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TEMPERATURE REACTION AND SURVIVAL OF EXPERIMENTAL ANIMALS AFTER MICROWAVE IRRADIATION

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In CBA mice and Wistar rats the diurnal dynamics of body temperature, the effect of keeping the animals in containers for irradiation, and the temperature reaction and survival of the animals after exposure to shf-fields of different intensities were investigated. The degree of elevation of the temperature and the survival rate of the animals were shown to depend on the power flux density and duration of exposure. The degree of elevation of the body temperature during irradiation and of its subsequent fall after irradiation can be regarded as prognostic signs of damage caused by the shf-field.

KEY WORDS: shf-field; body temperature; survival rate.

The study of the survival and temperature reactions of animals is necessary not only in the case of exposure to shf-fields of high intensity [1, 3, 5, 6], but also in connection with the development of methods of treatment and prevention of acute radio-wave lesions [2, 4]. However, the lack of a single methodological approach has led to disagreement in the interpretation of these indices. Some workers, for instance, consider that in acute radio-wave damage what is observed is mainly death "under the beam," and that animals which survive acute exposure do not die subsequently [3]. According to other investigators, moreover, death in the late periods after irradiation plays a significant role [2]. Investigations of body temperature are usually confined to the period of irradiation and do not extent to subsequent hours or days, although thermometric data are of considerable interest in the combined evaluation of the state of the body after exposure to microwave irradiation.

Accordingly the object of the present investigation was to study the temperature reaction and survival of experimental animals of different species after exposure to shf-fields of thermal intensities.

EXPERIMENTAL METHOD

Experiments were carried out on sexually mature CBA mice and Wistar rats. The body temperature and survival rate of the animals were studied for 30 days after a single exposure to microwaves (irradiation by the Luch-58 physiotherapeutic apparatus in the formed wave zone, with a frequency of 2375 MHz, power flux density (PFD) of 10, 40, and 60 MW/cm^2, exposures of 10, 30, 45, and 60 min, ambient air temperature 18-22°C, and relative humidity 60-75%). Irradiation was given in special containers made of radio-transparent material, and each animal was kept in an individual cage during irradiation. The rectal temperature was measured by a TPÉM-1 electrothermometer with skin detector before and at various times after irradiation.

The results were analyzed by the use of Student's criterion and methods of correlation and regression analysis.

EXPERIMENTAL RESULTS

During the day (from 9 a.m. to 4 p.m.) the body temperature of the mice fell on the average by 1.5°C, and considerable individual variations were observed. By contrast with the mice, the mean temperatures recorded in the rats were 36, 36.1, and 36.1°C at 9 a.m. and at 1 and 4 p.m. respectively.

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TABLE 1. Mean Rise of Body Temperature Depending on Exposure and Intensity of Irradiation in Animals of Different Species

Species of animals	PFD, MW/cm²	Exposure, min	ΔT, °C
Mice	40	10	0,1
	40	30	1,0
	40	45	0,9
	60	30	0,8
	60	45	1,7
Rats	10	10	0,3
	40	10	1,3
	40	30	2,1
	40	60	3,0
	60	30	2,8
	60	45	3,0

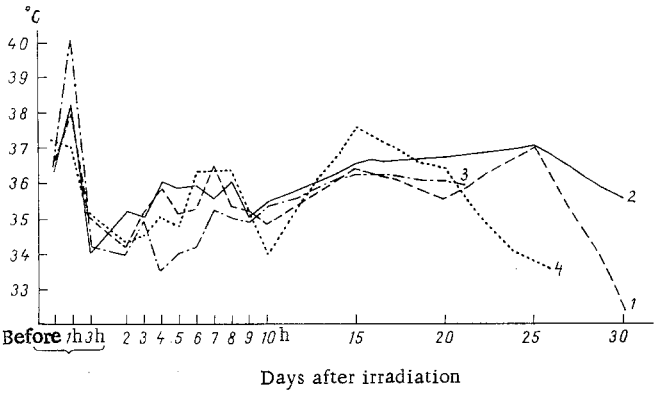

Fig. 1. Body temperature of rats after single exposure to microwave irradiation (PFD = 40 MW/cm², duration 60 min). 1) Rat No. 2, 2) No. 4, 3) No. 6, 4) No. 8. Abscissa, time after irradiation; ordinate, body temperature of animals.

