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PROBLEM IN ASSESSING THE EFFECTS OF RADIATION WITH "LOW DOSES". REVIEW

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Abstract

Introduction. The paper presents literature review devoted to the effect of "low doses" of ionizing radiation on health of population and the environment based on the analysis of modern scientific publications. At the moment a lot of research has been done in this area.

Purpose: to review scientific papers on the effect of "low doses" of ionizing radiation on a living organism and the environment.

Materials and methods. To achieve this purpose, we have searched and analysis of scientific publications in the databases: PubMed, Elsevier, ResearchGate, Cyberleninka, Republican scientific and technical library. The following keywords have been define before the start of the search: experimental studies, radiation, low doses. Exclusion criteria included review of publications became summary reports, newspaper articles and personal notifications. During search 1689 literary sources were revealed, 63 from which have been chosen as an analytical material of article.

Results. At the present time, assessing of the influence of "low doses" ionizing radiation have three opposite points of view. Some researchers point to the increased danger of "low doses", others reject any features of their effects and others indicate the existence of radiation hormesis, that is, the positive influence of ionizing radiation.

Conclusions. Despite the abundance of scientific literature this question still opens and requires further study.

Keywords: ionizing radiation, low doses, hormesis.

Резюме

ПРОБЛЕМА В ОЦЕНКЕ ЭФФЕКТОВ ОБЛУЧЕНИЯ «МАЛЫМИ ДОЗАМИ» ИОНИЗИРУЮЩЕГО ИЗЛУЧЕНИЯ. ОБЗОР ЛИТЕРАТУРЫ

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Введение. В статье представлен обзор литературы, посвященный влиянию «малых доз» ионизирующего излучения на здоровье населения и окружающую среду на основе анализа научных публикаций. На данный момент проведено большое количество исследований в этой области.

Цель: провести анализ научных литературных данных о влияние «малых доз» ионизирующего излучения на живой организм и окружающую среду.

Материалы и методы: для осуществления поставленной цели был выполнен поиск литературы в базах данных: PubMed, Elsevier, ResearchGate, Cyberleninka и Республиканской научно-технической библиотеки. Перед началом поиска были определены следующие ключевые слова: экспериментальное исследование, ионизирующее излучение, малые дозы. Критериями исключения публикаций в обзор были резюме докладов, газетные публикации, личные сообщения. В ходе поиска было обнаружено 1689 литературных источника, из которых 63 были выбраны в качестве аналитического материала статьи.

Результаты. В настоящее время в оценке эффектов влияния ионизирующих излучений в «малых дозах» существуют три противоположные точки зрения. Одни исследователи указывают на повышенную опасность «малых доз», другие отвергают какие-либо особенности их эффектов, третьи утверждают о существовании радиационного гормезиса, то есть позитивного действия ионизирующего излучения.

Выводы. Несмотря на обилие научной литературы, данный вопрос остается открытым и требует дальнейшего исследования этого направления.

***Ключевые слова**:* ионизирующее излучение, малые дозы, гормезис.

Түйіндеме

«ШАҒЫН ДОЗАДАҒЫ» ИОНДАУШЫ СӘУЛЕЛЕНУДІҢ ӘСЕРІН БАҒАЛАУДАҒЫ МӘСЕЛЕЛЕР. ӘДЕБИЕТКЕ ШОЛУ

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Кіріспе. Мақалада «шағын дозадағы» иондаушы сәулеленудің әсері туралы әдебиеттік ақпараттары келтірілген. Қазіргі заманғы ғылыми жарияланымдардың талдау негізінде осы мәселе аяғына дейін анықталмағаны анық.

Мақсаты: тірі организмге және қоршаған ортаға «шағын дозадағы» иондаушы сәулеленудің әсері туралы ғылыми ақпараттарды сараптау.

Материалдар мен әдістер: қойылған мақсатқа жету үшін іздестіру келесі деркқорларында жүргізілді: PubMed, Elsevier, ResearchGate, Cyberleninka және Руспубликалық ғылыми-техникалық кітапханасында. Таңдау келесі түйінді сөздер негізінде жүргізілген: эксперименттік зерттеу, иондаушы сәулелену, шағын доза. Әдеби шолу кезінде баяндамалар тұжырымдары, газет мақалалары мен жеке іс ақпараттар қарастырылмаған. Зерттеу барысында 1689 әдебиет көзі, оның 63-і талдамалық мақаланың материалы ретінде таңдап алынды.

