# Laser Device for the Protection of Biological Objects from the Damaging Action of Ionizing Radiation

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***Abstract* — The search for ideal protective agents for use in radiotherapy or post-exposure treatment of victims of radiation accidents is one of the actual problems of radiation protection. Laser irradiation device for the protection of biological objects from the action of ionizing radiation to be used in practice has been manufactured (invention patent RU 2 428 228 C2). This device is used to study the action of various doses of laser radiation and combined irradiation with laser and gamma-radiation, on peripheral blood parameters and number of bone marrow karyocytes of the experimental mice line C57BL/6. The mice were irradiated with ionizing and laser radiation, separately one by one in a special bench. The time interval between two types of irradiation did not exceed 30 min. First, the mice were exposed to γ-radiation then to laser radiation.**

**It was shown that laser radiation can be applied to improve the recovery of hematogenesis after the action of ionizing radiation on biological objects. Then, experiments were conducted to study the action of γ-rays and the combined action of laser radiation and γ -rays on survival, weight and skin of experimental mice. The authors investigated also the action of gamma-rays and combined effects of 650 nm laser radiation and gamma-rays on general mitotic index of bone marrow cells of mice.**

**The method of the laser radiation-protection of biological objects contributes to an increase in the viability of mice, prevents the damages of skin and also increases the mitotic activity of mice bone marrow cells.**

***Index Terms* — Laser radiation, radiation protection, stiulation of blood cell formation.**

## I. INTRODUCTION

The search for ideal protective agents for use in radiotherapy or post-exposure treatment of victims of radiation accidents is one of the actual problems of radiation protection.

The authors showed earlier (invention patent RU 2 330 695 C2) that the mice fibroblasts cells survival increases under the action of 633 nm laser radiation applied before and after both γ-rays and 150 MeV protons. The simultaneous action of laser and ionizing radiation on these cells also caused an increase of cell survival. The maximal radioprotection effect was observed when the energy density of the laser radiation was about 1 mJ/cm2 [1, 2].

Then the authors developed a device for radiation protection of biological objects in the experiment (invention patent RU 2 428 228 C2) that allows the irradiation of biological objects with a radioprotective dose of laser radiation through the start-up button being pushed (Fig 1).

This device is used to study the action of various doses of laser radiation and combined irradiation with laser and gamma-radiation (3 Gy), on peripheral blood parameters and number of bone marrow karyocytes of the experimental mice line C57BL/6.

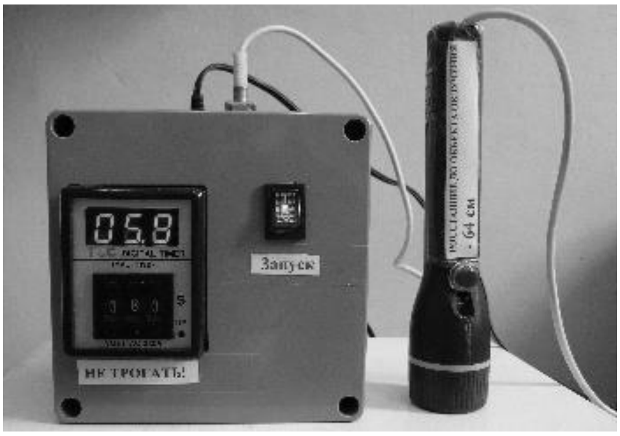


Fig.1. Laser device for the protection of biological objects.

## II. METHODS

Contributed papers will be selected on the basis of four - six pag The mice were irradiated with ionizing (wholebody irradiation) and laser radiation, separately one by one in a special bench at the Medical-Technical Complex of the Laboratory of Nuclear Problems of the Joint Institute for Nuclear Research [3]. Gamma-therapy device ROCUS-M ("Ravenstvo" Co, St-Petersburg, Russia), with Co60 source and 7600 Ku activity was used for the gamma- irradiation of cells. Dose power was 1.8 Gy/min at the place of irradiation. Laser radiation in the dose 1mJ/cm2 irradiated only the furry back of a mouse, or both the back and the abdomen of mice. In case of combined irradiation of mice, the time interval between two types of irradiation did not exceed 30 min. First, the mice were exposed to $\gamma$-radiation then to laser radiation..

