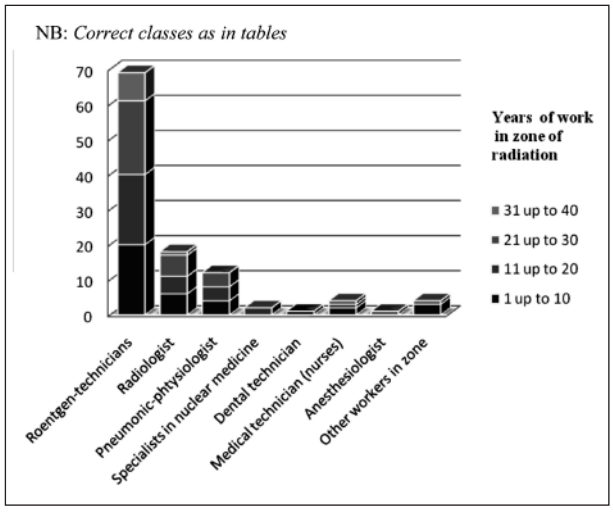

Figure 1 - Years of services up to diagnosis of cataract in exposed health workers

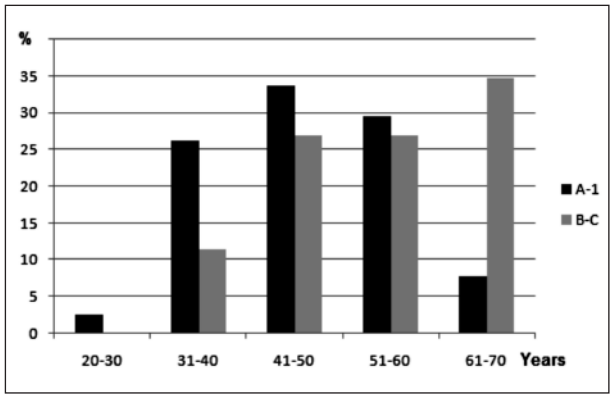

Figure 2 - Age at the moment of diagnosis of cataract in exposed and non exposed-groups
A-1: occupational exposed health-care workers with cataract;
B-C: non-exposed health-care workers with cataract (controls)

Table 3 - Duration of occupational exposure of health-care workers with and without lens cataract

Group	No.	DOE X±SD
A-1	115	16.86 ± 9.59
A-2c	100	14.22 ± 8.37
t-test		2.13
p-value		0.03

A-1: occupationally exposed health-care workers with cataract; A-2c: occupationally exposed health-care workers without cataract; DOE: Duration of Occupational Exposure

The mean age of subjects with cataract that developed during occupational ionizing radiation exposure (Group A-1) was higher than the mean age of cataract patients who did not work in the ionizing radiation zone (Group B-C) and also as compared to exposed workers without cataract (Group A-2c), $p<0.01$ (tables 4 and 5).

Among cataract patients, the prevalence of males was higher. Nevertheless, the ratio of gender and cataract incidence was significantly overturned

Table 4 - Age in exposed and non-exposed health-care workers with lens cataract

Group	No.	DOE X±SD
A-1	115	46.35 ± 9.78
B-C	26	40.30 ± 12.19
p-value		<0.01

A-1: exposed health-care workers with cataract;
B-C: non-exposed health-care workers with cataract

Table 5 - Age in exposed health-care workers with and without lens cataract

Group	No.	DOE X±SD
A-1	115	46.35 ± 9.78
A-2c	100	41.44 ± 8.41
p-value		<0.01

A-1: occupationally exposed health-care workers with cataract; A-2c: occupationally exposed health-care workers without cataract

in favour of the female sex if they were exposed to ionizing radiations, i.e. in Group A-1 (table 6). There was no difference in gender in the exposed workers with and without cataract (Groups A-1 and A-2c) (table 7).

There was a significant difference in cataract morphology between the exposed group A-1 and control group B-C ($p<0.01$; $\chi^2=12.55$). In Group A-1, the incidence of cortical cataract was 80% (No. = 92). In the controls B-C, with 53.8% of nuclear cataract (No. = 14), cortical cataract was prevalent in 46.2% (No. = 12).

The effects of other risk factors, such as blood sugar level, blood pressure and heart condition, were also analyzed. Elevated blood sugar levels were found in higher percentages in Group A-1, $p<0.01$ respect to Group A-2c (table 8). Hypertension and arrhythmia were found in higher percentages in Group A-1 (table 9).

Table 6 - Sex of occupationally exposed and non-exposed health workers with lens cataract

Group	No.	Sex			
		Male		Female	
		No.	%	No.	%
A-1	115	59	51.3	56	48.7
B-C	26	19	73.1	7	26.9
p-values		0.04			

A-1: occupationally exposed health-care workers with cataract; B-C: non-exposed health-care workers with cataract (controls)

Table 7 - Sex of exposed health workers with and without lens cataract

Group	No.	Sex			
		Male		Female	
		No.	%	No.	%
A-1	115	59	51.3	56	48.7
A-2c	100	46	46.0	54	54.0
p-values		0.44			

A-1: occupationally exposed health-care workers with cataract; A-2c: occupationally exposed health-care workers without cataract