Нәтиже. Қазіргі уақытта, «шағын дозада» иондаушы сәуле әсерін бағалауда үш қарама қарсы көз қарас бар. Бір зерттеушілер «шағын дозадағы» иондаушы сәулеленудің әсері қауіпті десе, екіншілері ешқандай әсері жоқ десе, үшіншілері оң әсерінің бар болуы, яғни гормезис туралы айтады.

Қорытынды. Ғылыми әдебиеттердің көптігіне қарамастан, бұл мәселе аяғына дейін анықталмаған және осы бағытта одан әрі зерттеулерді талап етеді.

Түйінді сөздер: иондаушы сәуле, шағын доза, гормезис

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Introduction

Our Republic has the areas where functioning nuclear power plants, uranium mining provinces, as well as the territories former Semipalatinsk nuclear test site. Therefore, the notion of the definition of "low doses" is very important for the implementation of environmental monitoring and protection of civic health near the located to them.

Aim: to review scientific papers on the effect of "low doses" of ionizing radiation on a living organism and the environment.

Materials and methods

To achieve this purpose, we have searched and analysis of scientific publications in the databases: PubMed, Elsevier, ResearchGate, Cyberleninka, Republican scientific and technical library. The following keywords have been define before the start of the search: experimental studies, radiation, low doses. Exclusion criteria included review of publications became summary reports, newspaper articles and personal notifications. During search 1689 literary sources were revealed, 63 from which have been chosen as an analytical material of article.

Results and discussion

Nuclear power plants comparison with other types of energy have huge energy potential for the economy of any country, but in case of accidents on them, the consequences and damage to the health of the population of the adjacent to the areas practically impossible to fill [1].

Based on the history of radiation exposure to a living organism, we know that significant effects occurred due to [13]: nuclear weapon tests (Semipalatinsk nuclear test site, Nevada Nuclear Test Site, Alamogordo test range, Pacific Proving Grounds and others); accidents at nuclear power plants (Chernobyl, Fukushima, Three Mile Island, Windscale); emissions of radioactive substances from industries working with the processing of nuclear products; dispersion of radioactive substances.

As a result, due to neutron activation of chemical elements, beta and gamma-emitting radionuclides in the soil composition is develop [14].

Gamma radiation affects internal tissues, when the source of radiation is outside the body, in this case, irradiation is considered to be external. Beta-irradiation affects internal organs only when the source of radiation enters the body (by inhalation of neutron-activated soil dust, contaminated water and products), thereby leading to internal irradiation [14, 24].

After the nuclear accidents at the Chernobyl nuclear power plant, and then at Fukushima, radiobiologists have the question of how to diagnose the biological consequences of "low doses" [31].

In radiobiology, the concept of "low doses" is associated with the dose at which the effects under investigation begin to appear [4, 17]. For all this, the upper limit of "low doses" is determined in different ways, depending on the evaluation criterion. When studying the effect of ionizing radiation on organisms, "low doses" are those that do not cause noticeable disturbances in vital activity. Based on this, some authors suggest to count for "low doses" of a person in the range up to 200mGy and 500mGy for mammals [5, 17, 36].

Along with this, there are also microdosimetric studies, according to which a dose can be considered low when the critical target receives on average no more than one radiation event. Therefore, all biological effects and the effects of ionizing irradiation on a living organism are divided into deterministic and stochastic [12].

Deterministic effects, which manifest themselves in the form of obvious pathology, with significant radiation doses. The peculiarity of such effects is that they assume the presence of a certain minimum threshold, below which the effect is absent, and above - depends on the dose received. Stochastic effects do not have a dose threshold, that is theoretically possible with a "low

dose" of irradiation, and the probability of occurrence is less, the lower the dose.

At the present time, in assessing the effects of the effects of ionizing radiation in "low doses", there are three opposite points of view. Some researchers point to the increased danger of "low doses," others reject any features of their effects, while others indicate the existence of radiation hormesis, that is, the positive action of ionizing irradiation [2].

