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RISK ASSESSMENT OF SOMATIC DISEASES IN THE COHORT OF URANIUM INDUSTRY WORKERS EXPOSED TO RADIATION IN SMALL DOSES. MESSAGE II

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Summary

Purpose of the article are studying the risk of chronic somatic diseases among uranium industry workers exposed to occupational radiation exposure, depending on the length of work and total accumulated radiation dose.

Material and methods: Results of cohort retrospective study among persons exposed to long-term influence of negative man-made factors on frequency and risk of somatic diseases in uranium industry workers are presented. The study covers 356 people of the group A staff of the Stepnogorsk Mining and Chemical Combine (SMCC) and 507 workers who make up the monitoring group.

The study of results statistical analysis was carried out using IBM SPSS Statistics 20 and Microsoft Excel. The following criteria and methods of statistical study were used to analyze the study data: Pearson's chi-squared test and correlation analysis.

Results: The results revealed a high prevalence of chronic diseases of workers of the main group, as well as a relationship with the total accumulated dose and experience with sources of ionizing radiation. Excessive relative risks have been identified for diseases of the endocrine and nervous system, eye, ear, circulation, digestion and skin. Cardiovascular pathology represented by essential arterial hypertension and coronary heart disease, was the most characteristic of the uranium industry.

Conclusion: In the studied cohort of workers, the prevalence of diseases depended on the length of work in the enterprise and the dose of radiation for diseases of the circulatory system, digestion, eye and nervous system. Diseases of the circulatory system, nervous, endocrine system, ear, skin can be classified as professionally conditioned.

Keywords: *disease prevalence, relative risk, uranium industry, workers, small doses of radiation.*

Резюме

ОЦЕНКА РИСКА СОМАТИЧЕСКИХ ЗАБОЛЕВАНИЙ В КОГОРТЕ РАБОТНИКОВ УРАНОВОЙ ПРОМЫШЛЕННОСТИ, ПОДВЕРГАЮЩИХСЯ РАДИАЦИОННОМУ ВОЗДЕЙСТВИЮ В МАЛЫХ ДОЗАХ. СООБЩЕНИЕ II

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Цель: Изучение риска хронических соматических заболеваний у работников урановой промышленности, подвергающихся профессиональному радиационному воздействию в зависимости от стажа работы и суммарной накопленной дозы облучения.

Материал и методы: Представлены результаты когортного ретроспективного исследования среди лиц, подвергавшихся долговременному воздействию негативных техногенных факторов на частоту и риск развития соматических заболеваний у работников урановой промышленности. Исследование охватывает 356 человек персонала группы «А» Степногорского горно-химического комбината (СГКХ) и 507 работников, составляющих контрольную группу.

Статистический анализ результатов исследования осуществлялся с использованием программного продукта IBM SPSS Statistics 20 и программы Microsoft Excel. Для анализа данных исследования использовались следующие критерии и методы статистического исследования: Хи-квадрат Пирсона, корреляционный анализ.

Результаты: Результаты выявили высокую распространенность хронических заболеваний работников основной группы, а так же связь с суммарной накопленной дозой и стажем работы с источниками ионизирующей радиации. Избыточные относительные риски были выявлены для болезней эндокринной и нервной системы, глаза, уха, кровообращения, пищеварения и кожи. Наиболее характерной для лиц, занятых на урановой промышленности, оказалась патология сердечно-сосудистой системы, представленная эссенциальной артериальной гипертензией и ишемической болезнью сердца.

Выводы: В изучаемой когорте работников распространенность заболеваний зависела от стажа работы на предприятии и дозы облучения для болезней системы кровообращения, пищеварения, глаза и нервной системы. Болезни системы кровообращения, нервной, эндокринной системы, уха, кожи можно отнести к профессионально-обусловленным.

Ключевые слова: распространенность заболеваний, относительный риск, урановая промышленность, работники, малые дозы радиации.

