

BIOLOGICAL EFFECTS OF MICROWAVE RADIATION

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In this paper the authors review the results of own clinical and experimental studies. Clinical examinations of 500 radar operators and matched controls showed no typical cases of »microwave sickness«. The studies on experimental animals pointed out the presence of considerable thermal effects, but only after high doses of microwave radiation.

In mid 60s in the Institute of Aviation Medicine in Zemun a research team was formed with the task of investigating the biological effects of microwave radiation. Most of the results of their work have been published (1—4). Investigations were carried out in two directions: 1. prospective clinical examinations of the personnel occupationally exposed to microwave radiation, and 2. laboratory investigations on experimental animals. The clinical investigations comprised periodical medical examinations of a representative group of examinees consisting of 500 radar operators. A control group consisted of 350 persons who matched the radar operators with respect to age, working regime, social and living conditions. All persons included into the study were subjected to systematic medical examinations once a year in the 1970—1980 period. Medical examinations were carried out by a team of specialists from the Institute of Aviation Medicine. The programme of clinical examinations included internal, neurological, ophthalmological and otological check-up. Laboratory tests included analysis of urine, peripheral blood cell counts, blood sugar, cholesterol, lipids and bilirubin. All the results obtained in radar operators and control subjects were statistically evaluated and compared. Simultaneously, the regime, intensity and duration of exposure of the examinees in the microwave fields were analysed in detail. Our group of radar operators was exposed to microwave radiation in the centimeter wave band, for about 2 hours daily in the near and far-field zone of a high

-power radar. During working day the examinees were exposed to a power density of up to a few mW/cm², which usually did not exceed 5 mW/cm². Power density in the fields irradiated by various types of radar was measured by a Narda Radiation Monitor — Model 8616 (USA) and a PO-1 (USSR) apparatus.

The experimental investigations were performed on rats and rabbits exposed to different radiation doses (1-100 mW/cm²) under various exposure conditions (from several minutes to several hours, days and months). Functional, haematological, biochemical, pathohistological and ophthalmological examinations of organs and tissues of the irradiated animals were performed. Radiation doses were determined by a Narda 8100B Microwave Monitor. A Rangoni-Puriccelli microwave generator emitting continuous waves of 2450 MHz frequency served as a source

Table 1

Comparison of mean percentage values of certain clinical and haematological changes between the exposed (group E, N = 500) and control group (group C, N = 550)

Diagnoses	Year					
	1970		1975		1980	
	E	C	E	C	E	C
1. Neurovegetative Dystonia	17	20	12	8.8	15	10
2. Neurosis	5	3.1	6	5.4	6.4	8.8
3. Hypertension	1	2.2	0.8	1.4	0.2	0.5
4. Reticulocytosis > 2%	2	1.4	1	1.4	1.4	0.2
5. Leucocytopenia < 4.10 ³	3	5.4	2	3.1	2.2	2.5
6. Erythrocytopenia < 4.10 ⁶	4	5.1	3	2.2	2	1.7
7. Lymphocytosis > 45%	5	3.1	6	5.1	4.4	3.1
8. Changes in cardiac functions (ECG)	2	3.1	2.2	3.4	2.6	5.1
9. Lens opacities (more than 0.5 mm, or numerous small multishaped opacities)	0.8	1.4	1	1.4	1	1.7
10. Hypotension	0.4	0.2	0.2	0.2	0.2	—

of microwave radiation. Some experiments were performed on animals which were kept free in plexiglass cages without metal parts during microwave exposure. The effects of high intensity microwave radiation were studied on the anaesthetized and immobilized animals.

Table 1 shows the frequency of some clinical findings in the group of radar operators and in the control group during a ten-year period. The differences between the two groups were not significant. It should be emphasized that during prolonged systematic examination of the health conditions of radar operators no case with typical signs of «microwave sickness» was found.

