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Research Article

Incidence Of Musculoskeletal Diseases In Irradiated Pregnant Women (1986-2016) After Exposure To Radioactive Iodine.

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Abstract

The incidence of musculoskeletal diseases in the group of irradiated pregnant women analyzed over the 30 years following the Chernobyl accident is significantly lower than that in non-irradiated individuals. The pattern of pathologies in both groups is virtually identical. The increase in incidence is dose-dependent in the range from 64 to 164 mGy. These findings can be explained by differences in the expression of thyroid gland genes sensitive to radioactive iodine.

Keywords: radioactive iodine, thyroid gland, morbidity, musculoskeletal system, Chernobyl disaster, pregnancy.

INTRODUCTION

Forty years have passed since the Chernobyl nuclear power plant disaster. During this time, the medical consequences associated with population exposure to radioactive emissions from the damaged reactor have become apparent. According to the prevailing beliefs at the time of the disaster, based on health data from the atomic bombings of Hiroshima and Nagasaki, an increase in leukemia was predicted in Belarus. However, this did not occur due to the fact that the Chernobyl disaster injured the health of population by a completely different pattern of radiation exposure. Unlike the Japanese conditions, where the main factor in the formation of doses was neutron irradiation resulting from nuclear explosions, the Chernobyl accident was accompanied by external gamma radiation, as well as internal irradiation due to the incorporation of cesium, strontium, and other isotopes. From the very first moment, the population was exposed to radioactive iodine (I-131, I-133, etc.), the isotopes of which were present in large quantities in the reactor emissions and, consequently, in the radioactive cloud. The first direction of movement of the radioactive cloud was to the northwest, therefore, the population of the south of Belarus (Gomel and Brest regions) was exposed to iodine. Radioactive iodine entered the body of Belarusian residents through inhalation, as well as orally through the consumption of whole milk and certain vegetables. In the body, it accumulated in the thyroid gland (TG), which led to the appearance of thyroid cancer in children 5 years later [1,2]. Currently, this pathology predominates in adults. These were the first stochastic effects after the Chernobyl disaster.

Researchers are currently interested in the question of the systemic effects of radiation exposure, which until recently were denied due to the relatively low radiation doses received by the population. However, according to Japanese authors, such effects occurred after the bombings of Hiroshima and Nagasaki [3].

In a series of previous studies, we were able to demonstrate the presence of non-oncological, i.e., systemic effects in pregnant women who were irradiated by radioactive iodine in the first hours and days after the Chernobyl accident. It was shown that in the cohort of irradiated women, compared to control women who were not exposed to radiation, there was an increased incidence of cardiovascular, digestive, nervous, and genitourinary diseases, while no increase in pathologies affecting the endocrine or respiratory systems was observed. The increase in pathology was characterized by a dose-dependent (according to the absorbed dose by the thyroid

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gland) and a fluctuating course over the subsequent 30 years [4-9].

This report describes data on the incidence of musculoskeletal diseases among the aforementioned group of irradiated pregnant women in comparison with a cohort of women who were not exposed to radiation.

MATERIALS AND METHODS

The study group consisted of women living in the Stolin District of the Brest Region, which was exposed to a radioactive cloud and contaminated with radionuclides released from the damaged Unit 4 of the Chernobyl Nuclear Power Plant. On the night of April 26, 1986, the cloud contained large amounts of radioactive iodine exposed the population to what is known as an "iodine shock." The necessary protective measures were not taken, resulting in radioactive iodine, primarily I-131, being absorbed into the bodies of residents. The study cohort included 221 women for whom information was available in the State Registry of Persons Affected by the Chernobyl Accident. This group of women was designated as the main group. The absorbed thyroid dose ranged from 48 to 246 mGy. Thirty-two women (14.5%) were in the first trimester of pregnancy, 91 women (41.2%) were in the second, and 60 women (27.1%) were in the third. Data on gestational age were missing for 38 women (17.2%).