## III. RESULTS

Table 1 contains the values of the peripheral blood and bone marrow karyocyte parameters of the intact mice, as well as those taken in different periods after the laser irradiation in various doses.

Table 1. Values of the parameters of peripheral blood and of the number of bone marrow karyocytes of C57BL/6 intact mice and the mice irradiated with laser

| Irradiation dose, *mJ/ cm²* | Period after irradiation, hour | Hemoglobin, g/l | Leukocytes, $10^3$ mcl | Karyocytes, mln |
|---|---|---|---|---|
| Intact mice | 0 | 132 ± 9,5 | 3,6 ± 0,3 | 60,5 ± 2,7 |
| 1 mJ/ cm² | 24 | 138,5 ± 16 | 1,66± 0,2☼ | 80,3 ± 4,8☼ |
| 1 mJ/cm² | 72 | 172 ± 27 | 4,1 ± 0,9 | 65,3 ± 5,7 |
| 2 x 1mJ/cm² | 24 | 199 ± 47 | 3,3 ± 1,3 | 69,2 ± 3,9 |
| 2 x 1 mJ/cm² | 72 | 224 ± 24,5☼ | 3,3 ± 0,5 | 72,9 ± 1,8☼ |

☼ - the values truly differ from those of the parameters of intact mice.

Data on the combined irradiation of the mice with $\gamma$ - rays and laser radiation are represented in Table 2.

The values of the parameters of the peripheral blood and the amount of the bone marrow kariocytes of mice 15 days after their irradiation with gamma-rays in the dose of 3 Gy, as well as those in the combined exposure to gamma-rays and laser radiation given in Table 3.

The obtained results show that laser radiation stimulates blood cell formation in the case of irradiation with laser and also after action of ionizing radiation. Therefore, the red spectral range laser radiation can be applied to improve the recovery of hematogenesis after the action of ionizing radiation on biological objects [4].

We also conducted experiments to study the action of gamma-rays in the dose of 5 Gy and the combined action of laser radiation with wavelength 650 nm and $\gamma$ - rays on survival, and skin of experimental mice. The experiments were performed on young male C57BL/6 mice with the mass of 11-15 g. They were accomplished in accordance with the bioethic regulations of conducting research on animals.

The method of the laser radiation-protection of biological objects contributes to an increase in the viability of mice, , prevents the damages of skin and also increases the mitotic activity of mice bone marrow cells[5].

Table 2. Values of the parameters of peripheral blood and karyocytes of the mice exposed to gamma-rays in the dose of 3 Gy, as well as with combined irradiation of gamma-rays and laser radiation

| Type and dose of irradiation | Period after irradiation, hour | Hemoglobin, g/l | Leukocytes, $10^3$ mcl | Karyocytes, mln |
|---|---|---|---|---|
| Gamma-rays in dose 3Gy | 24 | 133 ± 22 | 1,1 ± 0,1☼ | 11 ± 0,3☼ |
| Gamma-rays in dose 3Gy+laser in dose 1mJ/cm² | 24 | 170 ± 40 | 1,75 ± 0,1☼☼ | 16,5± 1☼☼ |
| Gamma-rays in dose 3 Gy+laser in dose 2x1mJ/cm² | 24 | 199 ± 47 | 2,1 ± 0,6☼☼ | 22,7 ± 1☼☼ |
| Gamma-rays in dose 3 Gy | 72 | 122 ± 8,6 | 2,1 ± 0,25☼ | 17,5 ±1,5☼ |
| Gamma-rays in dose 3 Gy+laser in dose 1mJ/cm² | 72 | 233 ± 32☼☼☼ | 1,3 ± ,13☼☼☼ | 18,9 ± 1,7 |
| Gamma-rays in dose 3 Gy+laser in dose 2x1mJ/cm² | 72 | 162,3 ± 29 | 1,5 ± ,16☼☼☼ | 18,6 ± 1,3 |

☼ - the values truly differ from those of the parameters of intact mice;

☼☼- the values truly differ from those of the parameters of mice 24 hours after their irradiation with gamma-rays in dose 3 Gy ;

☼☼☼- the values truly differ from those of the parameters of mice 72 hour after their irradiation with gamma-rays in dose 3 Gy .

