Evaluation of the Biological Effects of Police Radar RAMER 7F

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This paper presents results of experiments on the effects of electromagnetic radiation in the millimeter range (frequency 34.0 ± 0.1 GHz, power density 20 μW/cm^2) emitted by a police radar device. Considering the physical properties of the radiation in millimeter range (skin effects), the experiments were carried out on hairless mice. The main physiological parameters tested were body mass, body temperature, peripheral blood, and mass and cellularity of several important organs. Critical organs, the skin, and cornea were examined by electron microscopy. Differentiation ability of hematopoietic cells, progenitors of granulocytes and macrophages, and DNA synthesis in the cornea were compared in irradiated and nonirradiated animals. None of the parameters tested was affected to an extent that would indicate the start of a pathological process or the risk of damage to genetic material. **Key words:** cornea, electromagnetic radiation, police radar, skin. *Environ Health Perspect* 101:134–136(1993)

In 1992, a new device designed for control of highway traffic, police radar RAMER 7F, began to be manufactured in the Czech Republic. Devices based on similar principles are being used in other West European countries. The RAMER 7F emits electromagnetic radiation in the millimeter range. In this range there are several wavelengths exhibiting resonance interactions with atmospheric oxygen and water molecules in the gaseous phase. It has been shown that at certain wavelengths in this range, resonance interactions occur with living matter at the molecular and cellular levels. Indirect proof of these interactions is contactless acupuncture (*1*): better effects are obtained by an extremely low output of millimeter waves from electrodes drawn close to the acupuncture points. Furthermore, transfer of information between cells on frequencies in the millimeter range has been hypothesized (*2,3*). There has been much research in this field (*4–6*). Recently, resonance effects of millimeter waves were examined. It has been shown that there are frequencies at which, in a very narrow spectrum, the effect does not depend on output density but rather on the frequency (*7–10*). It has been demonstrated that the strongest effects of millimeter waves occur at sites already damaged due to inflammation, infection, ionizing radiation, etc. The question of resonance frequencies still remains open.

The aim of the present study was to verify whether the frequency used in the RAMER 7F causes adverse biological effects. It was decided to carry out biological research in parallel with technological development of the device. Results of this effort, together with the Czech Public Health Norms, should form a basis for the approval of the product from the health safety and ecological points of view.

Radiation in the millimeter range is absorbed in a very thin layer on the body surface and is highly absorbed by water. We refer to this phenomenon as the skin effect. Therefore, we chose hairless mice to test the biological effects of RAMER 7F. The mice are bred at the Institute of Biophysics.

The experimental apparatus is shown in Figure 1. The experiments were carried out with a functional model of a microwave generator with a Gunn diode operating at a frequency of 34.0 ± 0.1 GHz (continuous waves), which was the main part of radar head. The generator was operated with a source of 525 T, 3.5 V, and 0.4 A. The source was provided with a funnel antenna (56 × 68 mm) placed on a mobile stand, by which we could regulate the distance between the antenna aperture and the irradiated object. We measured the radiation output power with a Hewlett-Packard 436 A power meter (band 26.5 GHz) provided with a power sensor type 8485 (50 Ohm, range 1.0–100.0 mW). The generator output at the level of the wave guide was 3.5 mW. We also measured the output as a function of the distance from the antenna. The irradiated object was located at such a distance that the entire field was covered by the irradiated energy. The power density at the site of the experimental object was 20 μW/cm^2 if the irradiated object was at a distance of 100 cm from the wave-guide aperture. We placed a perspex cage (attenuation 0.1 dB) on a support made of a material that absorbed the radiation.

We irradiated hairless mice (age 8–10 weeks, both sexes) for 2 weeks, 17 hr/day, 5 days/week. The time of irradiation was chosen so that it included the period of highest biological activity of the animals (from 2 PM to 7 AM). One group contained 10–12 animals. We repeated the experiment twice. We processed a total of 24 irradiated and 40 control animals. We carried out measurements three times a week, always at the same time (7 AM). The temperature was measured by a thermistor thermometer with an accuracy of ± 0.1°C.

