BIOPHYSICS AND BIOCHEMISTRY

Effect of Infrared and X-Ray Radiation on Thymus Cells and the Rate of Growth of Ehrlich Carcinoma

A. R. Dyukina[1,2], S. I. Zaichkina[2], O. M. Rozanova[1], G. F. Aptikaeva[1], S. P. Romanchenko[1], and S. S. Sorokina[1]

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We studied the effect of infrared light with a wavelength of 850 nm and modulated frequency of 101 Hz and X-ray radiation on the induction of cross-adaptive and radiation responses in the thymus and on the rate of tumor growth in mice *in vivo*. Preliminary explosure to infrared and X-ray radiation was shown to result in recovery in thymus weight after irradiation in a dose of 1.5 Gy and also inhibited the growth rate of Ehrlich carcinoma. These data attest to common mechanisms of the adaptive response induced by infrared and X-ray radiation in mice. Infrared light can be used as an adaptogen to adapt the animals to adverse factors.

Key Words: *infrared and X-rays; cross-adaptive response; Ehrlich carcinoma; thymus; mice*

Infrared light and various devices based on the use infrared radiation are now widely used for the treatment of inflammatory processes in medical practice. One of them is Curator Professional device; the therapeutic effect of this device is optimized by modulation at a frequency of 101 Hz. The impact of this radiation has been shown to significantly increase cell viability and regeneration, improve blood circulation, and increase SDH activity in the blood lymphocytes. We have found that it does not affect the level of spontaneous cytogenetic abnormalities in mouse bone marrow cells, but reduces their radiosensitivity to irradiation in dose of 1.5 Gy, *i.e.* induces cross-adaptive response (AR) comparable in magnitude to the radiation AR induced by X-ray irradiation of mice by the standard AR scheme (0.1 Gy+1.5 Gy) [2].

[1]Institute of Theoretical and Experimental Biophysics, Russian Academy of Sciences, Pushchino; [2]Pushchino State University, Russia. ***Address for correspondence:*** dyukina@rambler.ru. A. R. Dyukina

Here we studied the effect of infrared and X-ray radiation on the induction of AR in the thymus and on the rate of *in vivo* tumor growth in mice.

MATERIALS AND METHODS

The study was conducted on 2-month-old male SHK mice (n=300) kept under standard conditions in a vivarium of the Institute of Theoretical and Experimental Biophysics, Russian Academy of Sciences, according to the recommendations of the Biomedical Ethics Commission. Light therapy device with a wavelength of 850 nm and modulated frequency of 101 Hz at a power 22 mW/cm^2 was used as a source of infrared radiation (IRR). X-ray irradiation was performed using the RUT facility (200 kV voltage and 1 Gy/min dose power). The animals of experimental group 1 were irradiated with a single adapting dose of IRR for 10 min and after 24 h with a challenging X-ray dose of 1.5 Gy. Group 2 animals were irradiated with X-rays in a dose of 0.1 Gy and after 24 h with challenging dose of 1.5 Gy.

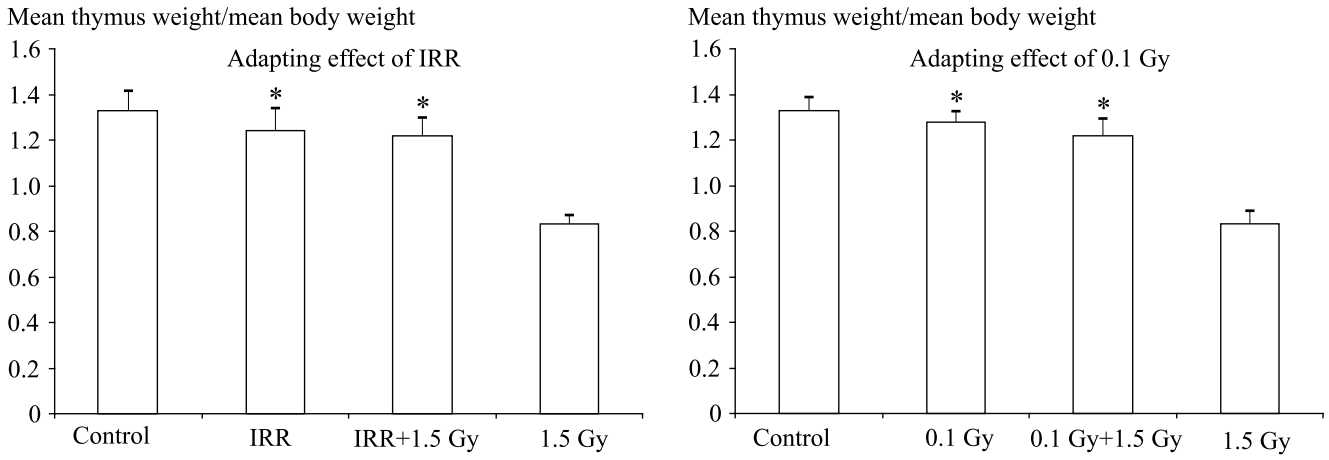

Fig. 1. RWT in mice preexposed to IRR (*a*) or X-ray in a dose of 0.1 Gy (*b*) by the AR scheme. *$p<0.05$ in comparison with mice exposed to the dose of 1.5 Gy alone.

Group 3 animals received only the dose of 1.5 Gy; group 4 animals were not irradiated and served as a natural background. The mice were sacrificed by cervical dislocation 28 h after irradiation with the challenging dose (at least 5 mice per point), and thymuses were isolated. The thymus, similarly to the bone marrow, is a hemopoietic organ with actively proliferating tissue. The relative weight of the thymus (RWT) was calculated as thymus-to-body weight ratio by group mean values: RWT=weight of thymus/body weight (mg/g).