Түйіндеме

АЗ ДОЗАЛЫ РАДИАЦИЯҒА ҰШЫРАҒАН УРАН ӨНЕРКӘСІБІ ЖҰМЫСШЫЛАР КОГОРТТАСЫНДАҒЫ СОМАТИКАЛЫҚ АУРУЛАРДЫҢ ҚАУПІН БАҒАЛАУ. ХАБАРЛАМА II

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Мақсаты: Уран өнеркәсібі жұмысшыларының арасында жұмыс уақытының ұзақтығына және радиациялық жиынтық мөлшеріне байланысты созылмалы соматикалық аурулардың даму қаупін зерттеу.

Зерттеу материалдары мен әдістері: Уран өнеркәсібі қызметкерлерінің соматикалық ауруларының жиілігіне және даму қаупіне теріс техногендік факторлардың ұзақ әсеріне ұшыраған тұлғалар арасында когорттық ретроспективті зерттеу нәтижелері ұсынылған. Зерттеуге Степногорск тау-көн-химиялық комбинатының (СГКХ) А тобынан 356 адам және бақылау тобына тиесілі 507 жұмысшы қатысты.

Зерттеу нәтижелеріне статистикалық талдау IBM SPSS Statistics 20 бағдарламалық өнімі және Microsoft Excel бағдарлама көмегімен жүзеге асырылды. Зерттеу мәліметтерін талдау үшін статистикалық зерттеудің келесі өлшемдері мен әдістері пайдаланылды: Пирсонның Хи-квадраты, корреляциялық талдау.

Зерттеу нәтижелері: Алынған нәтижелер негізгі топтың қызметкерлері арасында созылмалы аурулардың жоғары таралуын, сондай-ақ жинақталған жалпы дозамен және иондаушы сәулелену көздерімен тәжірибемен байланысын анықтады. Эндокриндік және жүйке жүйесі, көз, құлақ, қан айналымы, ас қорыту және тері ауруларының шамадан тыс салыстырмалы қаупі анықталды. Эссенциалды артериялық гипертензия және жүректің ишемиялық ауруы ұсынылған жүрек-қан тамыр патологиясы уран өнеркәсібіне тән болды.

Қорытынды: Зерттелген жұмысшылар тобында аурулардың таралуы кәсіпорындағы жұмыс ұзақтығына, қан айналымы жүйесі, ас қорыту, көз және жүйке жүйесі ауруларына радиациялық дозаға байланысты екендігі анықталды. Қан айналым жүйесі, жүйке, эндокриндік жүйелер, құлақ, тері ауруларын кәсіби түрде анықтауға болады.

Негізгі сөздер: кеселдердің таралушылығы, салыстырмалы тәуекел, уран өнеркәсібі, қызметкерлер, радиацияның кіші дозасы.

Библиографическая ссылка:

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Introduction

The effect of ionizing radiation in small doses on human health is mainly in the form of long-term stochastic effects, of which the mechanisms for the development of malignant neoplasms have been studied in more detail. At present, there is an increasing number of data for the link between exposure to ionizing radiation and contraction of non-tumor chronic diseases of uranium industry workers [1-3]. Despite a considerable number of studies, there are uncertainties and contradictions in the assessment of radiation damage effects on the health of uranium industry workers depending on accumulated dose [12, 13]. The aim of the study is assess risk of chronic somatic diseases in workers exposed to occupational radiation exposure depending on the length of work and total accumulated dose of radiation

Materials and methods

The source of data for the study retrospective cohort was the database of Institute of radiobiology and radiation protection nCJSC "Medical university Astana" Information System "Medical examination card of workers of uranium mining enterprise," developed in 2013 to monitor

professional impact of radiation background on health of workers of uranium mining enterprise. Observation data in the retrospective cohort were analyzed for the period 2013-2019.