We collected blood from the animals by cutting the tail vein. Erythrocyte and leukocyte counts and content of hemoglobin were determined with a Coulter counter (model Fn). We prepared blood smears to estimate the ratio of lymphocytes to granulocytes. The blood smears were evaluated microscopically after staining with May-Grünwald and Giemsa-Romanowski.

After collecting the peripheral blood, we sacrificed the animals by cervical dislocation. The spleen, thymus, adrenal glands, and femurs were taken and weighed. We determined counts of nucleated cells in the spleen, thymus, and femoral bone marrow with a Coulter counter. The bone marrow taken from the other femur was used for the cultivation of progenitors of granulocytes and macrophages (GM-CFC) using a one-layer method of semisolid fibrin gel on polystyrene petri dishes (*11*). We innoculated each petri dish with 2.5 × 10^5 nucleated cellular elements of the bone marrow in 2 ml of Iscove's modified Dulbecco medium with 20% fetal calf serum, to which 0.2 ml plasma, 0.2 ml $CaCl_2$, and 0.2 ml stimulation factor lung-conditioned medium were added. We cultivated the cells in a thermostat (Forma Scientific, Marietta, OH) at 37°C in a humidified atmosphere containing 5% CO_2 for 7 days. We performed the experiments in triplicate. The GM-CFC colonies were counted under an inverted microscope at 30× magnification.

After sacrificing the mice, we made preparations of cornea and other organs. They were rinsed with buffered phosphate solution and cultivated in 5 ml of Dulbecco medium containing 10% fetal serum. After 60 min cultivation at 37°C,

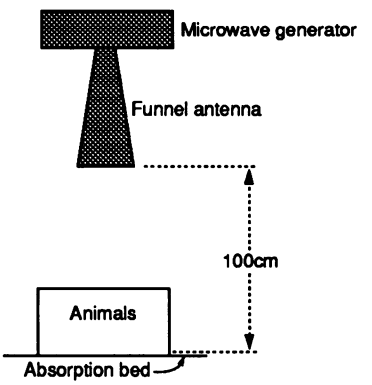

Figure 1. Experimental apparatus.

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we rinsed the preparations twice and prepared a suspension using collagenase treatment. Cells were counted with a Coulter counter. We determined the intensity of DNA synthesis as the number of disintegrations per minute using ^{3}H-thymidine (1 μCi/ml). One value represents a mean of five samples prepared from one cornea.

On day 3 after the termination of irradiation, we took samples from the cornea and the dorsal skin of experimental and control mice. Semithin sections were prepared for light microscopy. We stained these sections with methylene blue and basic fuchsin. Suitable loci of the semithin sections were selected for subsequent electron microscopic examinations. We made ultrathin sections with an ultramicrotome (Ultrotome 3), contrasted them with uranyl acetate and lead acetate, and examined and photographed the sections with an electron microscope (Opton EM 109).

Measurements of the body mass of mice of both groups are summarized in Figure 2. It is apparent from the graph that the irradiation did not cause any significant difference in the body mass of irradiated and control animals.

Figure 3 shows values of rectal temperatures of control and irradiated mice. It is apparent that no statistically significant differences exist between the two groups. An increase of temperature on days 7 and 14 (identical in both groups) was due to the fact that the measurements were carried out on Monday morning, after a weekend stay of animals in the institute vivarium, where the temperature was 2°C lower than in the microwave laboratory. The observed rise in temperature is explained by an increase of metabolism of the hairless mice at lower environmental temperature during this time.

Counts of erythrocytes and leukocytes in the peripheral blood are given in Figure 4. The values for erythrocytes of the irradiation group and of the control group do not differ. The values of hemoglobin concentration were also the same in both groups. Leukocyte count was statistically significantly decreased in the irradiated group as compared with the control group in both experiments. Differential analysis of blood smears showed a decrease in the percentage of granulocytes in irradiated mice. The observed changes may be the consequence of stress reaction on the effect of the radiation mediated by skin receptors and the system hypophysis-adrenal cortex, as the skin is the main site of interaction with the millimeter radiation.

