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ORIGINAL ARTICLE

Cancer incidence among bulgarian medical radiation workers: epidemiological study

N. Chobanova[1], M. Vukov[2], A. Yagova[1]

[1]*National Center of Radiobiology and Radiation Protection, Sofia;* [2]*National Center of Health Information, Sofia, Bulgaria*

Summary

Purpose: *To look for the cancer incidence in a cohort of medical radiation workers in relation to work history (year of first employment, duration of occupational exposure, and radiation doses received for the whole period).*

Materials and methods: *In this retrospective study the cancer incidence among 315 medical workers (radiotherapists, diagnostic radiologists and technical personnel) was compared with that of 320 other medical specialists not having occupational contacts with radiation sources, who worked in hospitals in the territory in Sofia for the period 1960-2000. Data concerning incident cancer occurrence were obtained via a questionnaire. Data for individual doses were extracted from the National System of Individual Dosimetric Control. Descriptive statistics, x^2 test, Fisher's exact test and ANOVA analysis were used.*

Results: *Cancer was more frequently diagnosed among radiation workers compared to other medical specialists ($p=0.018$). When analyzing by cancer type breast cancer was more frequently diagnosed in radiation workers ($p=0.037$). No significant relation was observed between cumulative radiation dose and cancer incidence ($p=0.12$), or cancer incidence by different cancer localizations ($p=0.13$). Similarly, no difference was found between year of first employment and cancer development in cases and controls ($p=0.854$ and $p=0.178$, respectively). Longer whole working period was significantly connected with lower cancer incidence in cases ($p=0.015$ and $p=0.062$ for cases and controls, respectively).*

Conclusion: *The present study shows that cumulative dose and the duration of work in an ionizing radiation environment does not substantially influence cancer development. Although we found higher cancer occurrence among cases compared to controls, those two factors do not give us ground to confirm that working in an ionizing radiation environment increases cancer incidence. It is important to continue the monitoring of the health status of medical radiation workers.*

Key words: cancer incidence, epidemiology, occupational radiation exposure

Introduction

Radiologists and radiologic technologists are among the earliest groups occupationally exposed to radiation. The first case of radiation-induced skin cancer has been registered only a few years after x-rays were discovered [1-5].

According to UNSCEAR report [4], there are 2.3 million medical workers in an environment of ionizing radiation worldwide. Eight cohorts of medical radiation workers are known in the literature - 3 in USA [5-8], and one in Canada [9,10], United Kingdom [11], China [12], Japan [13] and Denmark [14], whose cancer incidence and/or mortality has been traced.

It is well known that one of the factors that increase the risk of malignant diseases is ionizing radiation [15-17]. Cancer cases in excess have been monitored in almost all organs and systems but with different frequencies and latent periods. On the basis of the radiation cancer risk results are to be found from studies of populations exposed to relatively high doses and, above all, of those that survived the A-bomb in Hiroshima and Nagasaki [18,19].

Today great attention is being paid on the effects of the long term radiation with low doses of ionizing radiation and low dose rate. In the last decades occupa-

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Author and address for correspondence:

Dr. Nina Chobanova
Radiation Epidemiology Sector
National Center of Radiobiology and Radiation Protection
132, Kl. Ohridsky blvd
1756 Sofia
Bulgaria
Fax: + 359 2 621059
E-mail: n.chobanova@ncrrp.org

tional radiation systematically decreases to the level of the natural radiation background i.e. within the range of the low dosage. The average occupational radiation in medicine worldwide is 0.1 $mSv.a^{-1}$ [4].

Medical radiation workers typically are exposed to low doses at low dose rates to large parts of the body, which allows the assessment of cancer risk for many organs and tissues. Medical radiation workers cohorts hold a unique position in radiation studies and offer one of the few chances for obtaining information regarding chronic radiation exposure [1,3,4].

The aim of the present study was to look for the cancer incidence in a cohort of medical radiation workers in relation to work history (year of first employment, duration of occupational exposure, radiation doses received for the whole period).

Materials and methods

Study design

In this retrospective cohort study included were 635 medical workers who were employed between 1950-2000 in medical institutions in the territory of Sofia. The list of persons was extracted from the "Human Resources" departments of the corresponding medical institutions.

The cases were 315 individuals-radiotherapists, diagnostic radiologists, radiobiologists and technical personnel (roentgenology assistants, nurses, technicians). The minimal period of work in ionizing radiation environment for all of the cases included in the study was 10 years and the maximum ≥ 30 years (median 25).

