The incidence of malignant tumor among the adult population of Belarus, undergone to influence of radiation owing to the accident on the Chernobyl atomic power station

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ABSTRACT

Purpose: We presented results of long-term monitoring of incidence malignant tumor among the adult population of Belarus, according to the Belarus state register of the persons, undergone to influence of radiation owing the accident on the Chernobyl atomic power station.
Material and methods: The analysis of primary incidence of malignant tumor among various categories of the population living in Belarus and undergone the influence of ionizing radiation owing to the accident on the Chernobyl atomic power station is lead. The analysis is leading on the directly age-standardized parameters designed with the use of the world standard population. Levels, dynamics and growth rate in comparison with a similar parameters control group were estimated. Those localizations of a cancer which taking into account world experience can be radiation - induced to have been included in research only.
Results: The carried out research has revealed of statistically excess of a level and rate of incidence malignant tumors lung, stomach, colon, skin, urinary bladder among various categories of the population of the injured from Chernobyl accident in comparison with the control group. The most expressed distinctions were characteristic of the liquidators. The changes of levels and dynamics of incidence are revealed for organs of the breath, digestion, urinary system, which are the basic ways of receipt and deducing radionuclide's. Among all observable groups of the adult population the significant excess of incidence by thyroid cancer is revealed.
Conclusion: Among the adult population of Belarus should continue to monitor the incidence of malignant tumor, provide an assessment of doses to different groups of affected people, plan and conduct analytical radiation-epidemiological studies.
Key words: Chernobyl accident, cancer, population

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INTRODUCTION

About twenty five years are past after the technogenic accident on the Chernobyl atomic power station largest in the history of humanity. This catastrophe became not only the planetary technogenic radiation emergency of 20 centuries, but also by economic and social catastrophe. As a result Chernobyl accident the extensive territories of Belarus at the significant distance from the station proved to be contaminated the complex mixture of radionuclides. The density of the pollution of the soil of ^{137}Cs exceeded 37 kBq/m^2 is more than in 3300 populated areas of Belarus, including in 27 cities, with the population of approximately 2 million person, 26,9% of whom comprised children and adolescents. Most contaminated proved to be Gomel (1528 populated areas), Mogilev (866) and Brest (167) regions. The inhabitants of these territories underwent the sharp "iodine impact" in the first months after catastrophe and up to now, as before, they undergo the additional low-dose radiation exposure as a result of the stay on those contaminated by radionuclides territories, which is, as a rule, characterized by different combination of external irradiation with the internal from the incorporated radionuclides. Furthermore, for liquidation of the consequences of catastrophe, were drawn several hundred thousand people. They all to one degree or another underwent the action of the factors harmful for the health: radiation, psychogenic, chronic stress-factor, etc. On the influence of the ionizing radiation on the person and the environment known it is, perhaps, more than about any other factors, combined with the negative action. One of the most dangerous effects of radiation exposure is the intrinsic induction of malignant tumors, proven both in the experiment and in the course of the numerous long-term investigations of the medical consequences of the atomic bombing of Hiroshima and Nagasaki, other radiation emergencies, during the diagnostic and therapeutic application of sources of the ionizing radiations, with the control of the status of the health of professionals, who work in the atomic energy industry [1-8]. It was established that in the range the radiation doses, which exceed 0,5 Sv, is observed a reliable increase in the frequency of the appearance of the oncologic diseases [6-9]. At the same time, until now, remains unresolved a question about the induction of malignant tumors with the small radiation doses (to 0,3 Sv). But prolonged irradiation in the small doses of large population groups is one of the basic special features of Chernobyl catastrophe. In also the time the nonuniformity of pollution by the radionuclides of the populated areas and adjacent places, the biogeochemical special features of soils in the territories of the pollution, which caused different conversion factors of radionuclides on the food chains into the human organism, created definite difficulties in conducting of radiation monitoring and, therefore, in the estimation of real dose loads on each person. Thousands of scientific publications at present are dedicated to the problems of the medical consequences of Chernobyl accident, they conducted and are conducted large-scale studies within the framework of state programs and international projects. However, the absence of reliable individual radiation-monitoring information, the high natural and forced migration of population, other factors, inevitable with the large-scale radiation catastrophes, insufficient development of the methods of analytical epidemiology significantly complicated conducting studies of the medical consequences of accident on Chernobyl atomic power station, did not allow the authors to draw single-valued conclusions, but in many instances these conclusions were contradictory.