The absence of peculiarities in the effect of radiation in "low doses" is evidenced by the recognition of a linear no-threshold concept as the basis for the normalization of the radiation factor [32, 44, 45, 54, 55] Regions with increased of natural background radiation have not been detected changes in the health of the local population.

On the positive effect of radiation in small doses and radiation hormesis began to speak at the beginning of the development of radiobiology. Many researchers observed the stimulation of various life processes. A detailed review of such works relating to this and subsequent periods is given by the convinced follower of the ideas of radiation hormesis in Russia – A. Kuzin [6, 7].

After nuclear accidents, environmental pollution occurs. As a result, radioactive particles enter the body, which in turn leads to beta radiation. As a result of the accident at the Chernobyl nuclear power plant, the vast adjoining territories were contaminated with radioactive fallout. Studies on the evaluation of humoral immunity have determined that soil contamination has a strong correlation with the individual dose of 137Cs [50], 25 years after the accident at the Chernobyl NPP, the doses of internal exposure to residents living in contaminated areas of northern Ukraine are limited but still associated with pollution Soil 137Cs. In addition, the cause of internal exposure is the consumption of local products [60].

In 2011, the Fukushima nuclear power plant accident in Japan caused by an earthquake measuring 9.0 magnitude after the tsunami was a reminder that even modern systems are vulnerable to natural disasters [20]. Given that the magnitude of environmental pollution accident at the Fukushima nuclear power plant second after the Chernobyl nuclear power plant, scientists from Japan, reacted sharply and began to study the effect of "low doses" of radiation on the ecosystem. Atsuki Hiyama [22-25] and colleagues studied blue butterflies, permanent inhabitants of the Fukushima Prefecture and concluded that "low doses" significantly affect the genetic apparatus, which manifests itself in the form of changes in pattern and color, as well as the shape of the wings, the size of the chest, abdome. The first generation extended the process of pupation, the frequency of abnormalities showed a high inverse correlation with the distance of the collection sites from the Fukushima nuclear power plant. A decrease in survival was also observed. Based on these data, it is impossible to estimate the effect of low doses on the human body, since the cells of the wings of these butterflies are more stable than human cells to short-term high doses of radiation. But we must also take into account that larvae and pupae are more vulnerable to long-term low radiation doses.

At the moment, scientifically, no one can provide convincing data that the long-term impact of "low doses" on the population living in the Fukushima area is safe for people's health.

In 1920, Herman Joseph Muller [40, 41] found serious consequences after exposure to ionizing radiation in the descendants of irradiated parents. In his experiment, he irradiated - Drosophila - with X-rays and found developmental defects and other disturbances in the following generations. Based on this, he came to the conclusion that a "low dose" of irradiation and even a natural radiation with increasing range of norms can lead to induction of cancer and various mutations. His work was awarded the Nobel Prize in Medicine in 1946. In 1950, he warned that radioactive contamination of the lower atmosphere adversely affects the human gene pool.

Later Anne Graupner [21, 47] with a group of scientists conducted an experimental study in mice and found that radiation in "low doses" causes genotoxic effects. Radiation damage to DNA is more complex than endogenous, which in turn can lead to an irreversible reorganization of the DNA apparatus.

In 2001, SCEAR [59] presented a report about the health of the survivors of the atomic bombing of Hiroshima and Nagasaki. There, data were presented that the descendants of the surviving mutations in the genetic apparatus were not found.

Later, Inge Schmitz-Feuerhake [40] and co-authors analyzed the scientific papers on the effect of "low doses" of radiation on the genetic apparatus and concluded that the hereditary defects found were at doses from 1 mSv to 10 mSv.

Radioactive fallout from nuclear explosions has affected the population around the world to some extent. After the Chernobyl nuclear power plant accident in 1986, the inhabitants of Sweden suffered from 137Cs exposure, after five years, cancer growth was observed [35], in Belarus [29, 61], Russia [29, 39] and Ukraine [28], the incidence of thyroid cancer increased sharply in children. Based on these data, a screening of the incidence of thyroid cancer in Fukushima was carried out, which also showed a high growth of this nosology [48, 50].