Table 3. Values for peripheral blood parameters and the number of bone marrow karyocytes of the mice exposed to 3Gy gamma - radiation and those irradiated in the combined way with gamma-rays and laser radiation 15 days after their exposure.

| Type and dose of irradiation | Hemoglobin, g/l | Leukocytes, $10^3$ mcl | Karyocytes, mln |
|---|---|---|---|
| Gamma-rays in dose 3 Gy | 217 ± 14 | 2,3 ± 0,56☼ | 44 ± 1,6☼ |
| Gamma-rays in dose 3 Gy + laser in dose 1mJ/cm² | 204 ± 18 | 2,4 ± 1,3 | 58,6± 2,1☼☼ |

☼- the values truly differ from those of the parameters of the intact mice;

☼☼- the values truly differ from those of the parameters of mice 15 days after their irradiation with gamma-rays in dose 3 Gy.

Table 4 presents the values of the mitoses number per 1000 nucleated bone marrow cells in different periods after gamma- ray irradiation, laser irradiation and combined irradiation.

Table 4. The mitoses number per 1000 nucleated bone marrow cells in different periods after gamma ray irradiation, laser irradiation and combined irradiation

| Type and dose of irradiation | 24 hours | 72 hours | 15 days | 2 months |
|---|---|---|---|---|
| Unirradiated control | 14 ± 1.4 | | | |
| Gamma-rays in dose 3 Gy | 12.1 ± 1.3 | 5.5 ± 1.7☼ | 4.3 ± 0.57 | |
| Gamma-rays in dose 5Gy | | | | 8.3 ± 0.69☼ |
| laser in dose 1 mJ/cm$^2$ | 13.6 ± 0.5 | 11.2 ± 3.6 | 23.4 ± 2.5** | |
| laser in dose 2x1mJ/cm$^2$ | 13.8 ± 0.9 | 15.7 ± 1.4 | 17.3 ± 1.7** | |
| Gamma-rays in dose 3Gy + laser in dose 1mJ/cm$^2$ | 14.2 ± 2.7 | 0.5 ± 0.7* | 7.3 ± 1.1* | |
| Gamma-rays in dose 5Gy + laser in dose 1mJ/cm$^2$ | | | | 10.3± 0.7* |
| Gamma-rays in dose 3Gy + laser in dose 2x1mJ/cm$^2$ | 9.8 ± 0.8 | 8.6 ± 0.9* | 17.1± 1.5* | |

*- significantly higher than the value at irradiation only with gamma rays during the same irradiation period;

** - significantly higher than the value of unirradiated control;

☼- significantly lower than the value of unirradiated control.

## IV. CONCLUSION

The obtained results show that the red spectral region laser radiation not only improves the hematogenesis repair after the action of ionizing radiation on biological objects, as it was shown in Tables 1, 2 and. 3, but also increase the mitotic activity of the bone marrow cells. It should be stressed that the depressed hematogenesis is one of the most serious after-effects of irradiation of humans.

Thus, the procedures and remedies that can restore the hematogenesis functions of the organism play an exceptionally important role in therapy of radiation damage. Bone marrow transplantation, blood transfusion and medicinal preparations are used in the treatment. In this connection, the ability of the laser radiation to increase the mitotic activity of the bone marrow cells can be applied both in radiation protection and radiation damage therapy.

Radioepidermit accompanied by sensation of itching and tension of the skin, is widespread and constitutes a serious problem in humans who undergo radiation therapy for cancer treatment. Therefore, the aforesaid device at the doctor’s advice and consent of patients was used for the protection of the radiosensitive patients’ skin during the radiation therapy in the treatment of cancer at the Medical-Technical Complex of the Laboratory of Nuclear Problems of the Joint Institute for Nuclear Research.. Examined patients after exposure to gamma rays (10-20 minutes) were irradiated with laser device. Starting from the first day of exposure to laser the patients’ damaged skin recovered gradually, with no itching. The aforesaid device was also used for the protection of the radiosensitive patents’ mucous membranes of the stomatopharmix, longue and nasopharynx during radiation therapy sessions in the treatment of cancer..

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