In connection with this the purpose of present communication - to represent the results of the long-standing monitoring of incidence by malignant tumors among the adult population of Republic Belarus according to the data of the Belorussian state register of those, who were subjected to the action of radiation as a result of the accident on Chernobyl atomic power station.

MATERIAL AND METHODS

As source material for the conducted investigation served data of the Belarusian State register of the persons, undergone served influence of radiation owing to the accident on the Chernobyl atomic power station, the data of the Belarus cancer-register, the regional oncological clinics. With 1986 years on 1991 years the personal information on a state of health of the population, undergone to influence of ionizing radiation owing to the catastrophe on the Chernobyl atomic power station, collected in the All-Union distributed register, which was on the basis of the scientific research institute of medical radiology in the USSR (Obninsk). The information to the Register was represented by all without exception of the republic of former Soviet Union, including Belarus. After disintegration of the Soviet Union in May, 1993 has been created the Belarusian State register of the persons, undergone served influence of radiation owing to the accident on the Chernobyl atomic power station as independent structure. Now it represents a personal database about a state of health of various categories of the population injured of the Chernobyl accident.

The information in the State register acts from all medical institutions of Belarus, the basic source of the information is the primary medical documentation and given to prophylactic medical examination spent annually. The Belarus Cancer-register exists since 1973year in the computerized form and on a constant basis submits data in a database on disease a cancer on five Continents and is considered as the register of high quality [5,10].

Comparison of the information on for the first time revealed cases malignant tumors between the State register and the Cancer -register is quarterly carried out.

The aims of the study were:

1. The persons, who participated in liquidation of the consequences of an accident on Chernobyl atomic power station (liquidators, 1 Group of the primary account - GPA);
2. The persons, who evacuated or independently left zone evacuations in 1986 years (evacuated, 2 GPA);
3. The persons, who live in the territories with density of pollution radioactive ^{137}Cs more than 555 κBq/m^2, and also removal or independently gone away from these zones after the accident (3 GPA);
4. The persons, who live in the territory with the right to the evacuation and with the periodic radiation monitoring (^{137}Cs from 37 kBq/m^2 of 555 kBq/m^2, 5 GPA).

The analysis of incidence by malignant tumors among the persons 5 GPA is carried out based on the example to the Gomel region, in which lives 77% of entire population of Republic Belarus, that relates to this category of victims. The analysis of incidence is carried out by malignant tumors among the adult population within the period of 1993-2006 yr. The studied period is divided into two - 1993-1996 yr. and 1997-2006 yr. Primary incidence in the period of 1993-1996 yr. it is accepted as the incidence of the latent period (minimum latent period for the solid tumors it starts equal to 10 years after radiation exposure), i.e., actually for the spontaneous incidence to the radiation exposure. In a study, the following localizations of cancer are included: all localizations (C00-C97), the malignant tumor of the stomach (C 16), the malignant tumor of colon (C 18), the malignant tumor of lung (C 34), the malignant tumor of skin (C 44), the malignant tumor of kidney (C 64-65), the malignant tumor of bladder (C 67) and the malignant tumor of thyroid gland (C 73). As the control group during the study of incidence malignant tumors among the population, which suffered from the Chernobyl accident, selected Vitebsk region. The criteria of the selection of Vitebsk region as by control group, were following: the population of this region to the smallest degree suffered from the Chernobyl accident; in the territory of this region lives the smallest number of persons, moved in connection with fulfilling of Law "About the social protection of citizens, who suffered from the catastrophe on accident on the Chernobyl atomic power station". With the analysis of the incidence of control population group all cases of cancer, revealed among the persons, moved, evacuated into Vitebsk region, and also the liquidators, which live in this region, are excluded from a study. The analysis of incidence is carried out only for the adult population. Rough intensive, age rates on 5-years age groups for 100 000 populations for every year investigated period calculated in view of a sex. The average indices of incidence and error of averages were calculated within the studied periods. Only standardized indices were used for the comparison of the level of incidence among different groups of the victim of population with the control group. The standardization of the indices of incidence was carried out by the method of the truncated standard (TASR, truncated of age-standardized of rate) for the adult at the age of older than 20 years. Indices were standardized by the direct method with the use of a world standard. The statistical significance of differences in the indices of incidence rates was evaluated according to Student's criterion. Differences were considered as the statistically significant with the probability of error of less than 5% ($p<0.05$). The quantitative description of dynamics is realized assuming the regression analysis. The approximating function was the equation of the straight line of $y=a_0+a_1t$. The accuracy of approximation was determined by the value of the coefficient of determination (R^2). The received data are submitted according to the International classification of diseases X (ICD – X) of reconsideration.

