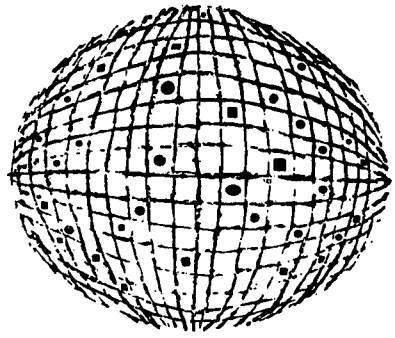
Glass
#2754



TECHNICAL INFORMATION SERVICE

AMERICAN INSTITUTE OF AERONAUTICS AND ASTRONAUTICS

750 THIRD AVENUE
NEW YORK, N. Y. 10017
Tel: 212 TN 7-8300

Changes in the Peripheral Blood of the Rat Exposed to Microwave Radiation (2400 MHz) in Conditions of Chronic Exposure

ZORAN DJORDJEVIĆ and ALEKSANDAR KOLAK
Institute of Aviation Medicine, Beograd, Yugoslavia

DJORDJEVIĆ, Z., and A. KOLAK. *Changes in the peripheral blood of the rat exposed to microwave radiation (2400 MHz) in conditions of chronic exposure.* Aerospace Med. 44 (9):1051-1054, 1973.

Changes in peripheral blood and some biologic parameters were investigated in rats chronically exposed to microwave radiation of a wave length of 12 cm and a power density of 10 mW/cm². A slight thermal effect was detected in the exposed animals as well as an increase in number of some blood elements during the first phases of irradiation with a later tendency towards normalization of these values. Opthalmologic investigations were also carried out during chronic exposure to radiation and later on in order to discover changes in transparent coats of the eye. By exposing experimental animals to simulated altitude after chronic exposure to microwave radiation investigations were carried out to check resistance of the exposed animals to hypoxic hypoxia. No significant difference in survival time in a barochamber was detected in experimental animals in comparison to the controls.

ALL INVESTIGATORS dealing with research studies of biological effects of microwaves agree that microwave radiation of high power density can result in serious damages of the organism exposed to radiation, but when low power densities are dealt with the opinion of well-known experts is often divided.[1,2,3,5,7,8,12] For example, the greatest number of investigators from the United States and other Western countries consider the microwave radiation intensities lower than 10 mW/cm² as not being able to cause any significant biological change in the irradiated organism,[6,7,9,10,11,14] while, on the other hand, Russian and Eastern countries' investigators are of the opinion that the microwave radiation of a power density of only several mW/cm² can result in evident damage of the irradiated organism.[1,4,8,13] Contradiction of the above-mentioned statements points to the fact that the biological effects of microwave radiation have not yet been investigated enough and that many questions of vital importance from this field still wait for the right answers.

MATERIALS AND METHODS

Our experiments were carried out in Wistar strain male rats, their weight ranging from 220 g to 260 g. Before and during the experiment the animals were kept in the same conditions of care and feed. All the animals were divided into four groups, each consisting of 10 animals. The first group was exposed to microwave radiation (10 mW/cm²) continuously for 2 hrs per day, during a period of 10 days. Control and experimental counts were determined the first and the last day of exposure to radiation and they included the following biological parameters: rectal temperature, body weight, blood picture with thrombocytes and hematocrit, and the ophthalmologic examinations were carried out by ophthalmoloscope and biomicroscope in maximal mydriasis. At the end, all the experimental animals together with the control groups (10 animals in each group) were exposed to simulated altitude of 11,500 m in a barochamber until they were dead. The survival time in conditions of hypoxic hypoxia was registered.

The second experimental group was exposed to microwave radiation of 2 hrs per day for a total of 20 days. It was treated the same way as the first group. The third experimental group was irradiated for 2 hrs per day for a total of 30 days and was treated the same way the other two groups were treated. With the exception of duration of exposure all other conditions of the experiment remained the same for all three groups. The fourth experimental group was exposed to high power density for one period only (20 min-50 mW/cm²) and then was relocated to a barochamber together with the control group. These animals as well as the previous ones were kept on a simulated altitude of 11,500 m until they were dead.