The comparison group included 40 women from the same district of the Brest region who lived in identical conditions but who became pregnant later, in 1987. By that time, I-131 had decayed, and therefore, they had not received any radiation dose due to that nuclide at the time of pregnancy. However, identical living conditions in the contaminated area of the district resulted in overall radiation exposure in the women examined, which was virtually identical in the study and control groups. The age of women in the control group at the time of the accident ranged from 16 to 35 years. Four women (10%) were in the first trimester of pregnancy, 10 women (25%) were in the second, and 16 women (40%) were in the third trimester. Data were missing for 10 women (25%).

Absorbed thyroid doses due to I-131 were calculated by S.M. Shinkarev, Head of the Laboratory for the Reconstruction of Population Radiation Doses at the A.I. Burnazyan Federal Medical Biophysical Center of the Federal Medical and Biological Agency of Russia, and Doctor of Engineering. Doses were calculated using a semi-empirical model from the 2004 iteration.

In addition, thyroid doses were determined for some cases based on radiometric, so-called "direct," measurements of the thyroid exposure dose rate over the thyroid area, conducted from April 26 to June 30, 1986 [10].

Total doses (1986-2016) due to residence in contaminated areas were calculated using the RESRAD-ONSITE program, version 7.2 (Environmental Science Division of Argonne National Laboratory, USA). Surface soil activity densities for cesium-137 in the Stolin district were provided by the State Institution "Republican Center for Hydrometeorology, Radioactive Pollution Control, and Environmental Monitoring."

Incidence data were obtained from the State Registry of Persons Affected by the Chernobyl Accident.

Only primary pathology incidence was considered in this study.

Statistical processing of the data was performed using the software applications Statistika 10.0 (StatSoft.Inc, USA) and SigmaPlot 12.5 (Systat Software Inc., Germany).

RESULTS AND DISCUSSION

Figure 1 presents the data from the analysis of the pathology incidence structure of Chapter XIII of ICD-10 "Diseases of the musculoskeletal system and connective tissue" (M00-M99) of irradiated and non-irradiated women.

Figure 1a. Structure of musculoskeletal diseases in irradiated (a) and non-irradiated (b) pregnant women. Note: The "Other" category included diseases occurring with a frequency of less than 4%.