The controls were medical staff (n=320) who did not have occupational contacts with sources of ionizing radiation.

Data necessary for the study were gathered from both groups by means of a specially prepared questionnaire for this purpose. Included were questions regarding work history, radiation protection methods, lifestyle characteristics, demographic factors, and health history including cancer. The method of approach in gathering information was identical for both groups.

Dosimetry

Data for individual doses were extracted from the National System of Individual Dosimetric Control based on the National Center of Radiobiology and Radiation Protection, Sofia.

Radiation dosage in occupational exposure is being characterized by the average year-effective dose and the average year-effective dose for a 5-year period [20]. The cumulative dose for the whole working period in an ionizing radiation environment was calculated, whereas the years in which the radiation dosage of the persons was kept under the level of registration for each separate report was accepted as "0" [21]. For cases for which the available dose information was not complete we used the average dose for the corresponding specialty. The average year-effective doses were different; for persons working in x-ray diagnostic radiology labs they were lowest (0.22-1.31 mSv/a); for nuclear diagnostic labs the average doses were between 0.43 and 3.2 mSv/a; and for nuclear treatment they were highest (0.73-4.15 mSv/a) [22].

Statistical analyses

Descriptive statistics, x^2 test, Fisher's exact test and ANOVA analysis were applied. The SPSS, version 11.01 for statistical processing of the data was used.

Results

The demographic characteristics of the cases and controls are presented in Table 1. Females predominated in both groups (72% and 82% for the cases and the controls, respectively). Almost even was the distribution of the population under investigation as per education level-43.5% and 46.2% had higher and 56.5% and 53.8% secondary education for cases and controls, respectively. Roentgenology assistants and nurses made up the largest group of the study (about 48% both for cases and controls).

The year of first employment, the whole employment period and the cumulative exposure dose for the study cohort are shown in Table 2. The greater part of the cases (55%) had begun work before 1970, in 57% of which the whole employment period was more than 30 years. The prevailing number of cases (77%) had received cumulative dose for the whole period of employment less than 50 mSv, about 18% between 50 and 100 mSv, and only 4.4% more than 100 mSv.

Table 3 depicts the distribution of cancer cases and mean age at cancer diagnosis. There were 33 and 17 cancers diagnosed for cases and controls, respectively, a difference which was statistically significant (p=0.018). When comparing the two groups by separate neoplasm localizations, a statistically significant difference was also found (p=0.037).

Cancer cases and specific cancer sites according to the year of first employment and the whole employment period for the study cohort are shown in Table 4.

Table 1. Demographic characteristics of cases and controls. All respondents (n = 635)

Characteristic	*Cases (n=315)*		*Controls (n=320)*		*p-value*
	Number	*%*	*Number*	*%*	
Sex					
Female	228	72.4	262	81.9	0.005
Male	87	27.6	58	18.1	
Education					
High	137	43.5	148	46.2	NS
College graduated	178	56.5	172	53.8	
Specialist					
Physician	104	33.0	146	46.0	NS
Roentgenology assistant, Nurse	149	47.3	155	48.4	
Physicist, Biologist	28	9.0	2	0.6	
Others	34	10.7	17	5.0	

NS: non significant

Table 2. Year of first employment, whole employment period and cumulative exposure dose for the study cohort

	Cases (n=315)		*Controls (n=320)*		*p-value*
	Number	*%*	*Number*	*%*	
Year of first employment					
Before 1970	172	54.6	292	91.3	0.00
After 1971	143	45.4	28	8.8	
Whole employment period (years)					
< 30	135	42.9	8	2.5	0.00
> 30	180	57.1	312	97.5	
Cumulative exposure dose (mSv)*					
< 50	243	77.2			
50 - 100	58	18.4			
> 100	14	4.4			

*The limit of the effective dose for the personnel is 100 mSv in 5 successive years in which the maximal effective dose for each year cannot exceed 50 mSv (Regulation for the basic norms for radiation protection, Nuclear Regulatory Agency, 2005)

Table 3. Distribution of cancer in cases and controls (n=635)

	Cases	*Controls*	*p-value*
Persons with cancer			
No	282	303	0.018
Yes	33	17	
Specific cancer location			
Breast cancer	20	8	0.037
Other cancers	13	9	NS
Colon	3		
Stomach	3		
Skin	2	1	
Hodgkin's lymphoma	1		
Lung	1	1	
Uterus	1	1	
Liver	1		
Larynx	1		
Thyroid		2	
Ovary		2	
Prostate		1	
Testis		1	

NS: non significant

No statistical significance was found between the year of first employment and cancer development for cases and for controls (p = 0.854 and p = 0.178 for cases and controls, respectively). When analyzing the separate specific cancer location the results were statistically non significant (p = 0. 520 for cases and p = 0.424 for controls).