RESULTS

Among the persons, who participated in liquidation of the consequences of Chernobyl catastrophe, during the period of 1993-2006 yr. there were registered 5484 for the first time revealed cases of malignant tumors, of them 4361 (79.5%) among the men. 73.0% of all cases of malignant tumors were diagnosed among the liquidators, which entered into the zone of evacuation and first priority evacuation in 1986-1987. In 2006 year the basic portion of destructors was found in the working age of 40-59 years (70.3%). From the total number of cases of cancer to the studied localizations it was 52.9%. The

number of person-years of observation composed 1038529. In the period of 1993-1996 yr. reliable differences in the average standardized indices of incidence by the malignant tumors of all localizations, colon, skin, kidneys, bladder among the liquidators and the population of the control group was absent, and incidence by the cancer of the stomach. Lung among the liquidators was statistically meant below analogous indices in the control group (Tab. 1).

Table 1. The average standardized indices of incidence by the malignant tumors among the liquidators and the population of the control group for the periods of 1993-1996 and 1997-2006.

Cancer localization	ICD-X	1993-1996		1997-2006	
		1 GPA	Control group	1 GPA	Control group
All localizations	C00-C97	331.8±12.9	351.7±9.6	470.3±10.5*	393.6±3.8
Stomach	C16	30.8±3.8*	47.0±1.1	48.4±2.7*	40.0±0.9
Colon	C 18	16.0±1.8	15.4±0.7	23.3±1.9*	17.4±0.3
Lung	C 34	39.0±7.3*	55.6±2.0	71.9±2.5*	52.2±1.2
Skin	C 44	26.8±2.7	29.1±1.7	44.8±3.7	40.7±1.4
Kidney	C64-C65	11.5±1.6	10.9±0.9	21.6±1.6*	16.2±0.5
Bladder	C67	11.4±1.1	9.8±0.5	18.8±1.2*	11.5±0.3
Thyroid gland	C73	19.1±2.9*	6.4±0.4	25.4±3.3*	11.9±0.5

* - statistically significant distinctions with control group ($p < 0.05$)

In 1997-2006 yr. among the liquidators the average standardized indices of incidence, with exception of cancer of the skin, reliably exceeded indices in the control group by the studied localizations of cancer. In 1997-2006 in comparison with 1993-1996 the average standardized index of incidence by the malignant tumors of all localizations among the liquidators grew by 41.7%, among the population of control group within the same period of time increase in the analogous index was 3.5 times lower and composed 11.9%. On the studied localizations of cancer, with exception of cancer of the thyroid gland, the rate of increase in the incidence among the liquidators was substantially higher than among the population of control group (Tab. 2).