Table 8 - Blood sugar level in examined groups

Group	No.	Blood glucose			
		Up to 6.0 mmol/l		Over 6.1 mmol/l	
		No.	%	No.	%
A-1	115	87	75.7	28	24.3
A-2c	100	90	90.0	10	10.0
B-C	26	22	84.6	4	15.4
A-1: A-2c		p<0.01			
A-1:B-C		p=0.32			

A-1: occupationally exposed health-care workers with cataract; A-2c: occupationally exposed health-care workers without cataract; B-C: non-exposed health-care workers with cataract (controls)

Table 9 - Cardiovascular disease in examined groups

Group	No.	Cardiovascular disease			
		Arterial hypertension		Arrhythmia cord's	
		No.	%	No.	%
A-1	115	37	32.2	25	21.7
A-2c	100	25	25.0	16	160
B-C	26	5	19.2	3	11.5
A-1: A-2c		p=0.23			
A-1:B-C		p=0.48			

A-1: occupationally exposed health-care workers with cataract; A-2c: occupationally exposed health-care workers without cataract; B-C: non-exposed health-care workers with cataract (controls)

Discussion

There have been diverse opinions on the ionizing radiation dose sufficient to cause cataract (6, 19). In our subjects, absorbed doses measured by TLD were very low. However, many ophthalmologists stated that there is no harmless dose for the crystalline lens (5, 9, 13, 16). Cataract is a specific effect of the radiation dose, but it may develop after continuous long-term exposure to low doses due to impaired metabolism and albumin denaturation as the result of the cumulative effects of radiotoxins, free radicals, exhausted antioxidative reserve and DNA damage in the epithelial cells of the lens.

The initial dotted opacity in the posterior lens pole subsequently continues to spread and the cu-

mulative damage due to radiation exposure gradually involves the entire lens, resulting in cataract and vision loss. Damaged epithelial cells are retained in the lens even after its removal in lens replacement surgery; therefore, chromosomal aberrations can be detected in these cells which otherwise would not be found in peripheral blood lymphocytes of these subjects, as an indicator of earlier increased exposure. DNA changes in these epithelial cells are not related to the radiation dose and they may be the result of exposure to very low doses of radiation (13, 21): DNA changes could directly or indirectly cause lens opacification as a cumulative effect of long-term exposure to radiation (1, 9, 13, 19, 21).

Cases with cataract due to occupational exposure in the area of ionizing radiations differed from other cases in the zone by length of occupational exposure, age, blood sugar level, type of workplace (radiology technicians versus nuclear medicine workers) but did not vary by gender and absorbed dose. In other health care workers, who did not work in the ionizing radiations zone, but with cataract, there was a different distribution by sex and by cataract morphology, as well as by correlation with work seniority and age. While occupational cataract occurs in all years of services, presenile cataract occurred after 14 years of service, and it is expressed as a rising linear function. In terms of age, occupational as well as presenile cataract varies according to time distribution. Occupational cataract was expressed in the form of a Gaussian Curve with a pick between 40-50 years, and presenile cataract was expressed as a linear correlation with the age.

Among exposed workers with already developed cataract, the majority was employed in the x-ray room, i.e., radiological technicians, who generally have the largest work burden in the x-ray radiation zone. Radiologists and technicians exposed to x-rays in interventional radiology were at highest risk of occupational radiation cataract if they spent more time in the direct beam without wearing protective glasses (19).

Development of cataract as an occupational disease depends upon several factors (1, 6, 9, 11, 13, 19).

In the subjects under study, risk of cataract depended upon the type of radiation (x), jobs, workplace (x-ray room, radiology department), age, duration of occupational exposure, gender, blood sugar level, etc.

The controls consisted of healthy workers outside the radiation zone who eventually developed cataract, but at an older age and after longer years of services, and differed in morphology, probably due to the effects of other risk factors (6, 9, 13, 15). Most commonly, the initial localization of cataract was in the posterior subcapsular region – PSC, with gradual development to cortical cataract (1, 2, 7). In the subjects exposed to ionizing radiations, the incidence of cortical cataract was significantly higher. About 90%, of senile cataracts showed other types of opacity. Different risks correspond to different morphological types. Diabetes enhances the risk of posterior subcapsular cataract, as well as ionizing radiations but also has an effect on other forms, cortical and mixed forms. Among other factors contributing to cataract risk, higher blood sugar levels also had effects on the subjects under study. A higher risk of cortical cataract was described in women. In our study, the sex ratio was in favour of females, if they were employed in the radiation zone. Blood pressure had a different influence on cataract development in males (17). Hypertension had no effect on PSC cataract. Nevertheless, in our study, neither blood pressure nor heart condition had any significant effect on the development of cataract.

The incidence of nuclear forms of cataract was significantly lower in the subjects working in the ionizing radiation zone. Nuclear cataract is commonly caused by non-occupational exposure to various noxae, such as smoking, obesity, excessive exposure to sunlight, while long-term wearing of spectacles and myopia increase the risk of mixed cataract (4, 7, 16, 20).

Conclusions

Occupational exposure to low doses of radiation, together with other risks such as: age, DOE, workplace or type of job (radiology technicians), type of

radiation (x-ray), sex, high blood sugar levels, could be a significant cofactor in cataract occurrence as an occupational disease of exposed health-care workers. More studies are required for a reliable conclusion.

NO POTENTIAL CONFLICT OF INTEREST RELEVANT TO THIS ARTICLE WAS REPORTED

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