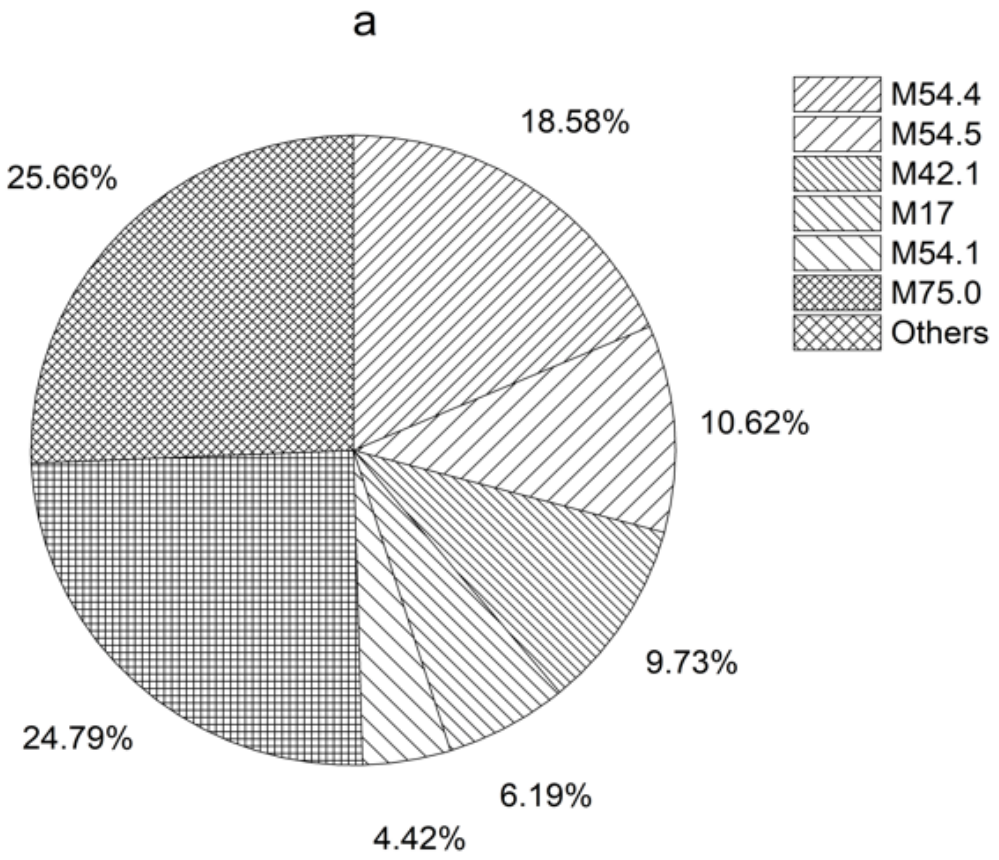
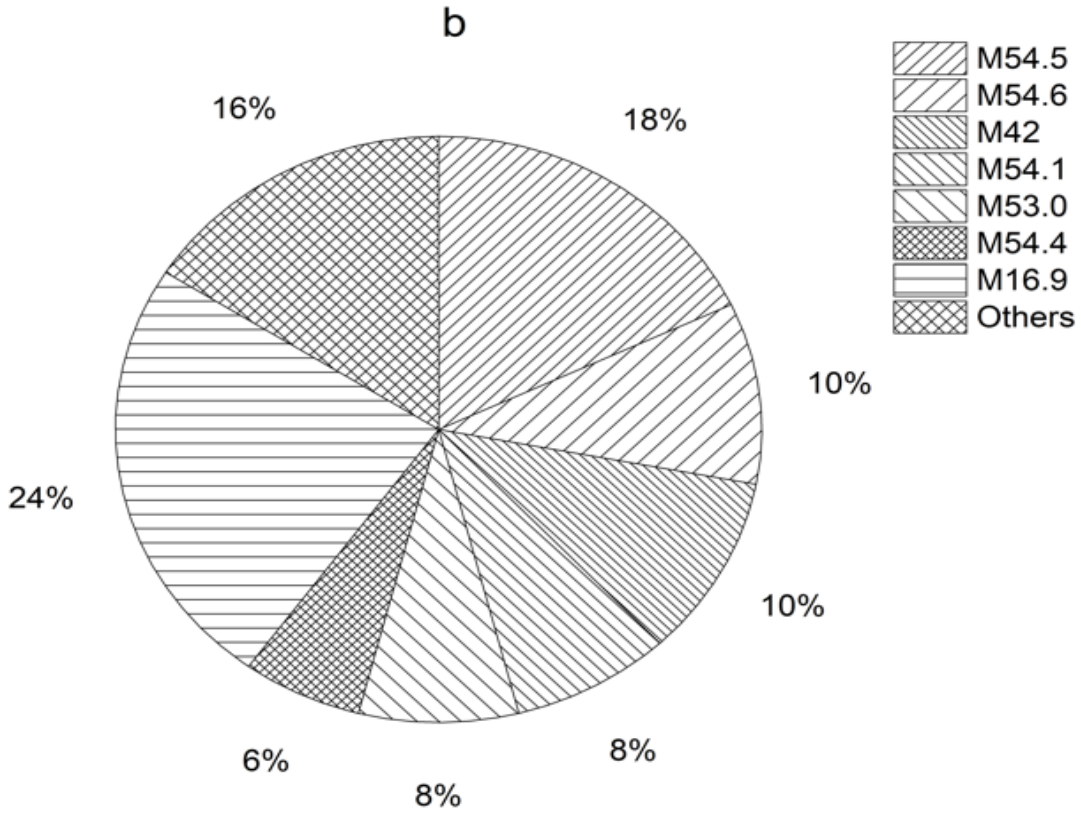


