Some Objective Laws of Biological Effects of the Repetitive Pulsed Microwave and X-Ray

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Abstract – The effect of repetitive pulsed microwaves (RPM) and the X-ray on mice organism was investigated. It was shown, that short-time irradiation of mice changes the leukogram and the cortisol level in blood. The effects showed a dependence on pulse repetition rate and state of health irradiation intensity. The effects had different dynamics and could reflect the generation of stress in organism.

1. Introduction

It is actually now to investigate the biological effects of RPM with nanosecond pulses and repetitive pulsed X-ray, which sources were developed not long ago [1]. The objective laws and mechanisms of action these types of radiation have not been investigated enough, but there is interesting experimental data. In particular, it has been demonstrated that the short-time irradiation of RPM or repetitive pulsed X-ray with repetition rates ranging between 3 and 28 pps disturbed individual embryogenesis of drosophila [2]. Besides, it changes the oxidative modification of lipids and proteins [3, 4], the wound regeneration dynamic [5], impedance of blood and hepatocytes [6, 7] and have an influence on the level of peroxide in mice hepatocytes [8]. The increasing of reactive oxygen species (ROS) level and initiation of oxidative processes can be cause of adaptive ability derangements and lead to stress.

The physiological status of organism can be estimated using the whole number of indicators in the peripheral blood. The blood, as internal environment, integrates all the systems and supports the constancy of the essential physiological and biochemical parameters. The blood is one of the most dynamic organism systems, which parameters can display all internal processes. The most important haematological indicator of functional state of organism is leukogram, the changes of that can denote serious shifts of homeostasis [9]. Besides, the cortizol level in peripheral blood can be as informative indicator of stress as leukogram [10, 11].

In view of the aforesaid, the purpose of presented work was investigation of changes of leukogram and cortizol level in peripheral blood after RPM and X-ray exposure.

2. Experimental setup and measurement procedure

Experiments were carried out on white mice of mass 25–30 g abiding by the standards of the humane treatment of animals [12]. Mice was exposed to 4000 pulses at once of the RPM or the repetitive pulsed X-ray, than peripheral blood specimens were taken after 6, 24, 72 and 120 hours. The leukogram was estimated using standard procedure [13]. The cortizol level was determined on a method solid-phase immune-enzyme analysis using assay kit “Steroid IFA-cortizol”.

The source of pulse periodic X-rays was the bremsstrahlung of a SINUS-150 accelerator (300 kV accelerating voltage; 2.5 kA electron beam current, 4 ns pulse duration). Laboratory generator based on the MI-505 magnetron (10 GHz, 100 ns pulse duration, 1500 W/cm² peak power density) served as RPM source.

3. Experimental results

The leukogram of mice peripheral blood after exposure RPM or repetitive pulsed X-ray. The data obtained showed, that repetitive pulsed x-ray exposure of mice with dose 20 mGy/pulse and pulse repetition frequencies 13 and 25 pps could not change the leukogram significantly.

But then, RPM effect depended on the pulse repetition frequencies. RPM exposure with 25 pps was not effective, but after exposure with 13 pps leukogram changed. The effect on neutrophilous part of granulocytic sprout came out as significant increase of segmentonuclear leukocyte (2.6 times greater) than sham (Fig. 1, a). However, that growth do not associated with activation of respective sprout, by reason of the number of rod nuclear cells did not change. Besides, the number of lymphocytes decreased (Fig. 1, b). In some cases the degenerative forms of leukocytes with hypersegmented nuclear occurred in peripheral blood smears (the old neutrophils), therefore nuclear index is low (Fig. 2).

Thus, the RPM exposure with 1500 W/cm² and 13 pps suppressed the elimination of segmentonuclear leukocytes from the blood vessels at first 24 hours after exposure, thereby that old neutrophils lingered temporarily in the blood-vascular system. However,
this phenomenon is reversible and after 72 hours activated regeneration of neutrophilous sprout (Fig. 2).

