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Study of Lipid Peroxidation-antioxidant Defense Systems in Rats under Radiation Exposure

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Abstract

BACKGROUND: Radiation exposure is one of the factors affecting the increased formation of free radicals. Evaluation of lipid peroxidation products is very important for determining the role of oxidative damage in the pathophysiology of various diseases.

AIM: The aim of the study was to study the effect of radiation at a dose of 6 Gy on the parameters of lipoperoxidation and the antioxidant system (AOS) in experimental rats.

MATERIAL AND METHODS: The work was carried out on 20 male Wistar rats weighing 240 ± 20 g. Experimental animals are divided into two groups: I - normal group; II - group exposed to γ-rays at a dose of 6 Gy. The content of lipoperoxidation products was determined in all animals, diene conjugates (DC) and malondialdehyde (MDA) and AOS glutathione reductase (GLR) and glutathione peroxidase (GlP), catalase (CAT) the activity of enzymes in peripheral blood lymphocytes and in the liver, spleen, the lymph nodes, adrenal glands, and thymus.

RESULTS: This study showed that the effect of ionizing radiation led to an increase in the level of DC and MDA, inhibition of the activity of CAT and GLP, GLR enzymes in almost all the studied objects, as a result of which the development of oxidative stress was observed in them. The results of the study indicate serious changes in the lipid peroxidation and AOS under radiation stress.

CONCLUSION: Based on the results obtained, it was found, that irradiation increases the intensity of the formation of POL products and their accumulation, reduces the activity of enzymes of the AOS in immunocompetent organs in irradiated animals, as a result, the lack of the AOS causes oxidative stress in the body.

Introduction

The assessment of the effects of ionizing radiation on the human body is a topical issue and requires research, in this regard, the issue of radiation damage is especially relevant [1], [2]. In addition, many people are forced to live in areas where the radiation background has increased as a result of radioactive contamination of the environment after the accident of nuclear power plants, tests, and the use of atomic bombs. The biological reaction of tissues and cells in the human body as a result of ionizing radiation depends on the dose and dose rate [3], [4], [5]. The effect of gamma radiation on non-lethal doses creates a chain of complex processes of cellular reaction, that is, as a result of irradiation of cells and tissues, there is an expression of genes and the breakdown of proteins [6], [7]. Local manifestations were recorded in the area of exposure to radiation: these changes are accompanied by DNA damage due to the action of the active form of oxygen, formed as a result of irradiation of the cytoplasm [8]. Due to the close proximity of cells, oxidative stress damages the genetic material of surrounding cells. In this case, the diversity of cell populations increases. Constant levels of point mutations, which persist in generations from 10 to 30 years, lead to the stimulation of apoptosis and reparative processes, which is recorded as a response to radio adaptation [9]. Therefore, the problem of the influence of ionizing radiation on the human body will be of great practical importance in the future. Radiation has an inhibitory effect on antioxidant activity in damaging doses, inhibits catalase (CAT) activity in blood plasma when animals are irradiated at a dose of 6.0 Gy, the amount of antioxidants in the tissues is insufficient to inhibit large amounts of free radicals [10]. Accumulation of free radicals in the irradiated body leads to poisoning of the organism, which develops during radiation damage, as well as the lack of organs over time as a result of irradiation at subletal doses leads to the development of a complex of syndromes, which can lead to complete loss of function [11], [12], [13]. Modern human living conditions

are characterized by a radioecological situation in a number of regions, which has become the subject of our interest for conducting a study determining the role of lipid peroxidation systems - antioxidant protection of the body under radiation exposure in the experiment [14], [15], [16], [17], [18], [19].

Methods

To achieve this goal, experiments were performed on 20 male Wistar rats weighing 240 ± 20 g. Experimental animals are divided into two groups: I - normal group; II - group exposed to γ-rays at a dose of 6 Gy. Experiments on animals were carried out in accordance with the requirements Minister of Health of the Republic of Kazakhstan July 25, 2007, №442 "Regulations on pre-clinical, medical-biological experiments and clinical trials in the Republic of Kazakhstan." The animals 30 days before the study on were irradiated once at a dose of 6 Gy at the Czech unit "Teragam." The active element Co60 radium was used as a source. The content of lipoperoxidation products was determined in all animals, diene conjugates (DC) and malondialdehyde (MDA) and antioxidant system (AOS) glutathione reductase (GLR) and glutathione peroxidase (GLP) [15], CAT [20] the activity of enzymes in peripheral blood lymphocytes and in the liver, spleen, the lymph nodes, adrenal glands, and thymus. The obtained results were statistically processed and evaluated by the t-Student criterion [21].