A generator for microwave therapy, "Meditron 200", which works continuously on a frequency of 2,400 MHz, was used as a source of radiation. Total output power of this equipment is 200 W.

The power density level was determined by a detector of microwave radiation, "Medik-Po 1" type. The animals were exposed to radiation in cages made of plexiglass and wood without metal parts. The animals were not immobilized nor where they anesthetized during the exposure to radiation. Rectal temperature counts were recorded before and after each exposure. Blood samples for laboratory tests were taken 24 hrs before exposure and 24 hrs after a series of irradiation. Tail blood of

rats was used for control and experiment counts. The animals were exposed to simulated altitude in a low pressure chamber where speed of ascent was 50 m/sec.

All experimental work was carried out in still air in a room maintained at 22° to 24°C and relative humidity of 45%-55%.

RESULTS

There was no significant difference in body weight of animals recorded before and after exposure. A certain slight increase in body weight recorded after 10, 20 and 30 days of exposure can be attributed to normal development and fattening for the above-mentioned time periods (Fig. 1).

Fig. 2 shows rectal temperature variations during exposure to microwave radiation of a power density of 10 to 50 mW/cm². High increase of body temperature is recorded in animals exposed to radiation of high power density (50 mW/cm²) for a short period up to 20 min, while only slight temperature increase was recorded (about 1°C for the first 30 min) in animals exposed to radiation of 10 mW/cm². Then a stagnation in temperature increase was recorded up to 2-hr exposure.

The results of hematocrit and hemoglobin show a tendency to increase in proportion to the period of animal exposure to microwave radiation of power density of 10 mW/cm². These results are shown in Fig. 3. The results of some elements of the blood picture are shown in Fig. 4. Broadly speaking, a tendency to increase the number of these elements is shown up to 20 days of exposure and then, in spite of continuation of animal irradiation, the vaules demonstrate a tendency of returning to the starting point recorded before the exposure. Eosinophyls are the only exception. Their number shows an opposite direction in respect to other elements of leucocyte formula; first, their number decreases up to 20 days of exposure and then it increases. However, the number of even these elements turns back to its starting level after a 30-day period of exposure.

Talking about erythrocytes, their number permanently increased during all phases of exposure to microwave radiation. A diagram of erythrocytes increase is particularly steep during the first 20 days of exposure, then it becomes considerably less steep.

No significant changes in eye transparent coats and eye fundus were detected by ophthalmologic investigations of animals exposed to microwaves for 10, 20 and 30 days in conditions of our experimental work.

Most important, results on the survival of experimental animals exposed to simulated altitude after irradiation (10 and 50 mW/cm²) are shown in Fig. 5. Statistical processing of these data determined the fact that there was no significant difference in length of survival time between the experimental group previously exposed to

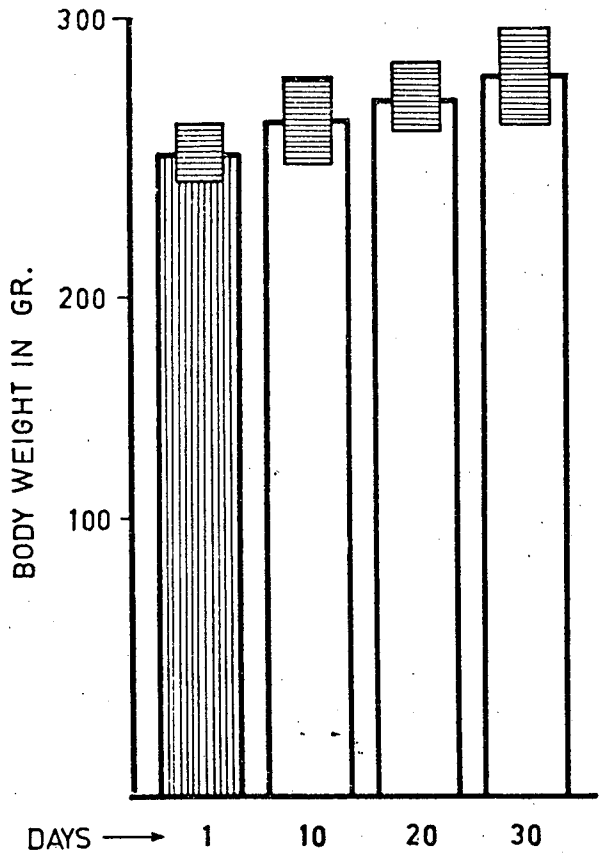


Fig. 1. Changes in body weight of rats irradiated with 10 mW/cm² microwave during 30 days of exposure. (Arithmetic means, ± st. errors)

