ACTION OF MICROWAVES ON THE CARDIAC RHYTHM OF A RABBIT DURING LOCAL IRRADIATION

(UDC 612.172.2.014.424.08)

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Translated from Byulleten' Éksperimental'noi Biologii i Meditsiny, Vol. 58, No. 7, pp. 67-69, July, 1964
Original article submitted April 29, 1963

The action of microwaves (MW) on the cardiac rhythm was demonstrated during the investigation of healthy persons working with microwave generators. Chronic irradiation with MW of nonthermal intensity led to the development of bradycardia. Changes of the same type have also been observed in experiments on animals, either during chronic irradiation or during a single exposure [1]. The chronotropic effect of MW of nonthermal intensity was later discovered actually in the process of irradiation [2, 3]. Investigations of the action of MW (continuous or intermittent, intensity 3-12 mW/cm^2) on the cardiac rhythm of the rabbit showed that irradiation of the ventral areas of the body causes bradycardia, whereas irradiation of the dorsal areas of the body, and especially of the head, gives a positive chronotropic effect.

A. S. Presman postulated that the negative chronotropic effect is reflex in nature and arises in different conditions of irradiation as a result of the action of MW on the skin receptors, whereas the positive chronotropic effect is the result of the action of MW on the brain cells and appears only in certain conditions of irradiation.

In the present study an attempt was made to determine the relationship between the character and the degree of the chronotropic effect and the conditions of irradiation and the localization of the irradiated area, and also to elucidate the role of the action of MW on the skin receptors in the formation of the chronotropic effect.

EXPERIMENTAL METHOD

The cardiac rhythm was recorded by means of a device by means of which the ECG pulses from an "Alvar" electrocardiograph were passed through a PS-64 scaler, transforming the rhythm 4:1, into a type PT-2 pulsotachometer, and from thence into an automatic recording instrument.

For irradiation of the rabbit's body, a rectangular chamber was used, lined internally with baffle-plates, in which the frame with the rabbit was placed. The MW source could be placed above any part of the rabbits's body.

Two forms of MW irradiation were used: intermittent pulsed and continuous pulsed. In the intermittent pulsed regime, a generator made at the All-Union Research Institute of Medical Instruments and Apparatus provided intermittent irradiation with series of short pulses of MW (λ = 10 cm, τ = 1 μsec, f = 700 pulses/sec, 2 series/sec, τ of a series 0.1 sec, mean intensity 350-385 mW/cm^2). In the continuous pulsed regime interrupted irradiation was given in the form of pulses of continuous MW (λ = 12.5 cm, τ = 0.1 sec, f = 2 pulses/sec, mean intensity of pulse 740-1250 mW/cm^2) by means of a "Micropan" generator.

Experiments were conducted on 15 male and 3 female rabbits, weighing 3.5-4 kg. Twelve localized areas of the rabbit's body were irradiated—6 on the dorsal aspect (the snout, the frontal part of the head, the occipital part of the head, the cervical, dorsal, and lumbar regions of the spine) and 6 on the ventral (region of the neck, heart, solar plexus, anterior half of the abdomen, posterior half of the abdomen, and inguinal region). Twelve series of experiments were carried out at these respective areas for each of the two systems of irradiation. The ECG was recorded by means of plate electrodes. The duration of irradiation was 20 min. Irradiation began 10 min after stabilization of the cardiac rhythm. The ECG was recorded for 30 min before irradiation, 20 min during irradiation, and 20 min after irradiation.

Changes in Cardiac Rhythm in Rabbits during Irradiation of Parts of the Body with MW in Intermittent Pulsed and Continuous Pulsed Conditions

Side of body	Region irradiated	Number of experiments	Continuous pulsed system			Number of experiments	Intermittent pulsed system		
			brady-cardia	tachy-cardia	rhythm unchanged		brady-cardia	tachy-cardia	rhythm unchanged
			in % of cases				in % of cases		
Dorsal	Snout	15	80	–	20	15	86.4	–	13.6
	Frontal	8	50	12.5	37.5	8	62.5	–	37.5
	Occipital	8	50	–	50	8	62.5	–	37.5
	Cervical spine	10	70	–	30	10	70	–	30
	Dorsal spine	8	25	25	50	8	25	12.5	62.5
	Lumbar spine	8	25	–	75	8	62.5	–	37.5
Ventral	Neck	10	70	–	30	10	80	–	20
	Heart	12	66.6	8.4	25	10	70	20	10
	Solar plexus	8	50	25	25	8	50	25	25
	Upper abdomen	8	62.5	12.5	25	8	62.5	12.5	25
	Lower abdomen	8	87.5	–	12.5	8	87.5	–	12.5
	Inguinal region in males	10	10	40	50	10	60	40	–
	Control	10	–	–	100	10	–	–	100

EXPERIMENTAL RESULTS

The results obtained are summarized in the table. Changes in rhythm of not less than 10 beats per min were regarded as significant (the variations in the heart rate in normal conditions amount to ±5 beats per min). It is clear from the table that irradiation of all parts of the body with MW as a rule evoked a negative chronotropic effect. The exception was the inguinal region in the males, during irradiation of which the number of cases of tachycardia was 40%. During irradiation of the same region in the female no such effect was observed; this may evidently be regarded as the result of the action of MW on the gonads. Comparison of the results of irradiation by the intermittent pulsed and continuous pulsed systems revealed no singificant difference in their effect.

To investigate the effect of MW on the cardiac rhythm during irradiation of parts of the body where the skin had been anesthetized, two areas were selected: the posterior half of the abdomen and the dorsal aspect of the neck, irraidation of which was accompanied by the maximal negative chronotropic effect. The skin was anesthetized with 0.25% trimecaine solution [4], 10-12 ml of which was injected subcutaneously into an area measuring about 30 cm^2. Irradiation began 30-60 min after injection of the anesthetic and was given in ordinary conditions by the continuous pulsed system.

These experiments (8 in each area) showed that MW irradiation of areas of the rabbit's body after preliminary anesthesia of the skin had no effect on the cardiac rhythm. Comparison between the results of the present study with the results of our previous experiments on the irradiation of rabbits with low-intensity MW [2, 3] reveals the following general features of the chronotropic effect of MW.

1. Irradiation of the ventral aspect of the rabbit's body, irrespective of the conditions and intensity of irradiation, produces a negative chronotropic effect.

2. Irradiation of the dorsal aspect of the body is accompanied by a chronotropic effect which differs in its character and severity, depending on the conditions and intensity of irradiation. Irradiation with MW of low intensity produces a positive chronotropic effect, especially pronounced during irradiation of the head; with the regime of irradiation used in the present investigation a negative chronotropic effect was observed. In experiments in which the skin of the parts of the body irradiated was anesthetized, the anesthetic used did not affect anything deeper than the subcutaneous cellular tissue. The fact that when the skin was anesthetized in the area to be irradiated, no changes were observed in the cardiac rhythm, confirms the hypothesis that a negative chronotropic effect arises as a result of the action of MW on the receptors of the skin.

LITERATURE CITED

1. A. S. Presman, Yu. I. Kamenskii, and N. A. Levitina, Uspekhi sovr. biol., 51, 1, 84 (1961).
2. A. S. Presman and N. A. Levitina, Byull. éksper. biol., 1, 41 (1962).
3. A. S. Presman and N. A. Levitina, Byull. éksper. biol., 2, 39 (1962).
4. N. T. Pryanishnikova and N. A. Sharov, Éksper. khir., 2, 83 (1962).