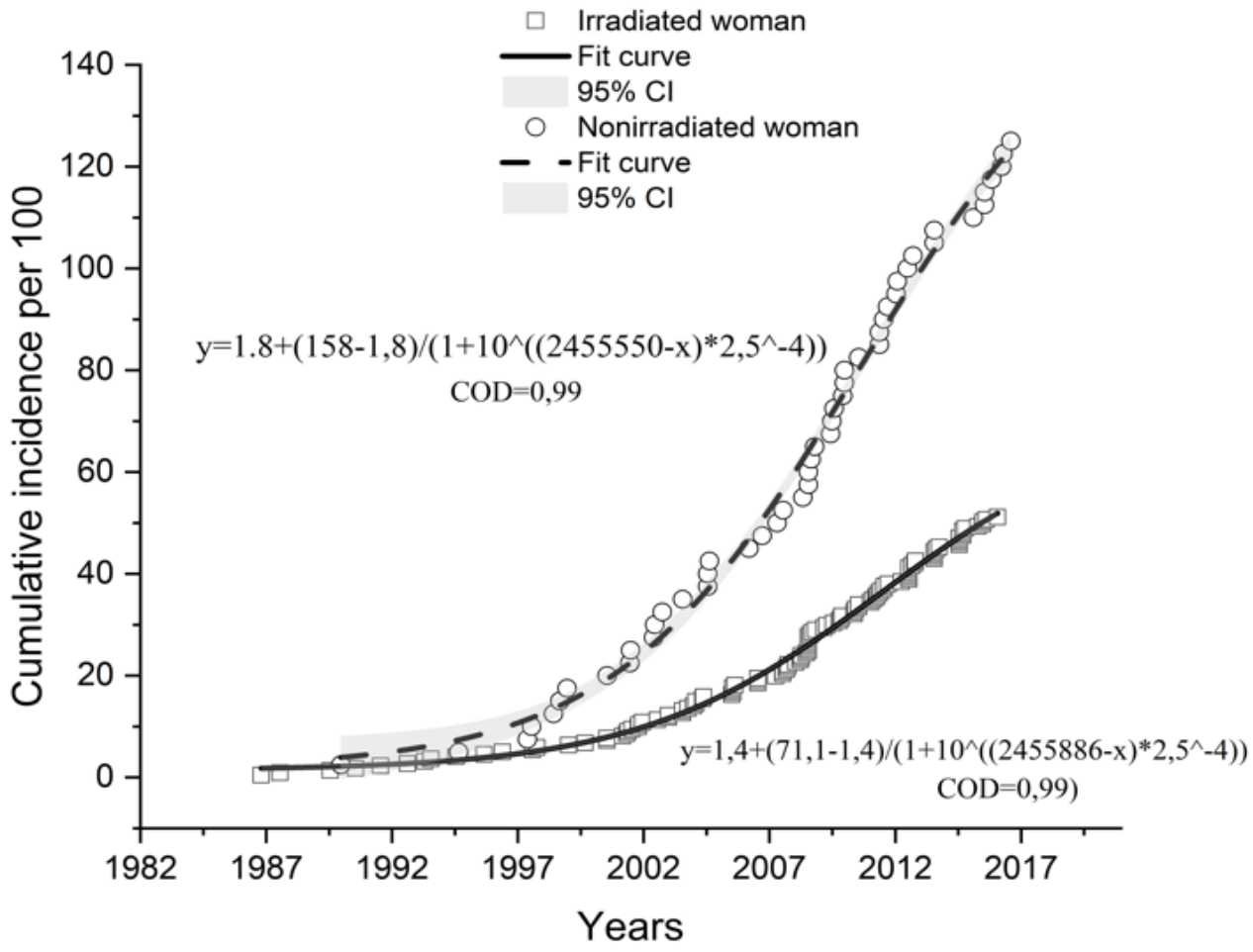
Figure 1b.



