A Model of Dosed Sublethal Microwave Thermostress

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UDC 616-001.17-092.9]-036.11:615.849.112]-07

Translated from *Byulleten' Eksperimental'noi Biologii i Meditsiny*, Vol. 117, № 3, pp. 254-256, March, 1994
Original article submitted June 8, 1993

A model of microwave thermostress (3085 MHz, 400 Hz, 1 μsec, d5000; 65±5 mW/cm², 18-20 min) with standardized physiological, biochemical, and morphological changes is examined. The model can be used in electromagentic-biological and pharmacological studies.

Key Words: *biorhythms; microwave thermostress; standardization*

Experimental models of UHF hyperthermia and lethality have been repeatedly used in biophysics and hygiene research to establish dose-effect relationships, to detect species sensitivity to a certain factor [4,5,7,12], and to select drugs which enhance resistance to thermal exposure and to ultrahigh frequency electromagnetic radiation (UHF EMR) [1,10]. The problem of achieving a biological standardization of such exposures is still a pressing one.

MATERIALS AND METHODS

Adult outbred male white rats weighing 180-190 g were used in the experiments. Each group consisting of 20 animals was exposed to total microwave radiation (3085 MHz, 400 Hz, 1 μsec, Δ5000) at energy flux densities (EFD) 65±5 mW/cm², exposure 18-20 min; 10±1 mW/cm², exposure 160, 30, and 5 min; and 0.4±0.1 mW/cm², exposure 30 min and 3 h. Rats were irradiated in an echo-free chamber, arranged in an "H" at fixed points of the distant zone. The animals were placed in standard penals of polymethyl methacrylate, where 3085 MHz EMR decay value was under 0.5 dB and EFD attenuation 1.12 times, that is, within the negligible error criterion. The estimated values of the averaged magnetic field densities (AMFD) averaged for body weight (26.4, 4.1, and 0.2 mW/g) and AMFD pulsed, respectively, 66.0, 10.3, and 0.5 W/g corresponded to the experimental conditions. Control animals were sham irradiated and then kept together with the experimental animals under standard conditions with a natural daily light regimen and balanced standard diet.

Functional parameters were assessed using the "open field" method (Opto-Varimex automated device, USA) with recording of the exploratory and motor activity, anxiety, emotional reactivity, food and water consumption, and daily motor rhythm in the groups of animals; the "rotating bar" method [10] was used to register muscle tone, movement coordination, attention, and physical endurance at a discretely increasing (3, 6, 12, and 18 rpm) bar rotation rate; the methods of defensive conditioned-reflex behavior in a Y chamber, learning, memory, and dynamic stereotype stability [3] were used, as were emotional reactivity parameters [12] and the stamina swimming test with 5% loading [6], and the hypoxic hypoxia loading test (staged "elevation" to a 9-12 km "altitude" in a pressure chamber [2]. Biochemical parameters were assessed using a Technicon analyzer (USA), an LKB 1251 bioluminometer (Sweden), and a standard test kit [8,9].

RESULTS

Repeated experiments using various schemes and regimens of single sessions or courses of irradia-

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0007-4888/94/0003-0256$12.50

TABLE 1. Biochemical Parameters in the Follow–Up Period After Acute Sublethal Microwave Thermostress in Rats (Mean±SEM)

Parameter	Control	Days elapsed after thermostress	
		1	7
Red cell superoxide dismutase, U/mg Hb	0.79±0.03	0.71±0.02*	0.74±0.02
Malonic dialdehyde, mmol/mg/Hb	2.94±0.12	3.51±0.10*	3.30±0.11*
Ceruloplasmin, mg/liter	230.2±8.4	211.3±5.5*	229.1±6.2
Glucose, mg%	113.7±3.7	103.1±2.7*	108.2±2.5
Bilirubin, total, mg%	0.10±0.01	0.18±0.01*	0.09±0.01
Lactate, mg/liter	1.87±0.11	2.42±0.11*	2.19±0.12*
Alkaline phosphatase, μmol/min×ml	252.2±10.7	302.5±12.6*	277.1±11.4*
Na^+, mmol	145.3±1.7	152.4±3.7*	147.9±1.9
K^+, mmol	6.6±0.1	6.2±0.2*	6.5±0.2
SGOT, μmol/min×ml	50.4±2.2	57.1±2.4	53.7±2.1
SGPT, μmol/min×ml	146.0±3.1	152.7±2.3*	149.4±2.5
Serotonin, mg/g tissue	0.282±0.015	0.217±0.012*	0.259±0.018
5–hydroxyindoleacetic acid, mg/g tissue	0.212±0.012	0.320±0.020*	0.234±0.016
"Rapid" chemiluminescent flash of brain homogenate:			
light sum, mV×sec	4103±312	4861±307*	4247±312
flash amplitude, mV	27.01±2.66	34.31±2.90	29.77±2.62
"Slow" flash:			
light sum, mV×sec	451.3±41.1	489.2±31.9	469.2±32.2
flash amplitude, mV	2.39±0.19	2.51±0.22	2.44±0.20