The study was conducted in two groups - main and monitoring, with 863 males. The first main is represented by the workers of group "A" of Hydrometallurgical Plant (HMP) of Stepnogorsk Mining and Chemical Plant (SMCP), in the number of 356 people, having professional contact with sources of ionizing radiation. The retrospective cohort included workers with officially registered individual total accumulated doses for the entire period of work on the HMP. Workers of the main workshops of enterprise throughout their working life consist of individual dosimetric control of external radiation and monitoring of internal radiation from incorporated uranium. The monitoring group was selected with a similar sex and age distribution, but not related to any ionizing radiation sources. This group was represented by workers of "Stepnogorsk thermal power station" LLP and workers of other enterprises, which numbered 507 people. The characteristics of the study groups are shown in Table 1.

Table 1.

Characteristics of workers of the main and monitoring groups.

Characteristic	Main group	Monitoring group
Number	356	507
Average age	45,9±11,3	44,7 ±12,2
Average service experience in the enterprise	10,1±8,5	11,15±8,82
Average total accumulated radiation dose	81,4±76,1	-

The calculation of the relative risk (RR) of disease development was carried out on the basis of the mathematical formula: $RR = [a/(a+ b)]/[c/(c +d)]$, where a is the number of detected workers with diseases of a certain class by ICD-10;

a+b - sum of patients and healthy main group,

c - number of identified persons with diseases of the same category in the monitoring group;

c+d is the sum of patients and healthy in the monitoring group.

The calculation of etiological proportion (EF) of diseases cases related to the effect of working conditions was carried out according to the formula: $EF = [(RR-1)/RR] \times 100\%$, where RR is the relative risk of diseases of a certain class in workers caused by harmful factors [6].

The study of results statistical analysis was carried out using IBM SPSS Statistics 20 and Microsoft Excel. The following criteria and methods of statistical study were used to analyze the study data: Pearson's chi-squared test and correlation analysis.

Results of study

When analyzing data 78.8% workers of main group have chronic somatic diseases, in the monitoring group this indicator was lower and amounted to 69.9% workers. When analyzing the cases of somatic pathology of the uranium industry workers, it was revealed that the level of their general incidence in almost all classes of diseases according to ICD-10 exceeds that in the control group of workers. In general, the prevalence rate of diseases was higher among the staff of group A and amounted to 243.8

per 100 workers, in the monitoring group, respectively, 154.6 per 100.

Further, intensive indicators were calculated that demonstrated the frequency of the phenomenon in the medium. This allowed us to determine the statistical significance of differences in incidence in both groups.

Significant differences in the incidence of diseases were recorded in the following classes of diseases: diseases of the circulatory system ($\chi^2 = 76.23$, $p < 0.001$), endocrine disease ($\chi^2 = 9.0$, $p < 0.05$), nervous systems ($\chi^2 = 23$, $p < 0.05$), eye disease ($\chi^2 = 29.15$, $p < 0.001$), ear ($\chi^2 = 13.74$, $p < 0.001$), digestion ($\chi^2 = 17.62$, $p < 0.001$), skin ($\chi^2 = 6.24$, $p < 0.05$).

The calculation of extensive indicators in the study groups was carried out only for those groups of somatic diseases which could be directly or indirectly associated with the radiation factor. Infectious diseases, neoplasms, congenital anomalies, as well as injuries and poisoning were excluded from the study. Pathology of the cardiovascular system (19.4%) turned out to be the most characteristic for the studied contingent of the main group, diseases of the eye and adnexa apparatus (17.1%) took second place in the staff of group A, and respiratory diseases took the third position in the study group (13.0%). In the monitoring group diseases of the

respiratory system (17.6%), diseases of the musculoskeletal system (16.8%) and diseases of the eye and its adnexa (16.0%) occupied the leading places.

Estimate the possible impact of radiation on the health of workers; we analyzed the instant prevalence of diseases according to the ICD-10 classes identified during a medical examination. To determine the risk of diseases in the main group in relation to the control, we calculated rough relative risks (RR) according to the ICD-10 classes.

Excessive gross relative risks ($RR > 1$) which may indicate that the working conditions of the uranium industry are an additional risk factor for the health of workers have been identified for most classes of diseases. We have identified the following classes of diseases with RR and a confidence interval that doesn't include zero, in which the possible influence of working conditions on the frequency of diseases included in the ICD-10 class cannot be ruled out: diseases of the endocrine and nervous system, eyes, ear, blood circulation, digestion, skin (table 2).