In rats irradiated for 30 min (PFD = 40 MW/cm²), the animals moved about restlessly after 10-20 min, but later they became apathetic and developed hyperemia of the ears, tail, and tips of the paws, and blood stained discharges appeared from the nose. Immediately after irradiation the body temperature was raised on average by 2.1°C, but after 3 h it fell to 0.5-1.3°C below its initial level, and remained low for the next 3-5 days. Individual animals died on the 19th and 23rd days after irradiation.

In the next series of experiments the duration of exposure to irradiation of the same intensity was doubled (60 min). The animals of this series can be divided into three groups: 1) those dying "under the beam," 2) those dying during the first day after irradiation, 3) those surviving or dying later. The initial body temperature did not affect the survival rate of the animals; meanwhile the rise of body temperature during irradiation in the animals which died during the first day averaged 4°C, whereas in those which survived or died later it was 1.5°C. The body temperature of the irradiated rats 3 h after irradiation fell to 34-35°C, whereas in those dying during the first day it fell to 31°C.

The results of thermometry on the rats for 30 days are shown in Fig. 1. The body temperature of these animals remained low during the first 10 days after irradiation, and then returned to normal, but before death on the 25th and 30th days (rats No. 2 and 8) it fell again.

Comparison of the degree of rise of temperature during irradiation (+Δ1) and its subsequent fall below the initial level (−Δ1) in individual animals revealed significant correlation between the two values (coefficient of correlation r = 0.66, m = 0.12). The more marked rise of temperature in the course of irradiation and its more rapid fall after the end of irradiation were thus observed in animals which died in the earliest days after irradiation.

TABLE 2. Distribution of Mortality of Animals by Periods after Irradiation Depending on Exposure and Intensity

Species of animal	Number of animals	PFD, MW/cm²	Exposure to irradiation, min	Time of death after irradiation, days								Died	Survived	Survival rate, %
				0	1	2	19	21	23	25	30			
CBA mice	8	n/i	н/о	—	—	—	—	—	—	—	—	—	8	100
	8	10	10	—	—	—	—	—	—	—	—	—	8	100
	8	40	10	—	—	—	—	—	—	—	—	—	8	100
	24	40	30	2	3	2	1	—	—	—	—	8	16	66,7
Wistar rats	8	н/о	н/о	—	—	—	—	—	—	—	—	—	8	100
	8	40	30	—	—	—	1	—	1	—	—	2	6	75
	10	40	60	4	2	—	—	1	—	1	1	9	1	10

Legend. n/i) Not irradiated; 0) death during period of irradiation.

In the analogous experiments on mice irradiated for 30 days at PFD = 40 MW/cm² the rise of body temperature was very small, but 3 h after irradiation the rectal temperature fell to 35.4 ± 0.8°C in mice which subsequently survived and to 29.2 ± 1.1°C in the animals which died.

Irradiation of mice and rats with an intensity of 10 MW/cm², whatever the exposure, did not cause changes in body temperature or death of the animals.

Rats were thus more sensitive to the action of microwaves in an shf-field of this frequency, when this method of irradiation was used. As a result of shf-irradiation, changes in the body temperature (Table 1) and mortality (Table 2) in the mice were less marked than in rats.

It is difficult at present to decide what caused death of the animals in the late stages after irradiation; it may perhaps be a disturbance of adaptation following exposure to microwaves, or a lowered resistance to infections and other harmful factors. Indirect confirmation of lasting disturbances is given by the fall of body temperature recorded for a long time after irradiation, and evidently associated with damage to the nervous system and a disturbance of temperature regulation in the irradiated animals. The degree of elevation of the body temperature during irradiation and of its fall thereafter can be regarded as important prognostic signs in acute radio-wave lesions. Death of the animals in the late period after irradiation necessitates further combined studies of the animal's state by the use of methods enabling the completeness of rehabilitation after exposure to irradiation to be assessed.

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