A lot of different researches of the SNTS have been carried out, the definition of the radioactivity of the environment [33, 34, 53, 56], and the health status of the population living near the regions. For example, an analysis of radiation risk among the Semipalatinsk historical cohort was conducted in relation to mortality from cardiovascular diseases. A significant high risk was found in people living in the landfill area than among those who lived in the villages of comparison [26]. A biomarker of leukemia for a given cohort was determined [62]. A study was conducted on the evaluation of polymorphisms of genes that have a potential relationship with thyroid cancer [19], and a dose-effect relationship was also established [63].

R. Rozenson [11] investigated the relationship between the irradiated population between radiation-induced changes in the immune status and allergic reactions. The author established that a number of individuals irradiated at a dose of more than 1000 mSv had a decrease in immunoregulatory subpopulations with a predominant deficiency of T suppressors with a simultaneous increase in immunoglobulin of class E, which in turn led to the formation of respiratory allergies and allergic dermatoses.

Kenji Iwata [41] and co-authors conducted studies on the prevalence of skin cancer in people living near the SNTS. According to their data, even many years after the closure of the polygon, "low doses" may be the cause of the development of this pathology.

According to the long-term results of scientists, the health of the exposed population living in the territories near the Semipalatinsk test site shows an increase in morbidity and mortality rates, a combination of multiple somatic pathology and psycho-organic disorders [15].

When assessing the hazard of radiation exposure, it is necessary to take into account the accompanying chemical factors, that is, regional features. For the first time, N. Chayzhunusova [16], in her studies, found that the assessment of the risk of radiation exposure should be carried out taking into account the concomitant effects of modifying chemical factors. According to the results of studies, the dose of ionizing radiation on the population of the Maiskyi and Lebyazhye districts was about 3 sZv. Along with this, in the territory of the Maisky district, there was a marked increase in the content of pesticides and mineral fertilizers. As a result, based on the obtained data, the author comes to the conclusion that the combined effect of ionizing radiation and chemical agents leads to a substantial reduction in the thresholds for the main effects of ionizing radiation. This is due to the fact that there was an excess of cancer, as well as congenital malformations in the Maiskyi district where there was a combined radiation - chemical effect. In the Lebyazhye district, where the dose was almost the same as in Maysky, but without pesticide exposure, no such effects were found

The exposed population of different continents complained the following similar symptoms: general weakness, fatigue, reduced efficiency. These symptoms have not a general diagnosis. In Japan after the atomic bombing of Hiroshima this syndrome is called "Genbaku Burabura Byo" (the impact of the atomic bomb) [37], in America among veterans who fought in the Persian Gulf, this syndrome is called "Gulf war syndrome" [27]. The liquidators of the Chernobyl nuclear power plant presented all these symptoms in the form of a psychoorganic syndrome. Therefore, they have been treated annually since 1990 to the present [9, 43].

It is believed that the nervous system is considered relatively resistant to ionizing radiation [3], but it should be noted that the experimental work of Achanta Pragathi and colleagues shows that ionizing radiation contributes to worsening of associative memories [18].

In Ukraine, the adolescents were examined for determining suicidal tendencies and the presence of depression. In the study group were children who were 6 years of age, in the womb and born 45 weeks after the accident. They have identified psychological problems associated with inadequate environmental assessment [30]. Mental health problems have been observed in many residents of the Fukushima prefecture [50].

To date, there is no single scientific justification for the pathogenesis of diseases of people living in environmentally unfavorable conditions. Very often, changes from the nervous system are treated as functional. The reported complaints of general weakness, fatigue, headaches, dizziness, decreased performance [38, 42] interpreted by some specialists as a desire to receive benefits or as a manifestation of radiophobia [10, 16].

Unfortunately, there is no specific data indicating that "low doses" of ionizing radiation may or may not be, one of the causes of "chronic fatigue" of the population. As, basically presented complaints are treated as the desire to receive benefits or psychological violations.

Thus, analysis of literature data suggests that in assessing the effects of irradiation with "low doses", there are three categories of researchers who hold different views. Existing judgments create the problem of "low doses", the study of which is relevant.

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