Note. Here and in Tables 2 and 3: an asterisk shows values with $p<0.05$ vs. control; $n=20$ rats per group.

tion of unadapted animals at a low-energy (0.3-0.5 mW/cm²) or at a compensated thermal level (9-11 mW/cm²) of UHF EMR EFD did not detect statistically reliable stable functional or biochemical shifts. During a compensated thermal UHF EMR exposure its moderately activating (by 10-20%) effect leveled in 15-60 min during the first session and disappeared during repeated irradiation sessions. A further search for a stable follow-up reaction of significant extent was carried out in experiments with high-energy UHF EMR exposure of animals.

A preliminary assessment of the duration of lethal radiation (acute lethal microwave hyperthermia) was made on the day of the experiment. Lethal exposure at EFD 65±5 mW/cm² varied from 18 minutes in March-July to 23 min in October-February and depended on the season, time of day, and ambient temperature. A reduction of the exposure duration by 1-2 min for other

TABLE 2. Functional Characteristics of Rats in Follow–Up Period after Acute Sublethal Microwave Thermostress (Mean±SEM)

Animal group, time interval	"Open field" locomotor activity in 5 min	Active avoidance conditioned reflex		Muscle tone and movement coordination, bar rotations per min		
		learning time, sec	number of pairings till criterion reached	6	12	18
Control						
1 h	1031±69	364±18	10.6±0.6	250±12	142±7	44±2
1 day	1067±63	232±6	7.4±0.4	242±10	167±8	77±4
7 days	1043±41	122±4	4.6±0.3	249±9	166±7	79±4
15 days	812±31	64±2	2.7±0.1	263±8	178±6	82±2
After sublethal thermostress						
1 h	83.3% rejection			57.1% rejection		
1 day	443±11*	529±34*	18.8±1.5*	145±11*	49.4*	7±1*
7 days	629±27*	387±29*	11.2±0.9*	176±9*	93±5*	71±2
15 days	455±10*	82±3*	4.9±0.2*	207±8*	181±7	83±4

TABLE 3. Functional Parameters of Rats in Follow-Up Period after Conditioning (Mean±SEM)

Animal group, time interval	Physical endurance (swimming), min	Resistance to hypoxia, min	Emotional status, score	Food consumption, g
Control (sham irradiation)				
1 h	663±14	47±4	+ +	–
1 day	674±10	46±3	0+	313±10
7 days	682±11	45±3	0+	307±9
15 days	692±13	46±2	0+	319±10
After sublethal thermostress				
1 h	144±6*	21±4*	–	–
1 day	252±6*	39±3*	0–	61±6
7 days	398±8*	43±3	0+	304±9
15 days	577±11*	44±2	0+	301±8

animal groups resulted in the development of acute sublethal microwave thermostress compatible with life. The rectal temperature rose to 41.7-42.2°C, relaxation, exophthalmia, and hypersalivation were recorded, and innate and conditioned reflex behavior was disturbed, as were emotional status, learning, memory, information reproduction, muscle tone and movement coordination, attention, physical endurance, etc. Pathomorphologic signs included gastric hemorrhages, adrenal hyperplasia, and thymus involution. Biochemical shifts corresponded to distress: reduced activity of superoxide dismutase and ceruloplasmin and a lowered content of glucose, potassium, and serotonin in the brain; increased levels of malonic dialdehyde, bilirubin, lactate, sodium, 5-hydroxyindoleacetic acid, alkaline phosphatase, SGOT and SGPT activities; brain homogenate chemiluminescence was increased (rapid and slow flashes) (Tables 1-3).

In general the biochemical parameters recovered within 7 days; functional disorders of the brain persisted for up to 15 days of the follow-up period.

The described experimental model may be used in standardized biophysical and pharmacologic studies.

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