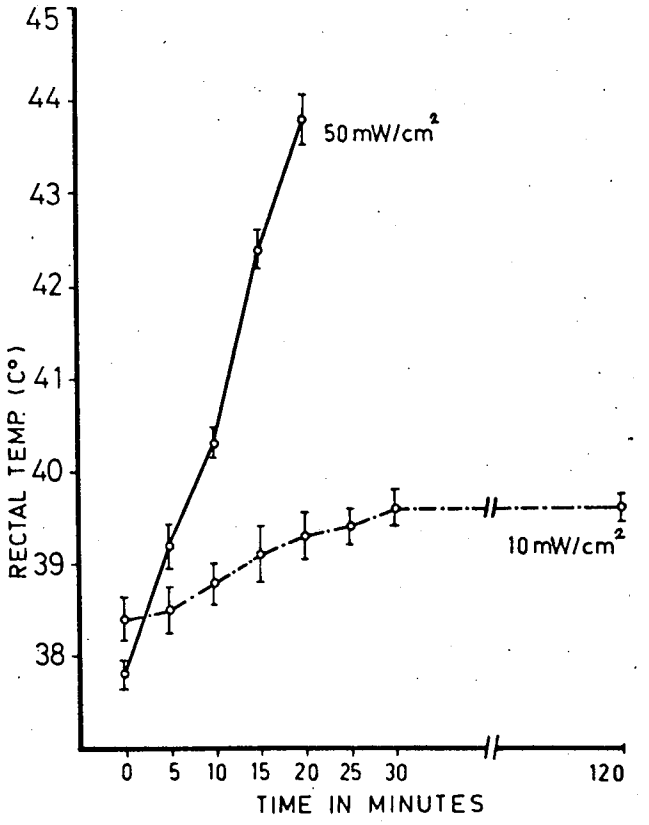


Fig. 2. Effects of exposure to microwaves (10 and 50 mw/cm²) on body temperature. (Arithmetic means, ± st. errors)

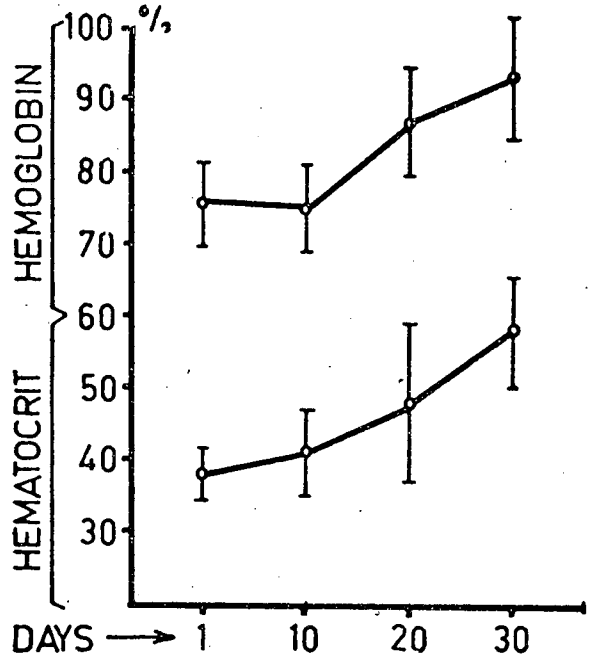


Fig. 3. Effects of microwave radiation (10 mW/cm² on the hematocrit and hemoglobin of rats. (Arithmetic means, ± st. errors)