Table 2. The growth rate of the average standardized index of incidence by the malignant tumors among the liquidators and the population of control group in 1997-2006.

Cancer localization	ICD-X	The growth rate (%)	
		1 GPA	Control group
All localizations	C00-C97	+41.7	+11.9
Stomach	C16	+57.2	-14.9
Colon	C 18	+45.4	+12.7
Lung	C 34	+84.4	-6.2
Skin	C 44	+66.9	+39.8
Kidney	C64-C65	+88.4	+49.4
Bladder	C67	+63.9	+17.4
Thyroid gland	C73	+33.1	+87.0

Among the adult population 2 GPA during the period of 1993-2006 yr. are registered 360 for the first time revealed cases of the disease by malignant tumors, of them 122 (33.9%) among the men, 238 (66.1%) among the women. The studied localizations of cancer composed 48.6% of all cases of cancer, of them 26.9% were fallen to cancer of the thyroid gland. The number of person-years of observation composed 77574. By only localization of cancer, on which was noted the statistically significant exceeding of the average standardized index of incidence among the persons 2 GPA in comparison with the control group as in 1993-1996 so in 1997-2006 there was cancer of the thyroid gland.

During the period of 1993-2006 among the adult population 3 GPA is registered by 3351 for the first time revealed a case of cancer, of them 1594 (47.6%) among the men, 1757 (52.3%) among the women. To the studied localizations of malignant tumors, it was 50.3% of all cases of cancer. The number of person-years of observation composed 769853.

The growths rate in the incidence the malignant tumors of all localizations, stomach, colon, lung, skin was substantially above among the persons 3 GPA in comparison with the control group (Tab. 3).

With the retention of the noted tendencies, it is possible to assume soon exceeding of the level of incidence on the above-enumerated localizations of cancer among the persons 3 GPA in comparison with the control group.

Among those 5 GPA, who live in the Gomel region, during the period of 1993-2006 are registered

Table 3. The growth rate of the average standardized index of incidence by the malignant tumors among the persons 3 GPA and the population of control group in 1997-2006.

Cancer localization	ICD-X	The growth rate (%)	
		3 GPA	Control group
All localizations	C00-C97	+36.7	+11.9
Stomach	C16	+11.3	-14.9
Colon	C 18	+54.4	+12.7
Lung	C 34	+44.9	-6.2
Skin	C 44	+90.9	+39.8
Kidney	C64-C65	+66.2	+49.4
Bladder	C67	+27.4	+17.4
Thyroid gland	C73	+145.6	+87.0

58196 for the first time revealed cases of malignant tumors, of them 28331 (48.7%) among the men, 29865 (51.3%) among the women. To the studied localizations of malignant tumors, it was 51.4% of all cases of cancer. The number of person-years of observation composed 11454337.

In the period of 1993-1996 the statistically significant differences in the average standardized indices of incidence between the population 5 GPA and the control group was absent (with the exception of cancer of the thyroid gland). In 1997-2006 among the persons 5 GPA the level of incidence by the malignant tumors of all localizations, colons, skin reliably exceeded ($p<0.05$) analogous index in the control group. Reliable differences in the levels of incidence remained cancer of the thyroid gland as before (Tab. 4).

Table 4. The average standardized indices of incidence by the malignant tumors among persons 5 GPA and the population of the control group for the periods of 1993-1996 yr. and 1997-2006.

Cancer localization	ICD-X	1993-1996		1997-2006	
		5 GPA	Control group	5 GPA	Control group
All localizations	C00-C97	385.0±11.7	351.7±9.6	444.6±10.7*	393.6±3.8
Stomach	C16	50.1±0.7	47.0±1.1	41.4±1.7	40.0±0.9
Colon	C 18	16.0±1.5	15.4±0.7	22.2±0.9*	17.4±0.3
Lung	C 34	51.6±0.7	55.6±2.0	47.4±0.8*	52.2±1.2
Skin	C 44	35.0±5.0	29.1±1.7	67.9±5.6*	40.7±1.4
Kidney	C64-C65	11.4±0.2	10.9±0.9	15.6±0.9	16.2±0.5
Bladder	C67	10.2±0.8	9.8±0.5	12.7±0.7	11.5±0.3
Thyroid gland	C73	8.1±0.3*	6.4±0.4	15.0±1.0*	11.9±0.5