Fig. 1. The number of segmentonuclear leukocytes (a) and lymphocytes (b) in peripheral blood of irradiated by RPM and sham mice: * – significant difference; \( p \leq 0.05 \)

Fig. 2. The nuclear index in peripheral blood of irradiated by RPM and sham mice: * – significant difference; \( p \leq 0.05 \)

The leukogram of wounded mice peripheral blood after exposure RPM. As was shown earlier, RPM with 1500 W/cm\(^2\) and 8 pps could stimulate the regeneration of full-layer skin wound of mice [5]. One possible reason of such stimulating effect may be the influence of RPM on leukocytic part of peripheral blood. One extra experimental run to test that assumption has been made; there were estimated leukograms of mice with full-layer skin wound. That mice irradiated RPM with 4000 pulses, 1500 W/cm\(^2\) and 8 pps during 5 days after wounding every day.

The data obtained showed, that wounding of itself led to stimulation of granulocytic neutrophilous sprout. Meanwhile, the rod nuclear neutrophils went into the peripheral blood, the number of segmentonuclear leukocyte and nuclear index increased (Fig. 3). That effect started to move right after wounding and continued all 120 hours of monitoring. Meanwhile the number of lymphocytes, monocytes and eosinicytes did not changed significantly.

Some alteration of leukogram was discovered in blood of irradiated mice with full-layer skin wound. This effect was characterized by reprotoportion certain forms of neutrophilic granulocytes: the number of segmentonuclear leukocytes was equal to this one in wounded sham group; the number of young cells – rod nuclear neutrophils – decreased to the level of healthy sham mice group (Fig. 4). The nuclear index proved to be lower than this one in sham (Fig. 5).

Fig. 3. The number of rod nuclear cells (a), segmentonuclear leukocytes (b) in peripheral blood of irradiated by RPM and sham mice: * – significant difference; \( p \leq 0.05 \)

Fig. 4. The nuclear index in peripheral blood of wounded mice: * – significant difference; \( p \leq 0.05 \)

Fig. 5. The cortizol level in peripheral blood of wounded mice: * – significant difference; \( p \leq 0.05 \)

Thereby, that wounding could stimulate the neutrophilous part of granulocytic sprout, but this stimula-
tion was eliminated after exposure of RPM. Consequently, concerned mechanism of wound healing through the reproportion of leukogram components is not determinative.

The cortizol level in peripheral blood of wounded mice after exposure RPM.

The wound healing process, including healing of full-layer skin wound, accompanies the inflammatory processes. In case of classical inflammation the special form of adaptive syndrome initiates [11]. The main characteristics of inflammatory process are sharply phase response, stress reaction of neuroendocrinal system, intensification of, leukocytopoiesis and mobilization of leukocytal depot [11]. As far as wound healing action of RPM was not accompanied by the increasing of leukocytopoiesis, it is possible initiation of another ways of mobilization of organism’s reserves, for example, formation initial stages of stress reaction. The level of cortizol commonly used as stress indicator [11].

Mice with full-layer skin wound have been irradiated by RPM with 4000 pulses, 1500 W/cm$^2$ and 8 pps during 5 days after wounding every day. The cortizol level in this irradiated group was above the wounded sham mice after 24 hours. This fact is evidence that RPM is stressor for mice. Than, after 72 hours cortizol level provided to be an equal to sham, but after 120 hours this level was significantly lower than sham (Fig. 5). Consequently, The RPM exposure can lessen the progress of stress, which was conditioned by wounding.

The cortizol level in peripheral blood of mice after exposure RPM or repetitive pulsed X-ray. So far as RPM exposure on mice with full-layer skin wound could change the cortizol level in the peripheral blood, it was interesting to refine the way of changing this indicator after irradiation healthy animals and whether this effect depends on pulse repetitive frequency or not.

It was found, the cortizol level in the peripheral blood of irradiated by RPM with 1500 W/cm$^2$ mice raced after 72 hours. The effects showed a dependence on pulse repetition rate (Fig. 6). The exposure with 8 pps was the most effective, but the exposure with 25 pps was not effective at all.

4. Conclusion

In conclusion, the RPM with 1500 W/cm$^2$ and 13 pps effectively affected on leukocytic sprout and could change the organism’s response to the stressor, like wounding. But repetitive pulsed x-ray was not effective. Meanwhile, the organism does not appeal to its reserves, but the functional activity of the mature cells increased.

References

[8] L.P. Zharkova, I.R. Knyazeva, V.V. Ivanov, M.A. Bolshakov, O.P. Kutenkov, and V.V. Ros-