It can be seen that the pattern of disease incidence is virtually identical between the two groups of women studied. Both groups experienced conditions associated with lower back pain (M54.5), spinal osteochondrosis (M42), radiculopathy (M54.1), and others.

A study of the cumulative incidence of this type of pathology revealed that the group of non-irradiated women (during the pregnancy) showed the higher rate of increase over the study period compared to the group of women irradiated exactly during the pregnancy (**Fig. 2**).

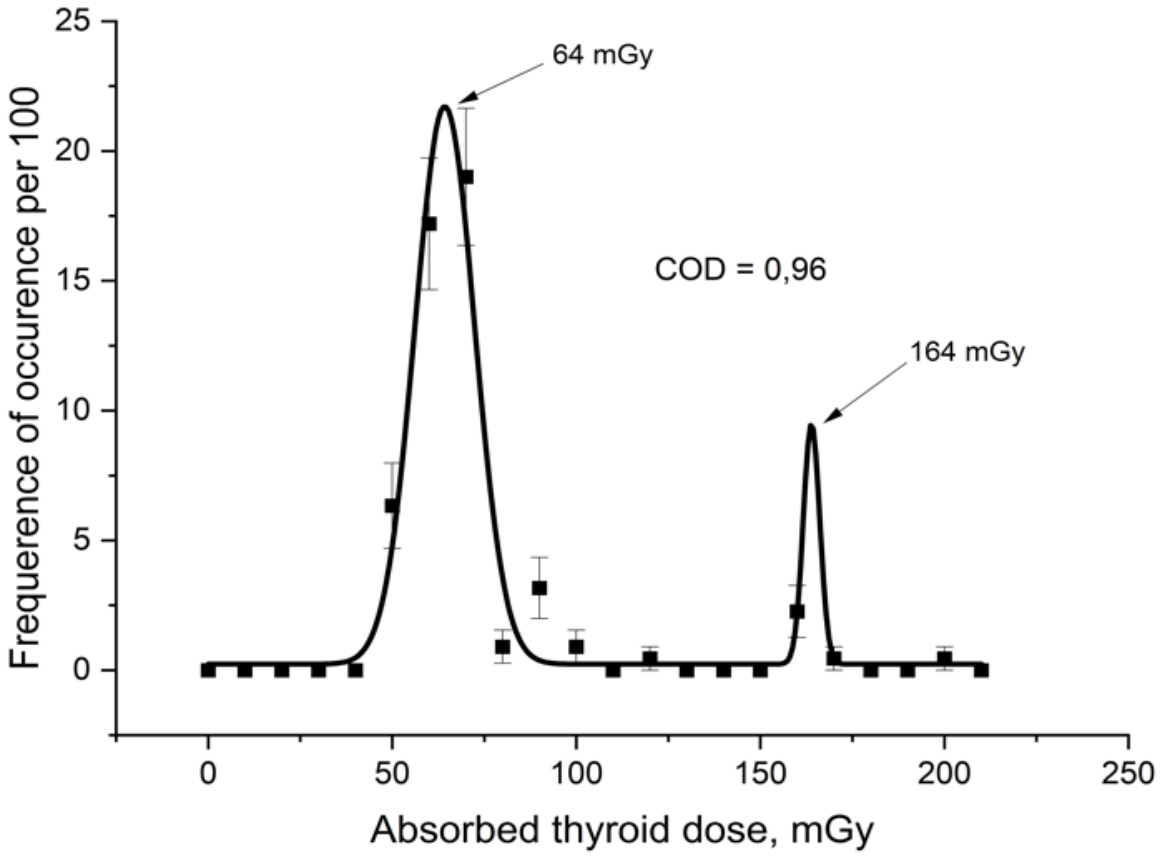
Figure 2. Cumulative incidence of musculoskeletal diseases in women irradiated and non-irradiated during the pregnancy over a 30-year period after the Chernobyl accident.