* - statistically significant distinctions with control group ($p <0.05$)

DISCUSSION

Analysis of the dynamics of the standardized indices of incidence among the liquidators during the period of 1993-2006 yr. revealed a reliable increase in the incidence by the malignant tumors of all localizations (b=12.8±3.3, t=3.9). including by the cancer of stomach (b=1.5±0.7, t=2.3). lung (b=3.4±0.8, t=4.4), skin (b=1.9±0.7, t=2.7) and kidney (b=1.3±0.3, t=4.7). The rate of growth in the incidence by the malignant tumors of all localizations among the liquidators, including by the malignant tumors of lung, stomach and kidney among the liquidators was statistically meant above in comparison with the control group. Reliable differences in the rate of growth in the incidence by the malignant tumors of stomach and lung among the liquidators in comparison with the control group were caused by the opposite directivity of the dynamics: the statistically significant increase in the incidence was noted among the liquidators, among the control group - decrease. The average standardized index of incidence composed by cancer of the thyroid gland among the persons 2 GPA in 1993-1996, 56.3±10.1 against 6.4±0.4 in the control group, in 1997-2006 – 79.1±17.3 and 11.9±0.5 respectively. To estimate the dynamics of incidence by the malignant tumors of separate localizations among the persons 2 GPA was impossible in connection with the very small number of this category of victims, registered in the Belarusian State register of the persons, undergone served influence of radiation owing to the accident on the Chernobyl atomic power station, and as a consequence - by the absence of the cases of diseases in the separate years (incomplete dynamic numbers). Among the persons

of 3GPA, just as among the persons 2 GPA, in the period of 1997-2006 yr. was noted the statistically significant exceeding ($p<0.05$) of the average standardized index of incidence only by cancer of the thyroid gland in comparison with the control group (29.6±3.2 among the persons 3 GPA and 11.9±0.5 among the control group). Among the persons 5 GPA in 1997-2006 the average standardized index of incidence by cancer of colon grew in comparison with 1993-1996 to 38.8%, the skin - to 94.0%, the bladder - to 24.5%. The growth rate of the incidence the localizations of cancer among the control group enumerated above was substantially below and composed 12.7%, 39.8% and 17.4% respectively.

Up to now universal scientific community acknowledged only the radiation- induced character of excess incidence by cancer of the thyroid gland among the children and adolescents, who were subjected to the action of radioactive iodine as a result of the Chernobyl accident [9-14]. A considerable increase in the incidence with cancer of the thyroid gland among the adult population they do not relate with radiation exposure by ^{131}I and this fact is not mentioned as that scientifically proven in the official scientific reports of international organizations. Those more does not acknowledge the fact of the accelerated increase in the incidence as other solid malignant tumors among the population, which lives on those contaminated by radionuclides territories, and destructors.

Among the adult population of Belarus should continue to monitor the incidence of malignant tumor, provide an assessment of doses to different groups of affected people, plan and conduct analytical radiation-epidemiological studies.

CONCLUSIONS

Thus, the conducted the investigation revealed the statistically significant exceeding of level and rate of the increase in the incidence by the malignant tumors of lung, stomach, colon, skin, bladder among different categories of a victim from the Chernobyl accident of population in comparison with the control group, which was not subjected to the additional action of the ionizing radiations pursuant to the Chernobyl accident. The most explicit differences were characteristic of the persons 1 GPA. Changes in levels and dynamics of incidence are revealed for the organs of the respiration, digestion, urinary system, which are the basic ways of entering and removal of radionuclides. Among all observed groups of adult population is revealed the significant exceeding of incidence by cancer of the thyroid gland.

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