For evaluation of the effect of infrared and X-ray radiation on the size of Ehrlich carcinoma, 4 groups were formed (15 mice in each). Group 1 animals were exposed to IRR for 10 min over 3 days before tumor transplantation. Group 2 mice were exposed to IRR in a single dose of 0.1 Gy before tumor transplantation. Group 3 mice were daily exposed IRR for 10 min over 3 days after tumor transplantation. Group 4 animals served as the control (transplantation without irradiation). To obtain solid tumor, ascitic fluid containing 2×10^6 cells in 0.1 ml of sterile isotonic NaCl was injected intramuscularly into hind paw. The tumor volume was measured with a caliper in three perpendicular directions once a week over 1 month after transplantation. Significance of differences between the groups was evaluated using Student's *t*- est.

RESULTS

After both adapting exposures, RWT in mice after subsequent irradiation in a dose of 1.5 Gy returned to the level of natural background in contrast to the group with a single irradiation in a dose of 1.5 Gy, where a sharp decrease in thymus weight was observed exhibited (Fig. 1). Hence, in the thymus, similarly to the bone marrow [2], AR of the same magnitude was observed after irradiation of both types. RWT after irradiation in adaptive doses virtually did not differ from that in non-irradiated animals. Thus, we can assume that both IRR and ionizing radiation in a dose of 0.1 Gy stimulate hemopoiesis. Low doses of radiation (0.05-0.1 Gy) also produce a stimulating effect on the proliferation of rat thymocytes [7] and the immune system and promote cell adaptation [5].

Tumor volume in mice exposed to adaptive irradiation was significantly lower than in the control group starting from day 24, *i.e.* inhibition of tumor growth was observed (Fig. 2). Inhibition of proliferation of tumor cells preliminary exposed to electromagnetic fields of different wavelengths was previously reported [4]. Similar results were obtained by other authors after irradiation of mice with IRR [6,8,9]. Exposure to IRR over 3 days after tumor transplantation had

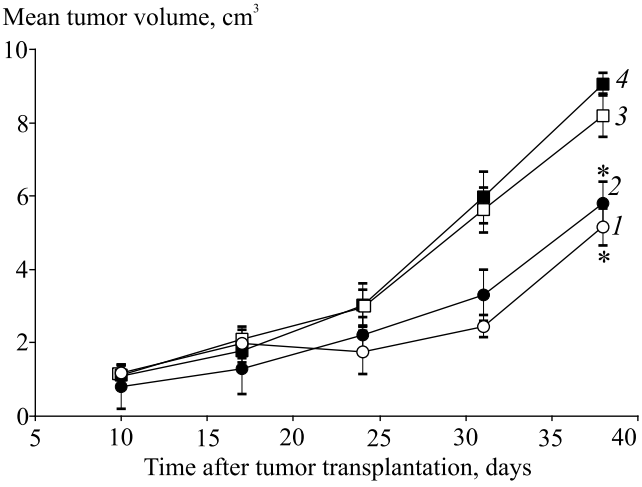

Fig. 2. Growth dynamics of solid ascitic Ehrlich carcinoma in mice after adaptive exposures to IRR or X-rays in a dose of 0.1 Gy. *1*) IRR (3 days)+tumor; *2*) 0.1 Gy+tumor; *3*) tumor+IRR (3 days);*4*) tumor without irradiation. *$p<0.05$ in comparison with the control group of mice.

no effect on tumor volume (Fig. 2). In contrast to our data, resonant acoustic exposure (10 min daily over 20 days) modulated in the range of 5-8 Hz had an antitumor effect in SHR mice with transplanted Ehrlich carcinoma [1]. Laser radiation (661 nm, 0.48 W/cm^2) produced a similar effect on M-1 sarcoma transplanted under the skin [3].

Our experiments showed that exposure to infrared and X-ray radiation promoted recovery of the thymus weight to the level of natural background after challenging irradiation in a dose of 1.5 Gy, *i.e.* AR was induced. Pre-exposure to these types of radiations (but not post-exposure) inhibited tumor growth. The obtained data attest to a common mechanism of the effect of infrared and X-ray radiation on mice and can be recommended for adaptation of animals to adverse effects with IRR.

REFERENCES

1. A. I. Gromov, V. A. Filov, A. N. Stukov, and L. A. Rybina, *Vopr. Onkol*., **52**, No. 5, 550-551 (2006).
2. S. I. Zaichkina, O. M. Rozanova, A. R. Dyukina, *et al*., *Byull. Eksp. Biol. Med*., **147**, No. 4, 407-410 (2009).
3. Yu. S. Romanko, A. F. Tsyb, M. A. Kaplan, and V. V. Popuchiev, *Byull. Eksp. Biol. Med*., **139**, No. 4, 456-461 (2005).
4. L. J. Hong, W. Yan, and J. C. Jiin, *Electromag. Biol. Med*., **20**, No. 3, 299-311 (2001).
5. S. Liu, *J. Radiat. Res. Radiat. Proces*., **13**, No. 3, 129-139 (1995).
6. H. Nagasawa, Y. Udagawa, and S. Kiyokawa, *Anticancer Res*., **19**, No. 3A, 1797-1800 (1999).
7. Y. Udagawa, H. Nagasawa, and S. Kiyokawa, *Anticancer Res*., **19**, No. 5B, 4125-4130 (1999).
8. V. Shapochnikova and Y. Korystov, *Scanning Microsc*., **9**, No. 4, 1203-1206 (1995).
9. H. Toyokawa, Y. Matsui, J. Uhara, *et al*., *Exp. Biol. Med*. (Maywood), **228**, No. 6, 724-729 (2003).