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MOLECULAR ORGANIZATION OF THE VAGUS NERVES AND CARDIAC MUSCLE IN VARIOUS FUNCTIONAL STATES

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The mitogenetic radiation of the rabbit vagus nerve was investigated during electrical stimulation of the opposite trunk. The radiation characterizes the structural states of the neuroplasm of the nerve and sarcoplasm of the heart. It was shown that during subthreshold stimulation the number of unbalanced molecular constellations rises. The physiological importance of this phenomenon is discussed.

KEY WORDS: mitogenetic radiation; unbalanced molecular constellations.

Spectral analysis of the mitogenetic radiation of the rabbit heart suggests that in response to weak stimulation of the vagus nerve the number of unbalanced molecular constellations (UMCs) in the sarcoplasm of the heart increases, but to threshold stimulation their number decreases [1]. Structural changes of this sort are interesting. Their further study was based on determination of degradation radiation. However, cooling of the heart (as a degrading factor) is impracticable because of the animal's reaction. One vagus nerve trunk was therefore cooled while the opposite trunk was stimulated, the argument being that chain processes arising in the heart muscle during stimulation of the nerve would in turn induce molecular structural changes in the second, unstimulated nerve [2]. This in no way ruled out, of course, the possibility of conduction of the processes through the brain centers.

EXPERIMENTAL METHOD

Short segments of the vagus nerves were exposed in the neck of an unanesthetized rabbit. Electrodes connected to a stimulator, generating pulses 1 msec in duration, with a frequency of 40 Hz, and of varied voltage, were fixed to one nerve. For the period of exposure a biological radiation detector was placed a few millimeters away from the unstimulated nerve, which was flooded with warm (37-38°C) or cold (5-6°C) physiological saline. Stimuli of threshold strength, slowing the heart beat (palpation) through the chest wall and of subthreshold strength were applied. The amplitude of the threshold stimulation was sometimes reduced during the experiments and in these cases the subthreshold stimuli were reduced correspondingly.

EXPERIMENTAL RESULTS

As Fig. 1 shows, in the resting state the nerve produced weak radiation, which remained at the same level both at the normal temperature and during cooling. During subthreshold

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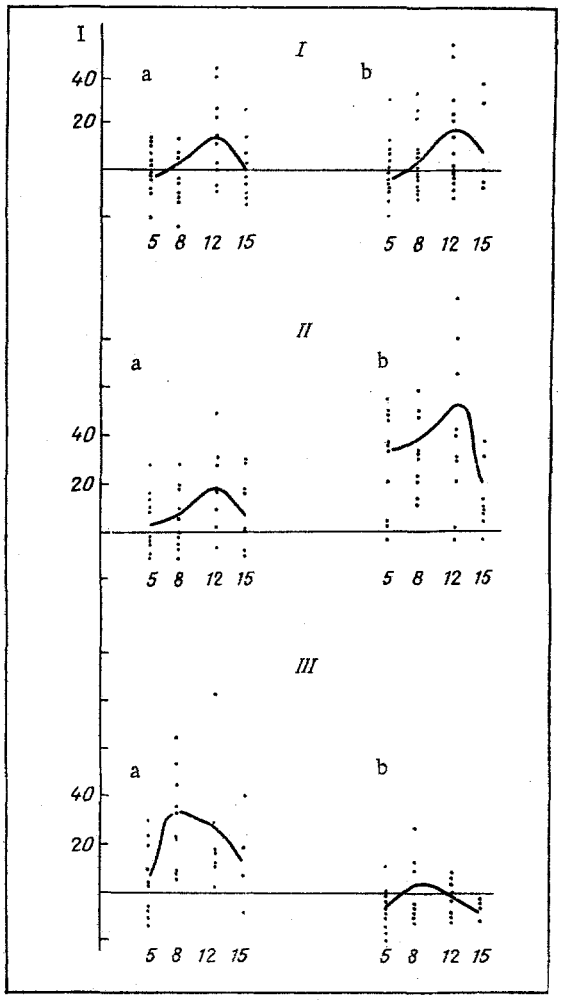

Fig. 1. Curves of radiation from vagus nerve (mean data): I) without stimulation; II) subthreshold stimulation; III) above-threshold stimulation; a) before; b) after cooling of the nerve. Abscissa, exposure (in sec); ordinate, relative intensity of radiation.

stimulation of the nerve, the opposite nerve emitted weak radiation at the normal temperature but its emission was sharply increased during cooling. Conversely, during stimulation of the nerve at above threshold strength, the radiation from the opposite nerve increased at the normal temperature, although cooling led to disappearance of the radiation.

Let us examine the data from the standpoint of an unbalanced structural state of the neuroplasm and sarcoplasm maintained while the nervous and muscular systems are at rest [2,4]. The unbalanced state means that the spatial parameters of the structures are "bound" to it to some degree by influences of surrounding structures, including distant ones, i.e., that this interaction is based on steric chain processes. Translating these molecular ideas to the macrolevel, at rest the tendency of the systems toward general balancing of the processes and toward the development of a dynamic whole comes to fruition.

It is logical to distinguish two main types of the unbalanced structural state: deformed excitatory states of complex, e.g., protein, molecules,* and mobile, temporary associations of less complex excited molecules, e.g., peptides — the UMCs that were spoken of at the beginning.† The probability of emission during an energy discharge of deformed molecules is small because of the distribution of the liberated energy among many intramolecular connections. However, during discharge of a UMC it is much greater and the degradation emission is in fact associated

*Widely examined in the recent biophysical literature [3].
†See also [2, 4].

with disturbances of constellations. The weak emission of the resting vagus nerve is regarded as predominance of the deformation type of imbalance, although the presence of UMCs cannot, of course, be ruled out.

However, the marked increase in degradation emission from the nerve during subthreshold stimulation of the opposite nerve points to structural changes in the substrate connected with the increase in the constellation form of imbalance. This phenomenon is of special interest, for subthreshold stimulation, in the writer's opinion, simulates the natural course of processes during preparation of the muscle for its macromanifestation, i.e., its response. However, while examining this phenomenon no mention will be made of the possible mechanisms of the molecular structural changes; only the physiological aspect of the phenomenon will be considered. The most valid suggestion is that the first stage of the incipient subthreshold state is some acceleration of the chain processes, especially in the more labile UMCs. However, even a small shift can have important consequences, allowing for the general state of balance of the processes. We can postulate that during subthreshold stimulation it not only does not cease, but actually becomes stronger, for the substrate response to acceleration of the processes by what can be regarded as compensatory phenomena — increased interaction between the structural elements. The consequent increased "binding" of the steric parameters increases the general imbalance of the substrate.

However, it must not be forgotten that we are concerned with purely functional concepts, namely changes of states, i.e., the dynamic quality of the structural states must also increase. The constellation form of imbalance corresponds closest of all to this demand. The argument presented above is of great biological significance if it is remembered that UMCs are molecular systems of undoubted importance for the general regulation of metabolism [4-6]. The state of subthreshold excitation must therefore be regarded as a preparatory phase, characterized by an increase in the imbalance of the substrate and the strengthening of its regulatory powers. However, an increase in the strength of endogenous or exogenous stimulation disturbs the compensatory powers of the substrate, with the consequent appearance of a reaction (in the present experiments, slowing of the heart beat). The energy potential of the UMC, it can tentatively be suggested, is utilized under these circumstances for several processes: activation of enzymes, changes in membrane permeability, distribution of charges, and so on. The character of radiation from the nerve in response to stimulation of above-threshold strength — disappearance of the degradation emission and an increase in emission at the normal temperature — corresponds to this hypothesis.

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