The increase in morbidity in this sample began to exceed that in the group of irradiated pregnant women 10 years after the Chernobyl disaster, and by 2016, there was 2.4-fold difference in morbidity.

Analysis of the pre-dose component associated with musculoskeletal pathology revealed that across the entire range of absorbed doses by the thyroid gland, two areas stand out as contributing to the increase in morbidity: 64 and 164 mGy (**Fig. 3**). Interestingly, as in other cases, i.e., when studying the incidence of other organs and systems in the group of irradiated pregnant women, we found a second peak associated with an increase in incidence around 160 mGy. This suggests that the same mechanisms of action of ionizing radiation on the body through the thyroid hormonal system may be involved in the increase in incidence in all studied cases.

Figure 3. Dose dependence of musculoskeletal system morbidity in irradiated pregnant women.



At a first approximation, one might expect specific changes in the musculoskeletal system in the group of women irradiated with radioactive iodine. However, we observe the opposite pattern. Firstly, the pattern of incidence of this pathology is virtually identical between irradiated and control women. Secondly, the cumulative incidence in non-irradiated pregnant women is characterized by a more rapid increase and higher incidence rates than the incidence in the cohort of irradiated women. A plausible explanation for all of this is needed. We have already noted several times that, while studying the effects of I-131 on the body, we were able to identify 27 genes in the thyroid gland that are sensitive to this isotope and exhibit reversible sensitivity to the radionuclide. This is reflected in their varying expression activity in response to the absorbed activity of the isotope [11]. Among these genes, there are many with functions that are in some way related to the functioning of the muscular and skeletal systems.

Thus, genes such as Atp2a1 (chromosome 16) and Tnnc2 (chromosome 20) are related to muscle function; through the excretion of a mediator protein, they are capable of influencing the contractility of striated muscles via calcium levels. Another group of genes (Tnni2 and Tnnt3), located on chromosome 11, again through the production of a mediator, can influence the functioning of essential muscle proteins – actin, troponin, and tropomyosin, which are directly involved in muscle contraction. Among the thyroid gland's radioiodine-sensitive genes, there are two genes associated with skeletal function. These are Ogn (chromosome 9) and Clec2d, the expression activity of which influences the differentiation of osteoblasts and osteoclasts, respectively. There are also genes that are involved in providing muscle fibers with energy (Eno3 and Ckm). Interestingly, the reversibility of expression activity, for example, of the Clec2d gene, is expressed as follows. Upon absorption of 13 kBq of I-131, its activity is inhibited by 2.1 times, while at 260 kBq, it is activated by 1.7 times.

The balance of thyroid hormones produced may influence specific functions in muscle tissue [12].

We believe that this behavior of thyroid genes, through the excretion of protein mediators and possibly thyroid hormones, may slow the development of pathological processes in bone and muscle tissue, resulting in a lower incidence of disease in the irradiated group. We observed a similar phenomenon associated with a lower incidence of respiratory disease in a group of irradiated women. Therefore, the mechanism we propose may be more widespread, dependent on specific thyroid genes sensitive to radioiodine.

CONCLUSION

The incidence of musculoskeletal diseases in the group of irradiated pregnant women analyzed over the 30 years following the Chernobyl accident is significantly lower than that in non-irradiated individuals. The pattern of pathologies in both groups is virtually identical. The increase in incidence is dose-dependent in the 64 and 164 mGy range. These findings can be explained by differences in the expression activity of thyroid gland genes sensitive to radioactive iodine.

Conflicts of interest

The research did not receive any specific support from public, private, or not-for-profit funding bodies, and the authors state that they have no conflicts of interest.

Abbrevations

ChNPP – Chernobyl Nuclear Power Plant, TG – thyroid gland, ICD -10 - International Statistical Classification of Diseases and Related Health Problems 10th Revision.

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