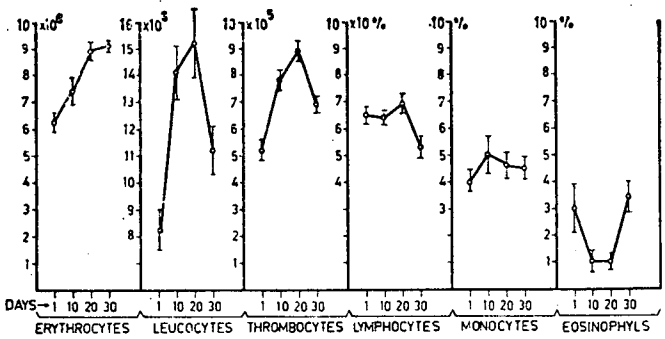


Fig. 4. Effects of chronic microwave irradiation (10 mW/cm²) on the blood picture in the rats. (Arithmetic means, ± st. errors)

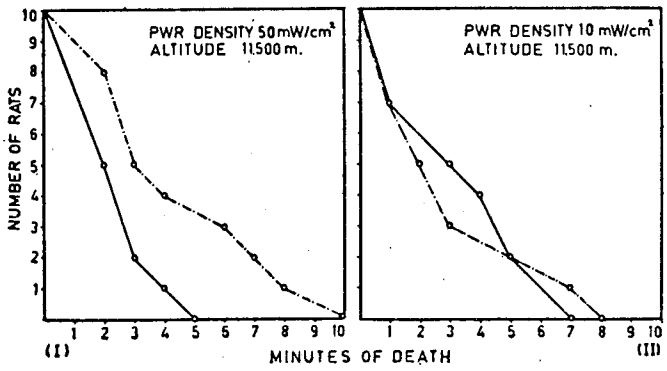


Fig. 5. Survival time of rats at the simulated altitude after exposure to microwave (10 and 50 mW/cm²). (Arithmetic means)

power density of 10 mW/cm² during 30 days and the control group. On the other hand, there was a significant difference in length of survival between the experimental group previously exposed for 20 min to power density of 50 mW/cm² and the controls. The experimental animals lived significantly shorter than the control animals in conditions of simulated altitude. Fig. 5 shows that all the animals of the experimental group died up to 5 min. after being put into a low-pressure chamber on simulated altitude of 11,500 m, while some of the controls survived even up to 10 min.

DISCUSSION

In our experiments we detected existance of thermal reaction of a minor degree in rats exposed to microwave frequency of 2,400 MHz and to power density of 10 mW/cm². These results are of special interest for the investigators of biologic effects of microwave radiation having opposing opinion on power density of 10 mW/cm². For example Joly,[7] in his study on the biologic effects of microwave radiation, states that a power intensity of 40 mW/cm² is needed in order to increase body temperature of rats exposed to centimetre waves while Presman,[13] in his detailed monograph on electromagnetic radiation, states that a microwave of centimetre area causes the increase of rectal temperature of rats exposed to power density of not more than 10 mW/cm². Our investigations proved that exposure of rats to microwave power density of 10 mW/cm² during a period of 2 hrs causes a slight increase of rectal temperature about 1°C during the first 30 mins, and then the temperature is stable and remains as such until the end of the 2-hr period of exposure to radiation. Rats exposed to 50 mW/cm² showed quick, and we could say violent, thermal reactions. During 20 mins exposure, rectal temperature of animals increased for about 6°C and further exposure to power density of 50 mW/cm² caused clonic spasm, convulsive seizure, and death of the animals. Our intention this time was not to investigate the effects of high doses of microwave radiation. Therefore the results obtained after the exposure of a group of animals to 50 mW/cm² served only for comparison to data obtained by our experimental groups being exposed to power density of 10 mW/cm².