Results

The results of the experiment showed that animals exposed to gamma rays, the activity of the enzyme GLR (Figure 1) in the AOS was a significant suppressed in liver tissue by 38.2% ($p < 0.01$), and in the spleen by 43% ($p < 0.01$), and in the thymus by 26% ($p < 0,05$), in the lymph nodes of the small intestine by 30% ($p < 0.05$) and in peripheral blood lymphocytes by 66% ($p < 0.001$), and in the adrenal glands did not change significantly compared to control group animals.

The activity of the GLP (Figure 2) enzyme showed the following activity in the study groups compared to the control group: in animals that were exposed to radiation, the spleen was suppressed by 36.3% ($p < 0.05$).

The following percentage differences in the activity of the CAT enzyme (Figure 3) were found in the study groups compared with the intact group of animals that have undergone the radiation factor in the liver is suppressed by 33% ($p < 0.05$), in the spleen suppressed by 56% ($p < 0.001$), and in the thymus by

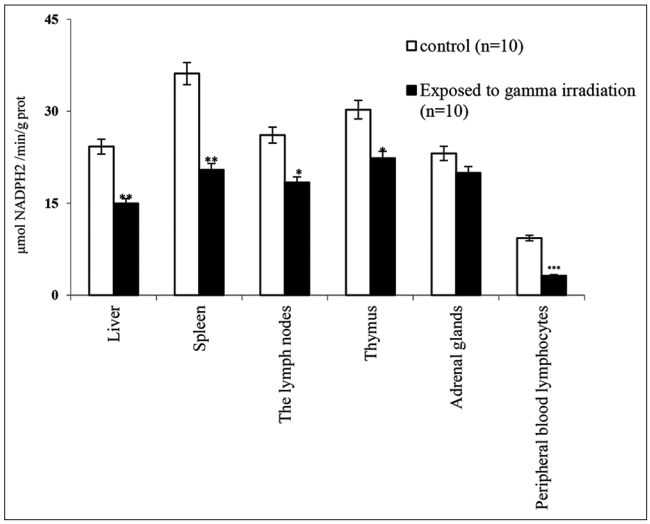


*Figure 1: The activity of enzymes (GLR) of the antioxidant system in immunocompetent organs in irradiated animals (6 Gy). The differences are statistically significant with the intact group: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$*

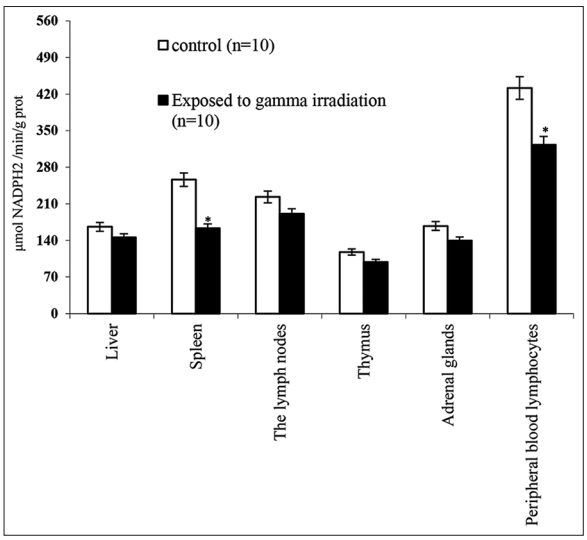


*Figure 2: The activity of enzymes (GIP) of the antioxidant system in immunocompetent organs in irradiated animals (6 Gy). The differences are statistically significant with the intact group: *$p < 0.05$, ** $p < 0.01$, *** $p < 0.001$*

52.13% ($p < 0.001$), and in lymph nodes of the small intestine by 36.41% ($p < 0.001$).

LPO activity was assessed by the content of DC and MDA. After irradiation in animals, the level of DC in all studied organs and tissues remains at an increased level.