When analyzing the whole employment period and cancer development the results indicated less cancer incidence with longer working period for both groups (p=0.015 and p=0.062 for cases and controls, respectively). According to the different cancer localizations a statistically significant difference was found in cases but not in controls (p=0.006 for cases; p=0.168 for controls).

The cumulative exposure dose (mSv) and diagnosis of cancer was also analyzed. The Pearson correlation coefficient (r =–0.212) was negative and statistically non significant (p = 0.237). No correlation dependence was established between the cumulative dose for the whole working period and cancer development. The difference between the average

Table 4. Cancer cases and specific cancer sites according to the year of first employment and whole employment period (years)

	Cases		*Controls*	
	Cancer, n=33	*p-value*	*Cancer, n=17*	*p-value*
Cancer according to the year of first employment				
Before 1970	19	0.854	14	0.178
After 1971	14		3	
Specific cancer site according to the year of first employment				
Before 1970	10 (breast); 9 (other)	0.520	10 (breast); 4 (other)	0.424
After 1971	10 (breast); 4 (other)		1 (breast); 2 (other)	
Cancer according to the whole employment period (years)				
< 30	21	0.015	2	0.062
> 30	12		15	
Specific cancer site according to the whole employment period (years)				
< 30	10 (breast); 11 (other)	0.006	1 (breast); 1 (other)	0.168
> 30	10 (breast); 2 (other)		7 (breast); 8 (other)	

dose received in cases with cancer and those without was not statistically significant (p = 0.121). The same applied with analysis of specific cancer localizations (p=0.129).

Aiming at the time in risk estimation, a person - years of observation of all persons in the study was carried out. As starting point of the observation we defined the first employment in an environment of ionizing radiation for cases and in the medical practice for controls. The end of observation was the year of the registered cancer cases or end of 2005 for persons without cancer. Person - years of observation for cases was 6143, and for controls 6601 years. The estimated incidence rate per 1000 person-years was 5.37 for cases and 2.57 for controls (p = 0.015).

Discussion

Persons exposed to occupational radiation exposure are subject to a strict dosimetric control and a specialized medical observation for the whole working period. Direct information for the effect of chronic low doses of radiation is possible from studies on workers in ionizing radiation environment. The estimation of cancer risk with low dose radiation exposure is a matter of particular interest.

The present study constitutes the first analysis of cancer incidence among medical workers in Bulgaria after the establishment of the National System for Individual Dosimetric Control.

Higher cancer incidence was found in cases compared to controls for all cancers as well as specifically for breast cancer. A possible explanation for this observation could be the fact that over 75% of the persons studied were women. Still, no dose-response association was evident between cancer rate and radiation cumulative dose, as well as no correlation was established between the years of work in an ionization radiation environment and cancer incidence rate.

About 55% of the cases had begun working in an ionizing radiation environment before 1970, when the radiation doses were relatively higher. Other studies also show higher risk for breast cancer, thyroid cancer and leukemia for workers in yearly calendar periods [7,8,12]. The radiation protection measures have marked a significant improvement and a great reduction in the occupational radiation in the last 50 years. The first Basic Standard for maximal acceptable dose is 5 ber (100 Sv) for one year, whereas according to the last Basic Safety Standards the limit for effective dose is 100 mSv in 5 successive years, in which the maximal effective dose for every year can not exceed 50 mSv [20].

Another possible explanation of the results in this study is the fact that the exposed population was diverse. Medical radiation workers included radiologists, radiotherapists, radiobiologists, technologists etc. As mentioned above, doses received by persons working in various specialties are different [22].

The possibility of risk factors other than radiation, for both cases and controls, cannot be ruled out.

The response bias must be also taken into consideration.

Based on the results of our study we conclude that there is no obvious association between work in an ionizing radiation environment and increase of cancer incidence.

The results obtained for the persons being exposed to occupational radiation are very important for the every day practice as those workers voluntarily accept the corresponding radiation risk. This fact, coupled with the increasing use of radiation in modern medical practice, determines the importance of continuation of monitoring the health status of the medical radiation workers.

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