Our experimental studies performed on small laboratory animals have shown that high doses of microwave radiation produced a strong thermal effect and caused a severe destruction of the vital organs presenting all characteristics of thermal damages. It is of interest to note that in some of our experiments we succeeded to induce cataractogenous microwave effects in the rabbit's eye after a relatively short exposure in the irradiation field (3 minutes) applying 100 mW/cm² (2450 MHz). Michaelson cited that the threshold limit for lenticular damage was about 100 mW/cm² (5), while Sadčikova (6) and other Soviet authors stated that possible cataractogenous effects of the microwaves could occur at a power density not exceeding several mW/cm². We failed to provoke microwave cataracts at a power density lower than 100 mW/cm² even during prolonged and repeated exposures. Also, it should be pointed out that several groups of anaesthetized animals were exposed to a power density of 100 mW/cm² and only rarely were cataractogenous changes provoked after a latent period of 14 days and more. We applied various intensities of irradiation (200 mW/cm² and more) but the anaesthetized animals rarely survived and death occurred immediately due to brutal hyperthermia. In the survivors deep burns developed in the irradiated area followed later on by destruction of soft tissues in the orbital region and by evisceration of the irradiated eye.

Our experimental results have confirmed that the effects of microwave radiation, either direct or indirect, are a consequence of local or general hyperthermia. Pathological effects of microwave radiation were detected only when exposure in the microwave field was followed by a regional or general increase in the body temperature of experimental animals. Thus, prolonged exposure of experimental animals to a high intensity microwave radiation (over 20 mW/cm²) caused various thermal injuries of tissues and, depending on the applied radiation doses, led to immediate death by brutal hyperthermia.

Exposure of small experimental animals (rats, rabbits) to low intensity microwave radiation (lower than 5mW/cm²) did not cause thermoregulation disorders, or more important local thermal effects. During these experimental investigations, pathohistological, bioche-

mical, haematological and functional examinations did not discover significant pathological changes in the irradiated animals even after a very long exposure in the radiation field (several days, weeks and months).

Our several-year observations and follow-up of health conditions of persons occupationally exposed to microwave radiation of lower intensities did not discover significant pathological changes which could be attributed to harmful effects of microwave radiation. The results of these examinations confirmed our opinion that non-thermal microwave radiation, at intensities usually present in conditions of occupational exposure will not cause significant functional and organic changes in occupationally exposed persons.

Considering that microwave radiation is a physical agent, it seems to us that harmful biological effects of radiation are better defined by the term »injury« than by the term »sickness«. For the same reason we do not find acceptable the term »microwave sickness« as a synonym for the complex of insufficiently defined symptoms of uncertain etiology.

References

1. Đoković, V., Dorđević, Z., Lazarević, N.: Pathohistological investigations of effects of different intensity microwave radiation (10—50 mW/cm²) on the reproductive organs of male rats. Acta Vet. (Beograd) 1—2 (1979) 55—62.
2. Dorđević, Z., Kolak, A.: Changes in the peripheral blood of the rat exposed to microwave radiation (2400 MHz) in conditions of chronic exposure. Aersp. Med., 44 (1973) 1051—1054.
3. Dorđević, Z., Lazarević, N., Đoković, V.: Studies on the hematologic effects of long-term low dose microwave exposure. Aviat. Space Environ. Med., 48 (1977) 516—518.
4. Dorđević, Z., Kolak, A., Stojković, M., Ranković, N., Ristić, P.: A study of the health status of radar workers. Aviat. Space Environ. Med., 50 (1979) 396—398.
5. Michaelson, S. M.: Microwave and radio-frequency radiation. In: Nonionizing Radiation Protection. Ed. M. J. Suess, WHO Regional Publications European Series No. 10, Copenhagen 1982. pp. 97—174.
6. Sadčikova, M. N.: Clinical manifestations of reactions to microwave irradiation in various occupational groups. Proceedings of the International Symposium »Biological Effects and Health Hazards of Microwave Radiation. Warsaw 1973. Polish Med. Publishers, 1974.

Sažetak

BIOLOŠKI UČINCI MIKROTALASNOG ZRAČENJA

Iznose se sumarni rezultati istraživanja mikrotalasnog zračenja na profesionalno eksponovanim ljudima i na eksperimentalnim životinjama. Klinička ispitivanja provedena su tokom 10-godišnjeg perioda, na 500 radarskih operatera i na kontrolnoj grupi od 350 radnika odgovarajuće dobi, pola i osta-

lih relevantnih parametara. Klinička i laboratorijska ispitivanja nisu pokazala pojave mikrotalasne bolesti, premda su pojedina radna mesta bila jako eksponovana.

U eksperimentima na životinjama štakori i kunići eksponovani su različitim dozama zračenja (1—100 mW/cm²) tokom više časova, dana ili meseci. Osim termalnog opšteg učinka izazvanog velikim dozama zračenja, utvrđene su i kataraktogene promene u eksperimentalnih životinja.

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