The results obtained on the basis of investigation of changes detected in peripheral blood of rats exposed to microwave radiation of power density of 10 mW/cm² point to some characteristic changes in blood pictures which we shortly described as a tendency to cytosis during the first phases of irradiation, while later on, during a chronic exposure, reversibility of these changes was detected. We are inclined to explain the above-stated uncertainties in the number of some elements in peripheral blood as the result of thermal effect of microwave radiation which, although of low intensity, was recorded in our experiments. Later, the tendency of these elements to return to issuing values could be taken as adaptation reaction to such radiation intensity. Our intention is to prove this supposition of ours by further experiments in which we shall prolong the period of exposure but will not change other conditions of the

experiment.

In the literature available to us we did not have a chance to meet with works dealing with investigations of microwave cataracts in the eye of the rat. It is interesting that Presman[13] states the fact that Soviet investigators detected cataracts in men permanently exposed to microwave of power density of only several mW/cm². We did not expect to find cataracts in our conditions of experimental works, but we wanted to actually determine ophthalmologic status of our experimental animals applying biomicroscopy before and after the exposure especially because of controversial results obtained by other authors.[11] Our results confirmed the hypothesis that microwave radiation of power density of 10 mW/cm² in conditions of exposure which we applied does not cause cataracts in the eyes of the exposed rats.

A survival test at a simulated altitude of rats previously exposed to microwaves was aimed to check the condition of general resistance to conditions of hypoxic hypoxia. Our results confirmed that animals previously chronically exposed to microwaves of a power density of 10 mW/cm² did not show considerable difference in length of the survival period when compared to the controls, while the animals previously exposed for only 20 mins to radiation of power density of 50 mW/cm² lived considerably shorter at the simulated altitude than the control animals. These results point out that chronic exposure of rats to microwave power density of 10 mW/cm² does not cause damages in physiological functioning of such a degree that could have an effect on resistance to hypoxic stress.

REFERENCES

1. BARANSKI, S.: Effect of chronic microwave irradiation on the blood forming system of guinea pigs and rabbits. *Aerospace Med.* 42:1196-1199, 1971.
2. BARRON, C. J., and A. A. BARAFF: Medical considerations of exposure to microwaves (radar). *JAMA*, 168:1194-1199, 1958.
3. CLEARY, S. F.: Considerations in the evaluation of the biological effects of exposure to microwave radiation. *Am. Industrial Hyg.* 31:52-59, 1970.
4. CZERSKI, P.; Voprosi gigieni i ohrani truda pri obsluzivanij generatorov mikrovoln. *Med. Lotn.*, 69, 1965.
5. DJORDJEVIC, Z.: Intenzitet mikrotalasnog zracenja u radarskim jedinicama i promene u krvnim slikama. *Radarista. Vojmosamit Pregl.* 27:538-541, 1970.
6. ELY, T. S., and D. E. GOLDMAN: Heat exchange characteristics of animals exposed to 10-cm microwaves. *IRE Trans. Med. Electronics*, 2:38-43, 1956.
7. JOLY, R.: Effets biologiques et danger éventuel des rayonnements T.H.F. des "Aériens-Radars". *Arch. des Mal. Prof. et de Secur. Sociall.* 29:121-130, 1968.
8. KOLESNIK, F. A.: Klinika hroniceskogo vozdejstvia elektromagnetnih voln S.V.C. VMA im. Kirov-Leningrad, 1961.
9. LEARY, F.: Researching microwave health hazards. *Electronics.* 8:49-53, 1959.
10. MICHAELSON, S. M., R. A. F. THOMPSON, M. Y. E. TOMAMI, H. S. SETH, and J. W. HOWLAND: The hematologic effects of microwave exposure. *Aerospace Med.* 35:824, 1964.
11. MILROY, W. C., and S. M. MICHAELSON: Microwave cataractogenesis: A critical review of the literature. *Aerospace Med.* 43:67-75, 1972.
12. PALMISANO, A. W., and A. PECZENIK: Some considerations of microwave hazards exposure criteria. Milit. Med., 7: 611-618, 1966.
13. PRESMAN, A. S.: Elektromagnetni volni i zivaja priroda. Moskva, 1967.
14. SWANSON, J. R., V. E. ROSE, and Ch. H. POWELL: A review of international microwave exposure guides. *Am. Indust. Hyg. Assoc. J.* 31:623-629, 1970.