After irradiation in animals, the level of DC (Figure 4) in blood lymphocytes remains at an increased level ($p < 0.05$), and no changes were observed in the thymus. The concentration of DC in the lymph nodes of the small intestine in animals of group II, exposed to gamma irradiation, increased from 0.30 ± 0.02 to 2.67 ± 0.20, or 8.9 times ($p < 0.001$), an increase in the indicator is observed in the liver from 0.64 ± 0.05 to 1.73 ± 0.12 ($p < 0.001$), spleen from 1.24 to 2.67

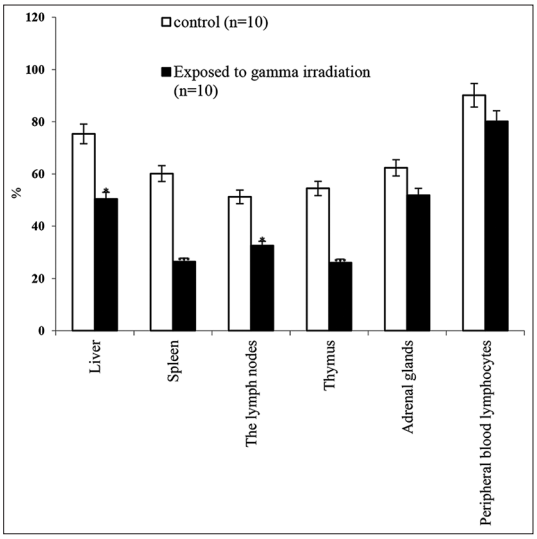
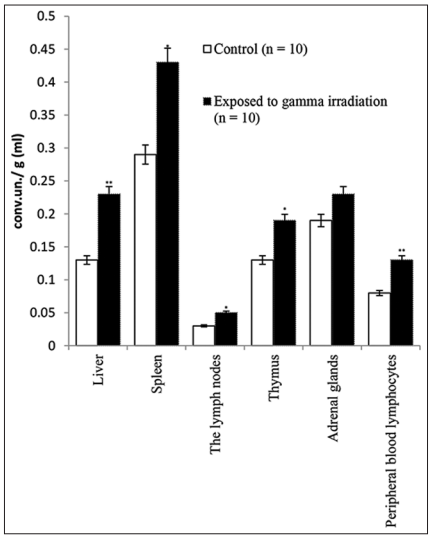


*Figure 3: The activity of enzymes (CAT) of the antioxidant system in immunocompetent organs in irradiated animals (6 Gy). The differences are statistically significant with the intact group: *p < 0.05, **p < 0.01, *** p < 0.001*



*Figue 5: The content of MDA in various objects of research and series in the experiment. The differences are statistically significant with the intact group: *p < 0.05, **p < 0.01, ***p < 0.001*

(p < 0.001). From the side of the adrenal glands, no significant changes were observed.

In animals exposed to gamma rays, MDA (Figure 5) activity was significant increased in the liver in 1.76 times (p < 0.01), and in the spleen in 1.4 times (p < 0.5), and in the thymus 1.46 times (p < 0.05), in the lymph nodes of the small intestine 1.6 times (p < 0.05) and in peripheral blood lymphocytes 1.6 times (p < 0.01), in the adrenal glands did not change significantly compared to control group animals.

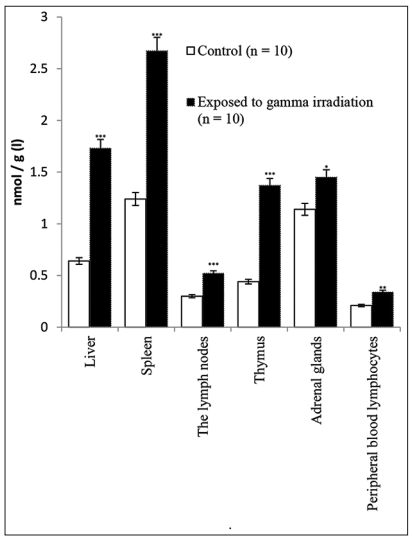


*Figure 4: The content of DC in various objects of research and series in the experiment. The differences are statistically significant with the intact group: * p < 0.05, ** p < 0.01, *** p < 0.001*

Discussion

The conducted study revealed that exposure to ionizing radiation led to an increase in the level of DC and MDA, inhibition of the activity of CAT and GLP enzymes, GLR in almost all the studied objects, as a result of which the development of oxidative stress was observed in them. The results of the study indicate serious changes in lipid peroxidation and the AOS under radiation stress. The POL-AOS imbalance creates prerequisites for the emergence of immunopathological conditions that contribute to the development of pathologies.

Conclusion

Based on the results obtained, it was found, that irradiation increases the intensity of the formation of POL products and their accumulation, reduces the activity of enzymes of the AOS in immunocompetent organs in irradiated animals, as a result, the insufficient quantity of the AOS causes oxidative stress in the body.

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