Then, the etiological fraction (EF) of the cases of diseases associated with the impact of working conditions was calculated and the degree of professional dependence of the diseases of the uranium industry workers was evaluated according to certain criteria. [6]

Table 2.

Relative risk of chronic diseases of workers of the main group and their relation to the dose.

Class of disease according to ICD 10	p	RR	CI	EF, %	Degree of prof. conditionality	Exposure to dose
Diseases of the endocrine system	<0,05	2,7	1,4-5,4	63	high	-
Nervous system diseases	<0,001	2,1	1,6-2,9	53	high	$\chi^2=4,16$, $p=0,042$
Diseases of the eye and adnexa	<0,001	1,8	1,4-2,2	44	average	$\chi^2=6,23$, $p=0,013$
Diseases of the ear and mastoid process	<0,001	2,4	1,5-3,8	58	high	-
Diseases of the circulatory system	<0,001	2,6	2,1-3,2	62	high	$\chi^2=19,37$, $p<0,001$
Diseases of the digestive system	<0,001	1,8	1,4-2,4	44	average	$\chi^2=14,18$, $p=<0,001$
Diseases of the skin and subcutaneous tissue	<0,05	1,9	1,1-3,1	47	high	-

As can be seen from table 2 among the staff of group A of the HMP, the criteria for professional conditionality ranged from unreliable to high.

In summary, the strength of cause-effect relationships was assessed, which in turn is determined by the relative risk (or etiological fraction) based on the following criteria:

a) relative risk of 5 or more (etiological share of 80% or more), the disease is identified as occupational;

b) relative risk of 5 to 2 (etiological proportion of 80 to 50%), the disease is considered professionally determined;

c) relative risk of less than 2 (etiological fraction less than 50%), the relationship is considered weak and to establish a causal relationship between the disease and labor factors, another argument must be used.

Thus, data obtained in the course of this study showed that diseases of the circulatory system, nervous, endocrine system, ear, and skin can be classified as professionally determined.

Among specialists in human radiation protection, it is customary to use a sign - "dose dependence" - as a criterion that allows one to attribute or not classify certain changes to the category of radiogenic ones [7]. For the calculation of radiation risk, the initial data were individual total accumulated radiation doses by uranium production workers based on the results of individual dosimetric control. The documented radiation burden of group A staff ranged from 2.61 to 519.64 mSv. Depending on the accumulated radiation dose, the main group of the study was divided into 2 subgroups: 1) 0-100 mSv (241 people, 67.7%); 2) 100 or more mSv (115 people, 32.3%). An

analysis of the data revealed higher incidence rates in a subgroup of workers with an accumulated dose of more than 100 mSv. As the dose of radiation increases, the incidence of diseases of the circulatory system, digestion, eye and nervous system in workers increases significantly. Since the value of the Pearson correlation coefficient between the radiation dose and the work experience turned out to be equal to unity ($p = 0.01$), therefore, these values are completely interconnected and prevalence of diseases, depending on the work experience has the identical characteristic presented above.

Based on the indicators of specific gravity, gross relative risk, and dependence from dose the disease circulatory systems take a leading position in the disease structure of HMP workers. Thus, the incidence of group A staff the disease circulatory systems was 44.4 per 100 of workers, in the monitoring group this indicator was 2 times less the 17.2 per 100 of workers. When analyzing results the prevailing diseases in this category of diseases were arterial hypertension, vein disease, and coronary heart disease.

In the group of persons not in contact with sources of ionizing radiation with significantly less incidence per 100 people, the structure of it was similar to the main group of workers and repeated general patterns of prevalence of certain nosological forms of SDS diseases: 54% of all diseases were arterial hypertension, 18.4% - coronary heart disease, 17.2 - vein diseases.