Values of the mass of organs are given in Figure 5. The mass of the spleens of irradiated animals is significantly increased. No statistically significant differences were found in the mass of the thymus and suprarenal glands. Cellularities of the spleen, thymus, and femoral bone marrow are shown in Figure 6. No statistically significant differences were found between the control and the irradiated group.

The numbers of GM-CFC are summarized in Table 1. It is apparent that, even though no differences were observed in cellularities of femurs in the control and irradiated groups, the number of GM-CFC calculated per femur was statistically significantly increased in the irradiated group.

In duplicate experiments, DNA synthesis in cornea cells (data not shown) was decreased by 25%, but this was not statistically significant due to high variability of the individual samples. Nevertheless, we consider this finding noteworthy even considering the possibility of eye infection after a longer exposure.

Light-microscopic examination of the cornea of irradiated and control mice showed that the action of electromagnetic waves in the millimeter range did not cause any damage to the cornea at the doses and intensities examined. The continuity of the anterior, stratified squamous epithelium of the cornea was preserved in irradiat-

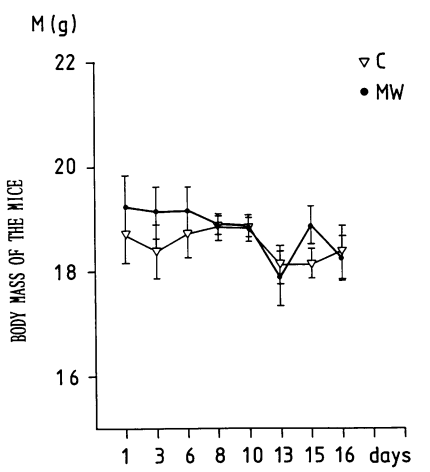

Figure 2. Body mass of the mice. C, control group; MW irradiated group. Number of animals in each point = 20.

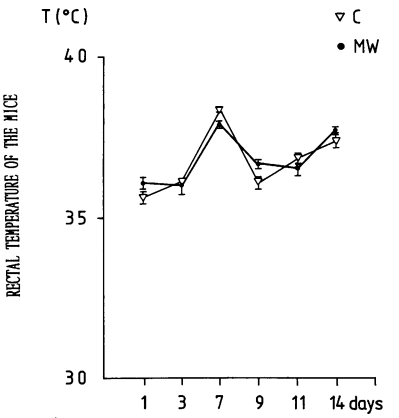

Figure 3. Rectal temperature of the mice. C, control group; MW, irradiated group. Number of animals in each point = 20.

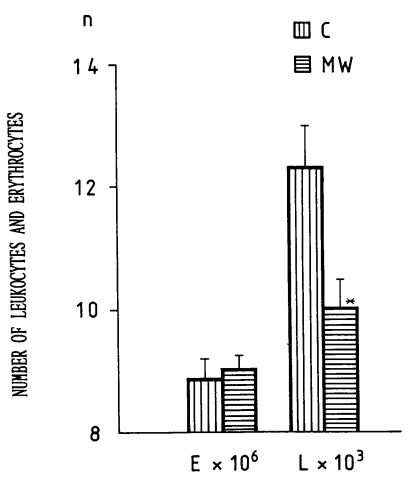

Figure 4. Numbers of leukocytes and erythrocytes in the peripheral blood. L, leukocytes; E, erythrocytes; C, control group; MW, irradiated group. Number of animals in each point = 20. *$p \leq 0.05$.

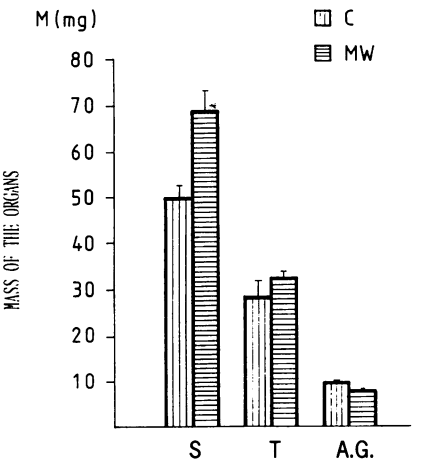

Figure 5. Mass of the organs. S, spleen; T, thymus; AG, adrenal glands, C, control group; MW, irradiated group. Number of animals in each point = 20. *$p \leq 0.05$.

