

# NONTHERMAL ACTION OF MICROWAVES ON THE CARDIAC RHYTHM OF THE FROG

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In experiments on rabbits the author discovered [2, 3] the development of a negative or positive chronotropic effect in response to microwave irradiation depending on the conditions of irradiation and the localization of the irradiated area.

A. S. Presman [4] put forward the hypothesis that the chronotropic effect of microwaves (MV) is reflex, and a negative effect arises after irradiation in various conditions because of the action of the MV on the cutaneous receptors and a positive effect as the result of the direct action of the MV on the brain structures, which is possible only when certain conditions of irradiation are used.

To continue the investigation of the mechanism of action of MV on the cardiac rhythm, experiments were carried out on a cold-blooded animal (the frog).

Whereas, the action of high-frequency (HF), and ultra-high frequency (UHF) fields on the cardiac rhythm of cold-blooded animals has frequently been studied, no such investigations have been undertaken in the microwave (VHF) range. The object of the present investigation was to study the effect of MV on the cardiac rhythm of frogs when applied extracardially and directly.

## EXPERIMENTAL METHOD

Two groups of experimental investigations were carried out.\*

In group 1 the object was to determine the character of the action of MV on the cardiac rhythm of intact frogs. Two series of experiments were included: series I—irradiation of the dorsal region of the frog; series II—irradiation of the frog's head (dorsal aspect).

The experiments of group 2 were carried out to discover the role of the individual parts of the reflex arc in the mechanism of action of MV on the cardiac rhythm. These experiments were carried out in association with depression of the central nervous system by general anesthesia, disturbance of the extracardial innervation, and on preparations of the denervated frog's heart *in situ*.

Three corresponding series of experiments were carried out: series III—irradiation of the dorsal region of the anesthetized frog; IV—irradiation of the dorsal region of the frog with a denervated heart; series V—irradiation of the denervated frog's heart.

The cardiac rhythm was recorded by means of needle electrodes on a specially built apparatus. The potentials of the ECG (from an "Alvar" electrocardiograph) were fed into a type PT-2 pulsotachometer, and from it into a type N-370-M recorder.

Irradiation was provided by a type LMS-253-A microwave generator (continuous waves,  $\lambda = 12.5$  cm), feeding a rectangular water-filled transmitter with an aperture of  $72 \times 34$  mm. The intensity of irradiation was  $0.03-0.06$  mW/cm<sup>2</sup> (heating of the tissues is not observed with irradiation of this intensity).

Frogs of the species *Rana temporaria* weighing 30-40 g were used. The animals were fixed to a wooden board covered with wax (abdomen downward when irradiating the dorsum and head and abdomen upward when irradiating the heart). The frog was completely covered by a slab of absorbent KhV-10 material in which a rectangular hole was made exposing only the part to be irradiated, and the transmitter was placed above it. The dorsum and head were irradiated through a hole measuring  $50 \times 35$  mm and the heart through a hole measuring  $13 \times 13$  mm.

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\*The experiments were conducted at the Central Research Institute of Balneology and Physiotherapy.

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As a rule, irradiation began 10-15 min after stabilization of the cardiac rhythm and continued for 20 min (dorsum and head) and 15 min (heart). Recording the rhythm began 20 min before irradiation and ended 10-15 min after.

The animals were anesthetized with urethane (0.045 g/0.1 cm<sup>3</sup> water, into the dorsal lymph sac). The extracardial innervation was destroyed by dividing the cardiac branches of the vago-sympathetic trunk bilaterally. For irradiation of the denervated heart, the thorax was opened, both branches of the vagosympathetic trunk were divided, and the pericardium was removed. A humid atmosphere was maintained constantly around the heart.

#### EXPERIMENTAL RESULTS AND DISCUSSION

Series I. In 10 experiments in which the dorsal region was irradiated the following changes were observed in the cardiac rhythm (within the limit of 6% of the original level): a decrease in the rate in 50%, an increase in 20%, and changes in both directions in 10% of cases. In 20% of cases there were no changes.

Series II. In 10 experiments in which the dorsal aspect of the frog's head was irradiated, no slowing of the cardiac rhythm was observed, but it became quicker (on the average by 9% of the initial level) in 80% of cases and the rhythm remained unchanged in 20%.

Series III. In 10 experiments in which the dorsal region of the anesthetized (20-30 min before irradiation) frog was irradiated, no changes in the cardiac rhythm were found.

Series IV. In 10 experiments in which the dorsal region of the frog with denervated (20-30 min before irradiation) heart was irradiated, no changes took place in the cardiac rhythm.

Series V. In 8 experiments in which the denervated heart was irradiated directly in situ, no changes in the cardiac rhythm were observed.

The results of the experiments of series I and II on intact frogs showed that irradiation of the dorsal region with microwaves of nonthermal intensity gave a mainly negative chronotropic effect (slowing of the rhythm), while irradiation of the head gave a mainly positive effect (an increase in the rhythm). Similar results were obtained previously [2, 3] in experiments on rabbits. This suggests that the character of the chronotropic effect of microwaves of nonthermal intensity is determined purely by the localization of the part of the body irradiated, whether in warm-blooded or in cold-blooded animals.

The results of the experiments of series III, IV, and V showed that the chronotropic effect of microwaves does not develop if the central nervous system is depressed (by general anesthesia), if the extracardial innervation is disturbed and, finally, if the denervated heart is irradiated directly in situ. Comparison of these results with the fact previously established [1], that during irradiation of rabbits with anesthetized cutaneous receptors, the chronotropic effect of the microwaves likewise did not develop, confirms the validity of the hypothesis that this effect is reflex in nature.

In fact, if any link of the reflex arc was broken—by blocking the cutaneous receptor link of the arc (by local anesthesia), in the rabbit, or by depressing the central nervous system by general anesthesia (the central link of the arc), or by destroying the extracardial innervation (the efferent link) in frogs, irradiation with microwaves did not produce a chronotropic effect.

#### LITERATURE CITED

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