Discussion

There are very few epidemiological studies regarding the health status of workers associated with the extraction and processing of uranium. Moreover, the results of these works are often contradictory. Of the small number of studies, most of them relate to the study of mortality and the relationship of occupational factors with the formation of tumors. Thus, the workers of the uranium industry in France did not show any significant excess of mortality, moreover, the cohort of employees of the uranium mining in many parameters was healthier in comparison with the general population [9]. In epidemiological studies of German uranium industry workers, convincing evidence was found of a connection between low doses of uranium alpha emitter and the risk of developing lung cancer, also for certain subtypes of non-lymphoblastic leukemia [10, 11, 13]. The health status of workers in the US uranium industry was investigated. Due to the accumulation of uranium primarily in the kidneys and bones, the researchers suggested increased mortality from tumors of bone and kidney tissue. No association with kidney cancer was found, but a positive, but not statistically significant, dose-effect relationship was found between the absorbed dose in the kidneys and their chronic non-tumorous diseases. In addition, there was a statistically significant positive relationship between the dose of radiation of the bone marrow and the occurrence of multiple myeloma [14]. Data on the prevalence of non-tumor somatic diseases of uranium workers are even more limited. Studies in the available literature are aimed at studying stochastic effects of chronic exposure to low doses of ionizing radiation in the course of professional activity, analysis and assessment of the prevalence of the main

somatic diseases of uranium mining workers, depending on professional period of work and total dose of external radiation. In the structure of morbidity, the first rank places among uranium mining workers were diseases of the circulatory system, nervous system and breathing. The incidence of workers in many classes of diseases was higher among the workers with the most experience and among those who were in the process of working under the influence of radiation with a dose of more than 100 mSv [4]. The foregoing indicates that the potential chronic effects of uranium on human health under occupational conditions have not been adequately studied.

The results are showed that the frequency of chronic somatic diseases among uranium mining workers was more than 1.5 times higher than in the control group. In the structure of the prevalence of diseases, diseases of the circulatory system, eyes and respiratory system prevailed. In general, the results of the study are consistent with the literature. Thus, a study of the cardiovascular pathology of the workers of the agricultural complex in Seversk, who has professional contact with sources of radiation, revealed a high prevalence of diseases of the circulatory system, especially coronary heart disease [5]. In addition, arterial hypertension and coronary heart disease are the most common cardiovascular diseases, which make a decisive contribution to morbidity and mortality in developed countries [6, 7]. The organ of vision, as is known, in particular, the structures of the lens are also very radiosensitive. Damage to the respiratory system may be due to a high level of dust in the workplace, in addition, a sharp cooling of the body at low air temperature in the room or in the open area.

In summary of the study, numerous data were obtained that make it possible to attribute some classes of diseases to professionally determined, viz., diseases of the circulatory system, nervous, endocrine system, ear, and skin. In addition, a dose-dependent increase in the risk of developing diseases of the endocrine system, nervous system, diseases of the eye and its adnexa, circulatory system and digestive diseases was found. In total, the results of the study testified to the negative impact of working conditions on the overall incidence of uranium industry workers exposed to chronic exposure to small doses of radiation. The working conditions prevailing at the enterprise of the uranium industry influence the formation, level and nature of general somatic morbidity.

Conclusion

The study results of health condition of the workers of HMP enterprise in Stepnogorsk revealed a high incidence of the investigated population. The most characteristic of the study population of main group was the pathology of cardiovascular system (19.4%), the second place in group A staff was occupied by diseases of the eye and its appendage apparatus (17.1%), the third position in the study group - diseases of respiratory organs (13.0%). In the studied cohort of workers, the prevalence of diseases depended on the length of work in the enterprise and dose for diseases of the circulatory system, digestion, eye and nervous system. Diseases of the circulatory system, nervous, endocrine system, ear, skin can be classified as professionally conditioned. In workers of main group

among diseases of the circulatory system, one of the leading places is essential arterial hypertension and coronary heart disease.

Competing interests: The authors collective declares absence of potential conflicts of interest related to the content of the article.

The results of the study are published for the first time in the article.

The article has not been published in other publications and is not considered in other publishers.

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Литература:

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