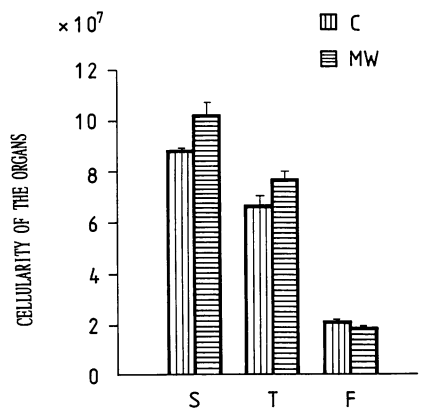

Figure 6. Cellularity of the organs. S, spleen; T, thymus; F, femoral bone marrow; C, control group; MW, irradiated group. Number of animals in each point = 20.

Table 1. Number of progenitors of granulocytes and macrophages (GM-CFC) in the femoral bone marrow of mice after 14 days of irradiation

Group	*n*	No. of GM-CFC $\times 10^5$ cells ± SE	Femoral cellularity $\times 10^7$ ± SE	GM-CFC number per femur ± SE
Control	15	31.18 ± 2.42	1.435 ± 0.124	4544.36 ± 631.47
Irradiated	15	50.98 ± 4.50**	1.516 ± 0.07	7678.60 ± 275.27*

*$p \leq 0.05$.
**$p \leq 0.01$.

ed mice; no changes of an ulcerous nature were found. No differences were observed in the substantia propria corneae and the posterior epithelium (endothelium) of the cornea of the irradiated and control animals. These observations were confirmed by the electron-microscopic examination.

Examination of the skin by both light and electron microscopy showed that the skin of the irradiated animals was not affected by the action of electromagnetic waves. The stratified squamous epithelium was undamaged, the process of cornification on its surface was normal. No changes, as compared with control mice, were found in other parts of the skin (follicles, subcutaneous tissue, fat tissue). The continuity of the skin epithelium of the irradiated mice was preserved, and the process of gradual flattening and cornification of the cells proceeded normally. No differences were found between the irradiated mice and the controls.

Evaluation of indicators of overall metabolism (i.e., of the body temperature and mass) showed that after 17 hr of irradiation/day for 14 days, no differences occurred between the control and irradiated groups. No substantial differences were found in the mass and cellularity of the spleen, thymus, adrenal gland, and femoral bone marrow. An organism, which is in the state of homeostasis under normal circumstances, can react to an external stimulus by putting some of the functions out of balance through feedback mediated by a complex regulation system. The skin, which contains numerous receptors (heat, pain, etc.) and nerve terminations, is the most probable site of interaction in the case of whole-body irradiation of mice with millimeter radiation. The decreased leukocyte count in the peripheral blood can be explained as a nonspecific reaction of the organism (mediated by skin receptors) (*12*) to the long-lived action of the radiation. A slight increase of the mass of the spleen, an important organ of the hematopoiesis, may be associated with this effect. The decreased leukocyte count affects, via feedback, the state of hematopoietic cells in the bone marrow, which becomes manifested by an increase in precursors of granulocytes and macrophages. Practical use of the RAMER 7F would not result in long-term exposure of humans to radiation, and the occurrence of these effects is improbable. The eye, in particular the cornea, is the critical organ. Decreased DNA synthesis in cells of the cornea indicates that caution should be used if the eye could be exposed to millimeter waves for a long time. The observed changes in the cornea are probably the result of some regulatory mechanisms. This conclusion is supported by the fact that no structural changes were found upon histological examination of the cornea. Therefore, instructions for use of RAMER 7F contain a warning of the danger of long-term irradiation to the eyes.

The millimeter radiation emitted by RAMER 7F did not significantly influence examined parameters in irradiated animals. Therefore, we have recommended the device for practical use with cautions about long-term exposure and possible effects on the eyes.

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